ECoG signature of large-scale functional connectivity in the human brain

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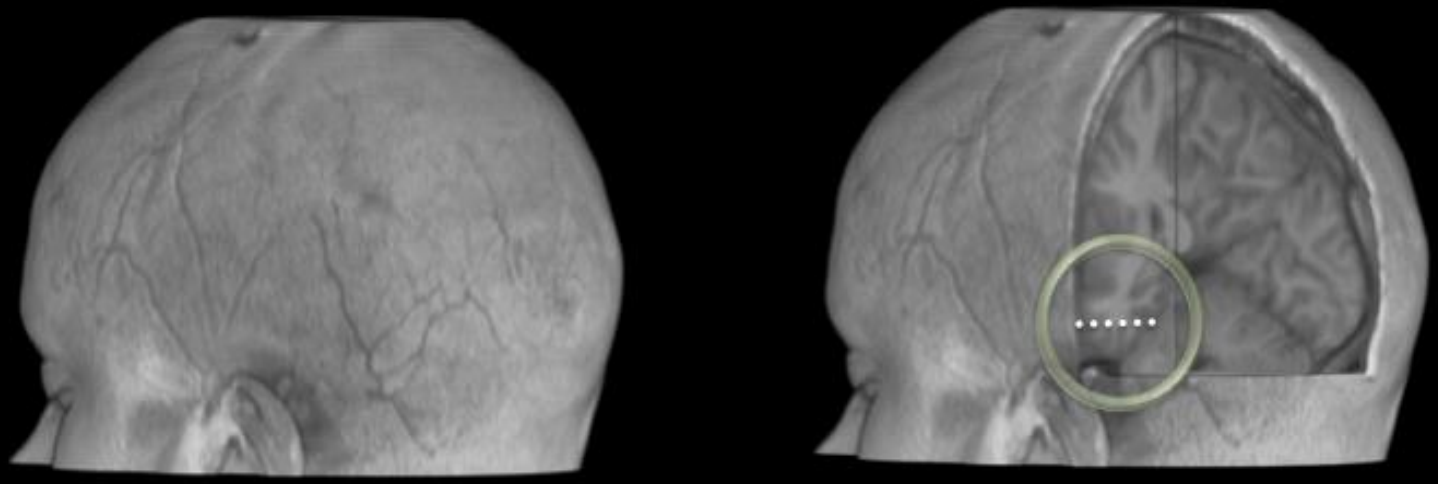
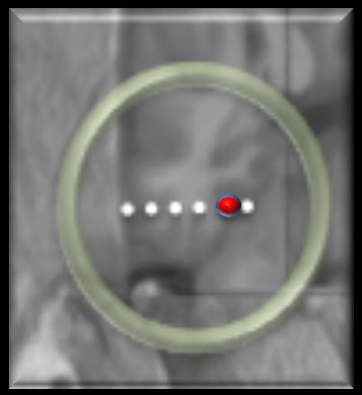
ICON – Brisbane – 31st July 2014

SEEG vs ECoG

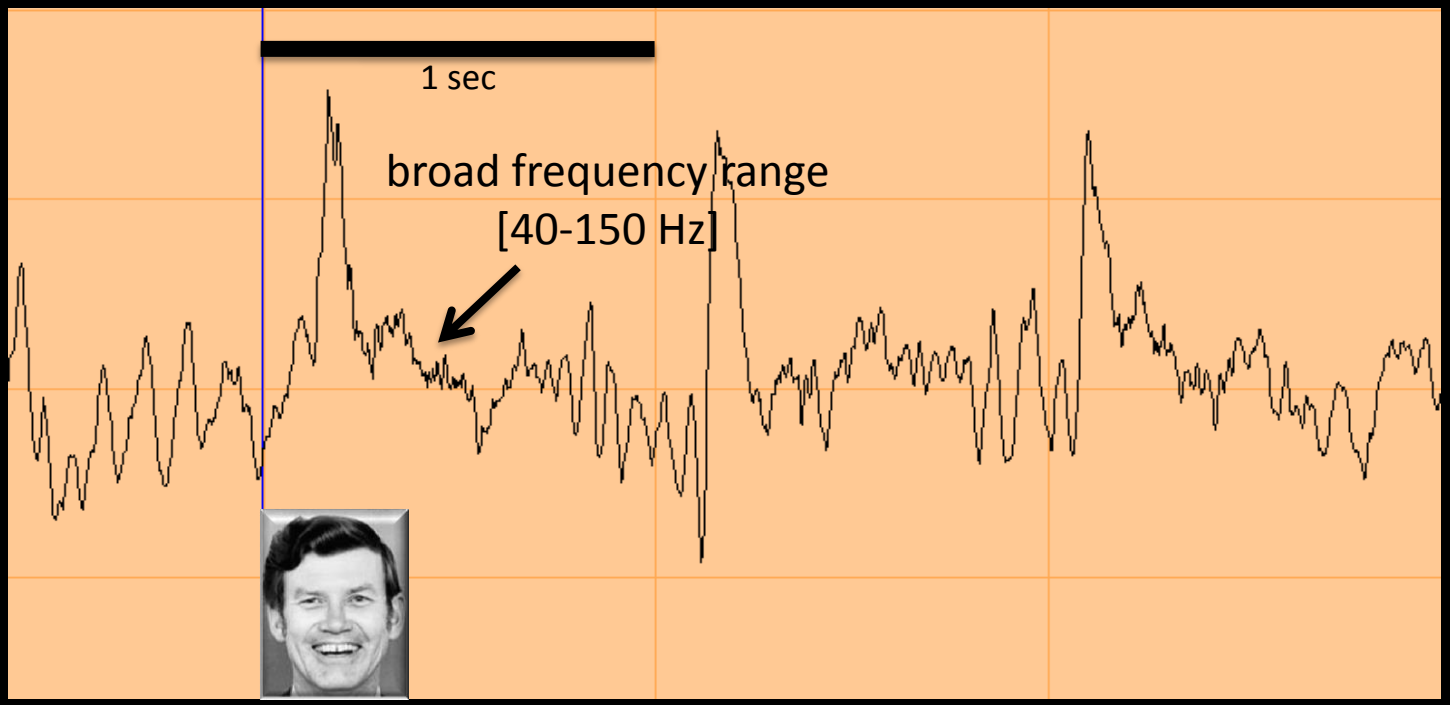
most epilepsy centers in France use depth electrodes (stereotactic EEG or SEEG)
different from the more international « cortical grids »

High-Frequency Neural Activity in Humans

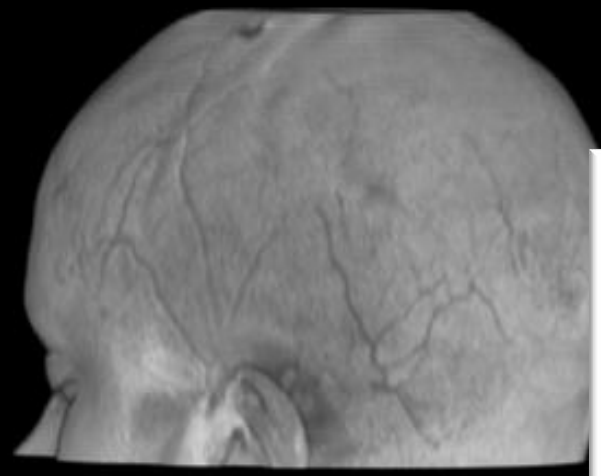


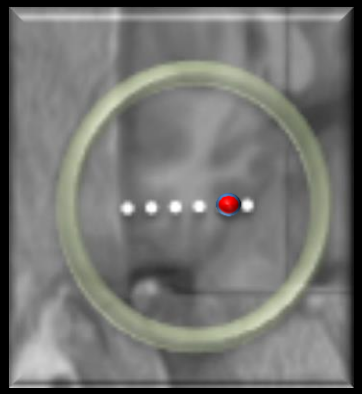


fusiform gyrus



formerly known as « the gamma-band response »





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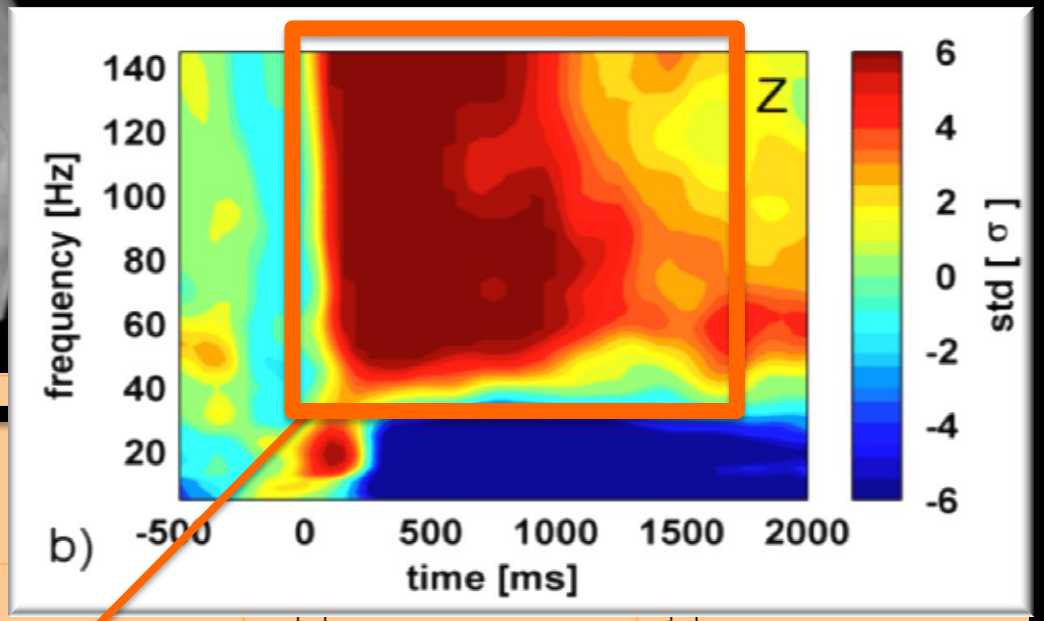
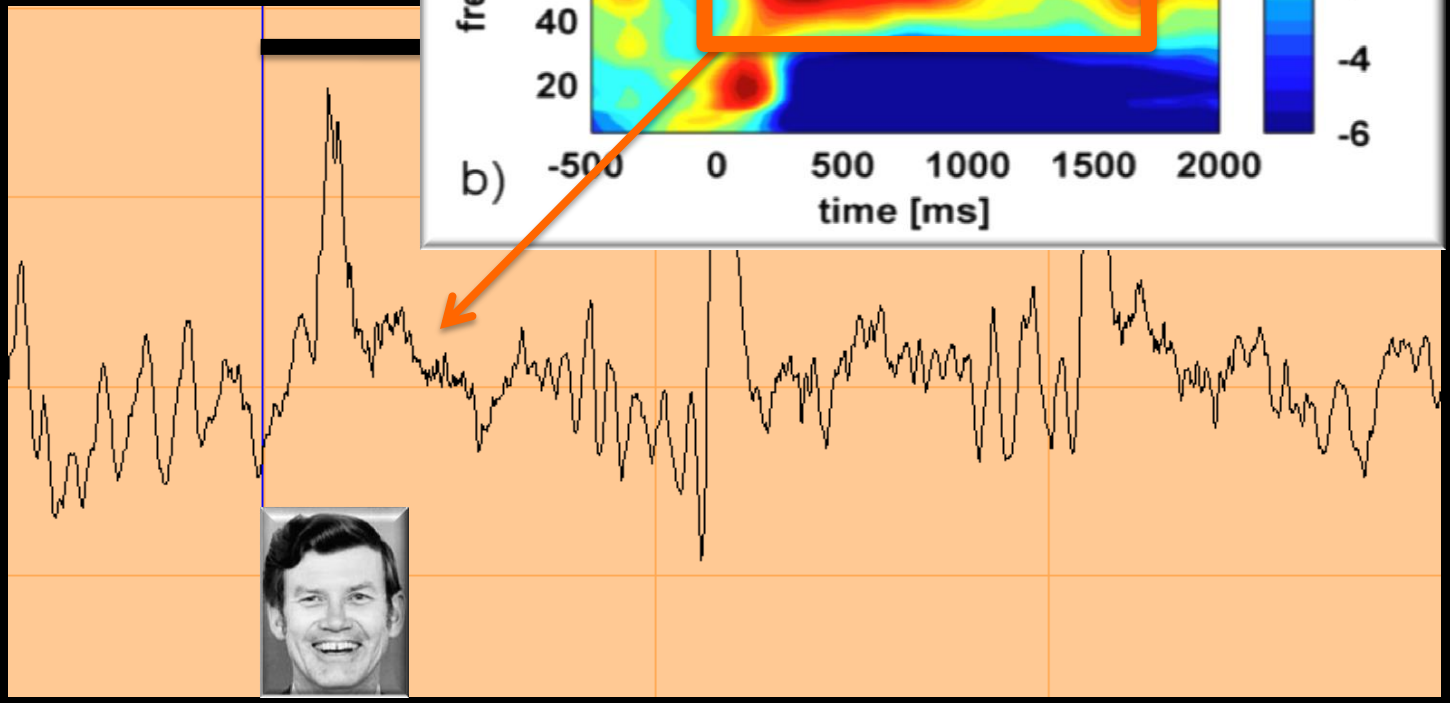
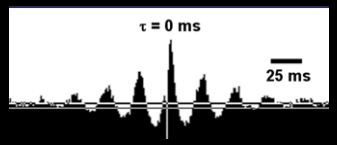


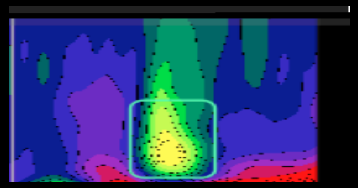


High-Frequency Neural Activity in Humans : How Ironic !

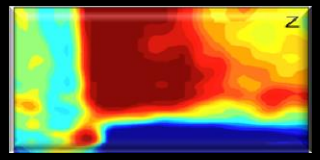
synchronous neural assemblies firing around 40 Hz in early visual areas (multi-units recordings) – Wolf Singer's group – 1988 +++



gamma-band responses to visual stimuli
(scalp EEG in humans) – Bertrand's group – 1997 +++



broadband energy increase in response to visual stimuli
(intracranial EEG in humans) – Lachaux, Varela, Kahane .. – 2000 +++



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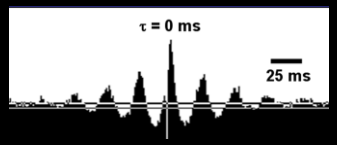

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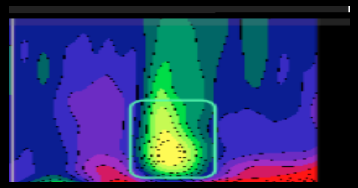

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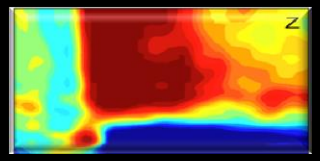

« I don't know what it is, but it's not my gamma. I like it, though »
Wolf Singer, visiting the lab

High-Frequency Neural Activity in Humans

For now, we try to call it High-Frequency neural Activity, or **H F A**$_{[50\text{-}150]}$
(but friends still call it « gamma » or « high-gamma »)

Progress in Neurobiology 98 (2012) 279–301

Contents lists available at SciVerse ScienceDirect

Progress in Neurobiology

journal homepage: www.elsevier.com/locate/pneurobio

High-frequency neural activity and human cognition: Past, present and possible future of intracranial EEG research

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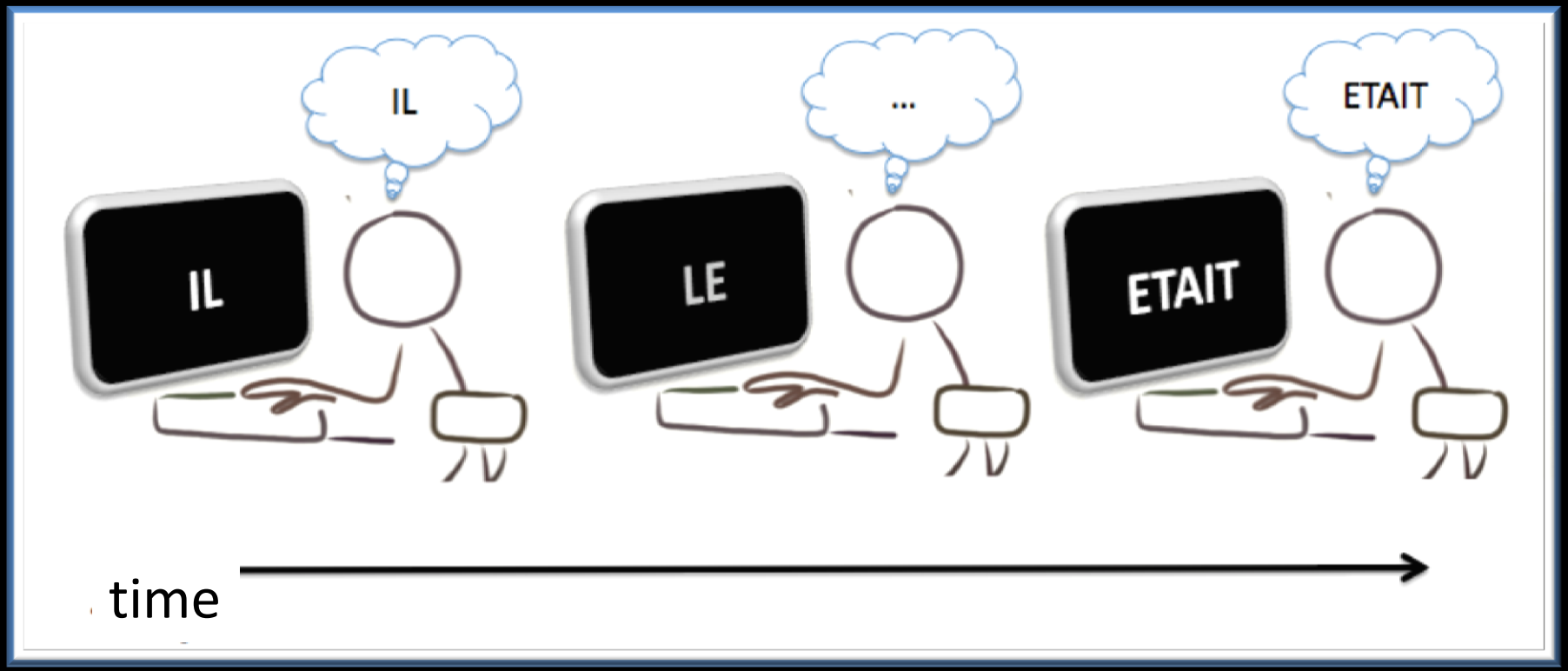
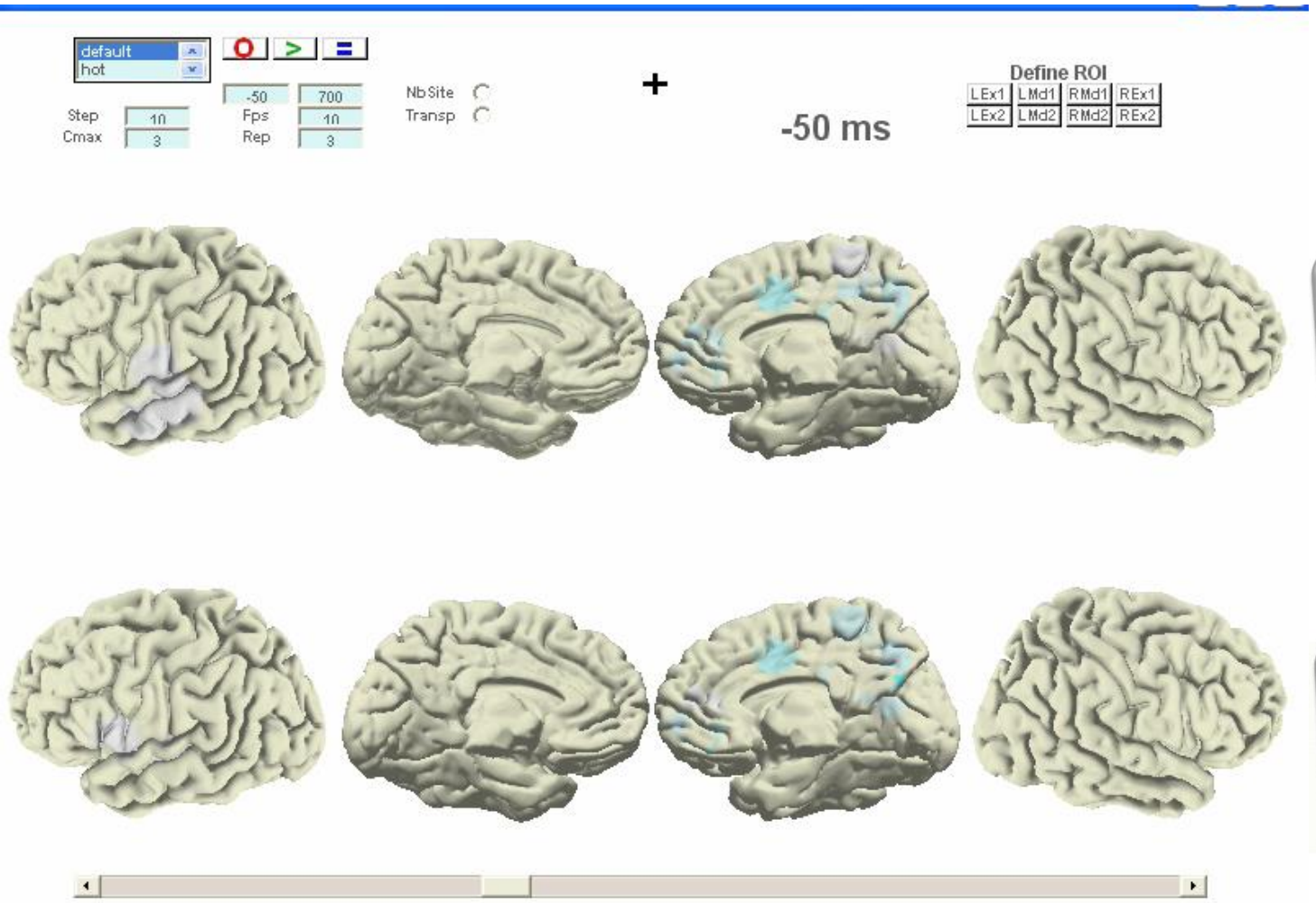
HFA : from TF maps to dynamic brain imaging

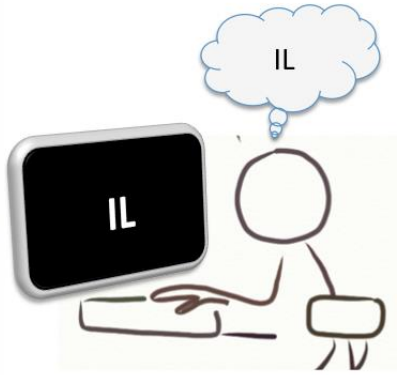


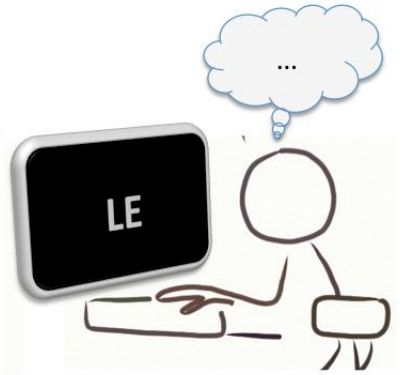
IL LE ETAIT PETIT CHAT UNE MANGE FOIS LA DANS

Jung et al. Hum Brain Map 2007 – paradigm from Nobre et al. Brain 1998

HFA : from TF maps to dynamic brain imaging

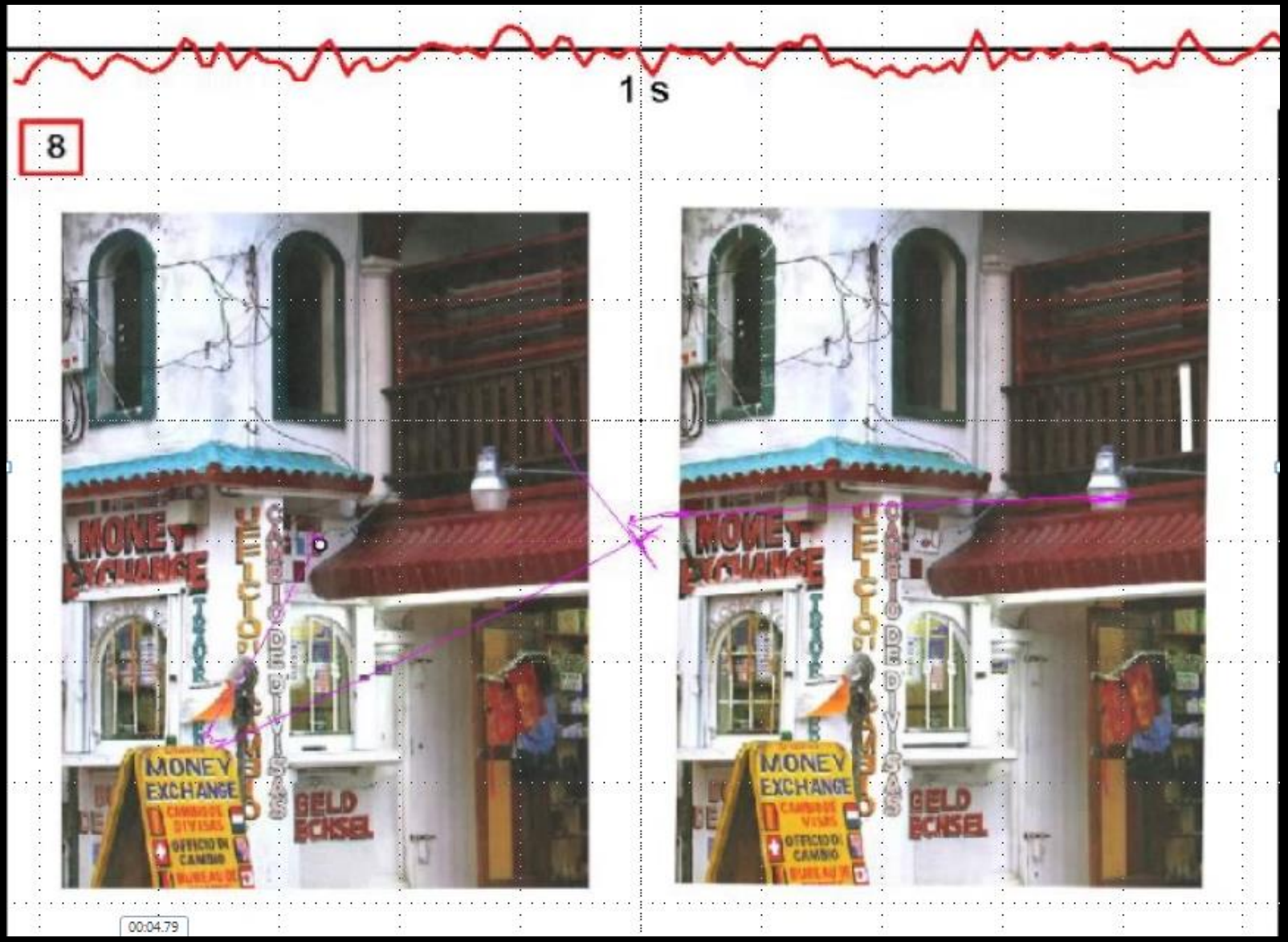






Jung et al. Hum Brain Map 2007

HFA : from TF maps to real-time imaging



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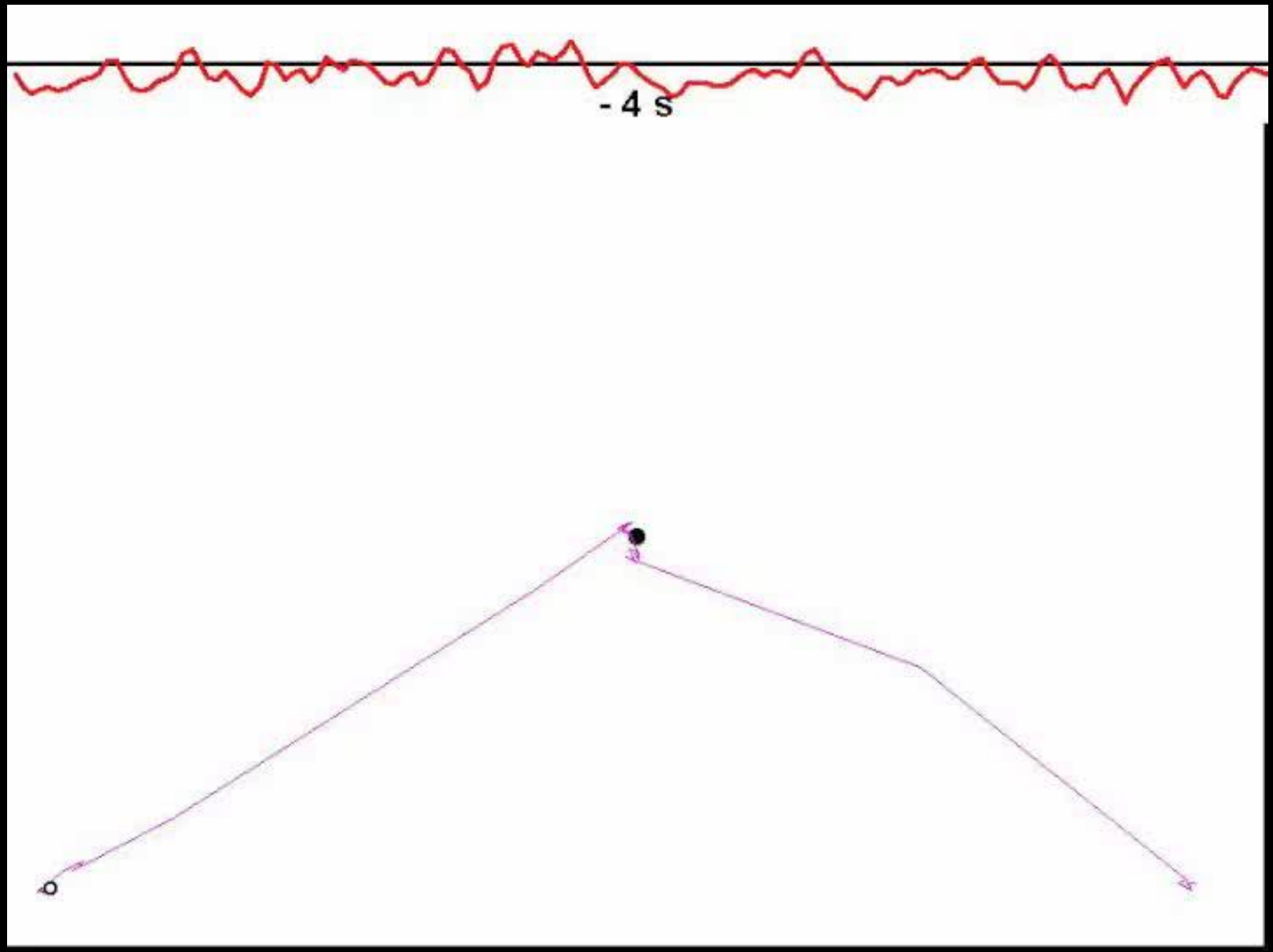

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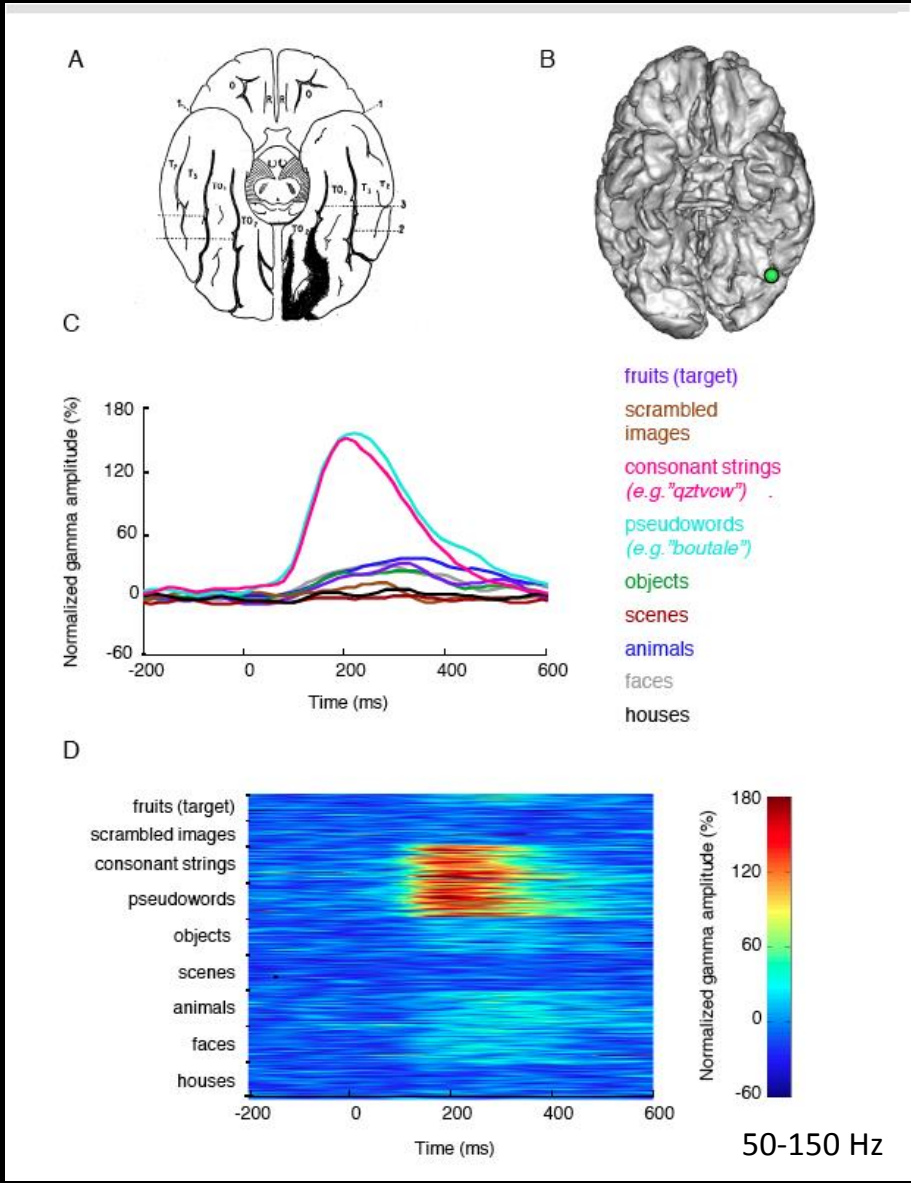
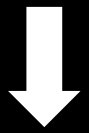


site in the
left fusiform gyrus
highly selective to
letter-strings
(and digits)

Hamamé, Swed Neurology 2012

HFA : from TF maps to real-time imaging

great strengths of intracranial EEG (and HFA)



relatively immune to eye-movement artefacts

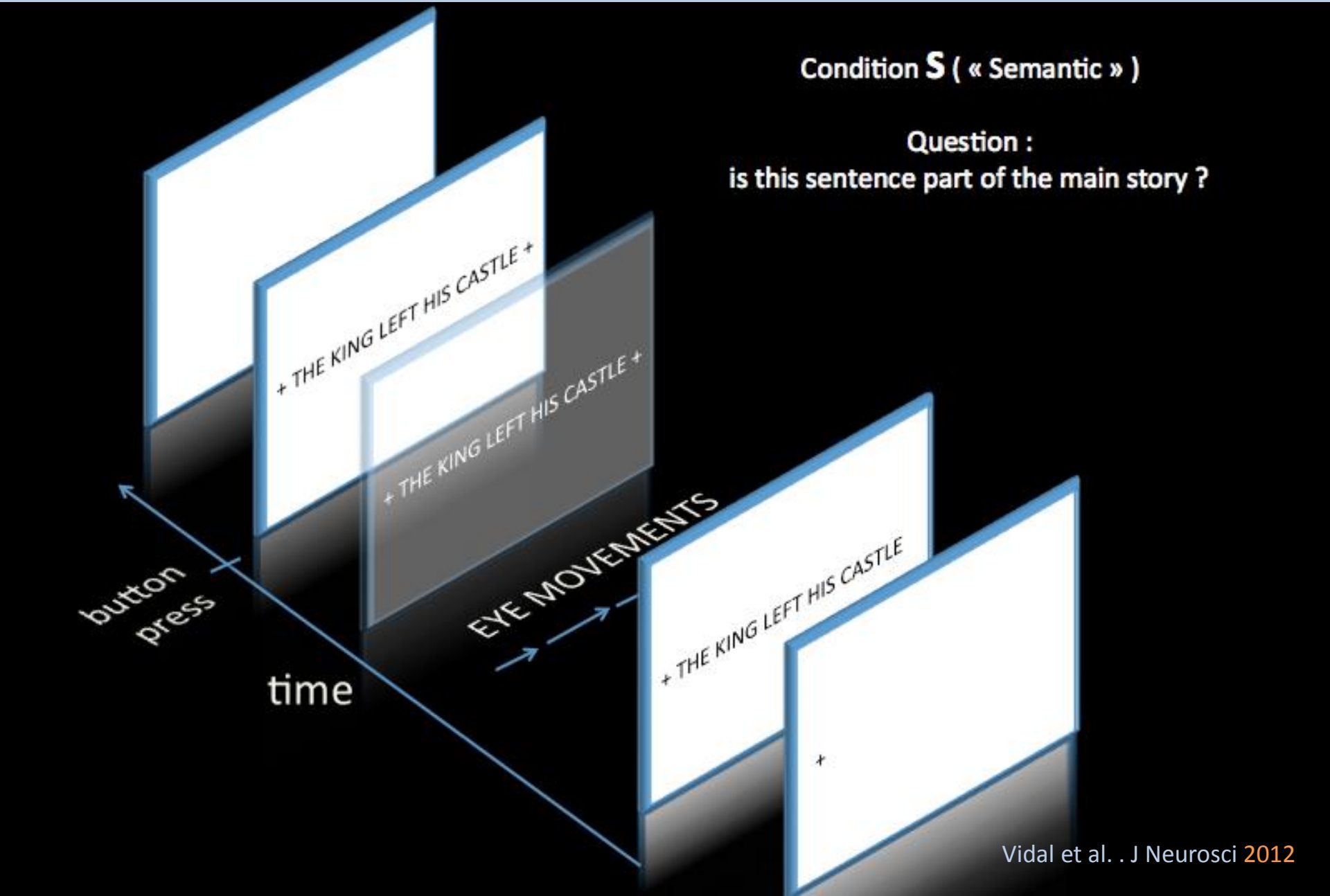
no real need for averaging across « trials »

then,

perfectly adapted to study the dynamics of cognition
in relation to natural oculomotor behavior

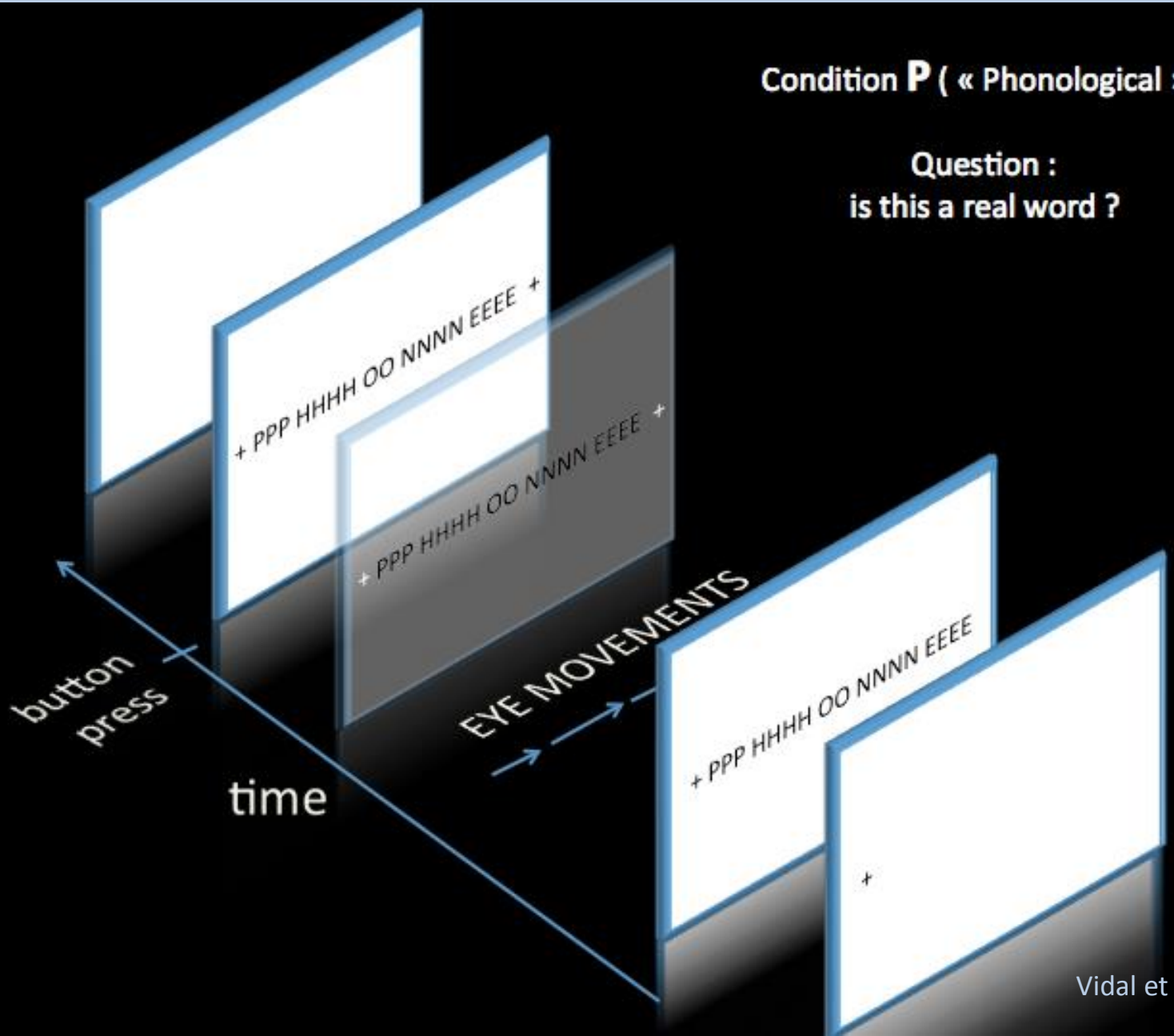
for instance during ... reading

HFA and functional connectivity



Vidal et al. . J Neurosci 2012

HFA and functional connectivity



Vidal et al. . J Neurosci 2012

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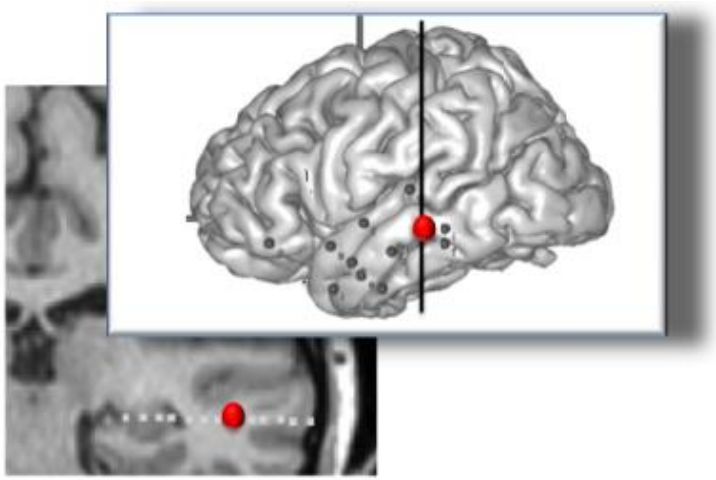
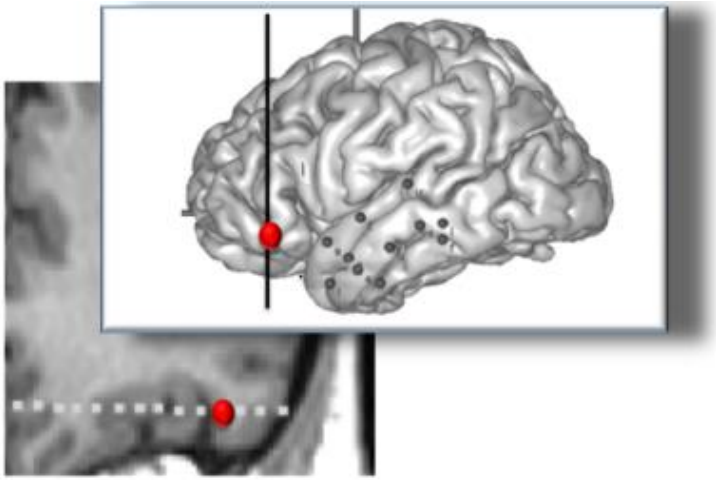
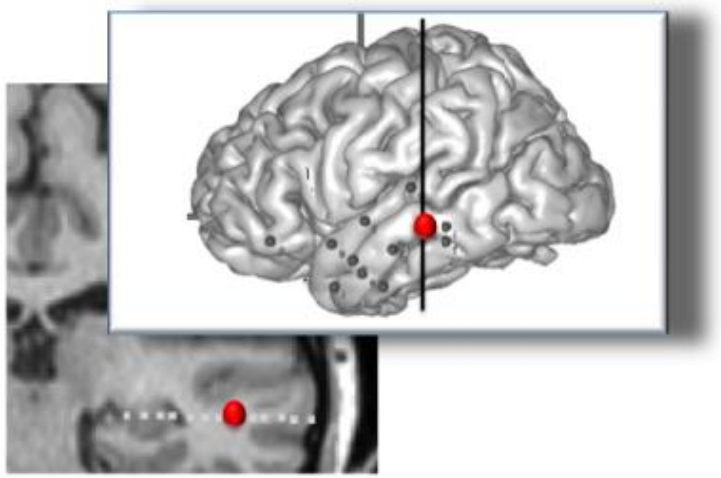


Medial Temporal Gyrus



Inferior Frontal Cortex

HFA and functional connectivity



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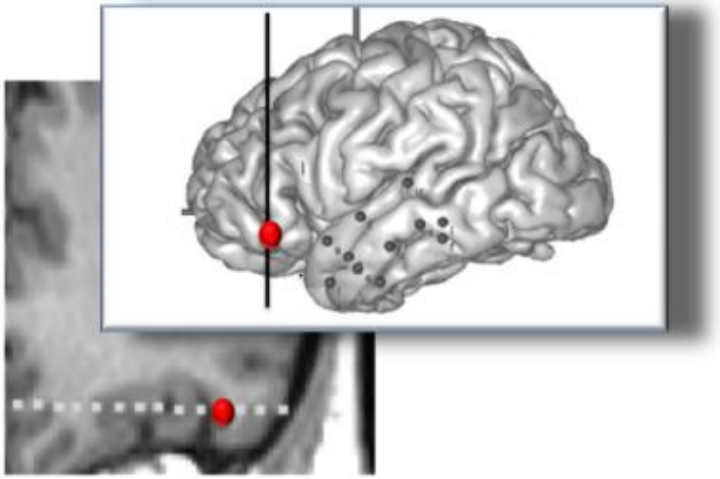
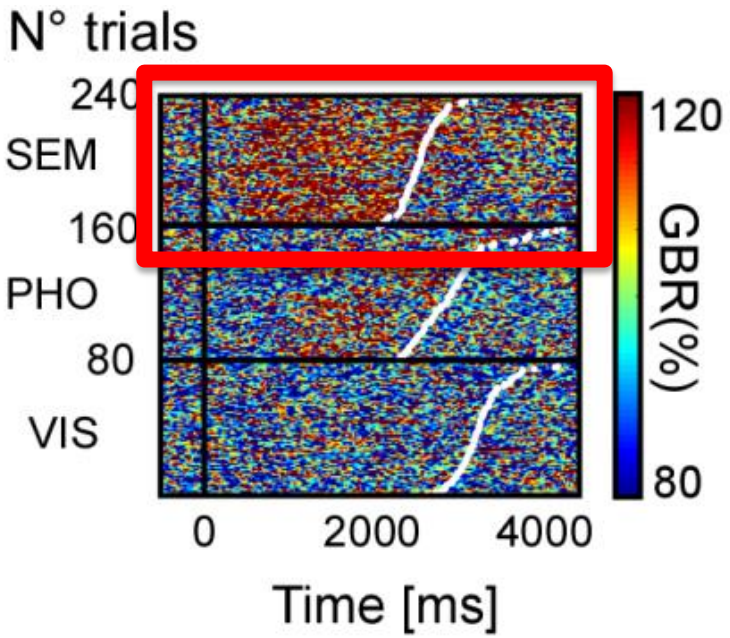
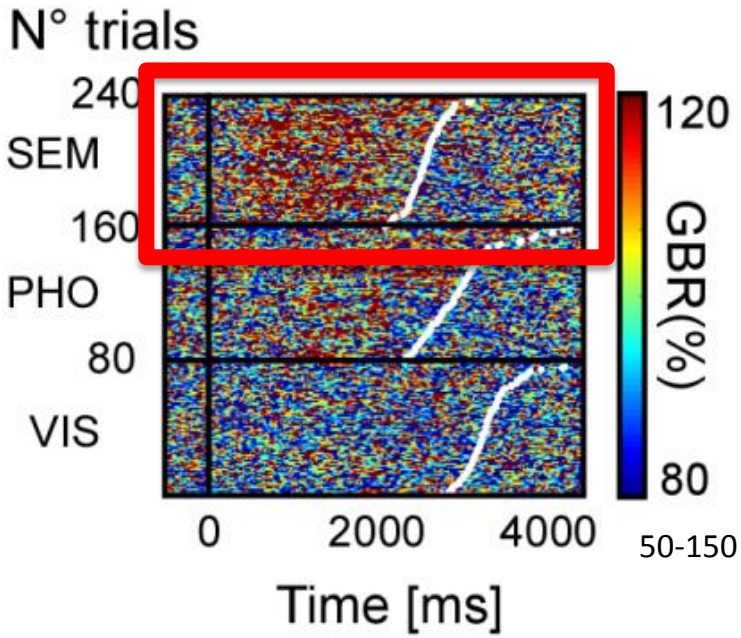


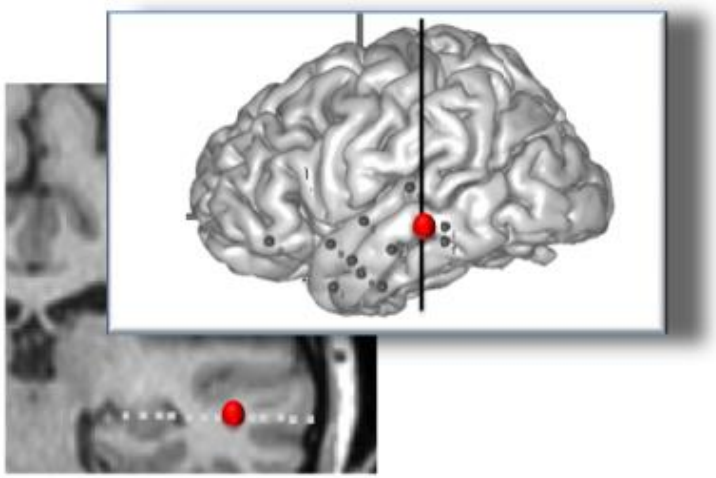
Inferior Frontal Cortex





50-150 Hz

HFA and functional connectivity



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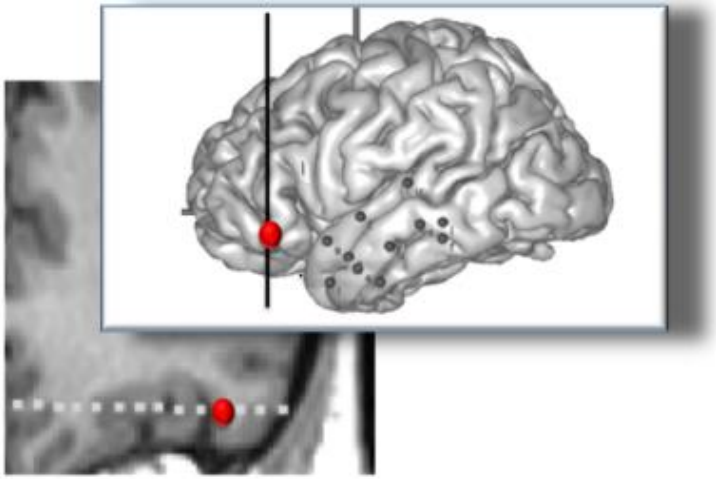


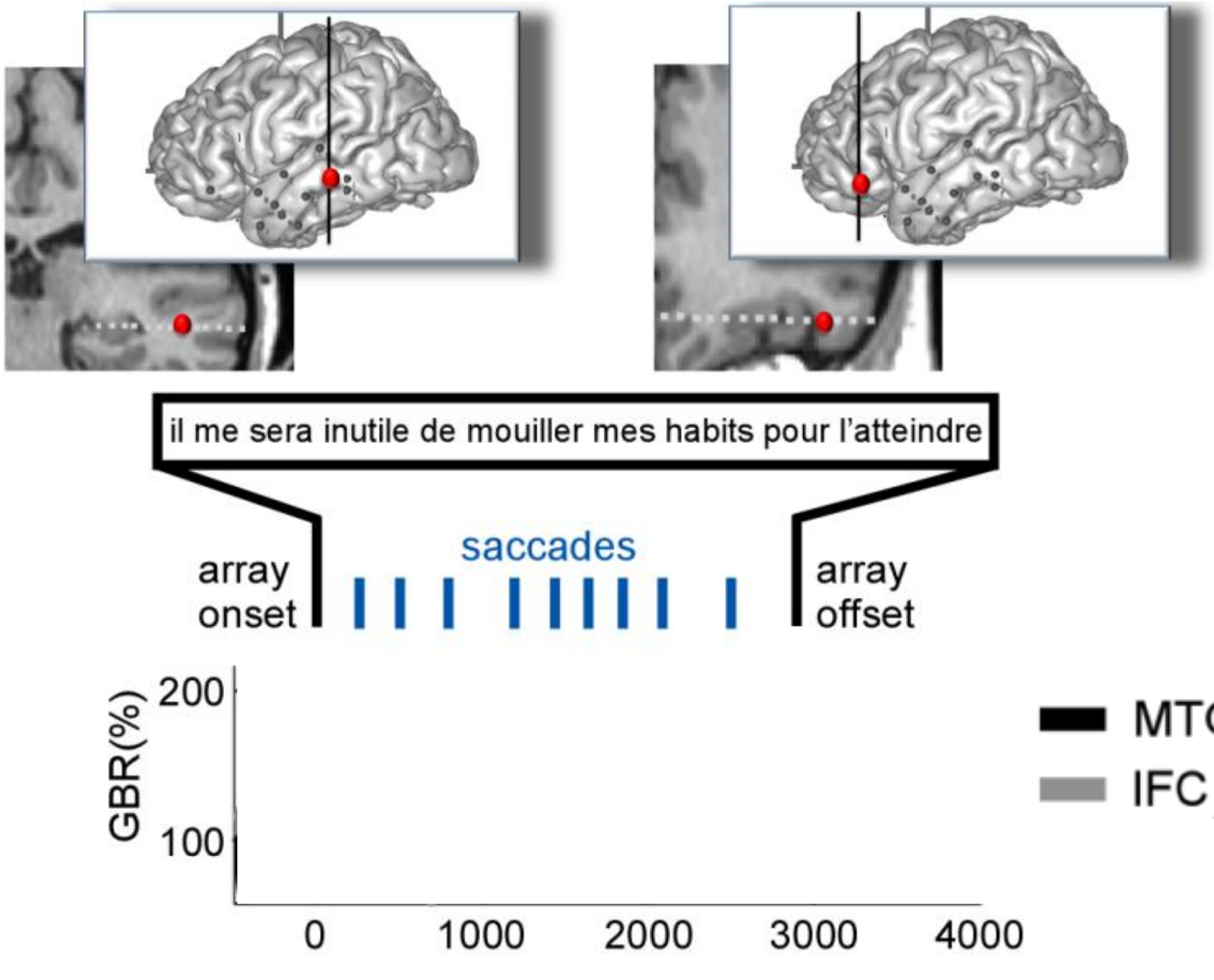
Inferior Frontal Cortex

MTG and IFG have similar dynamics
do they 'work' together ?

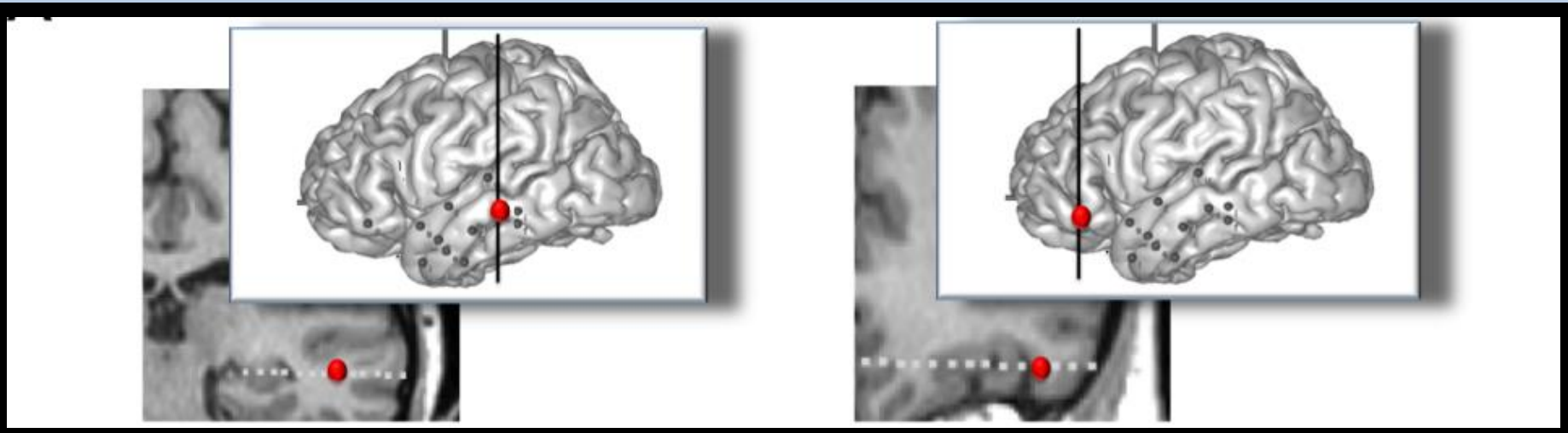
If they work together, then we expect them to work at the same time
i.e. during each sentence – they should « more active » at the same time ...
... and « less active » at the same time

can we observe high correlation coef. between HFA amplitude fluctuations ?
« a la » Yuval Nir (Nature Neuro. 2008)

HFA and functional connectivity



HFA and functional connectivity

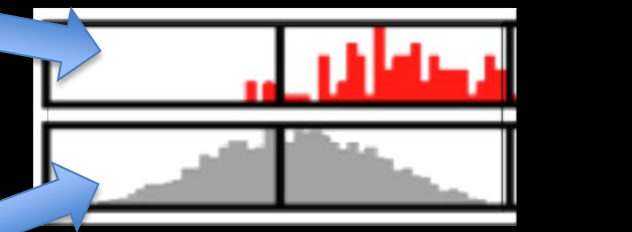


compare

distribution of correlation coefficents
trial i (site 1) x trial i (site 2)

and

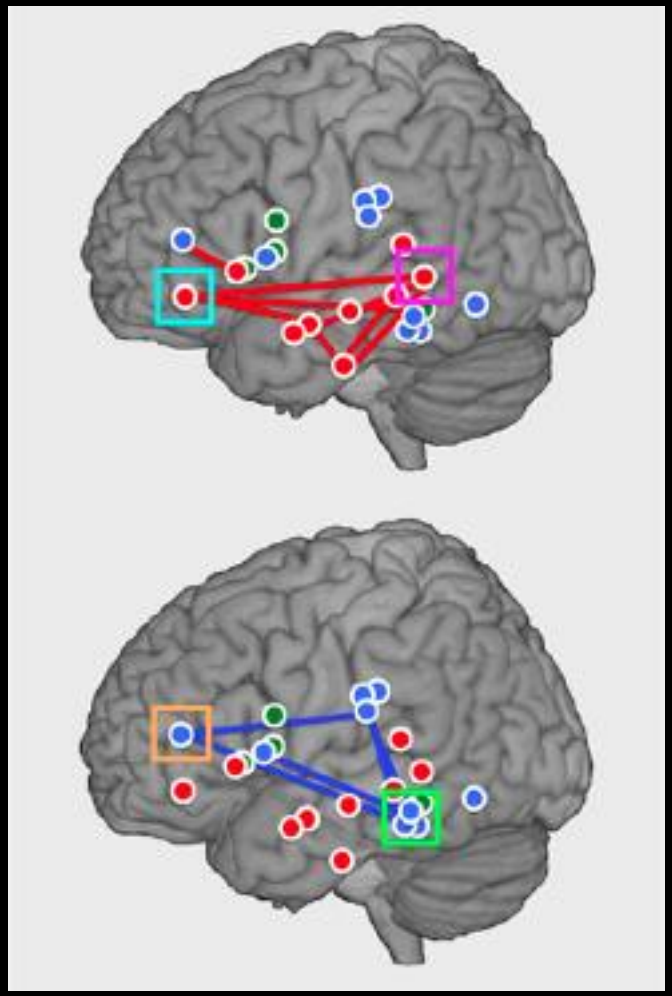
distribution of correlation coefficents
trial i (site 1) x trial j≠i (site 2)
(surrogates)



... get p-value

Vidal et al. . J Neurosci 2012

HFA and functional connectivity



a semantic network

a phonological network

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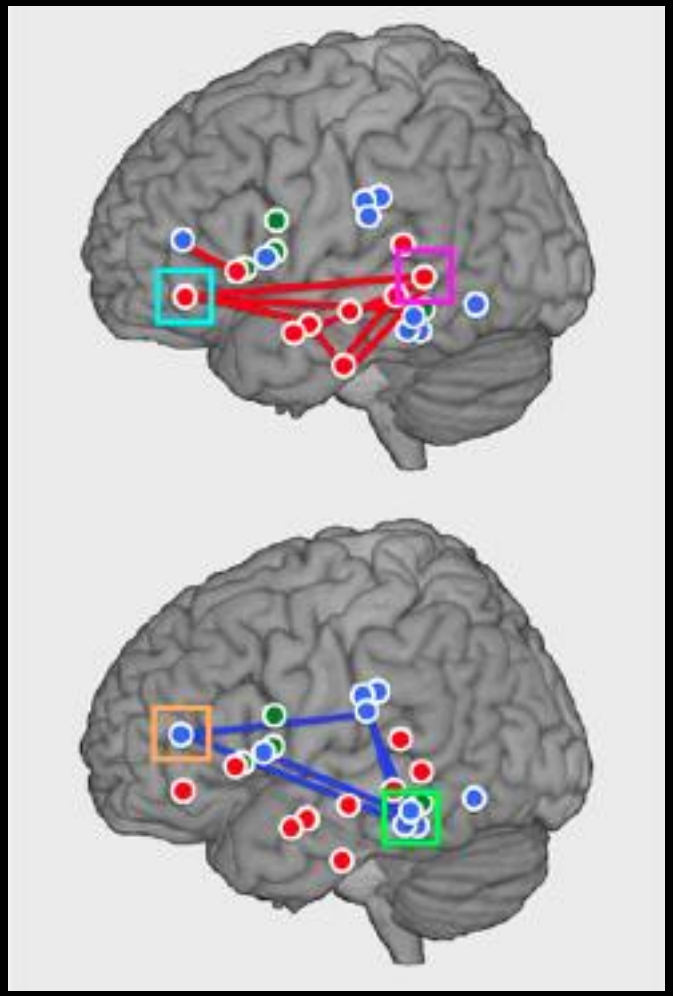
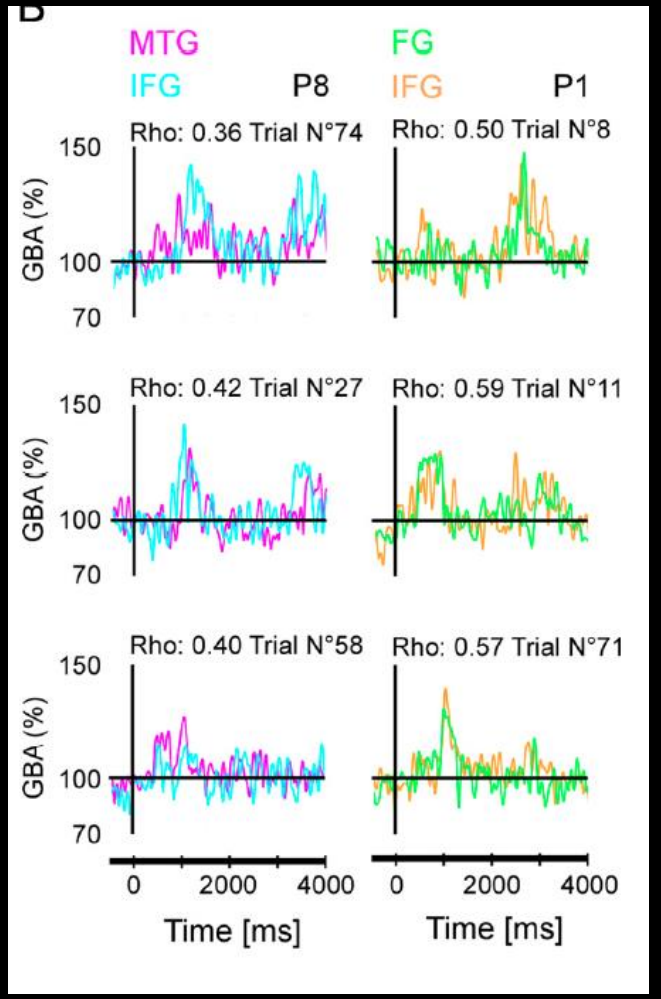
HFA and functional connectivity





Vidal et al. . J Neurosci 2012

Summary

if two cortical regions A and B work together to implement a cognitive process (overt or covert)

then,

fluctuations of their activity within the task should be correlated

then,

their HF amplitude fluctuations [50-150 Hz] should be correlated

thus,

it seems like the first thing to check when looking for networks
... maybe even before synchrony, coherence, granger, ...

Thank You

Philippe Kahane
Lorella Minotti
Dominique Hoffmann
Cécile Sabourdy
Monica Baciu
Alexandra Juffard
Patricia Boschetti
Véronique Dorlin
Martine Juillard
Julien Bastin
Marcela Perrone

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