Università degli Studi di Foggia

Dipartimento di Scienze Cliniche e Sperimentali

Cattedra di Fisiologia

Neurophysiology of Human Primary Consciousness

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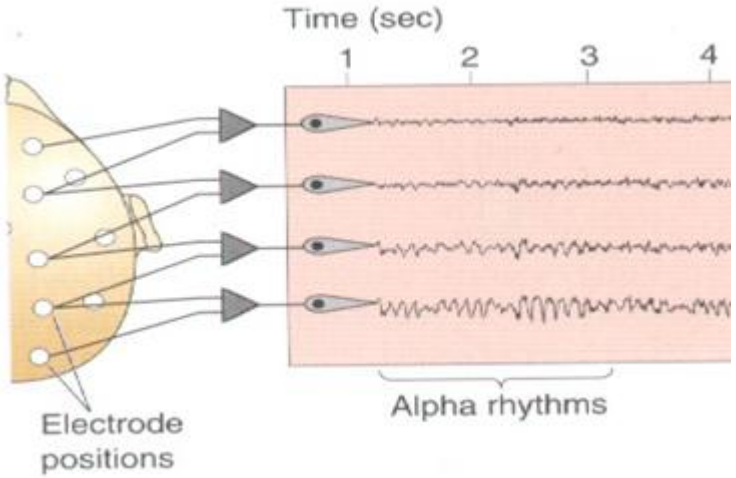
4. Section of Neurology, Catholic University of Rome; Rome, Italy

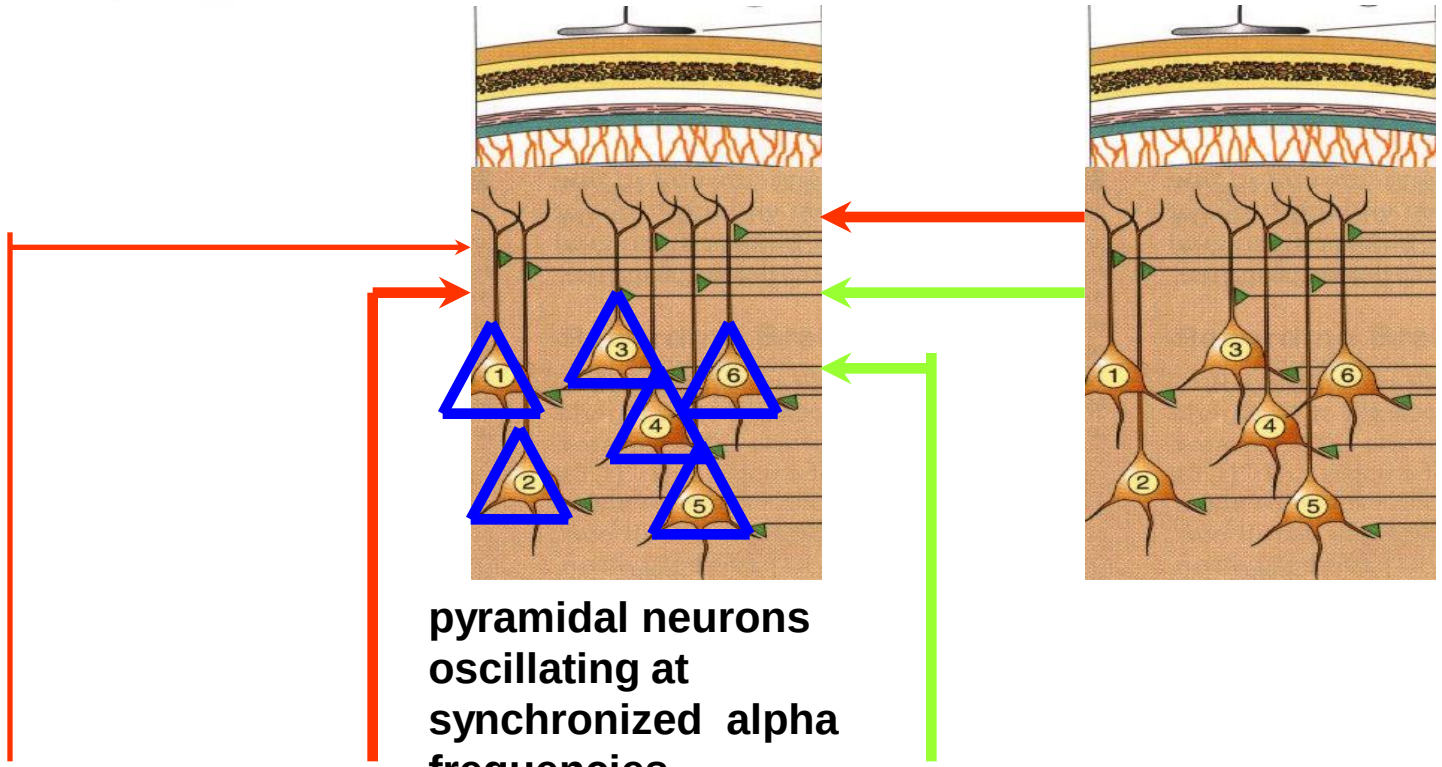
Primary (phenomenal) consciousness vs. non conscious stimulus processing

In the figure, primary consciousness sub-serves reading of the newspaper article, while non conscious processes elaborate walking people stimulus

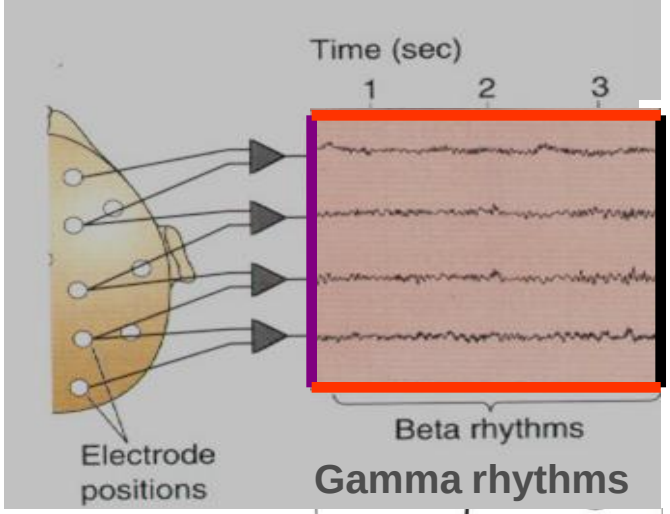
REST



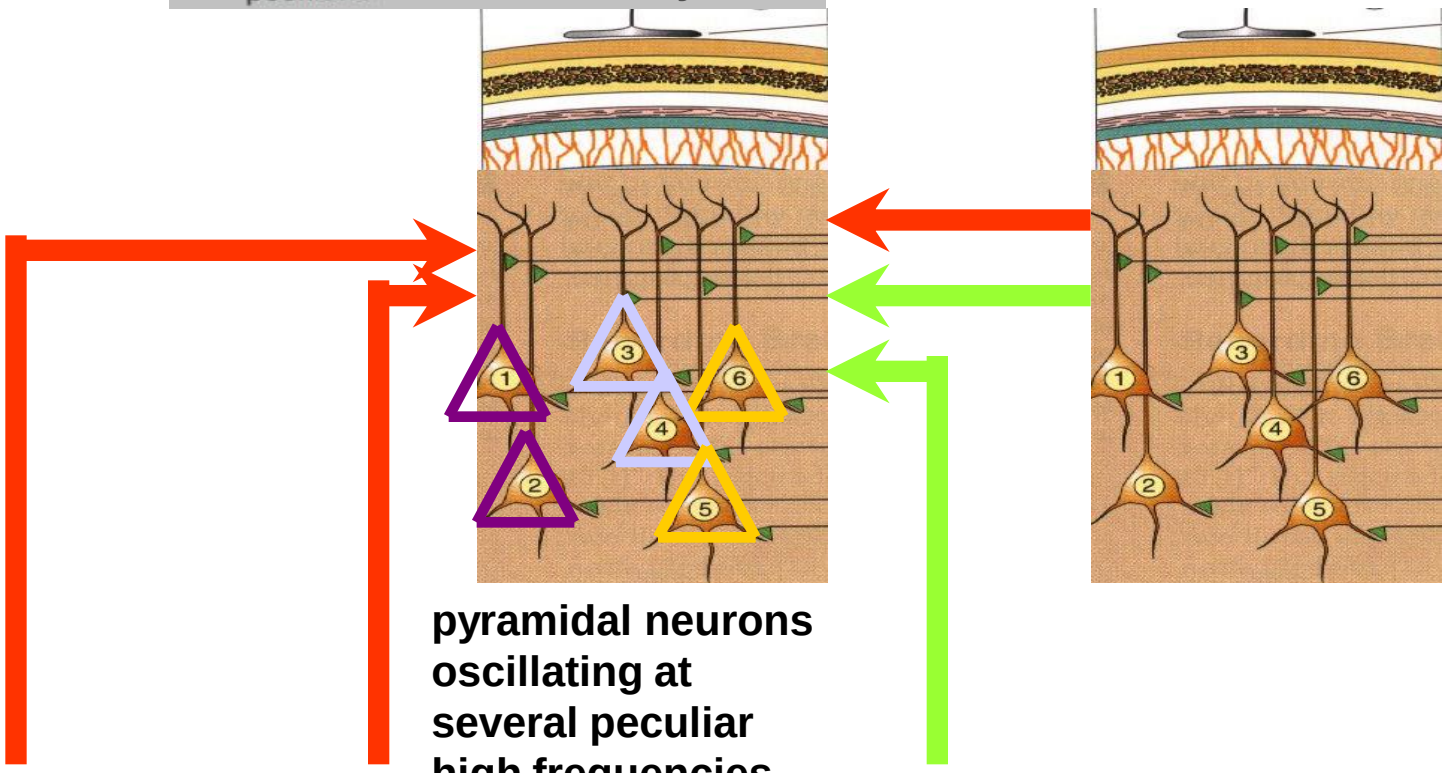
Dominant resting (eyes-closed) alpha rhythms are coherent over wide cortical areas and corresponding thalamic nuclei



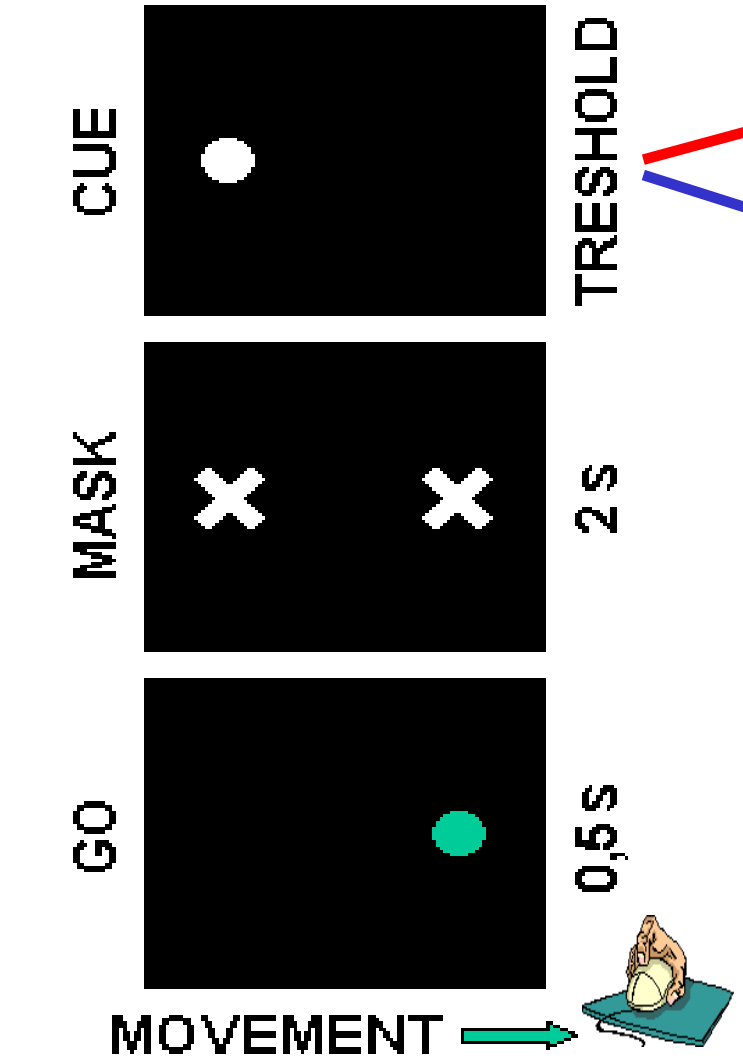
ACTIVITY



High-frequency EEG rhythms substitute alpha rhythms during activity. ERPs may be formed by re-phasing of EEG oscillations



Primary consciousness of visuo-spatial functions can be experimentally studied giving visual stimuli at threshold time (passive view)



50% of the cue stimuli are consciously detected ("seen")

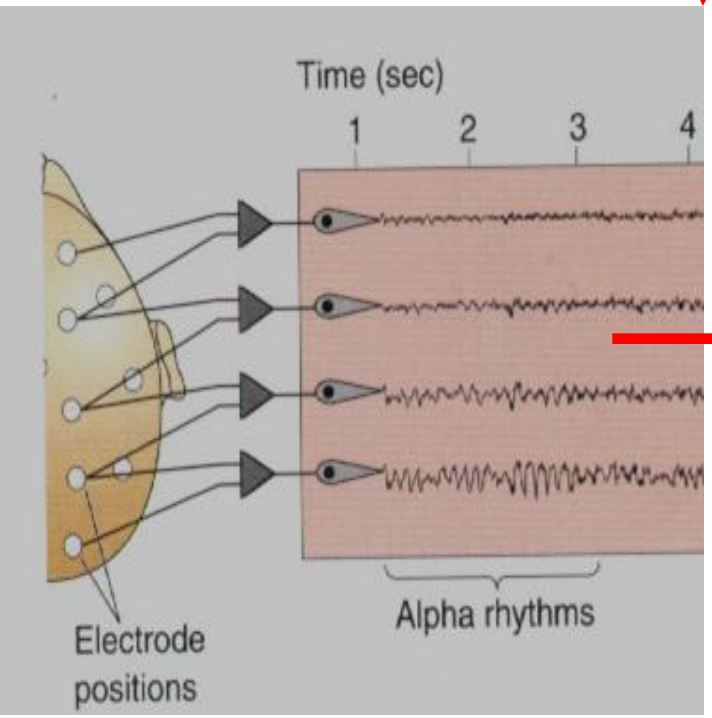
50% of the cue stimuli are consciously missed ("not seen")

(unpredictable) go at right, movement at right button

self-report ("seen" or "not seen")

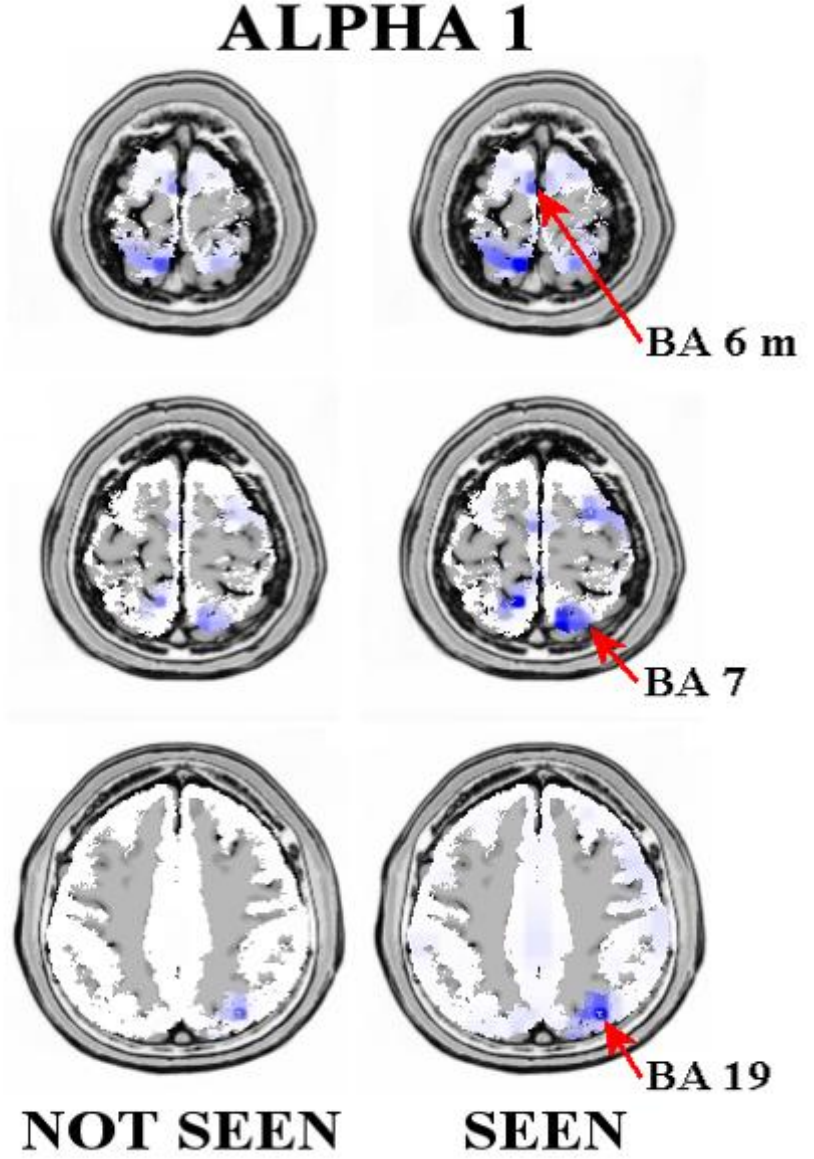
Occipital and posterior parietal sources of pre-stimulus alpha rhythms are related to consciousness of visuo-spatial stimuli

Cue stimulus onset



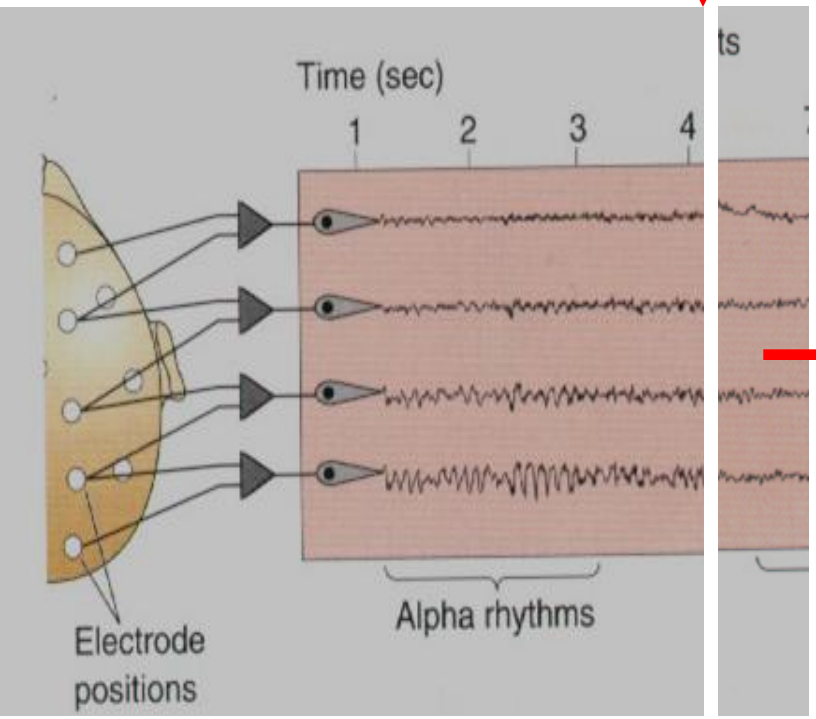
C. Babiloni, F. Vecchio, GL Romani and PM Rossini. Visual-spatial consciousness is related to pre- and post-stimulus alpha rhythms: a high-resolution EEG study. Cerebral Cortex 2006

LORETA sources



Occipital and posterior parietal sources of alpha ERD are related to consciousness of visuo-spatial stimuli

Cue stimulus onset



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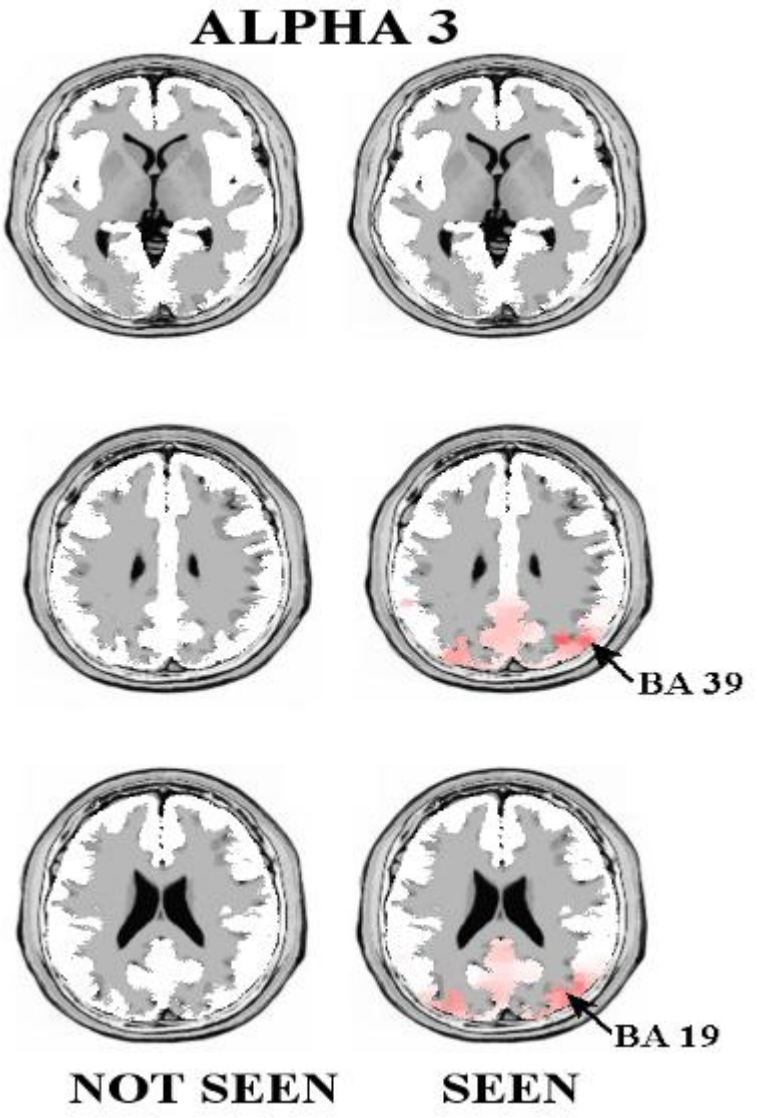
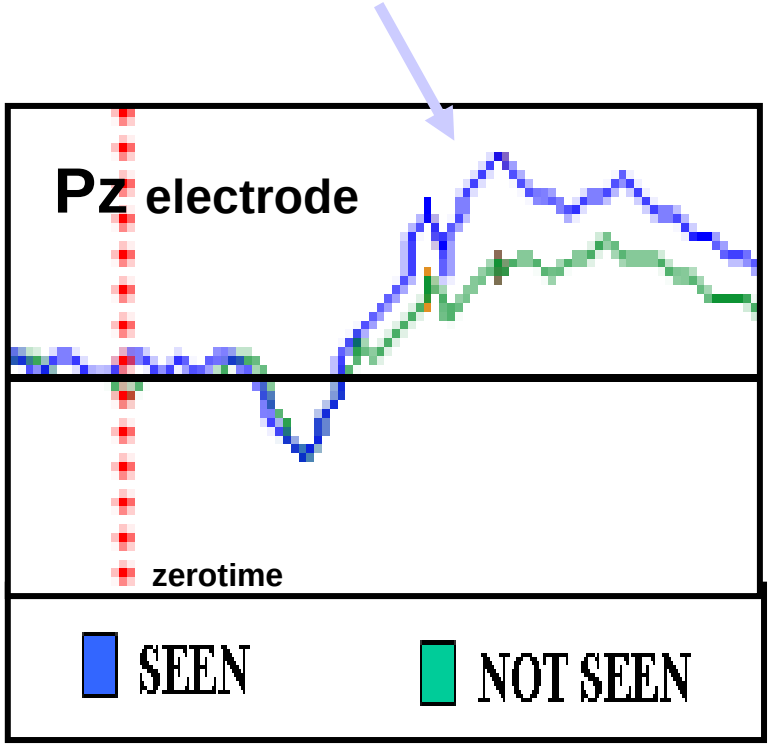
LORETA sources

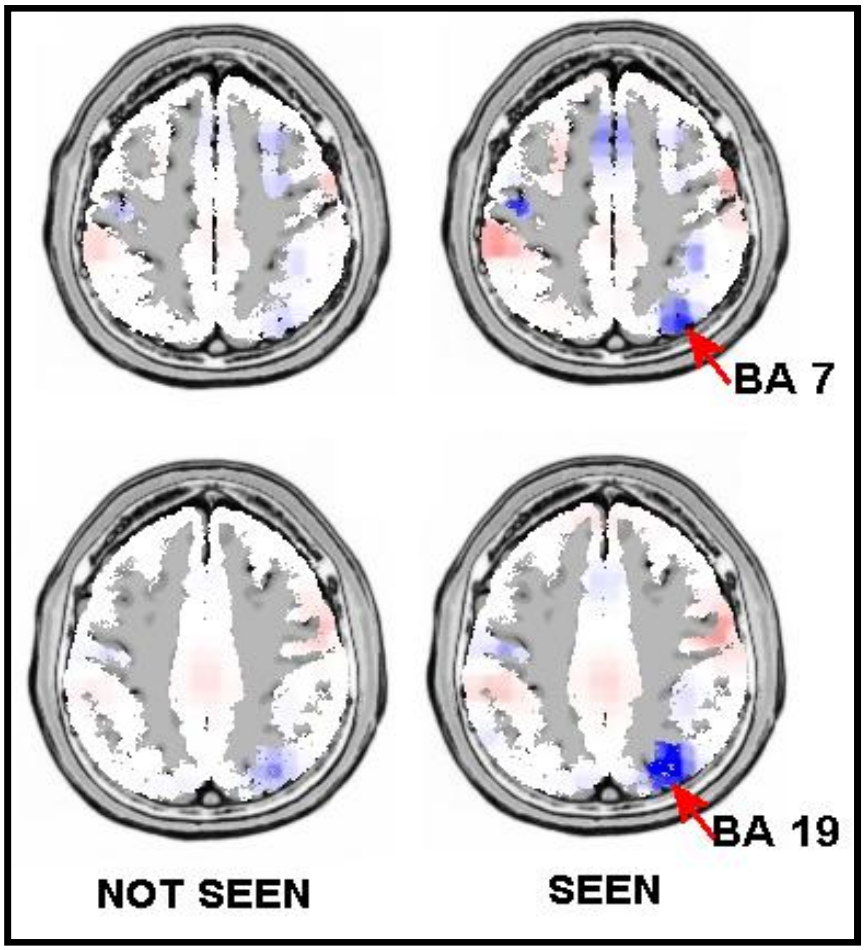


Occipital and posterior parietal sources of P3 are related to consciousness of visuo-spatial stimuli

P3 peak (about +400 ms post-stimulus)

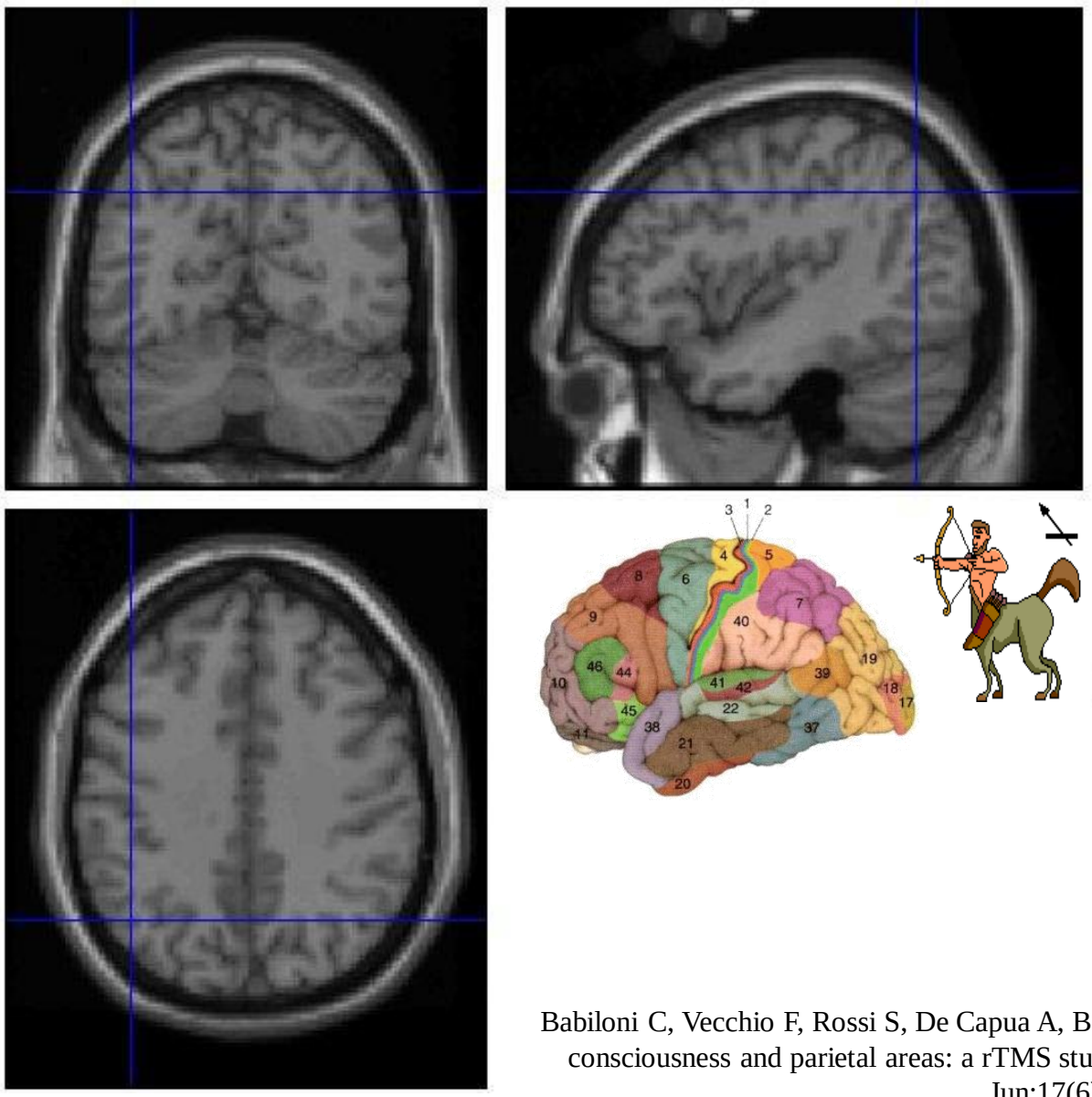


LORETA sources



C. Babiloni, F. Vecchio, M. Miriello, GL Romani and PM Rossini. Visual-spatial consciousness and parieto-occipital areas: a high-resolution EEG study. Cerebral Cortex 2005

Are parietal alpha ERD epiphenomena for visuo-spatial consciousness?



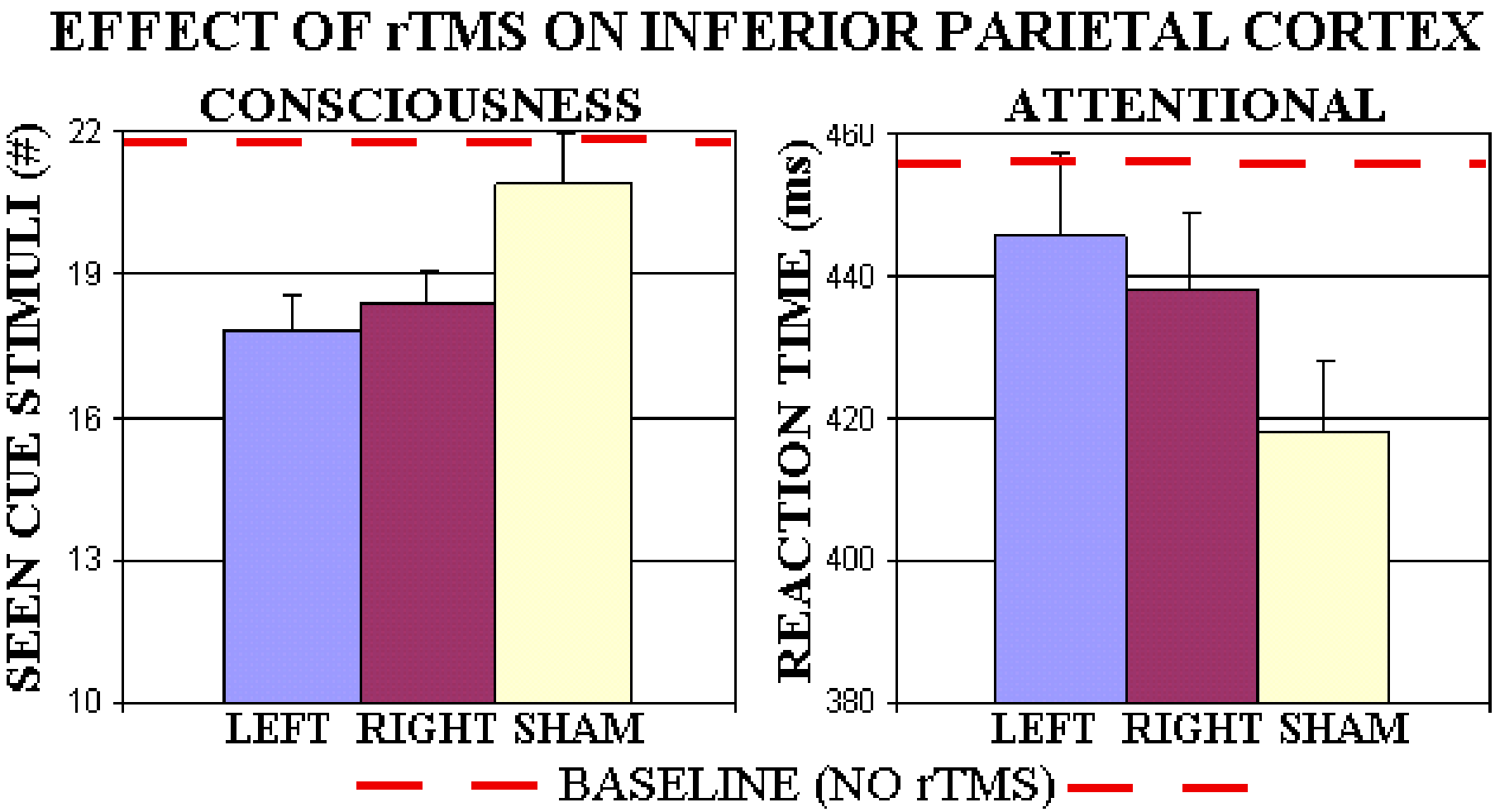
Repetitive transcranial magnetic stimulation (rTMS) over

BA 7-39

BA 6 (sham)

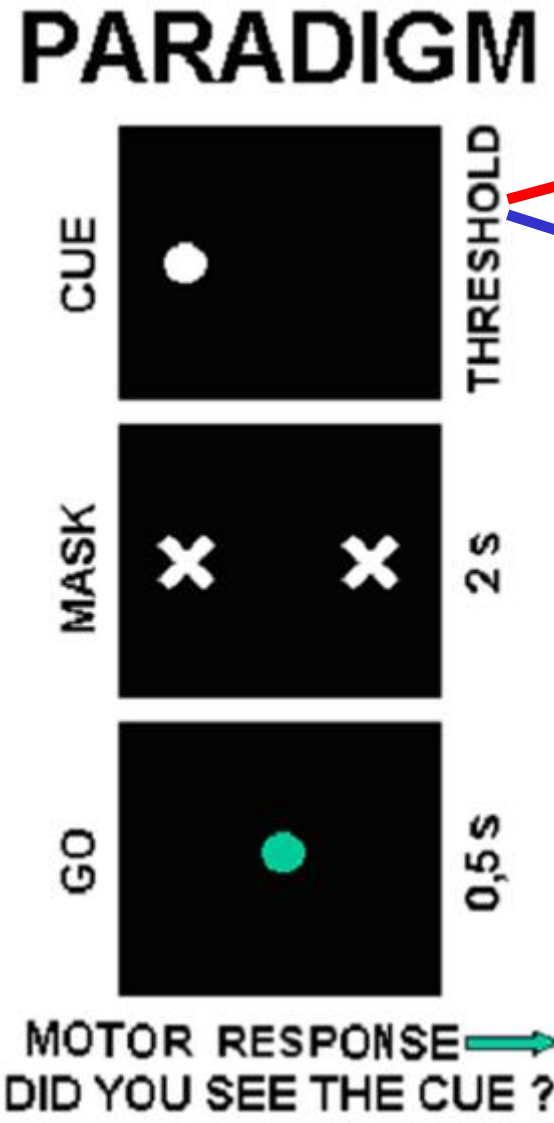
Babiloni C, Vecchio F, Rossi S, De Capua A, Bartalini S, Ulivelli M, Rossini PM. Visuo-spatial consciousness and parietal areas: a rTMS study. Cerebral Cortex 2006. Cereb Cortex. 2007 Jun;17(6):1486-92.

Visuo-spatial attention and consciousness are impaired by rTMS in parietal areas showing maximum alpha ERD



Babiloni C, Vecchio F, Rossi S, De Capua A, Bartalini S, Ulivelli M, Rossini PM. Visuo-spatial consciousness and parietal areas: a rTMS study. Cerebral Cortex 2006. Cereb Cortex. 2007 Jun;17(6):1486-92.

Primary consciousness of frontal executive functions can be experimentally studied (paradigm of “inverted response”)



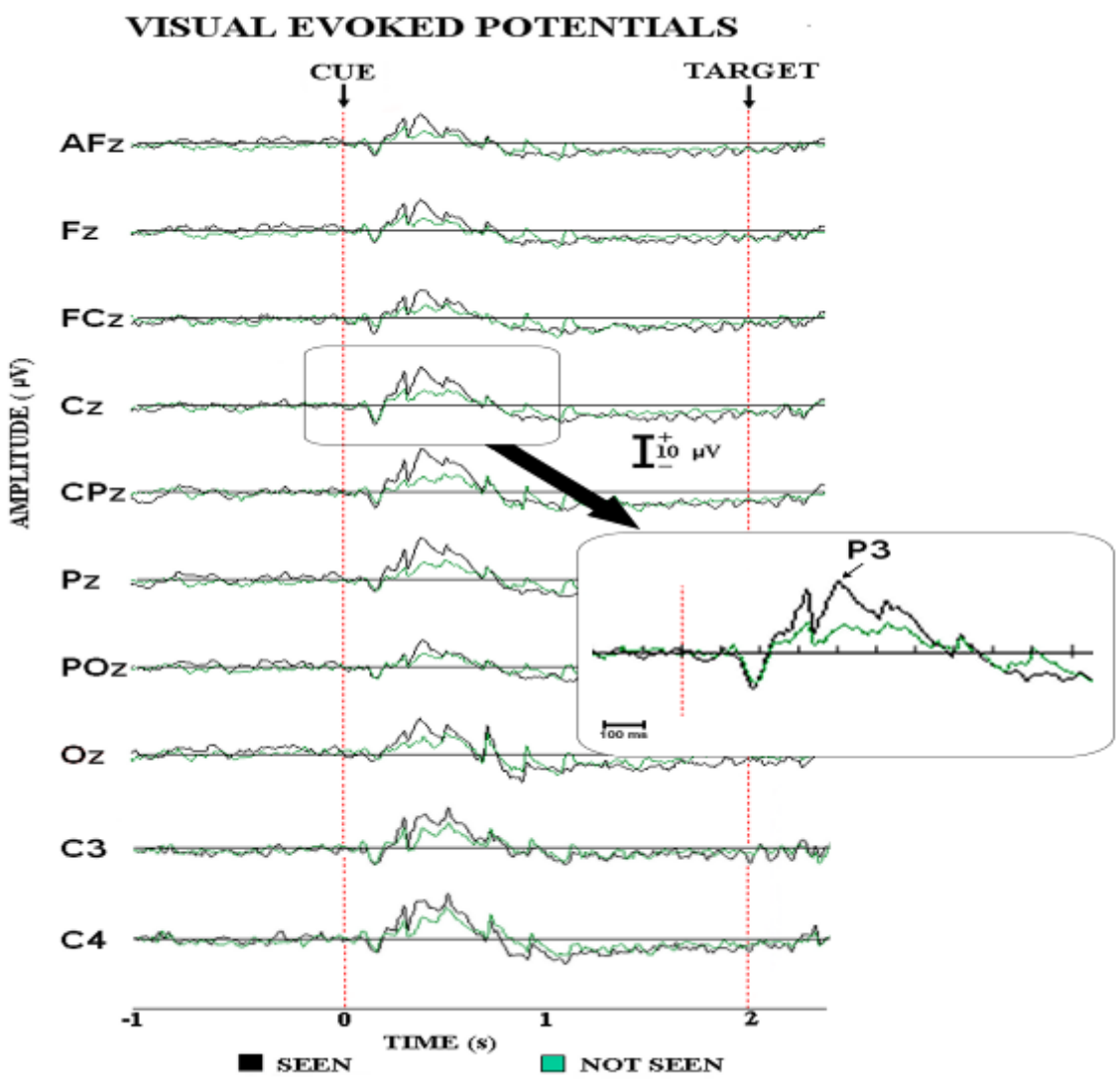
50% of the cue stimuli are **consciously detected** (“seen”)

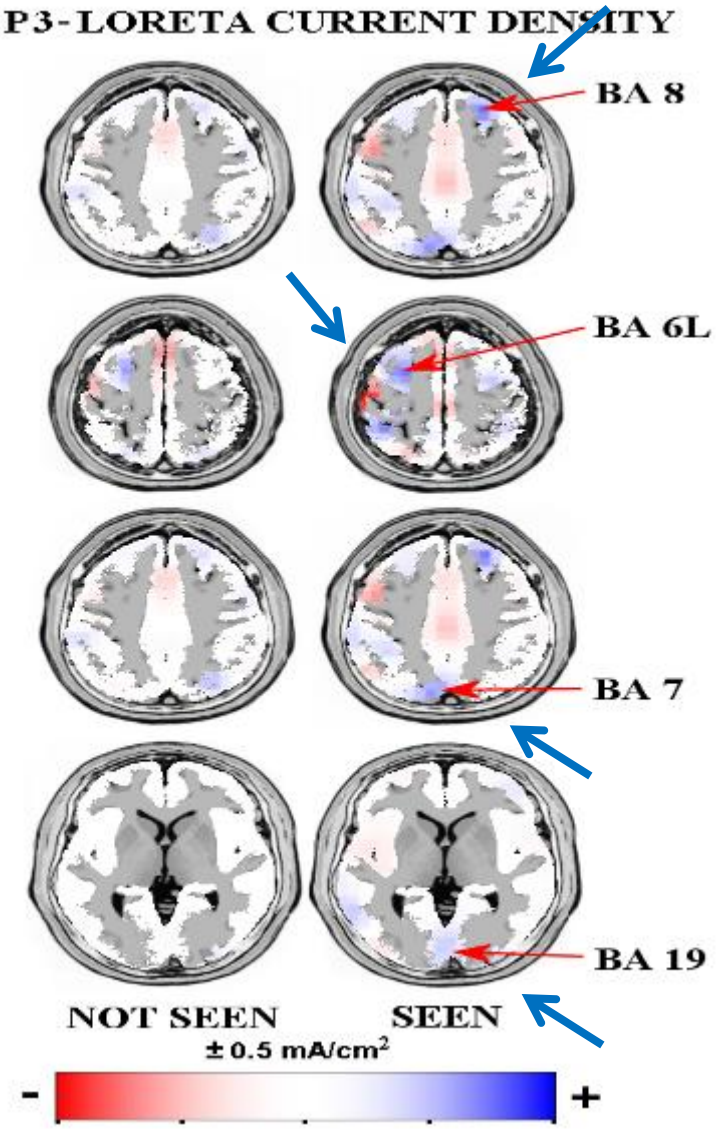
50% of the cue stimuli are consciously missed (“not seen”)

(unpredictable) go at **right**, movement at **left** button

self-report (“seen” or “not seen”)

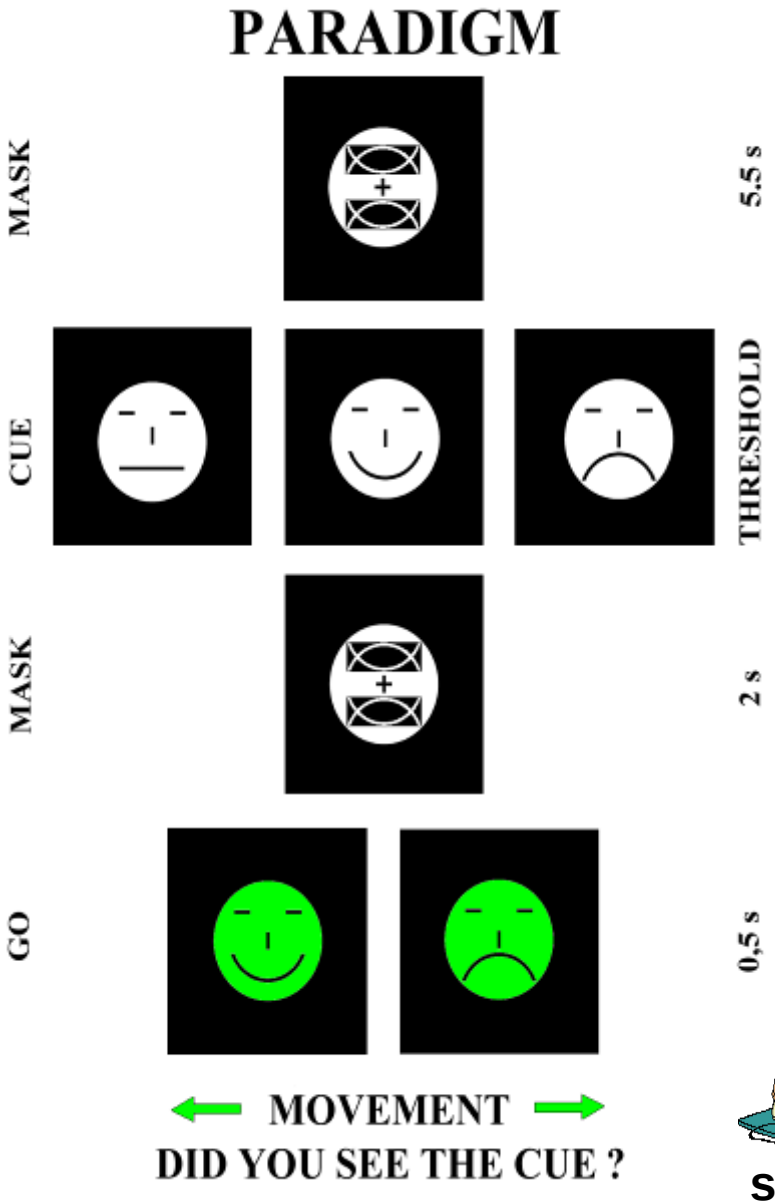
Frontal and parieto-occipital sources of P3 are related to consciousness of visuo-spatial stimuli during executive functions





Babiloni C, Vecchio F, Iacoboni M, Buffo P, Eusebi F, Rossini PM. Cortical sources of visual evoked potentials during consciousness of executive processes. Hum Brain Mapp. 2009 Mar;30(3):998-1013.

Primary consciousness of emotional faces can be experimentally studied (passive view)



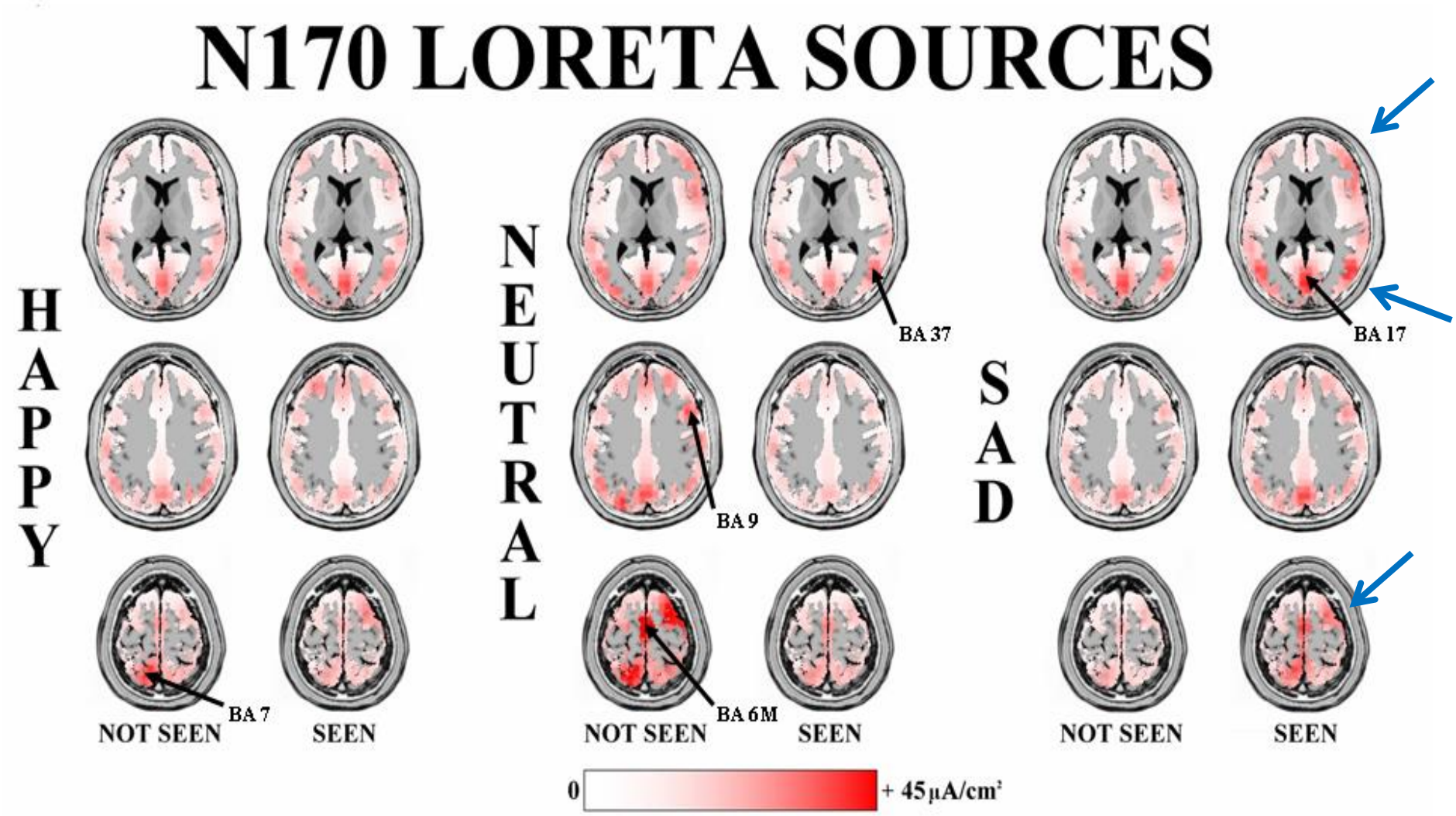
50% of the cue stimuli (just one face for each event) are **consciously detected** (“seen”)

50% of the cue stimuli are consciously missed (“not seen”)

happy (**sad**) icon, movement at left (**right**) button

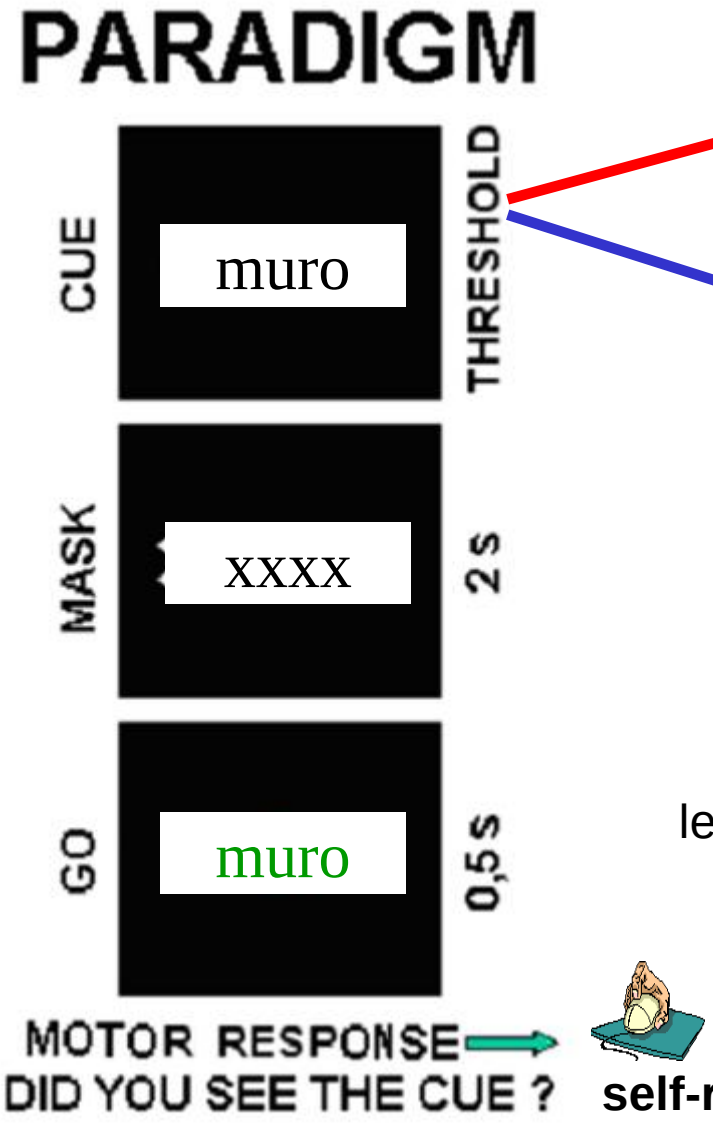
self-report (“seen” or “not seen”)

Frontal and posterior parietal sources of N170 are related to consciousness of emotional sad faces



Babiloni C, Vecchio F, Buffo P, Cibelli G, and Rossini PM. Cortical responses to consciousness of schematic emotional facial expressions: a high-resolution EEG study. Human Brain Mapping 2009

Primary consciousness of words can be experimentally studied (passive view)



50% of the cue stimuli are consciously detected (“seen”)

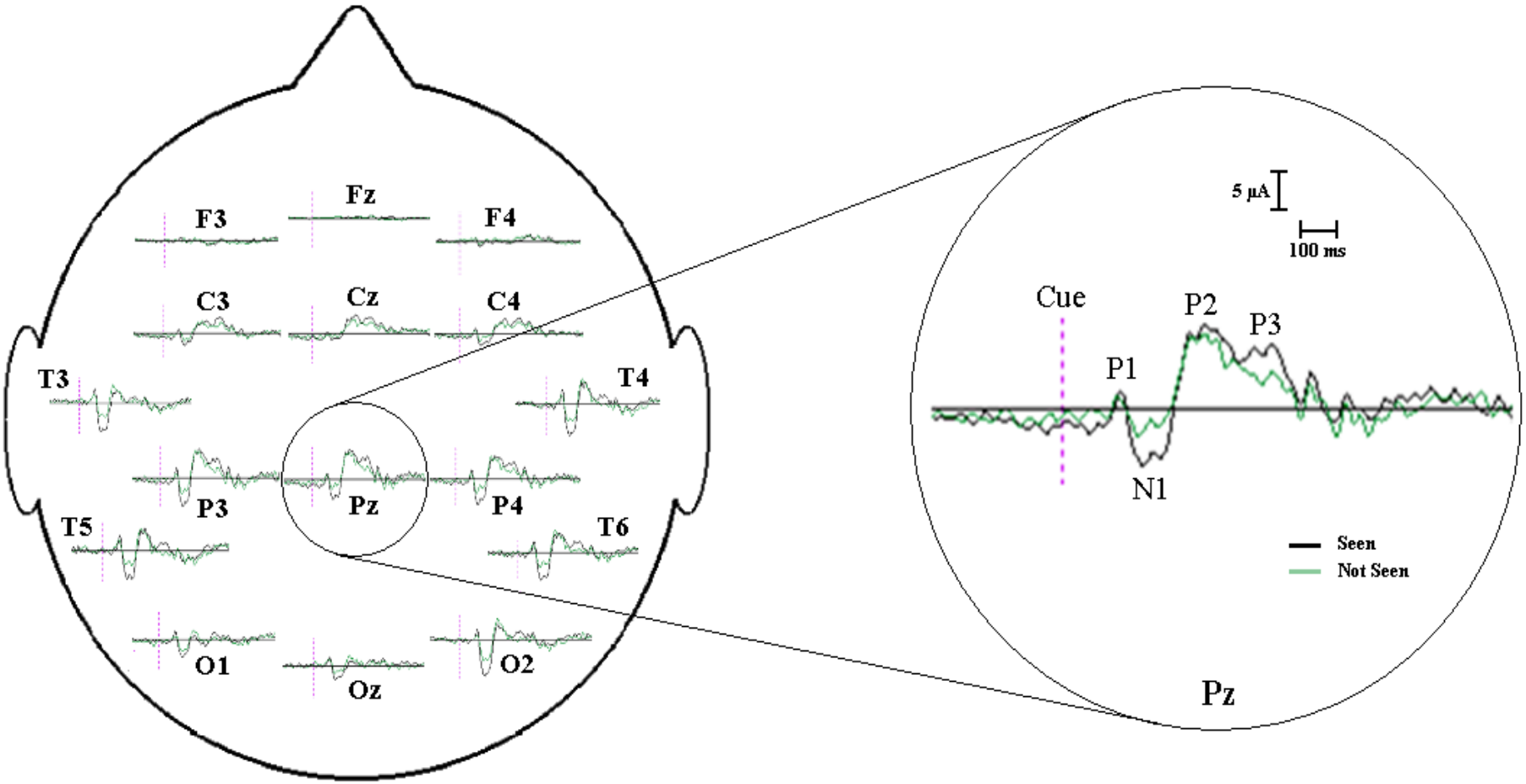
50% of the cue stimuli are consciously missed (“not seen”)

Cue and go stimuli: **muro** (wall), **mulo** (mule), **cane** (dog), **pane** (bread)

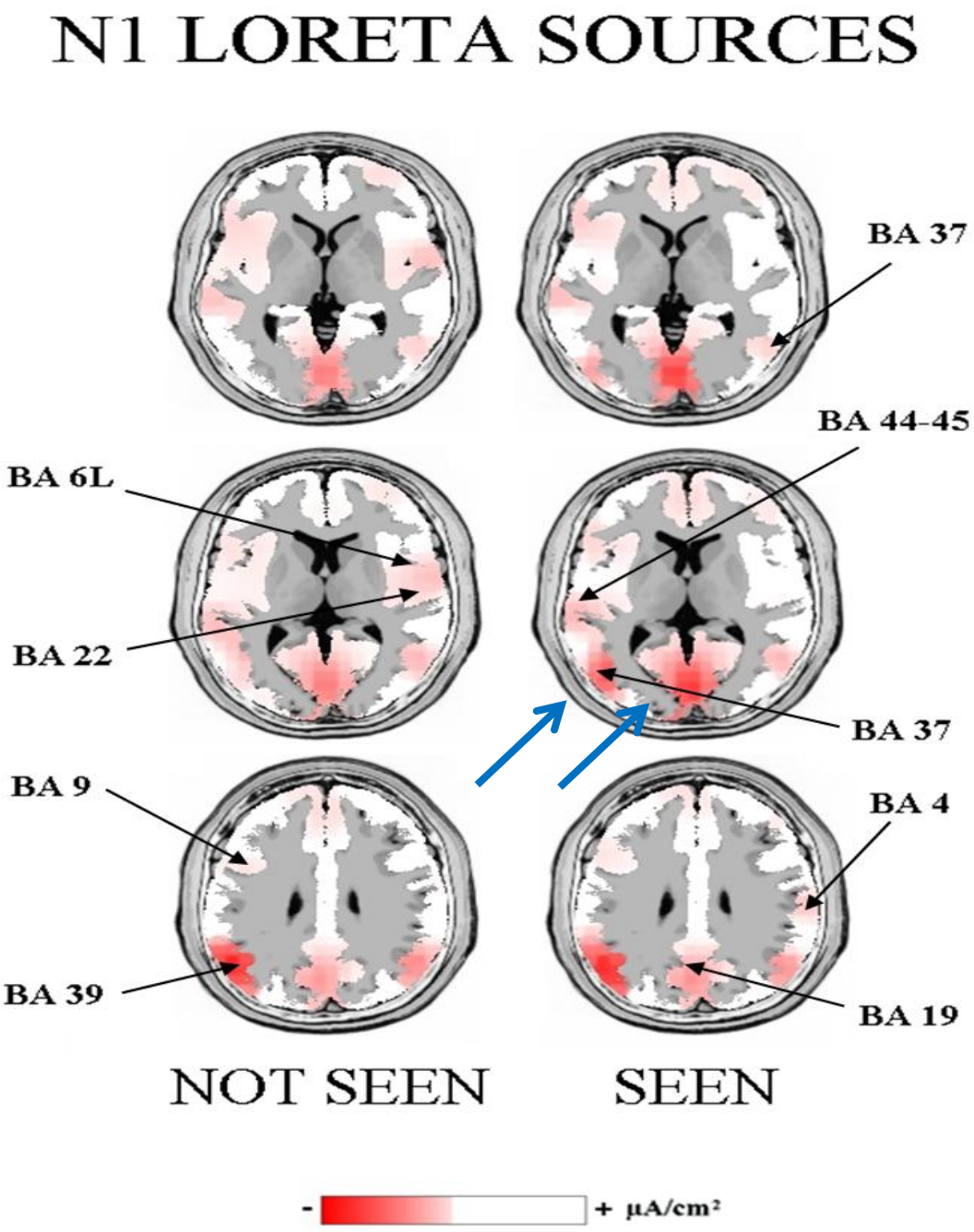
left or right mouse button if the go stimulus was a living or nonliving being

self-report (“seen” or “not seen”)

ERPs to cue stimuli (words) are higher in amplitude at N1 and P3 peaks during primary consciousness



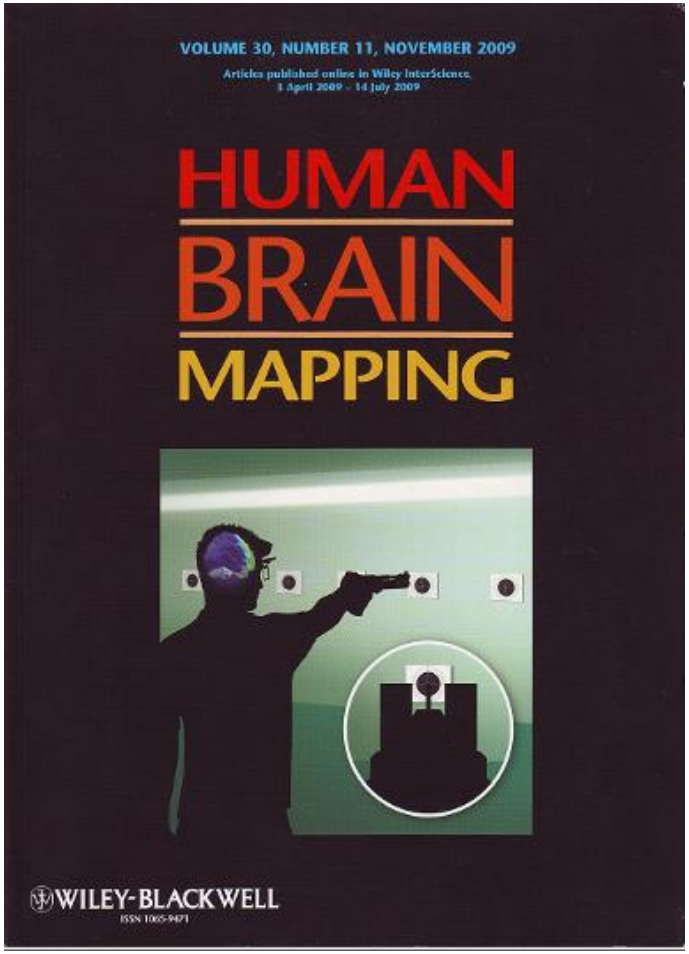
Babiloni C, Vecchio , Buffo P, De Sero R., Rossini PM. Cortical sources of visual evoked potentials during consciousness of executive processes. NeuroImage (moderate revisions).



Occipito-temporal N1 sources are related to primary consciousness of words

Babiloni C, Vecchio , Buffo P, De Sero R., Rossini PM. Cortical sources of visual evoked potentials during consciousness of executive processes. NeuroImage (moderate revisions).

Reduced cortical EEG activation during focused attention in elite pistol shooters. Restriction of conscious experience?

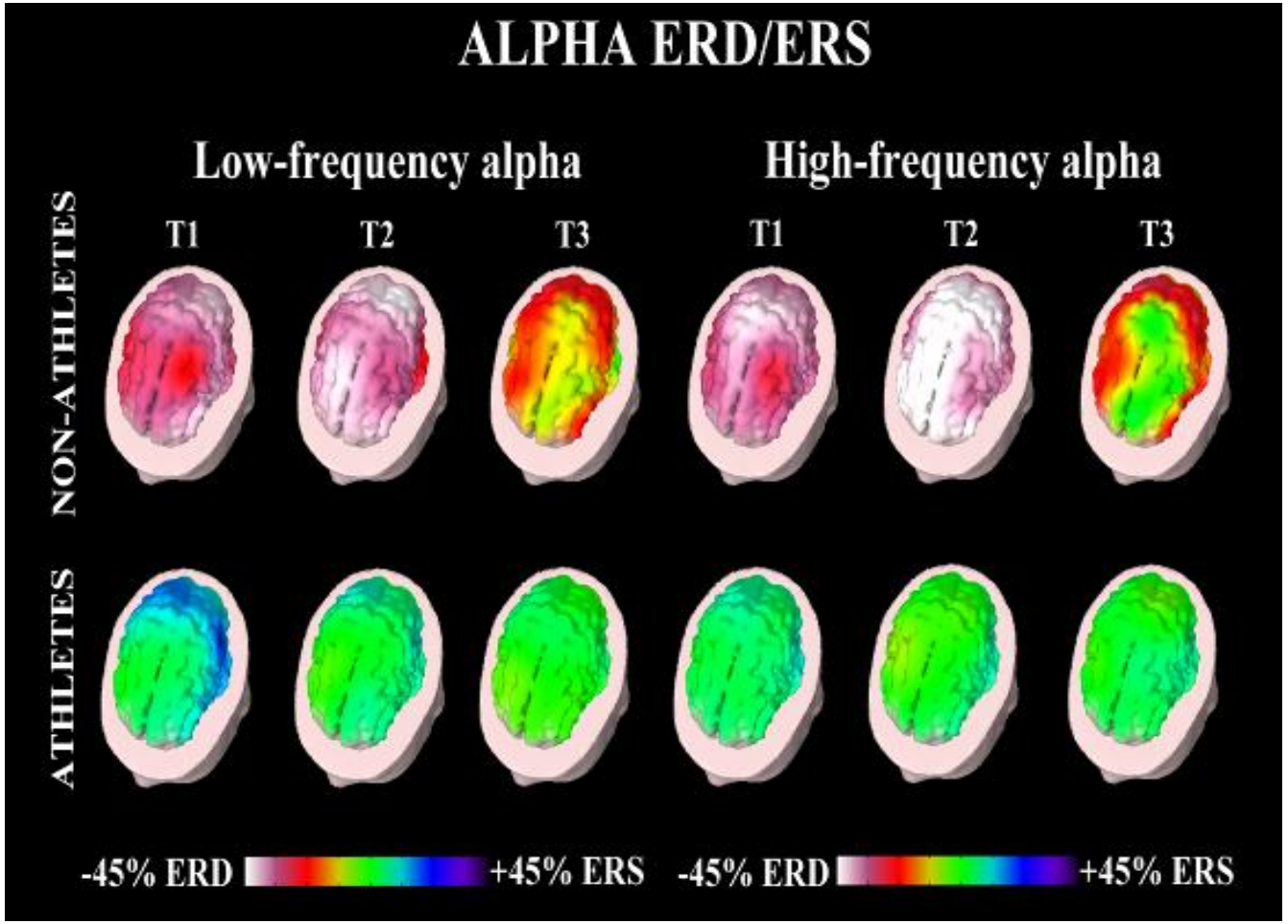


Del Percio C, Babiloni C, Bertollo M, Marzano N, Iacoboni M, Infarinato F, Lizio R, Stocchi M, Robazza C, Cibelli G, Comani S and Eusebi F. Visuo-attentional and sensorimotor alpha rhythms are related to visuo-motor performance in athletes Hum Brain Mapp. 2009

VIDEO

Postural freezing of elite shooters is related to selectivity/neural efficiency as revealed by widespread cortical EEG deactivation: a "disconnection" from irrelevant stimuli of the external world?

More efficiency



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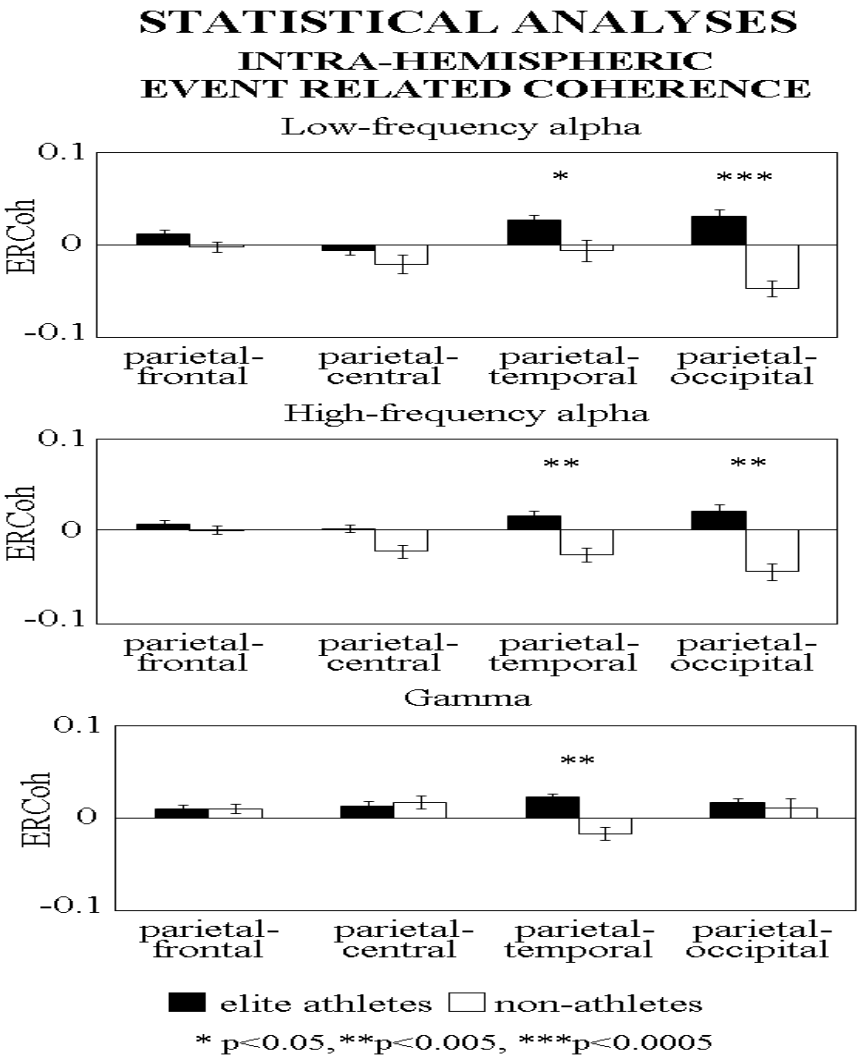
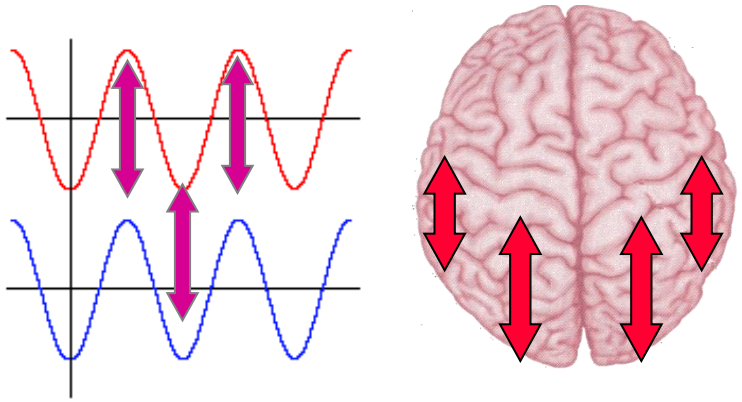
Compared to non-athletes, pistol shooters show stronger parieto-temporal and parieto-occipital alpha coherence

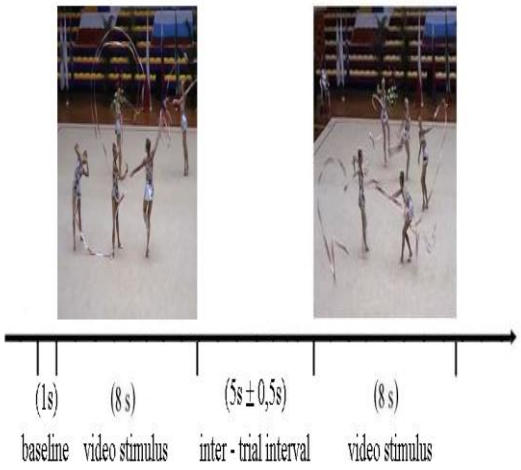


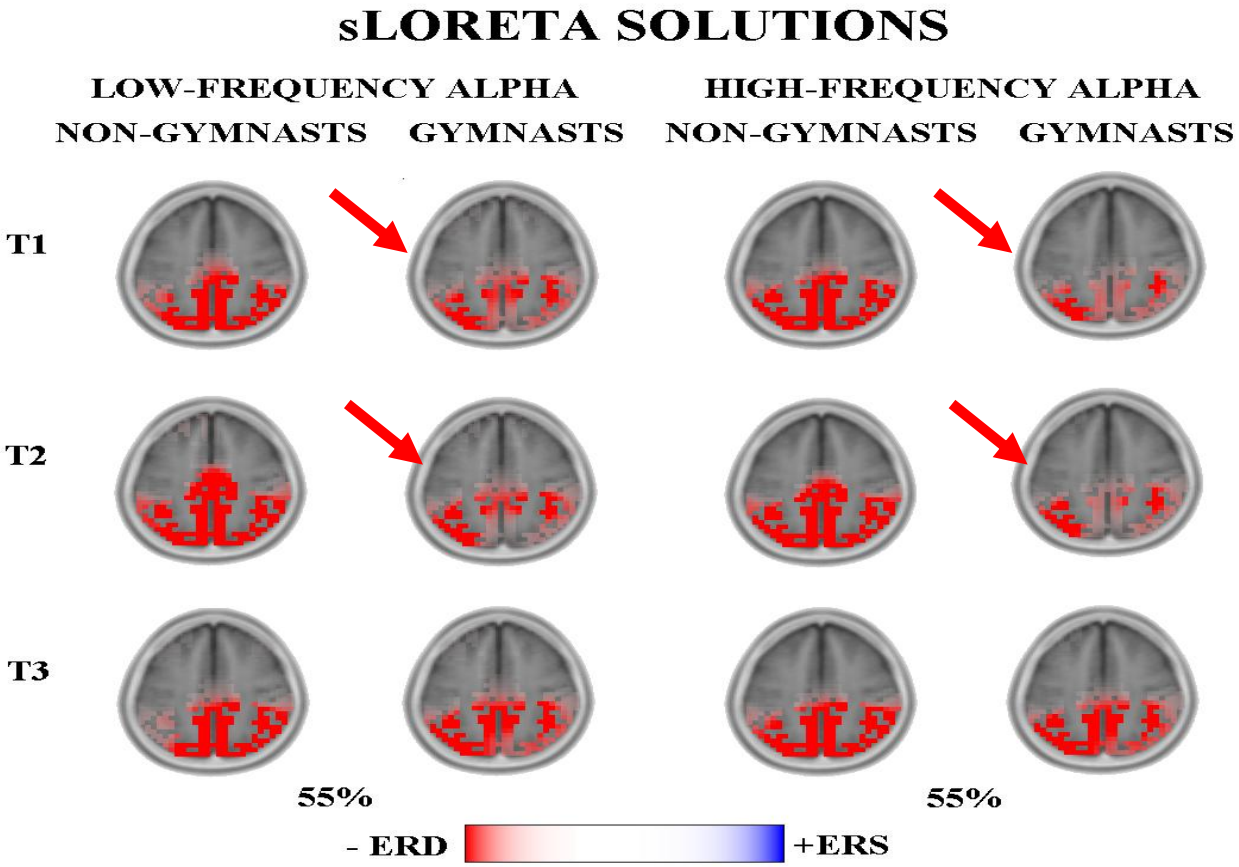


high cortical coherence

Del Percio C, Babiloni C, Bertollo M, Marzano N, Iacoboni M, Infarinato F, Lizio R, Stocchi M, Robazza C, Cibelli G, Comani S and Eusebi F. Visuo-attentional and sensorimotor alpha rhythms are related to visuo-motor performance in athletes Hum Brain Mapp. 2009

Understanding of the sporting performance by other athletes is related to selectivity/neural efficiency of parietal cortical activation (mirror systems) as revealed by EEG mapping. More efficiency?

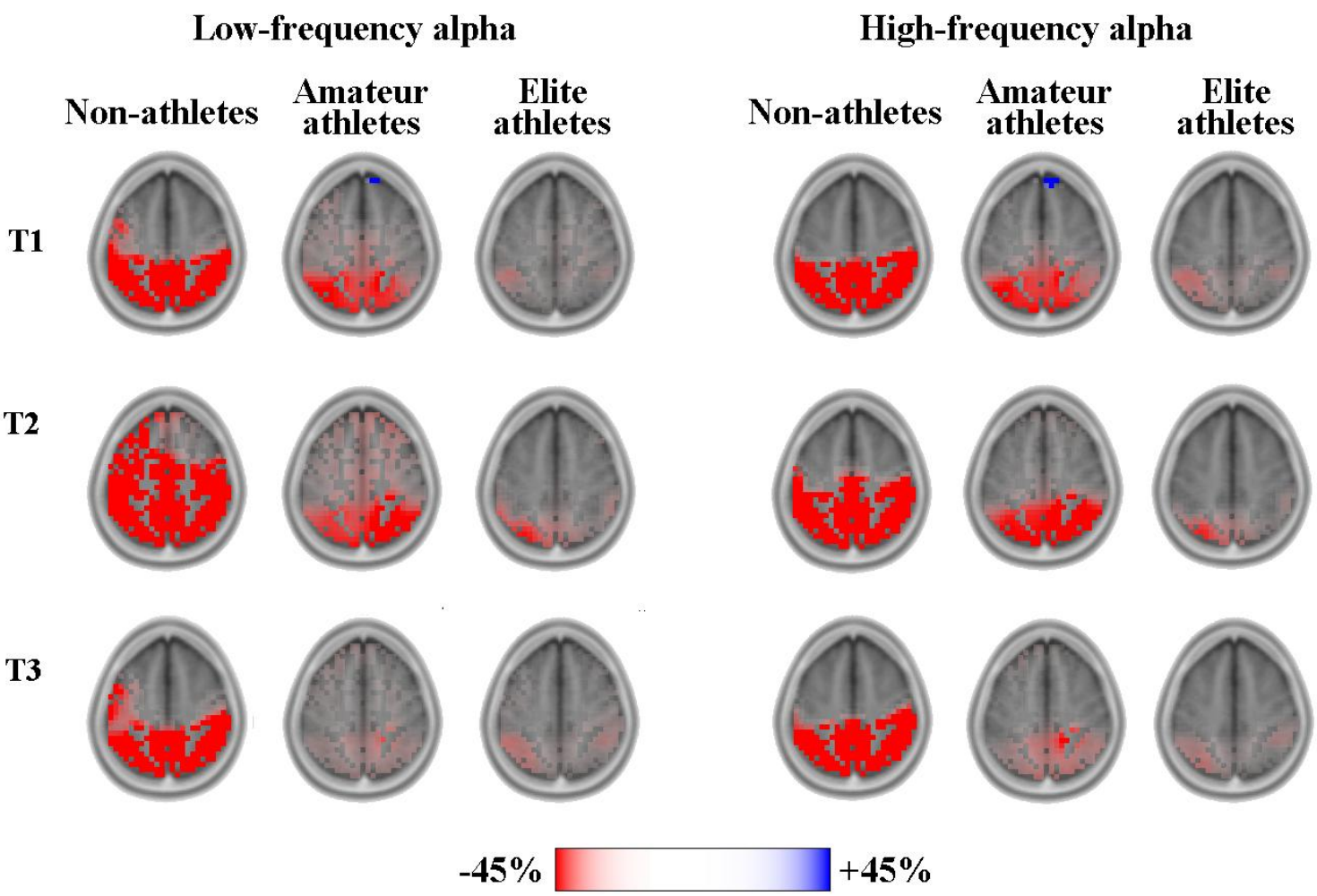




Babiloni C, Del Percio C, Rossini PM, Marzano N, Iacoboni M, Infarinato F, Lizio R, Piazza M, Pirritano M, Berlutti G, Cibelli G, Eusebi F. Judgment of actions in experts: a high-resolution EEG study in elite athletes. Neuroimage. 2009 Apr 1;45(2):512-21.

Low- (about 8–10 Hz) and high-frequency (about 10–12 Hz) alpha rhythms were lower in amplitude in the elite karate athletes compared to the non-gymnasts in occipital and temporal areas (ventral pathway) and in dorsal

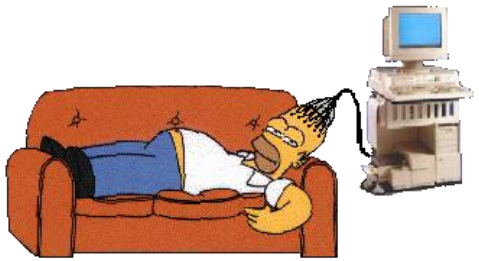
sLORETA SOLUTIONS



Babiloni C, Del Percio C, Rossini PM, Marzano N, Iacoboni M, Infarinato F, Lizio R, Piazza M, Pirritano M, Berlutti G, Cibelli G, Eusebi F. Judgment of actions in elite amateur katate athletes a: a high-resolution EEG study. Behavioral Brain Research. 2010

EEG provides the high temporal resolution necessary for the study of secondary ("extended") consciousness including autobiographical and moral consciousness

Resting state alpha sources are especially depressed in persistent vegetative state (PVS) subjects (awake but not conscious) who will not recover consciousness at 3-months follow up



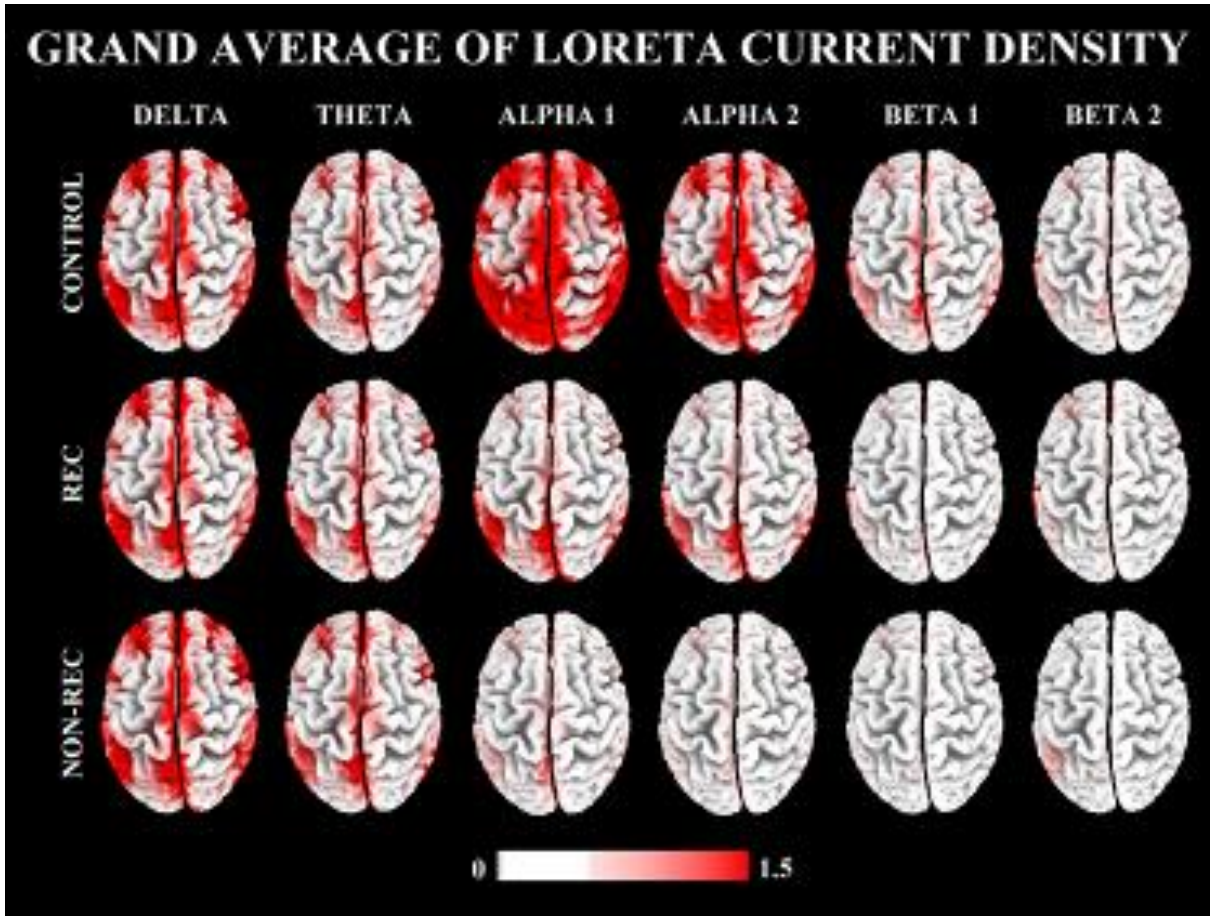
Resting EEG data

Resting EEG data:

30 normal controls

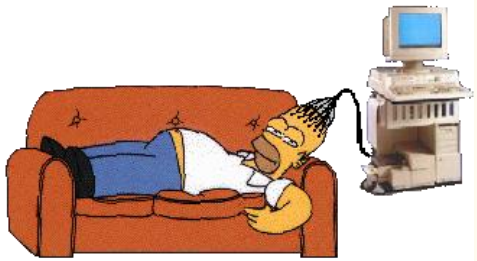
12 PVS recovered

32 PVS not recovered



Babiloni C, Sarà M, Vecchio F, Pistoia F, Sebastiano F, Onorati P, Albertini G, Pasqualetti P, Cibelli G, Buffo P, Rossini PM. Cortical sources of resting-state alpha rhythms are abnormal in persistent vegetative state patients. Clin Neurophysiol. 2009 Apr;120(4):719-29.

In PVS subjects, permanent deterioration of secondary consciousness may be related to abnormality of resting state alpha rhythms



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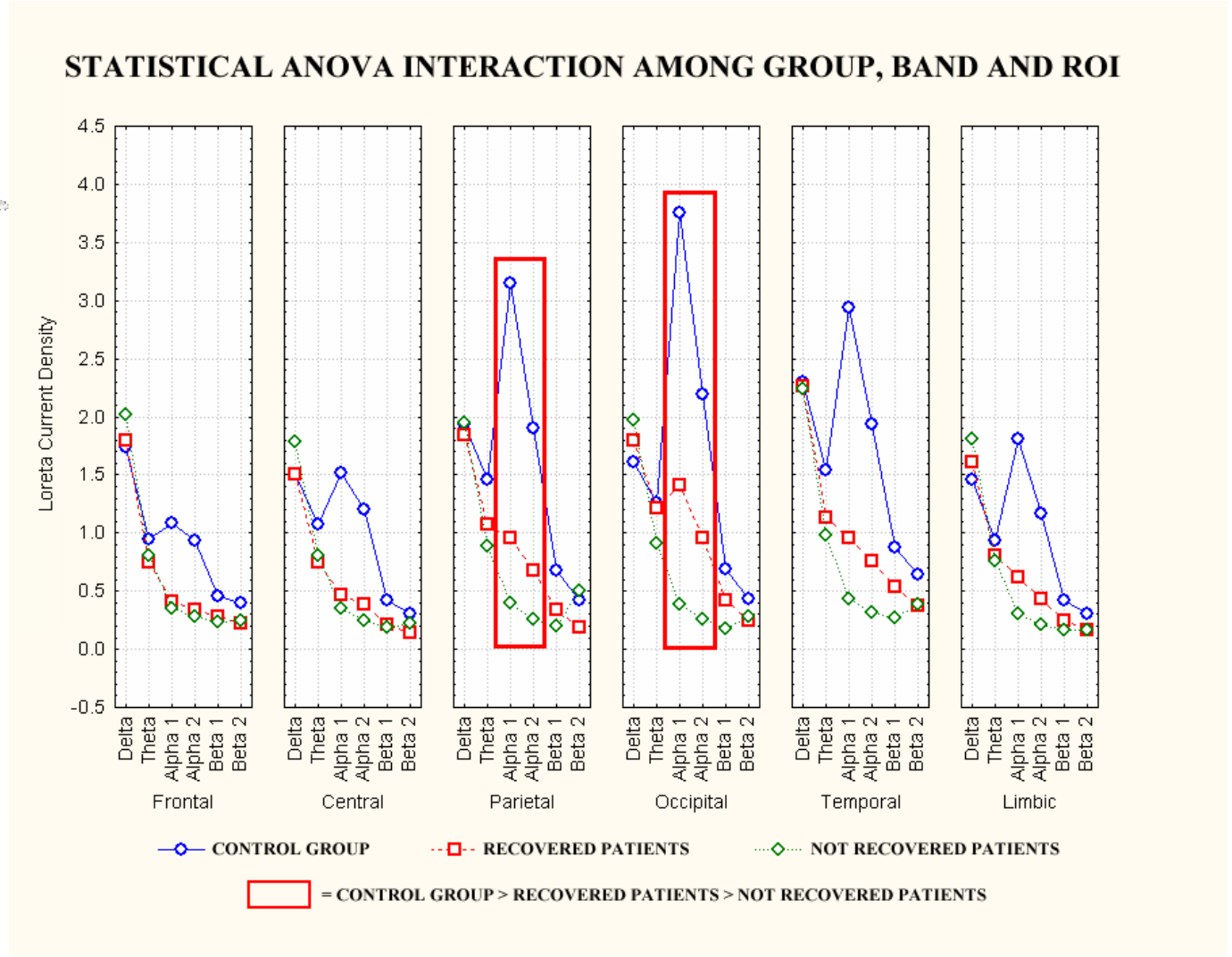

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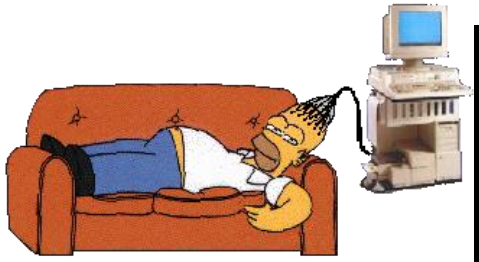
Resting state alpha sources are depressed in locked in syndrome (LIS) subjects (they are conscious but with some abnormalities in emotional experiences)

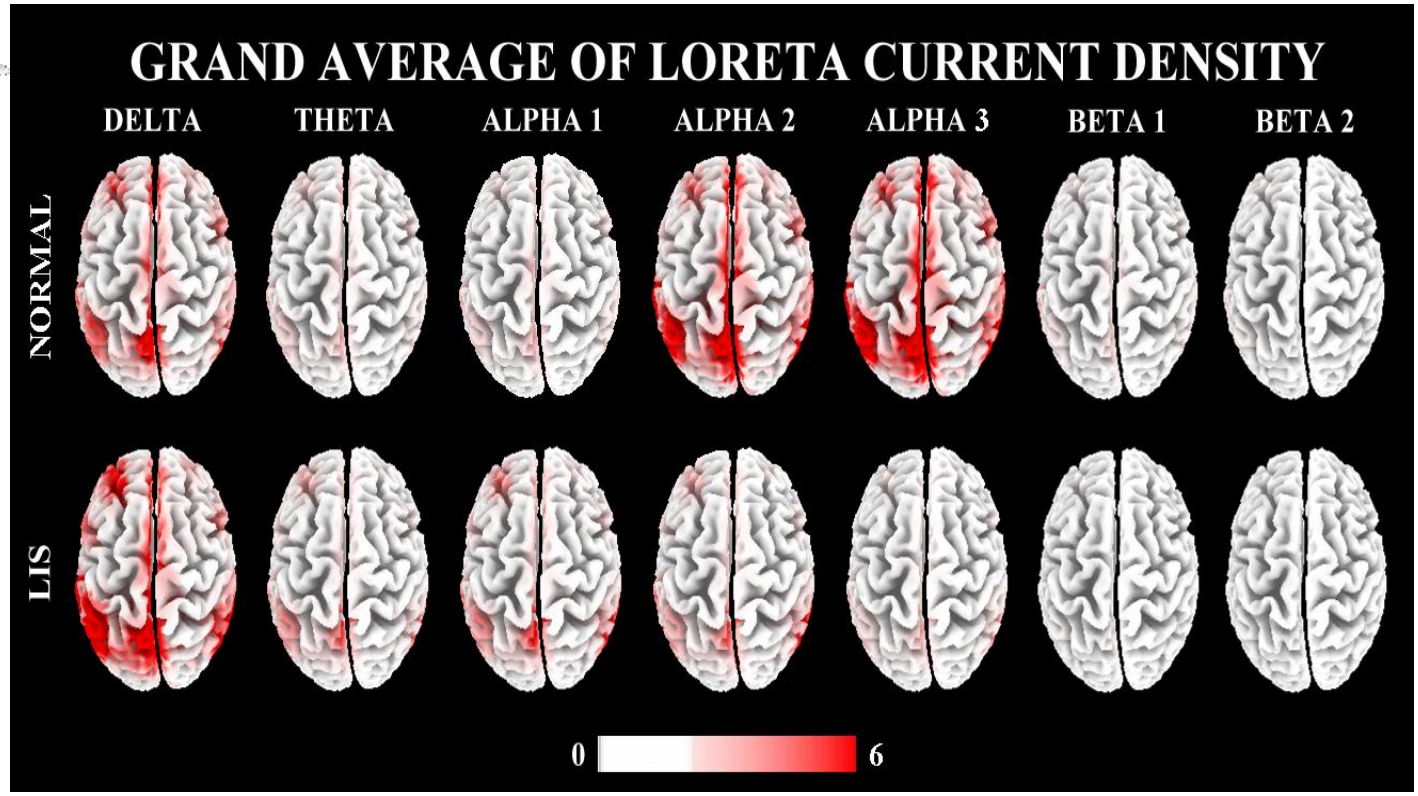


Resting EEG data

Resting EEG data:

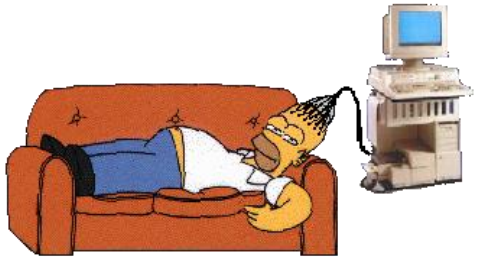
15 normal controls

13 LIS



Babiloni C, Sarà M, Vecchio F, Pistoia F, Sebastiano F, Onorati P, Albertini G, Pasqualetti P, Cibelli G, Buffo P, Rossini PM. Resting state brain rhythms in patients with locked in syndrome: an EEG study. Clinical Neurophysiol. 2010.

In LIS subjects, some abnormal conscious experience may be related to abnormality of resting state alpha rhythms

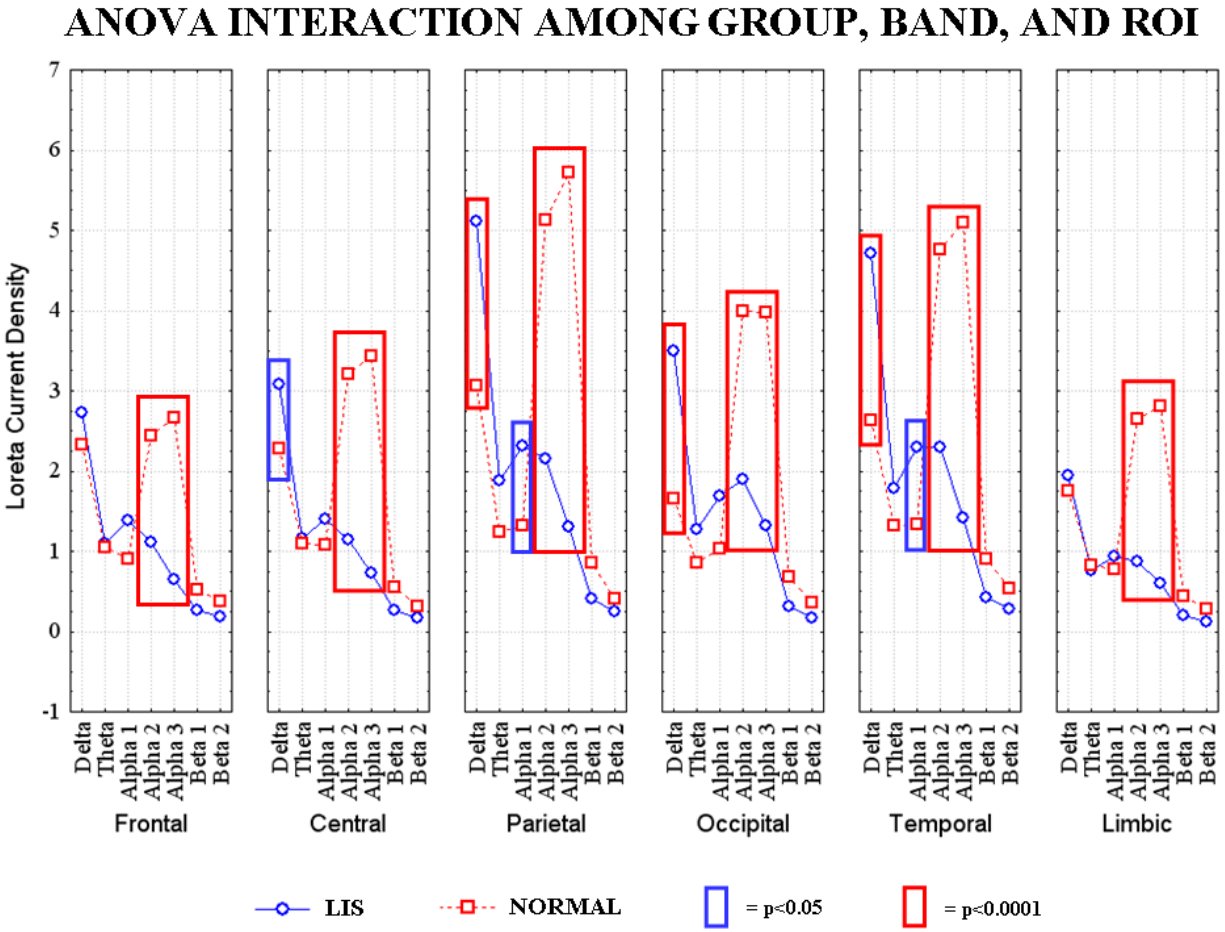


Resting EEG data

Resting EEG data:

15 normal controls

13 LIS



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Conclusions: mapping alpha rhythms or ERPs unveils cortical processes related to primary and secondary consciousness

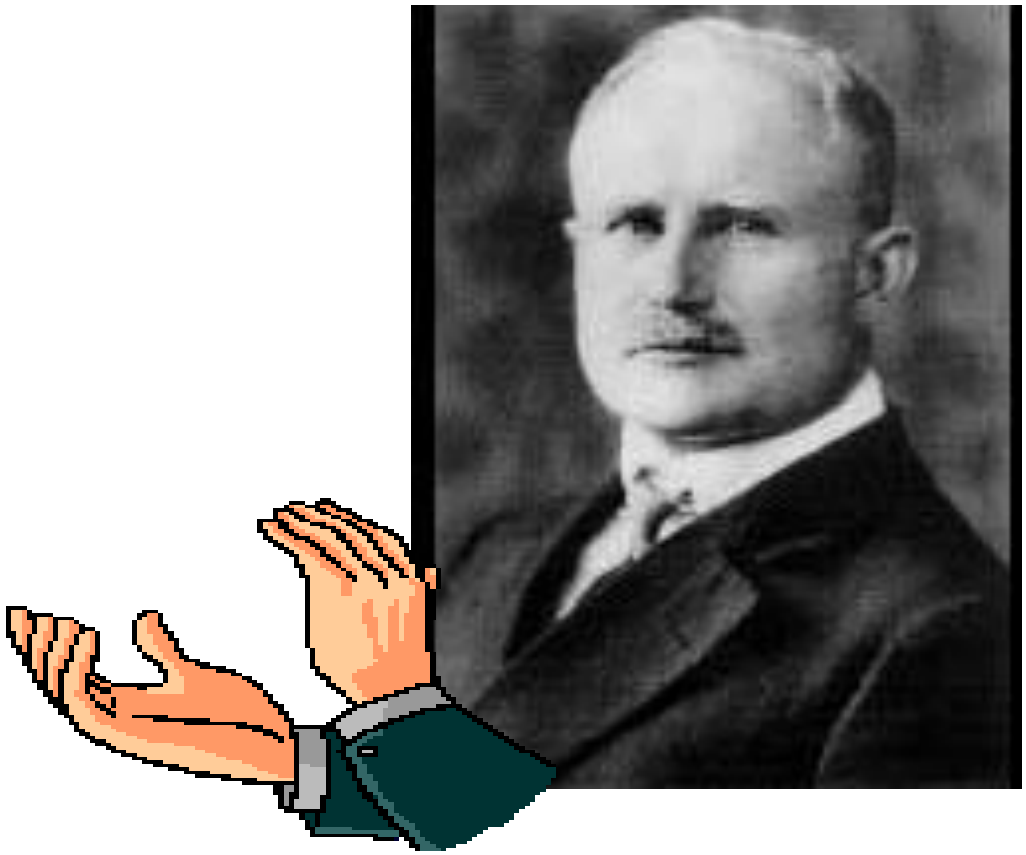
Cortical alpha rhythms before and during the stimulus are related to primary consciousness ("neuromodulatory context of cortical neural synchronization/desynchronization")

ERPs disclose the spatio-temporal evolution (100-400 ms post-stimulus) of cortical responses related to primary consciousness ("re-phasing and synchronization of cortical neurons")

Cortical resting state alpha rhythms are abnormal in subjects with persistent abnormal consciousness and in subjects with locked in syndrome

Cortical resting state alpha rhythms reflect efficiency of attention processes in elite athletes

Thanks for your consciousness



The father of EEG: H. Berger