

## SIMPOSIO VIII

# REVISITING THE NEURAL CORRELATES OF CONSCIOUS PERCEPTION VIA THE COMBINATION OF INTRACRANIAL AND HIGH-DENSITY EEG

### Speakers

*Andrea Pigorini*

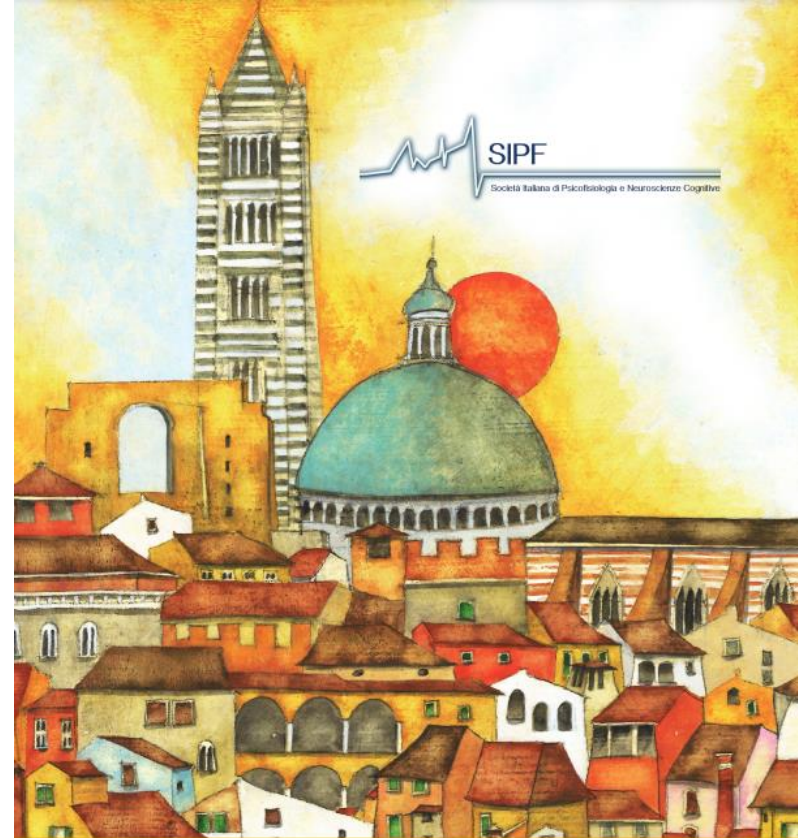
*Ezequiel Mikulan*

*Maria Del Vecchio*

### Chairs

*Pietro Avanzini*

*Maria Del Vecchio*



**XXXI CONGRESSO NAZIONALE SIFP**  
**Past, Present and Future Brains**

Siena 9-11 novembre 2023  
Museo Santa Maria della Scala



# Mapping perceptual awareness with multiple sensory stimulations, no-report paradigm and intracerebral recordings in humans

**XXXI Congresso Nazionale SIPF**

*10-11-23*

*Andrea Pigorini*



## Neuronal spatiotemporal boundaries of elementary conscious perception

*Mapping perceptual awareness with multiple sensory stimulations,  
no-report paradigm and intracerebral recordings in humans*

**XXXI Congresso Nazionale SIPF**

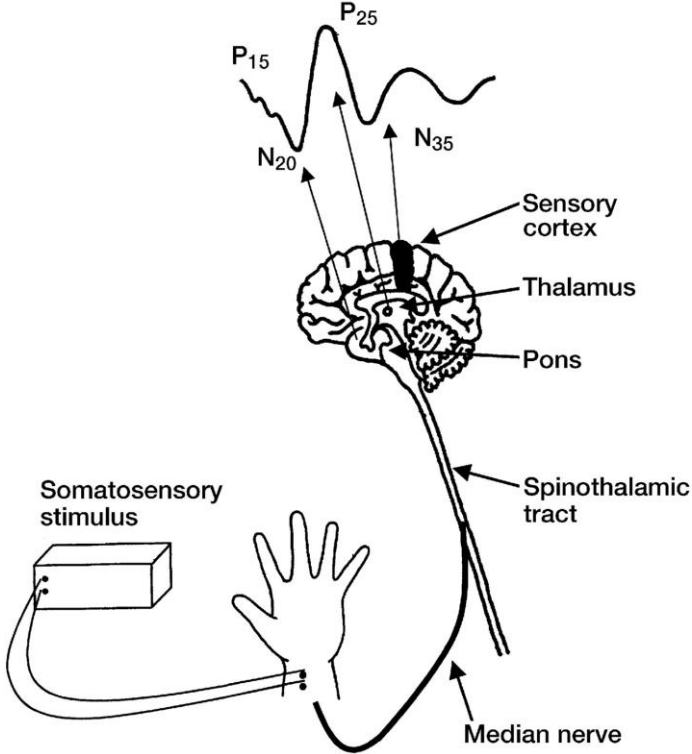
*10-11-23*

*Andrea Pigorini*

**What makes a very simple stimulus  
experience?**



# What makes a very simple stimulus experience?

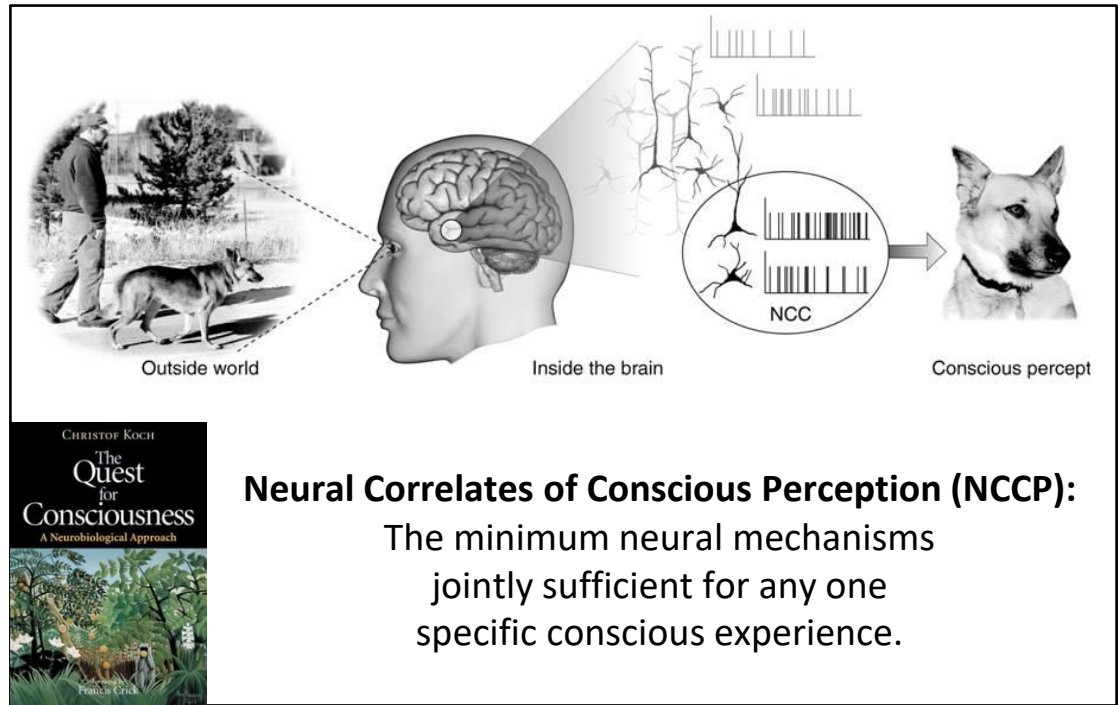


## Towards a neurobiological theory of consciousness

Francis Crick and Christof Koch

### Prolegomenon to the study of consciousness

We make two basic assumptions. The first is that there is something that requires a scientific explanation. There is general agreement that we are not conscious of all the processes going on in our heads, though exactly which might be a matter of dispute. While we are aware of many of the results of perceptual and memory processes, we have only limited access to the processes that produce this awareness (e.g. "How did I come up with the first name of my grandfather?"). In fact, some psychologists<sup>5</sup> have argued that we have only very limited introspective access to the origins of even higher order cognitive processes. It seems probable, however, that at any one moment some active neuronal processes correlate with consciousness, while others do not. What are the differences between them?



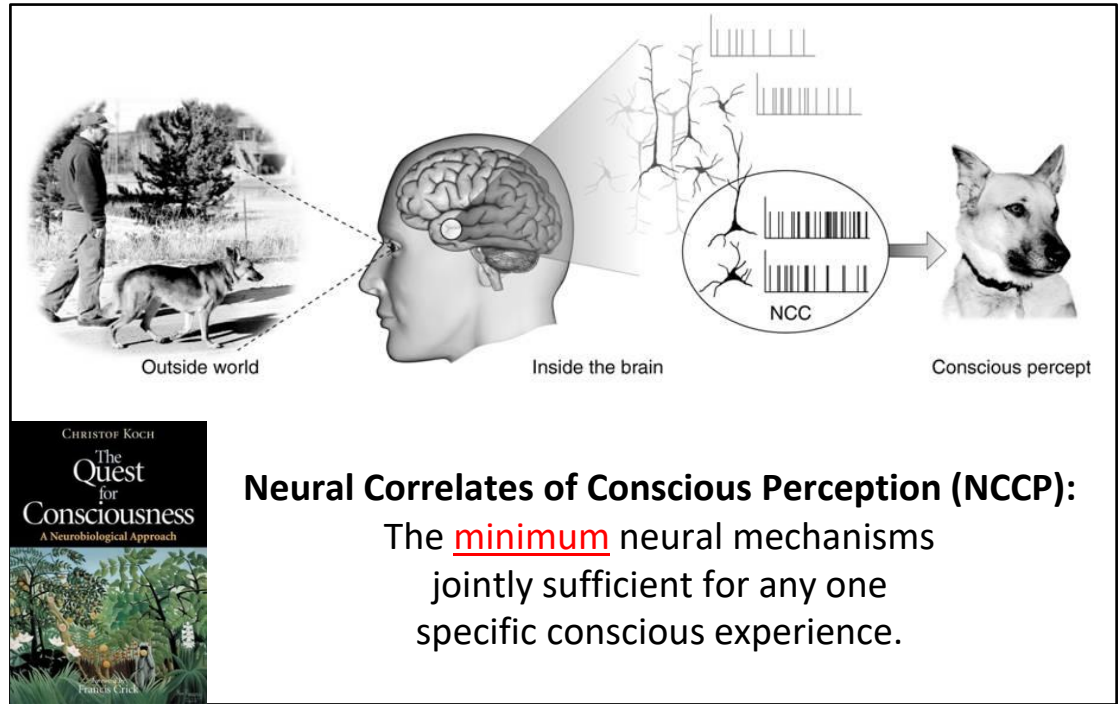
**Neural Correlates of Conscious Perception (NCCP):**  
The minimum neural mechanisms  
jointly sufficient for any one  
specific conscious experience.

## Towards a neurobiological theory of consciousness

Francis Crick and Christof Koch

### Prolegomenon to the study of consciousness

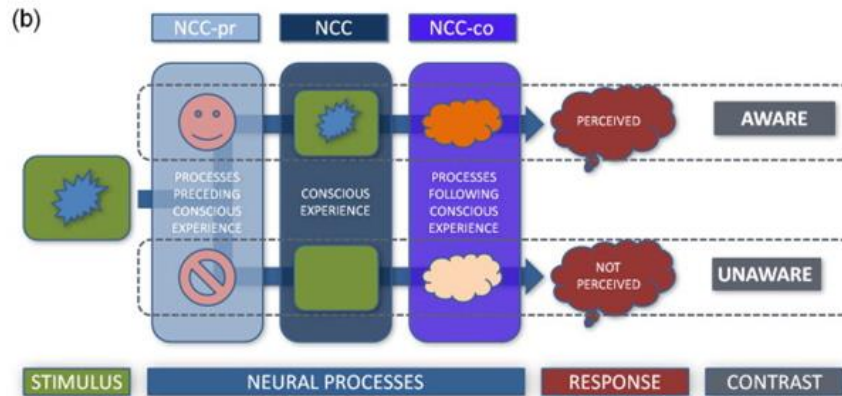
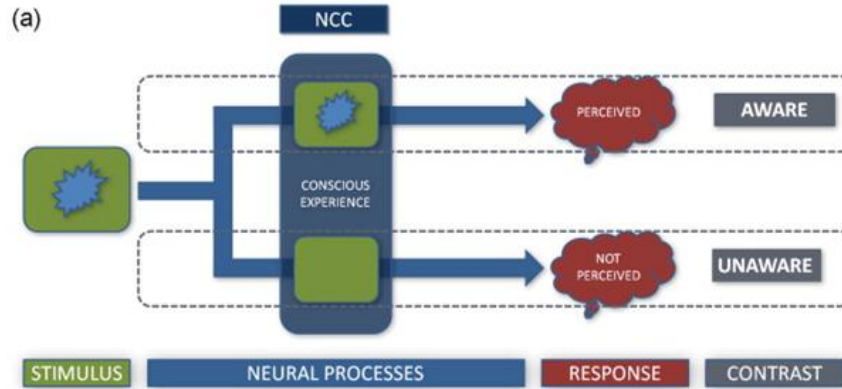
We make two basic assumptions. The first is that there is something that requires a scientific explanation. There is general agreement that we are not conscious of all the processes going on in our heads, though exactly which might be a matter of dispute. While we are aware of many of the results of perceptual and memory processes, we have only limited access to the processes that produce this awareness (e.g. "How did I come up with the first name of my grandfather?"). In fact, some psychologists<sup>5</sup> have argued that we have only very limited introspective access to the origins of even higher order cognitive processes. It seems probable, however, that at any one moment some active neuronal processes correlate with consciousness, while others do not. What are the differences between them?



### Neural Correlates of Conscious Perception (NCCP):

The minimum neural mechanisms jointly sufficient for any one specific conscious experience.

**By definition looking for NCCP implies contrasting two conditions**





**In search for neural correlates  
of conscious perception:  
experimental issues**

**1) Report**

**In search for neural correlates  
of conscious perception:  
experimental issues**

- 1) Report**
- 2) Task-relevance**
- 3) Experimental model**
- 4) Sensory modality**
- 5) Spatio-temporal grain**

# In search for neural correlates of conscious perception: **experimental issues**

1) Report

2) Task-relevance

3) Experimental model

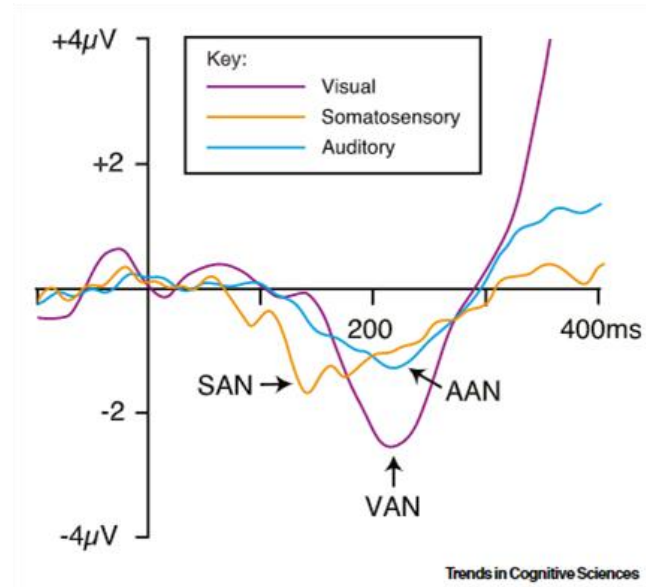
4) Sensory modality

5) Spatio-temporal grain

## Opinion

Perceptual awareness negativity: a physiological correlate of sensory consciousness

Cole Dembski,<sup>1</sup> Christof Koch,<sup>2,\*</sup> and Michael Pitts<sup>1</sup>



**In search for neural correlates  
of conscious perception:  
experimental issues**

**In search for neural correlates  
of conscious perception:  
the ideal experiment**

**1) Report**

**2) Task-relevance**

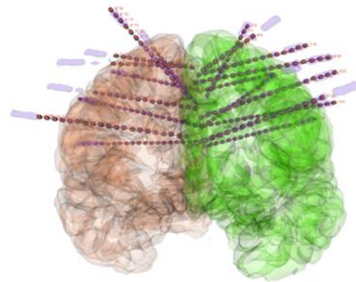
**3) Experimental model**

**4) Sensory modality**

**5) Spatio-temporal grain**

In search for neural correlates  
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**experimental issues**

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- 2) Task-relevance
- 3) Experimental model
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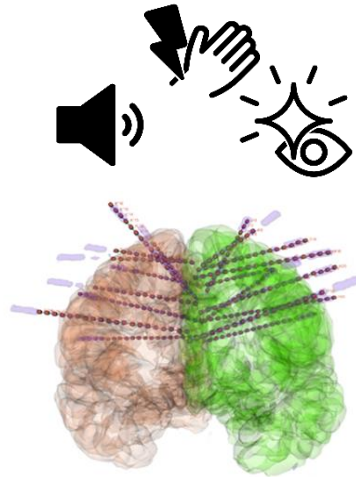


In search for neural correlates  
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- 5) Invasive/Intracranial

In search for neural correlates  
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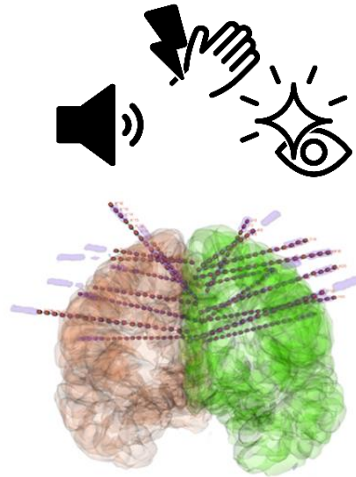


In search for neural correlates  
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- 4) Across sensory modalities
- 5) Invasive/Intracranial

In search for neural correlates  
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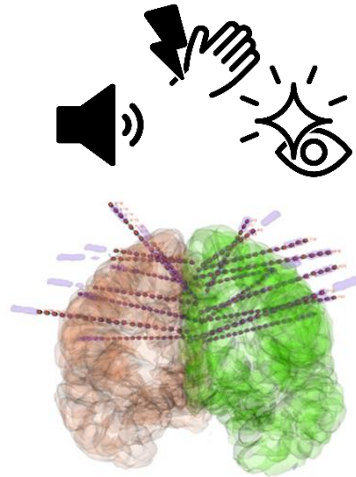


In search for neural correlates  
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- 3) In humans
- 4) Across sensory modalities
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In search for neural correlates  
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**experimental issues**

- 1) Report
- 2) Task-relevance
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In search for neural correlates  
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**the ideal experiment**

- 1) No-report
- 2) Task-irrelevant
- 3) In humans
- 4) Across sensory modalities
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In search for neural correlates  
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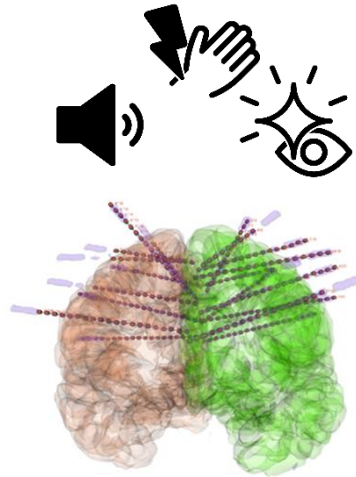
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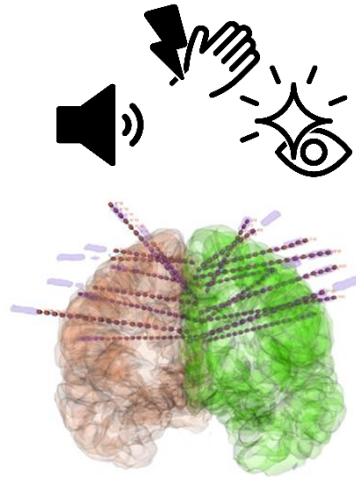
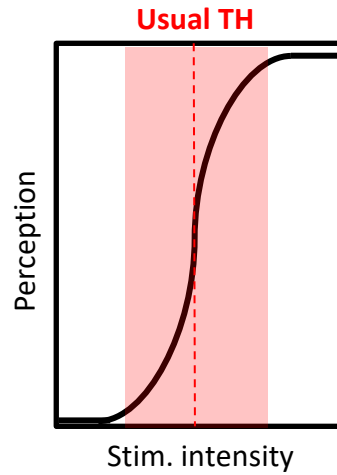
2) Task-irrelevant

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4) Across sensory modalities

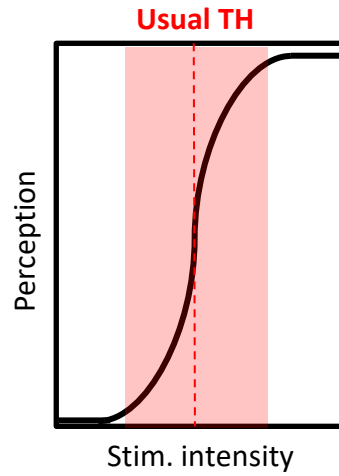
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In search for neural correlates  
of conscious perception:  
**the ideal experiment**

- 1) No-report
- 2) Task-irrelevant
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Clearly above threshold

< saliency

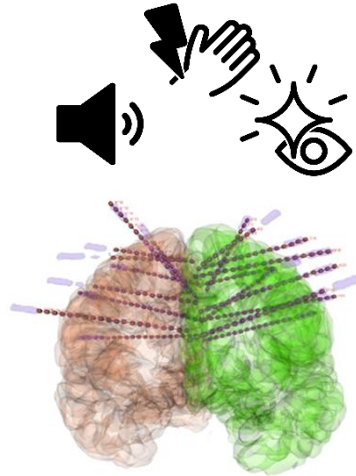
1) No-report

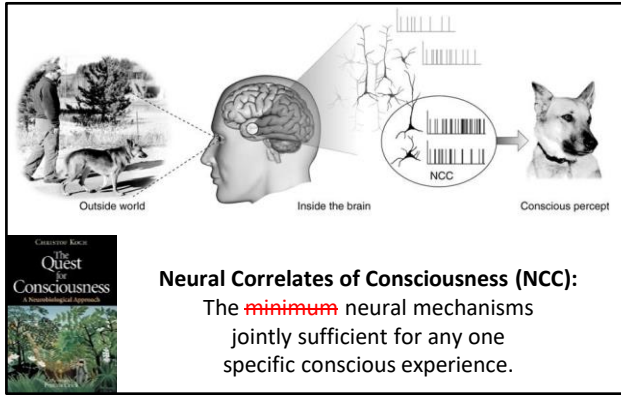
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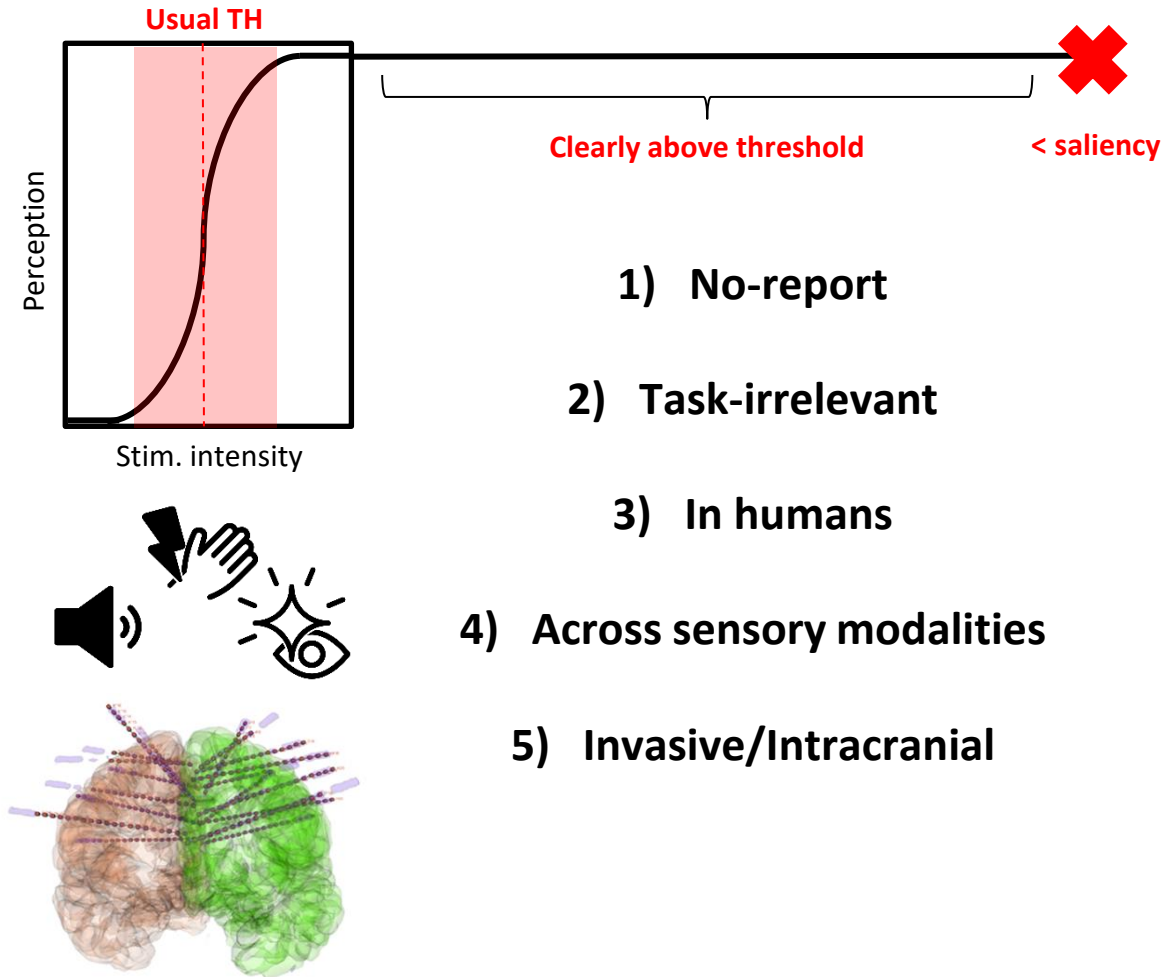




We look for something that is necessary and sufficient although non-minimal

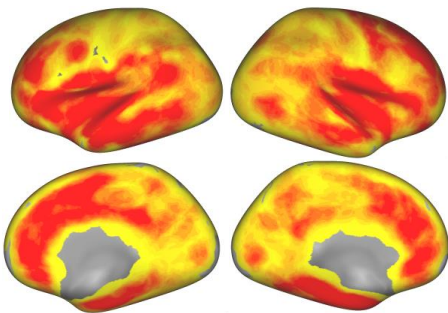


spatio-temporal domain of specific NCCP





**111 patients**  
**10527 contacts**



10  350

## Experimental paradigm



Clicks - **85dB**



Median Nerve  
Stimulation - **MT**



Flash - **3cd/m<sup>2</sup>**

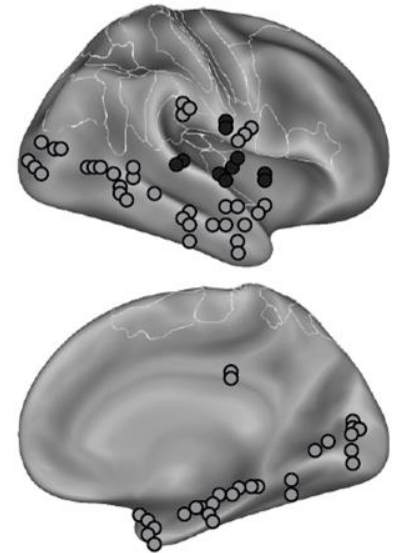
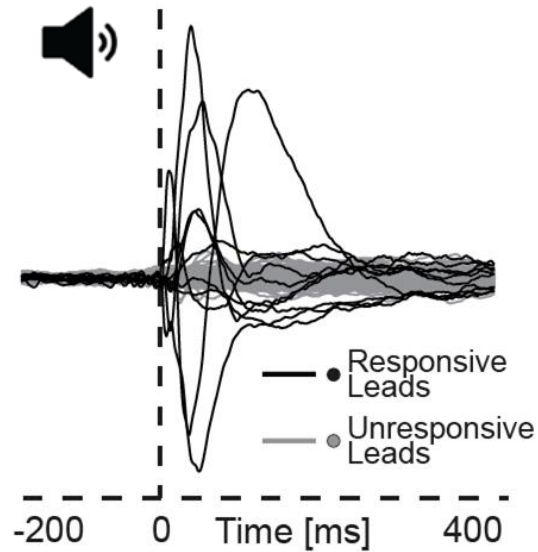
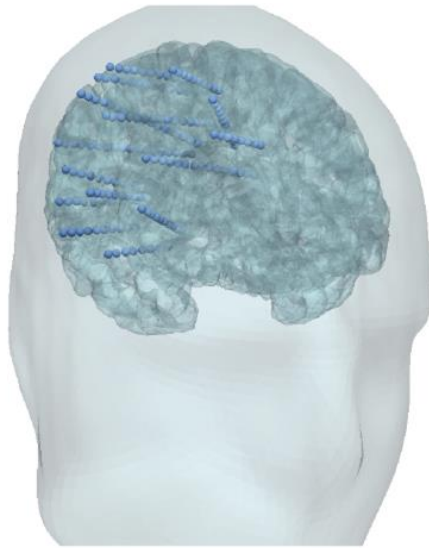
Three stimulation modalities obtained with standard clinical procedures:  
**undoubtedly above threshold and task irrelevant**

At the end of the stimulation subjects are asked to report whether they  
perceived stimuli:  
**delayed report**

~100 trial per each condition delivered at 1Hz:  
**less than 2 mins per stimulation session**

## RESULTS (1)

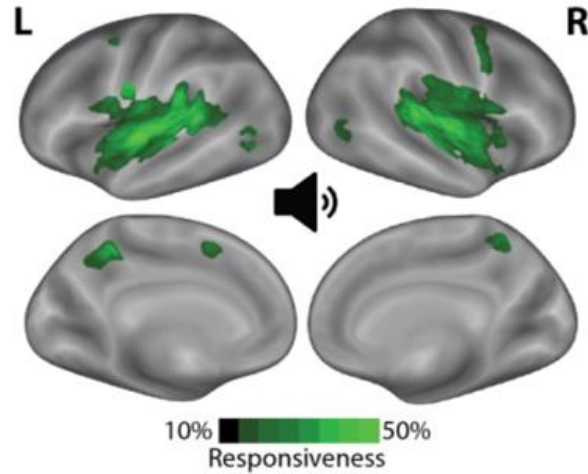
### Event Related Potentials responsiveness



## RESULTS (1)

### Event Related Potentials responsiveness

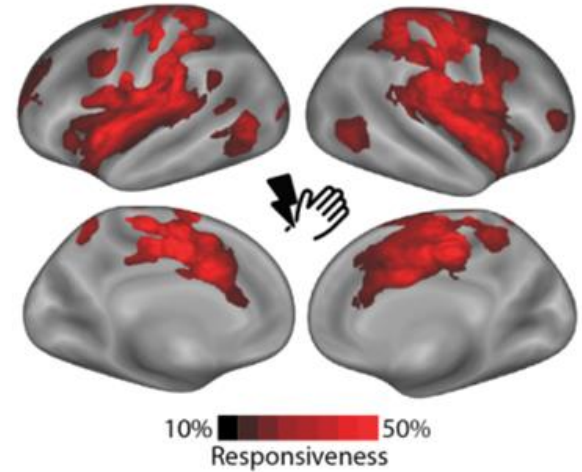
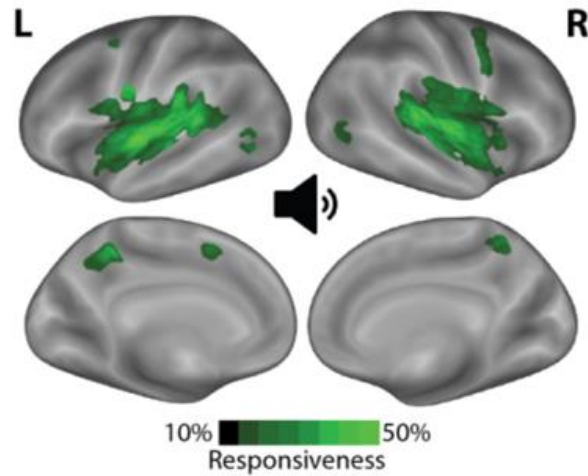
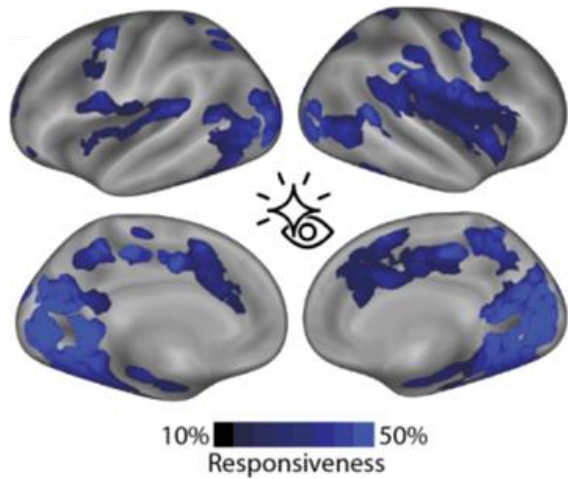
**N=111**  
**patients**



## RESULTS (1)

### Event Related Potentials responsiveness across modalities

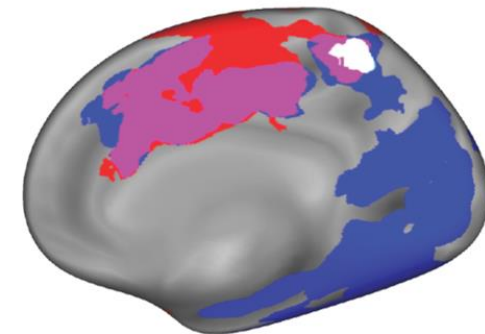
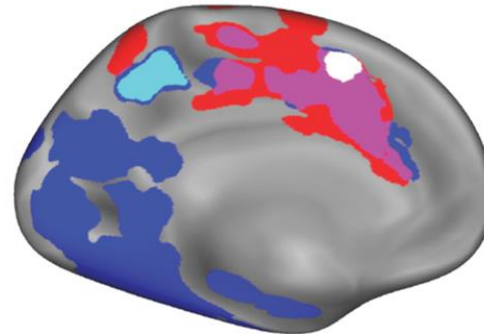
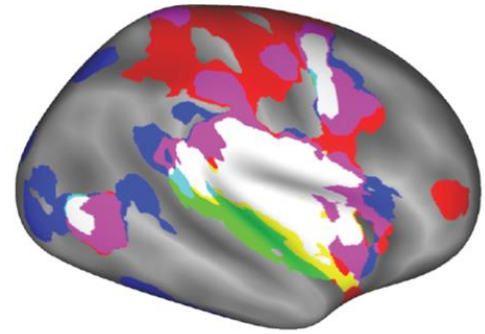
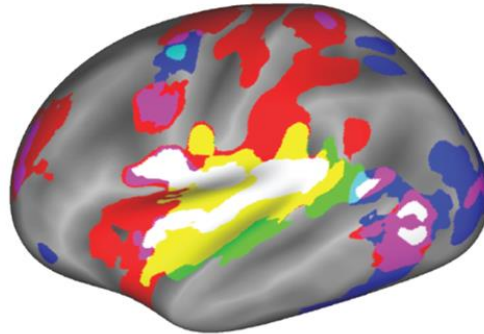
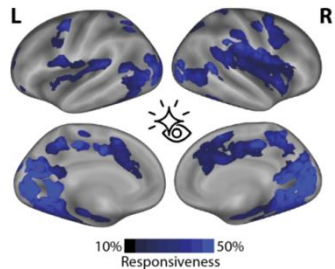
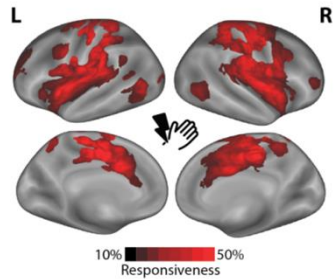
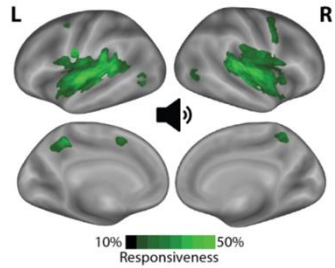
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# RESULTS (1)

## Event Related Potentials responsiveness across modalities

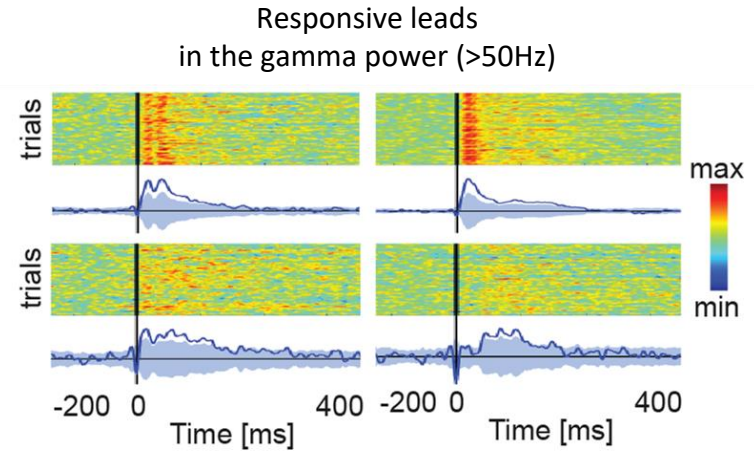
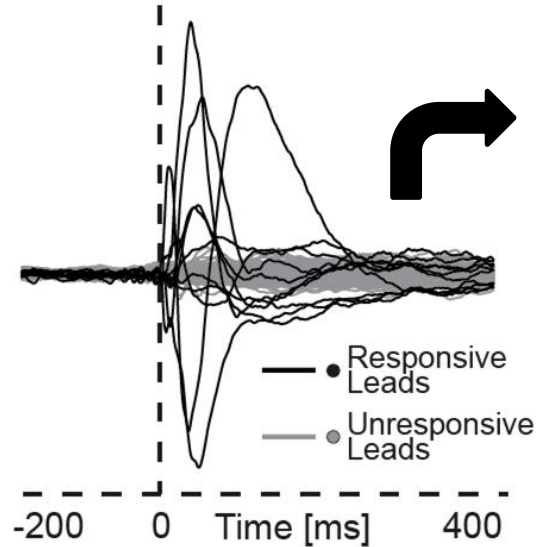
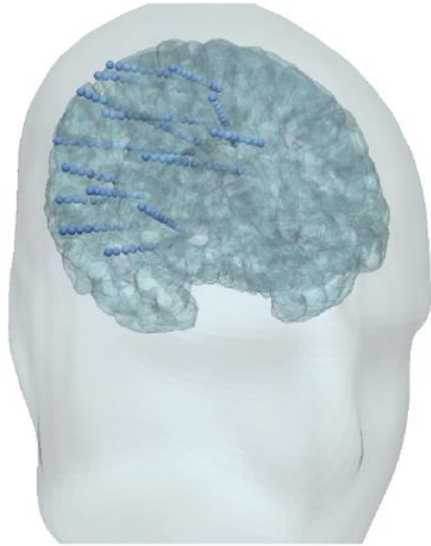


Areas responsive to:



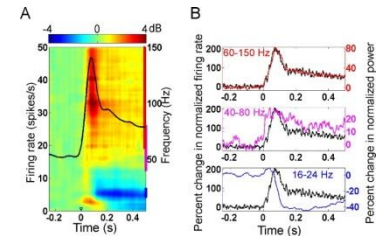
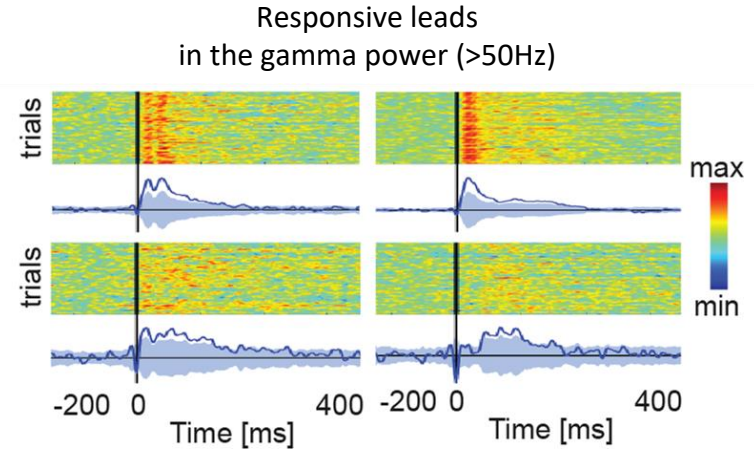
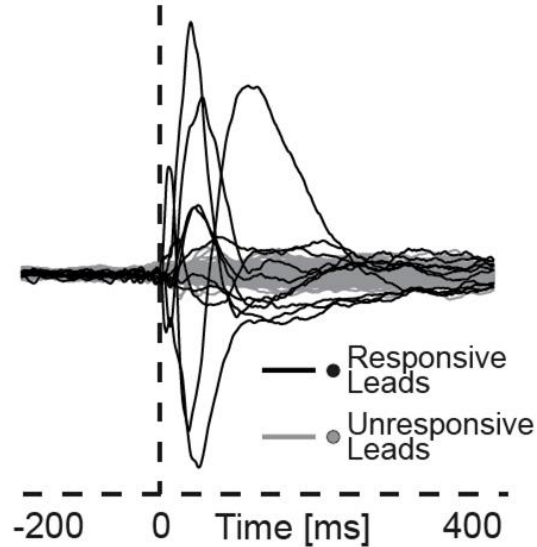
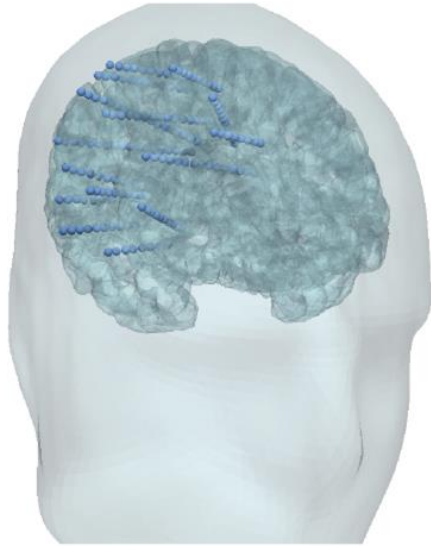
## RESULTS (2)

### Segregated gamma power activations across different sensory modalities.



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Gamma is a good proxy for firing rate

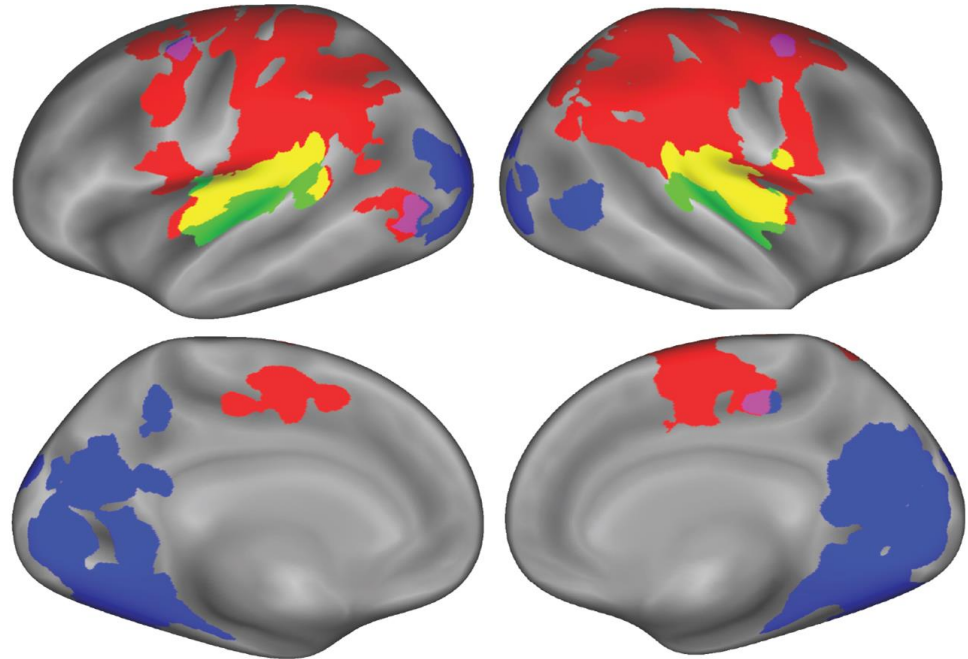
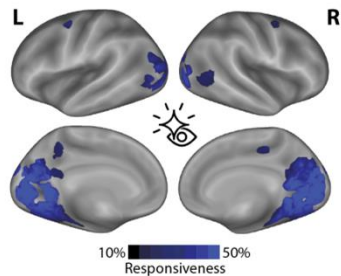
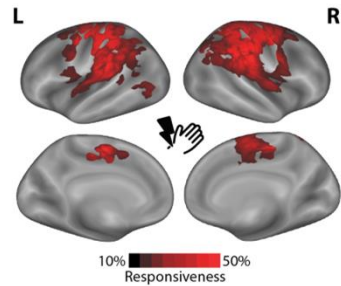
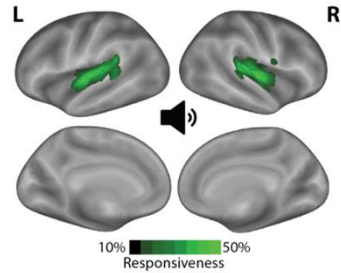
*Ray, JNeurosc, 2008;*

*Vidal, Front Hum Neurosc, 2010;*

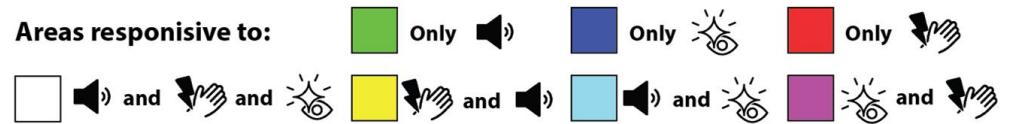
*Buzsaki, Nature Rew, 2012.*

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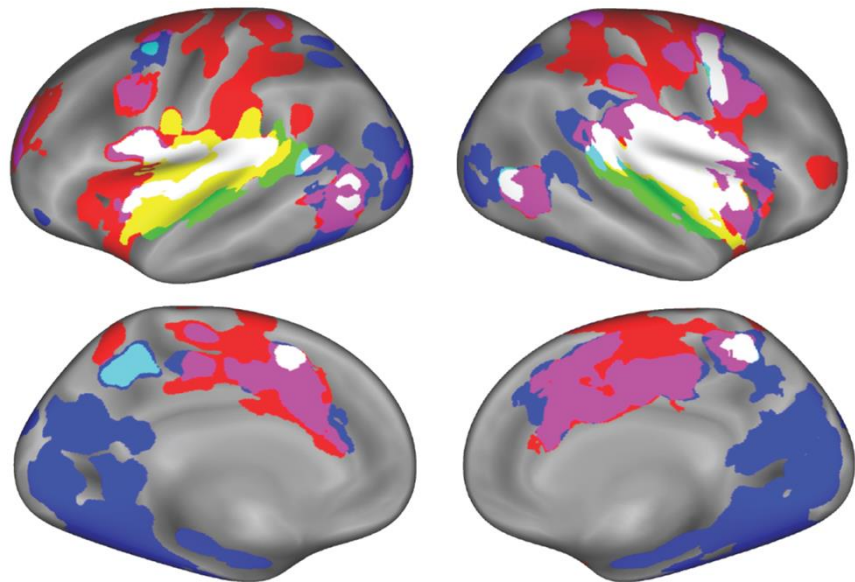
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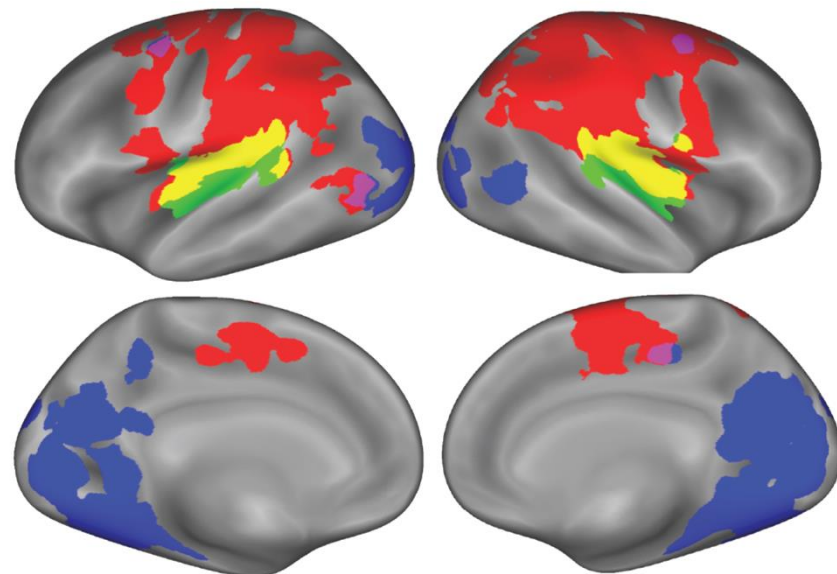
Areas responsive to:



## ERP responsiveness



## GAMMA responsiveness

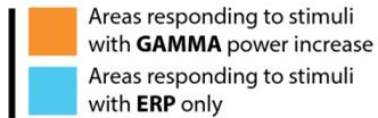
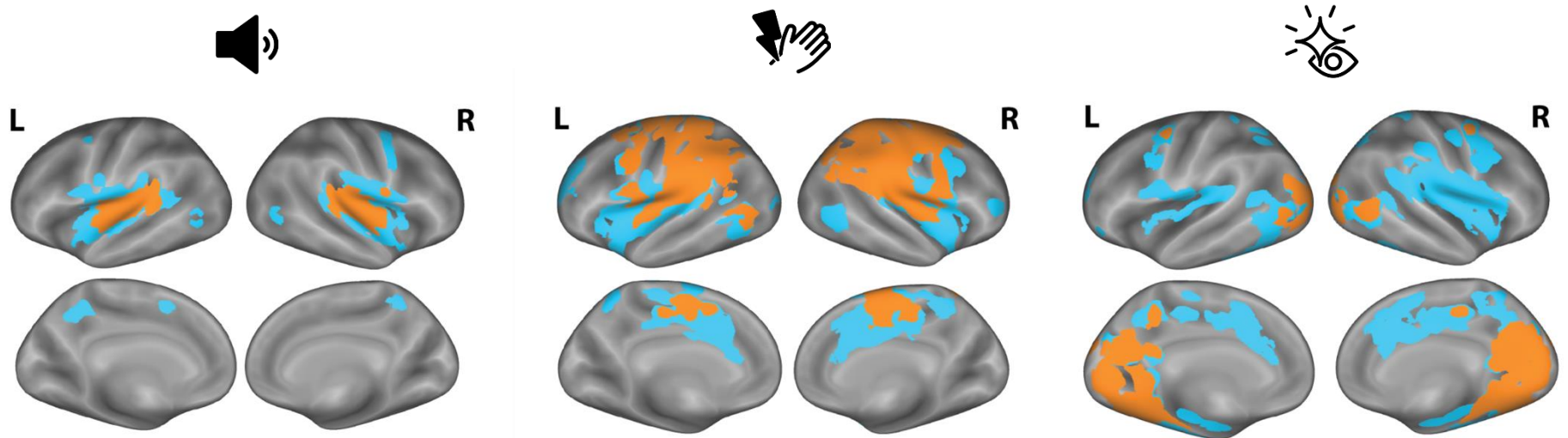


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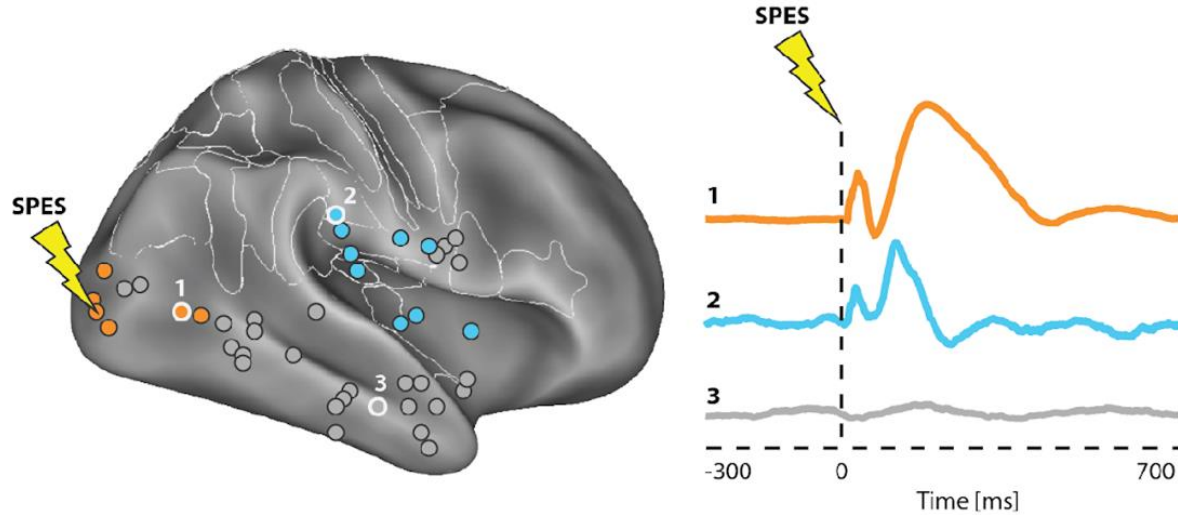
## RESULTS (3)

### Event Related Potentials extend beyond the segregated clusters of Gamma power



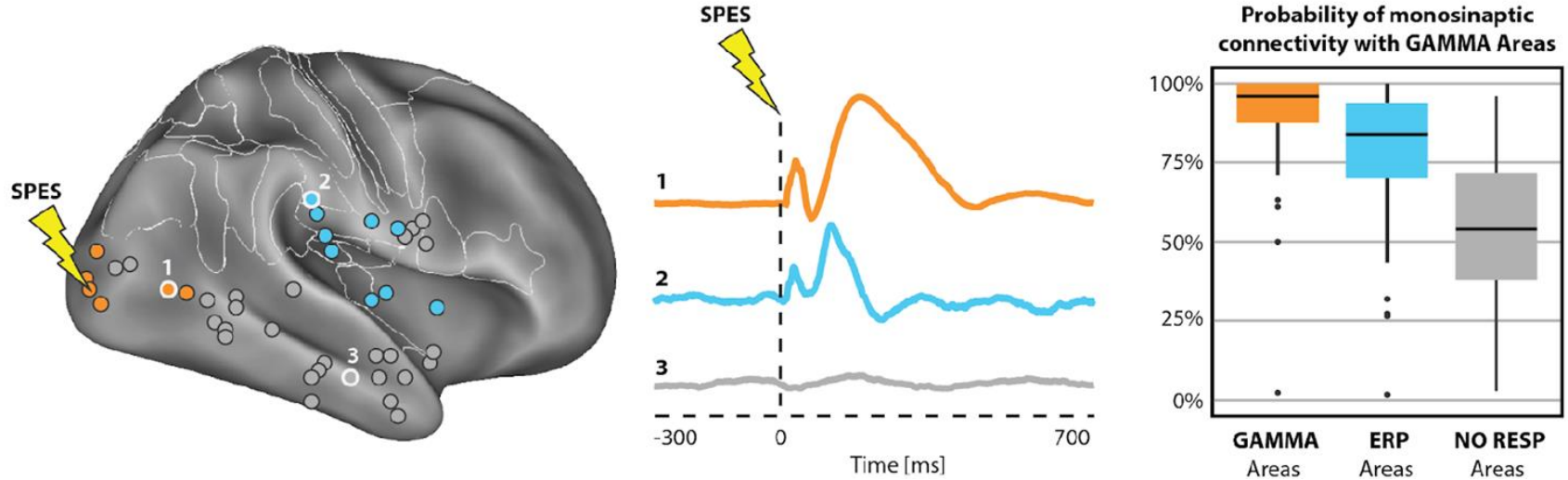
## RESULTS (3)

Event Related Potentials extend beyond the segregated clusters of Gamma power through feed-forward monosynaptic connections.



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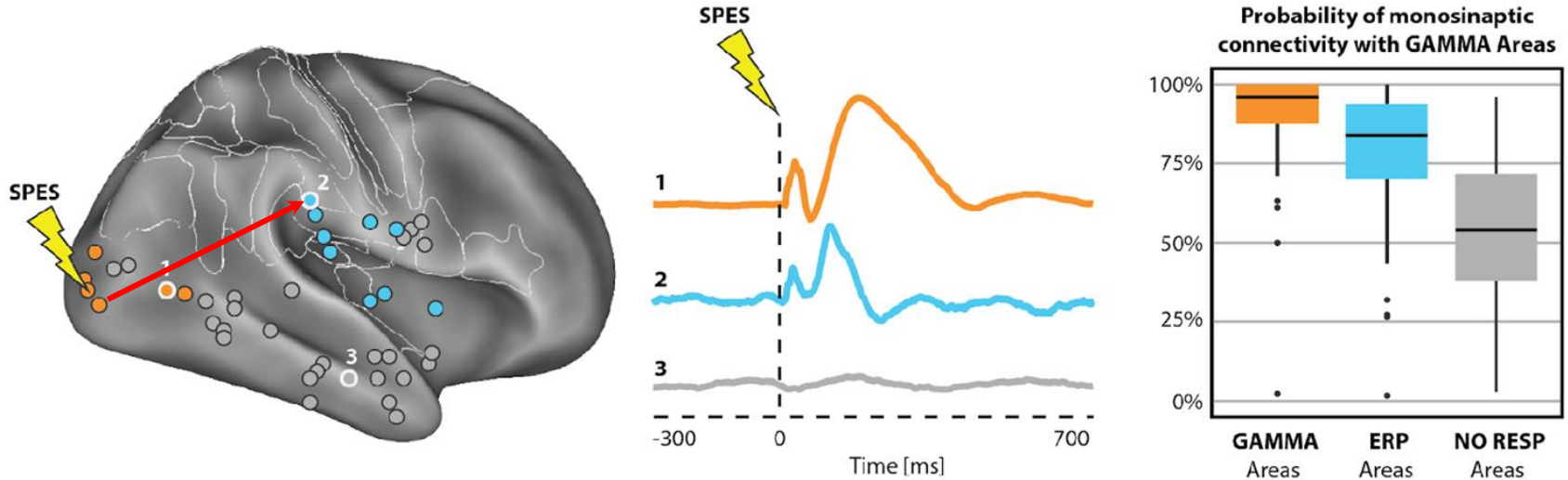
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## RESULTS (3)

Event Related Potentials extend beyond the segregated clusters of Gamma power through feed-forward monosynaptic connections.



The neuronal activity (*gamma*) generated by the peripheral stimuli in **specific, segregated areas** induces, through **feed-forward monosynaptic** connections, local post-synaptic potentials (*ERP alone*) at **distant sites**.

## RESULTS (4)

### Responsiveness in the PAN time windows

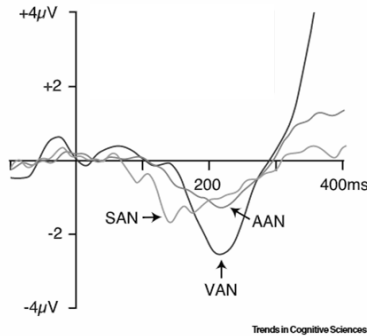


Table 1. Latencies and topographies of the VAN, AAN, and SAN<sup>a</sup>

	VAN	AAN	SAN
<b>Time window</b>	170–290 ms	130–230 ms	125–180 ms
<b>Average peak latency</b>	230 ms	180 ms	140 ms
<b>Topography</b>	Occipital	Fronto-central	Fronto-central

 CellPress

Trends in  
**Cognitive Sciences**

**Opinion**

Perceptual awareness negativity: a physiological correlate of sensory consciousness

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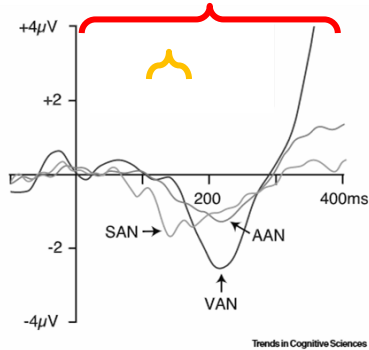
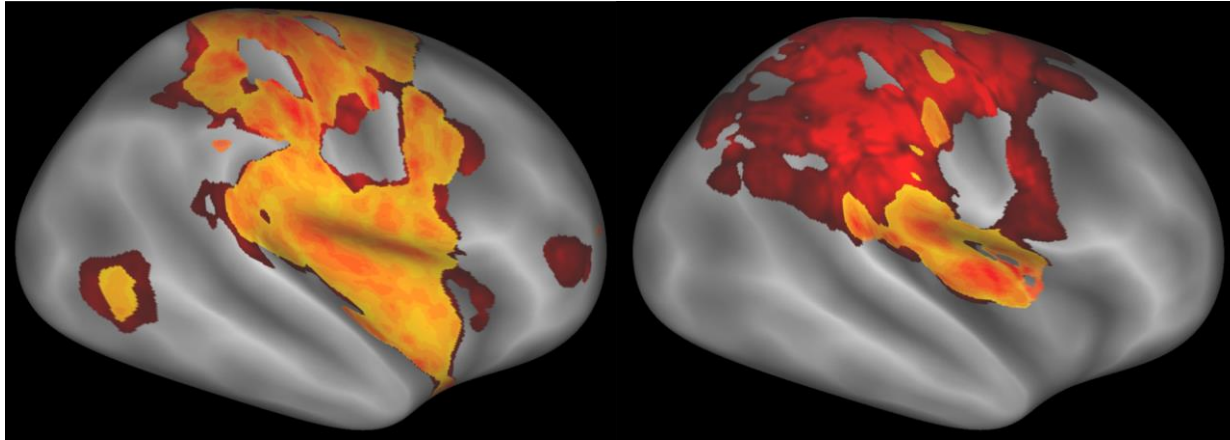


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ERP  
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GAMMA  
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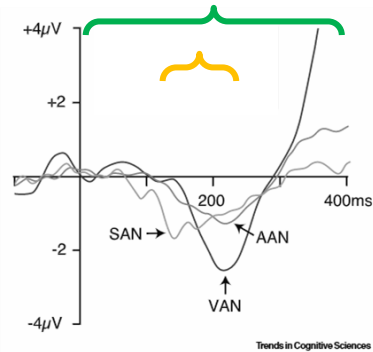
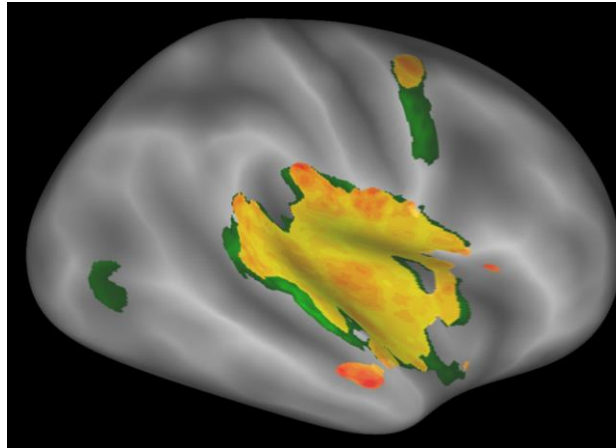


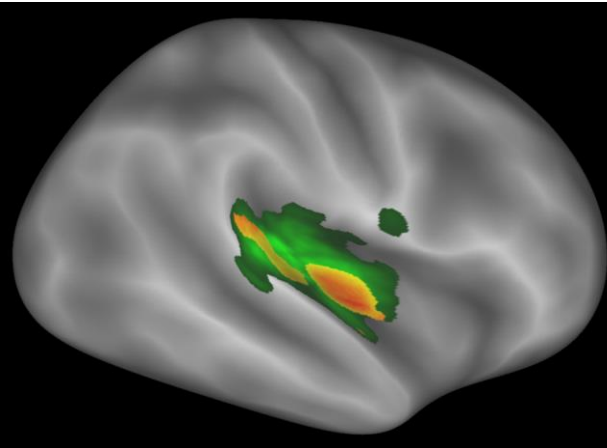
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responsiveness



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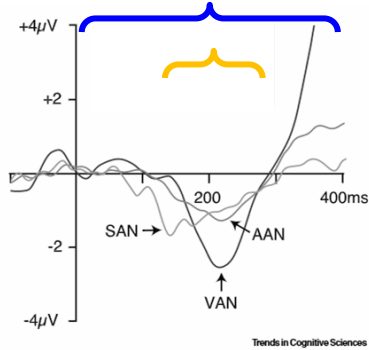
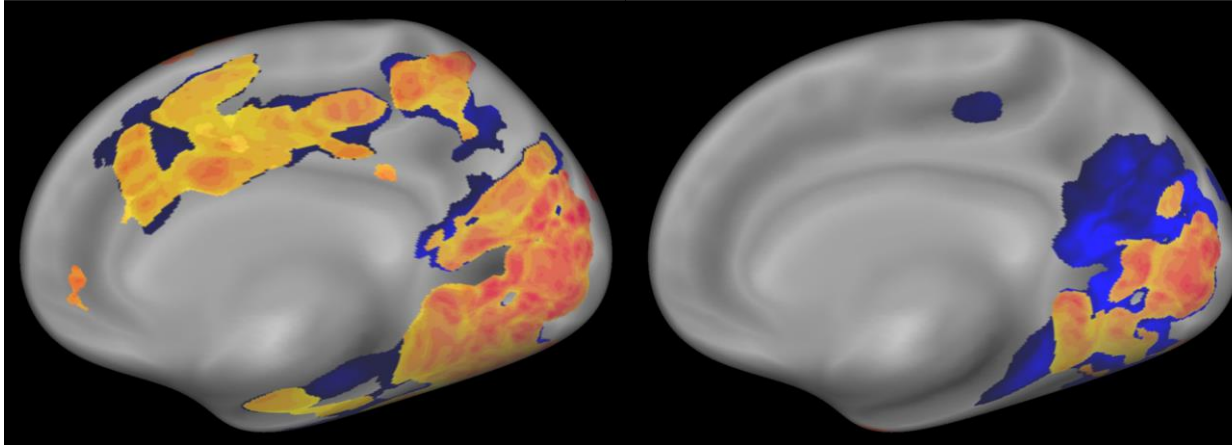


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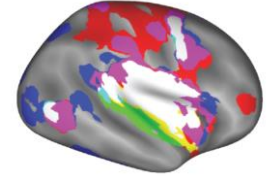
ERP  
responsiveness



GAMMA  
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## Take home

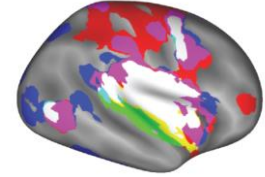
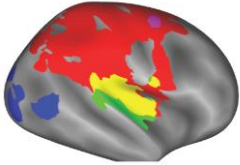
(1) Elementary stimuli across different sensory modalities evoke widespread Event Related Potentials that converge in perisylvian areas



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(2) The associated Neuronal activations (gamma), instead are limited to segregated cortical circuits...

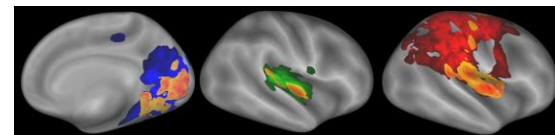
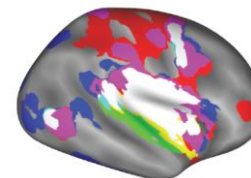
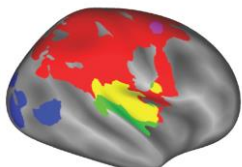


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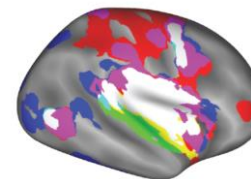
(3) ... and well defined time windows.



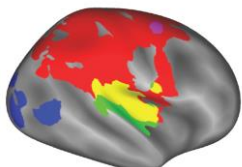


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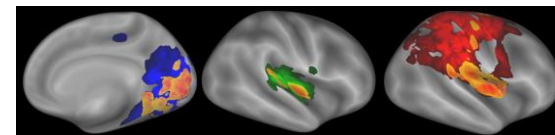
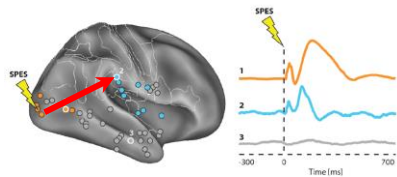


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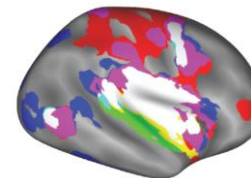
(3) ... and well defined time windows.

(4) Areas responding with ERP alone are probably facilitated by monosynaptic inputs from areas responding with neuronal activations

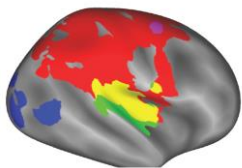


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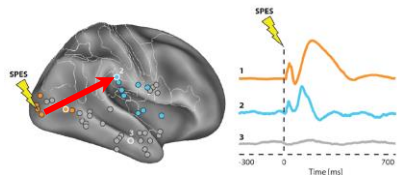
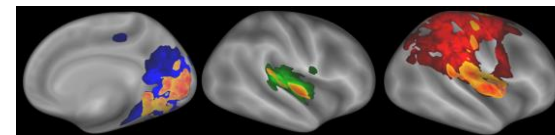


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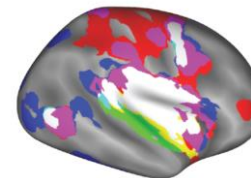
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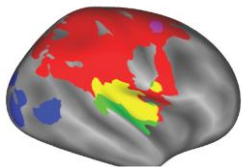
(5) Have we found the NCCP? → NO

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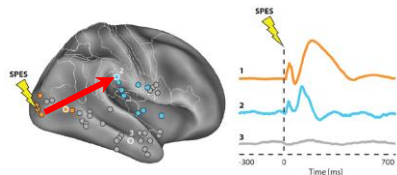
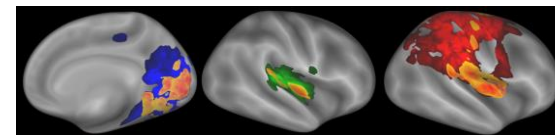


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(5) Have we found the NCCP? → NO

(6) We have defined their spatio temporal boundaries and we have proposed a new approach for looking at NCCP

# !! Thank you !!



Maria Del Vecchio  
Ezequiel Mikulan  
Flavia Zauli  
Ivana Sartori  
Marcello Massimini  
Pietro Avanzini

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Mario Rosanova  
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