The simple complexity of the language the 'Body and Brain' system uses communicating with the environment

Franca Tecchio

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The organization of the 'Body and Brain' system determines its communication language

Feedback, Synchrony, Plasticity

Structure-function unit:
functional shape – structural pattern

Listening to intervene

Fractal governing principles
transcranial Individual neuroDynamics Stimulation (tIDS)

Functional Source Separation (FSS)

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Feedback

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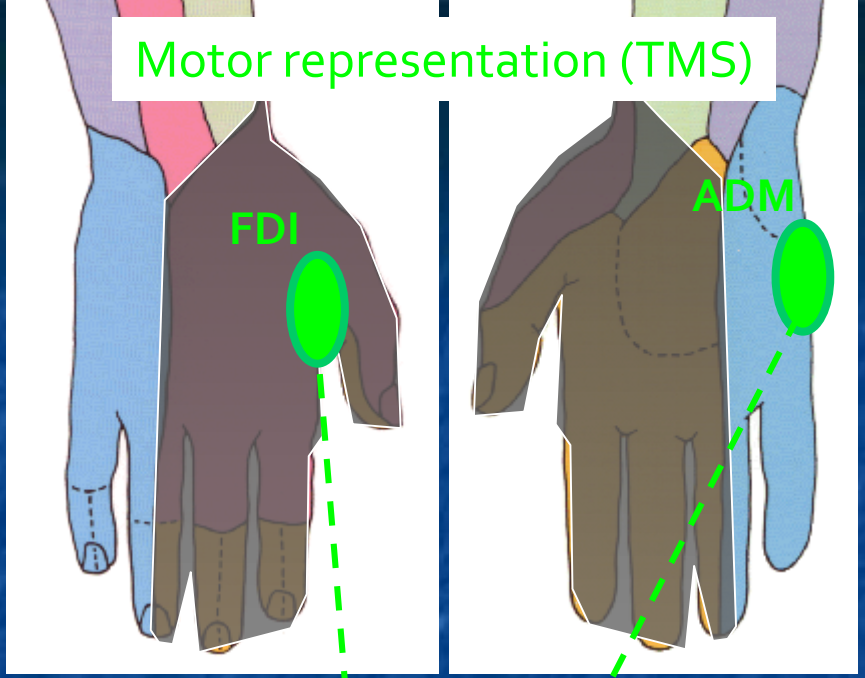
Somatosensory representation changes the ***Motor*** one

Rossi et al. Neuroimage 1998

Motor representation (TMS)



Sensory innervation

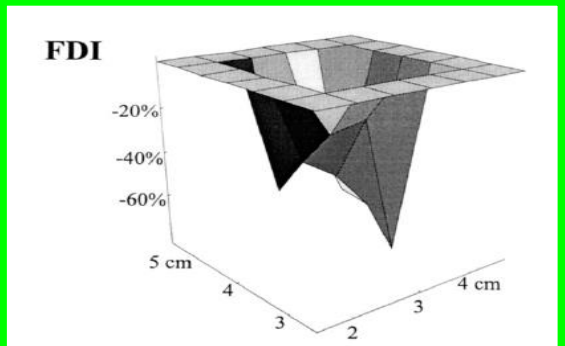
ulnar

median

radial

FDI and ADM
motor ulnar innervation

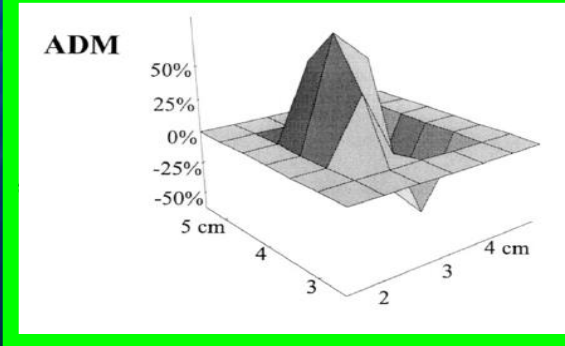
FDI without sensory perception



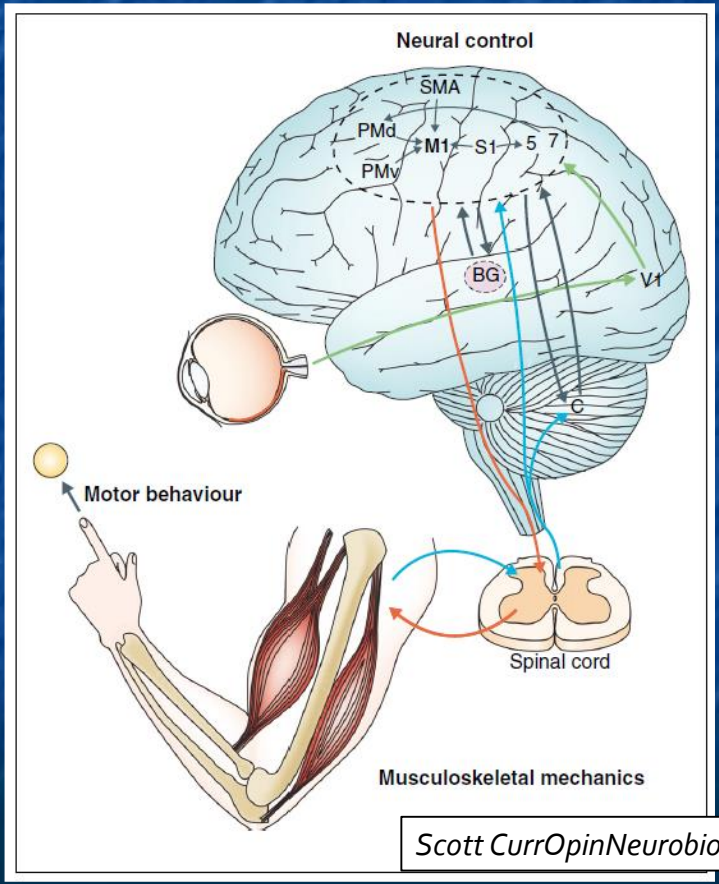
Median and radial anesthesia

ADM and FDI
intact motor innervation

ADM with sensory perception

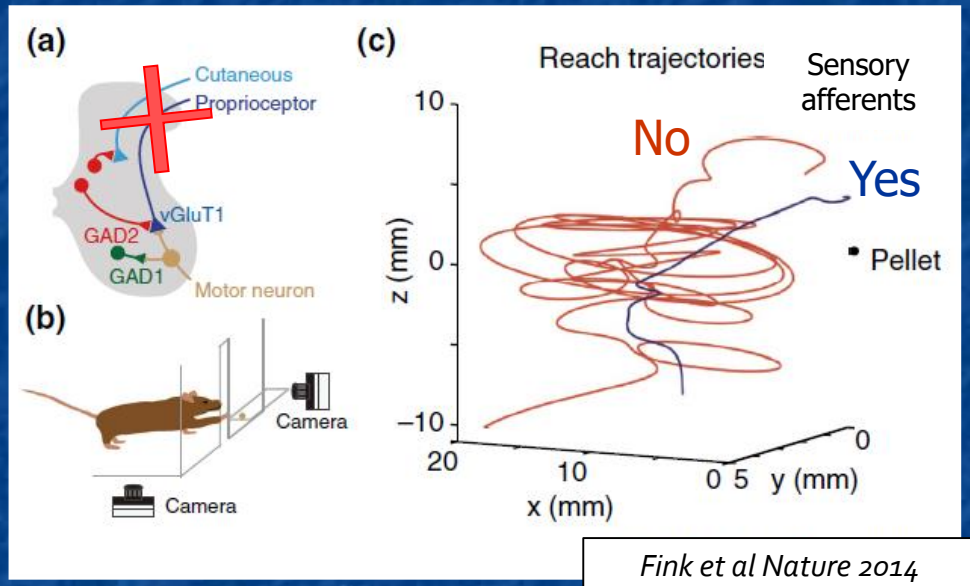


Feedback



Scott CurrOpinNeurobiol 2017

Pharmacological block of primary afferent impairs voluntary movement control.



Fink et al Nature 2014

Synchrony

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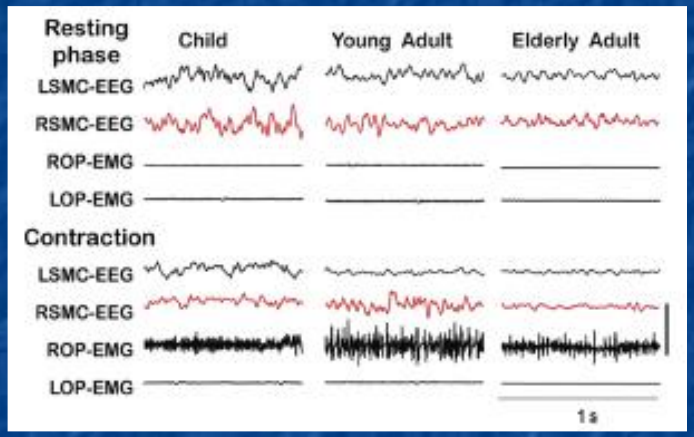
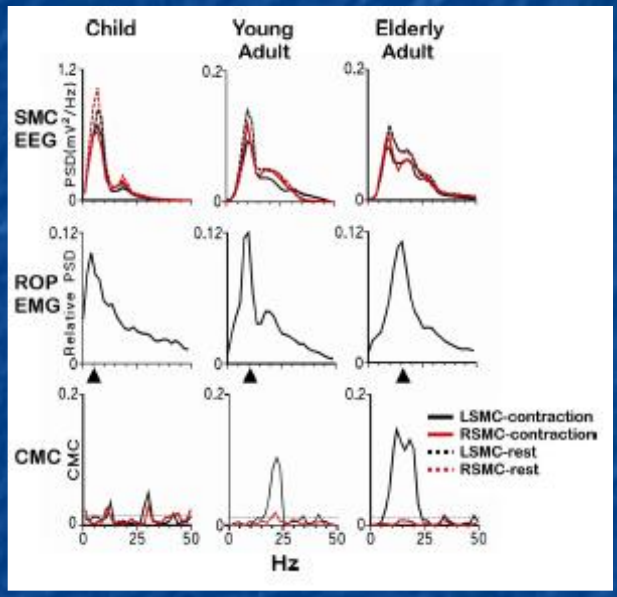
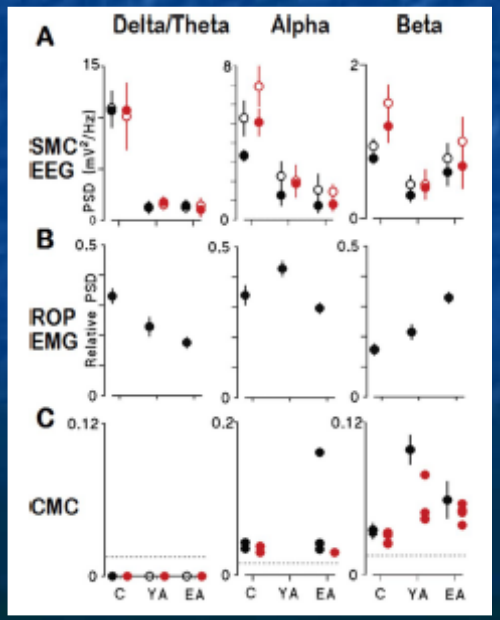
Synchrony between cortical and muscular activity
Tuning corticospinal system activities along life





	Rest	Right contraction
Contra	○	●
Ipsi	○	●

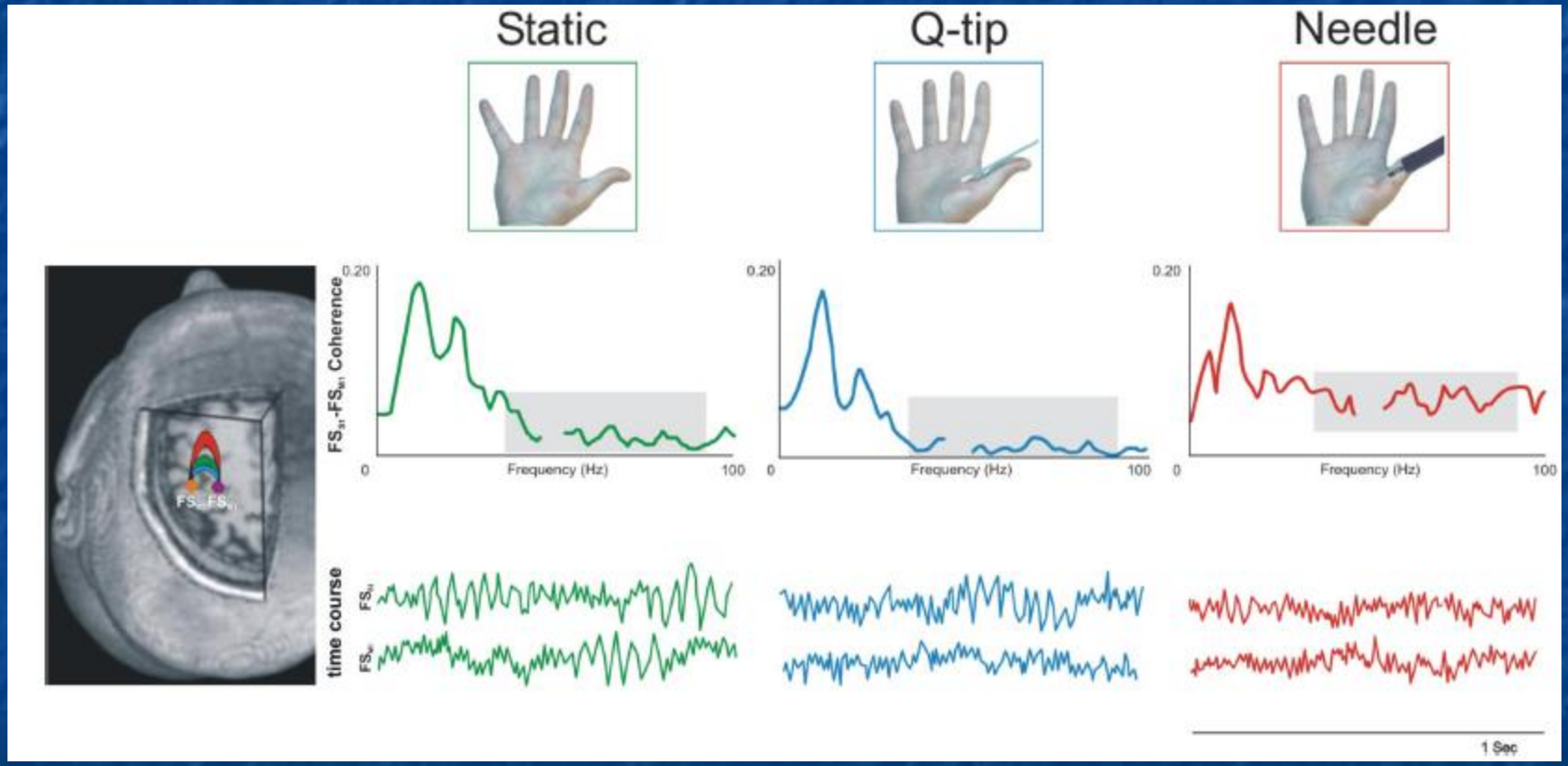


With maturation, the corticospinal system increases

- the frequencies of activity fluctuations
- F-specific reactivity (rest>movement)
  - Contra vs. Ipsi lateral specificity

Graziadio et al J Neurosci 2010
(12 children 10 y. adults 10 e. adults hv)

At cortical level, the **synchrony** between primary somatosensory (S1) and motor (M1) areas mediates the empathic sharing of others' pain



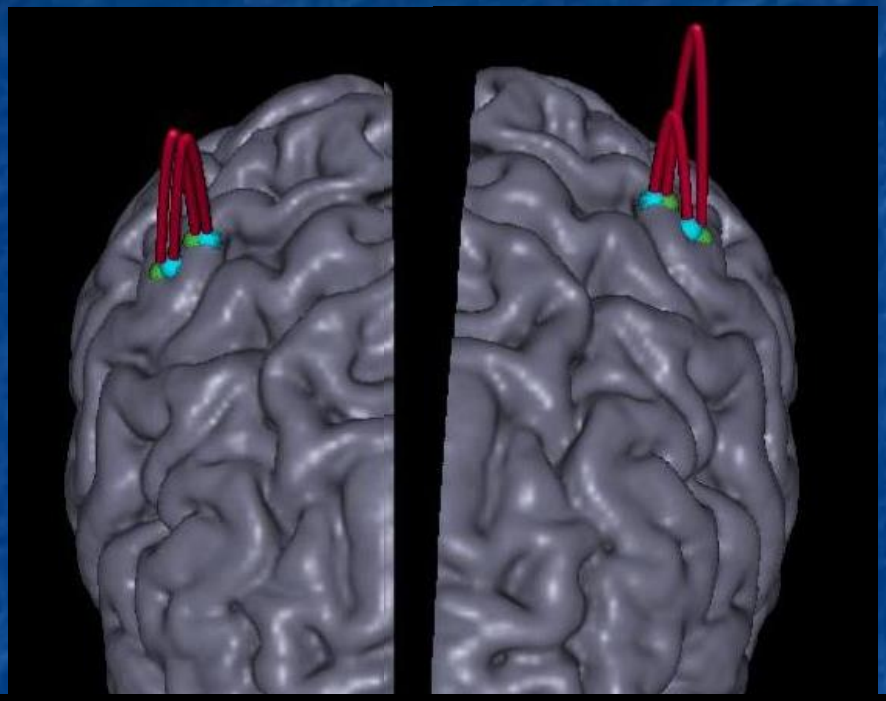
Betti et al J Neurosci 2009
(12 controls)

Intra-cortical **synchrony** is higher for more dexterous controlled districts

Hemisphere

Right (non-dominant)

Left (dominant)

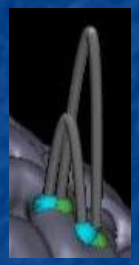


In the left dominant hemisphere both ICC_T and ICC_L correlated with the dexterity (FtW test) of the finger they represent.

Tecchio et al Neuroimage 2007, 14 controls

Thumb (higher dexterous)

Little finger (lower dexterous)



Intra-cortical connectivity (ICC) within the areas devoted to thumb (ICC_T) and little finger (ICC_L)

Local intra-cortical synchrony (ICC) appears to be a new code for sensorimotor dexterity complementary to 'magnification' principle

Plasticity

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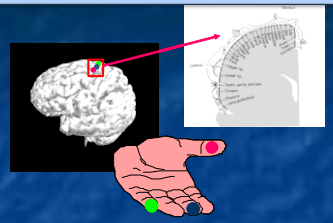
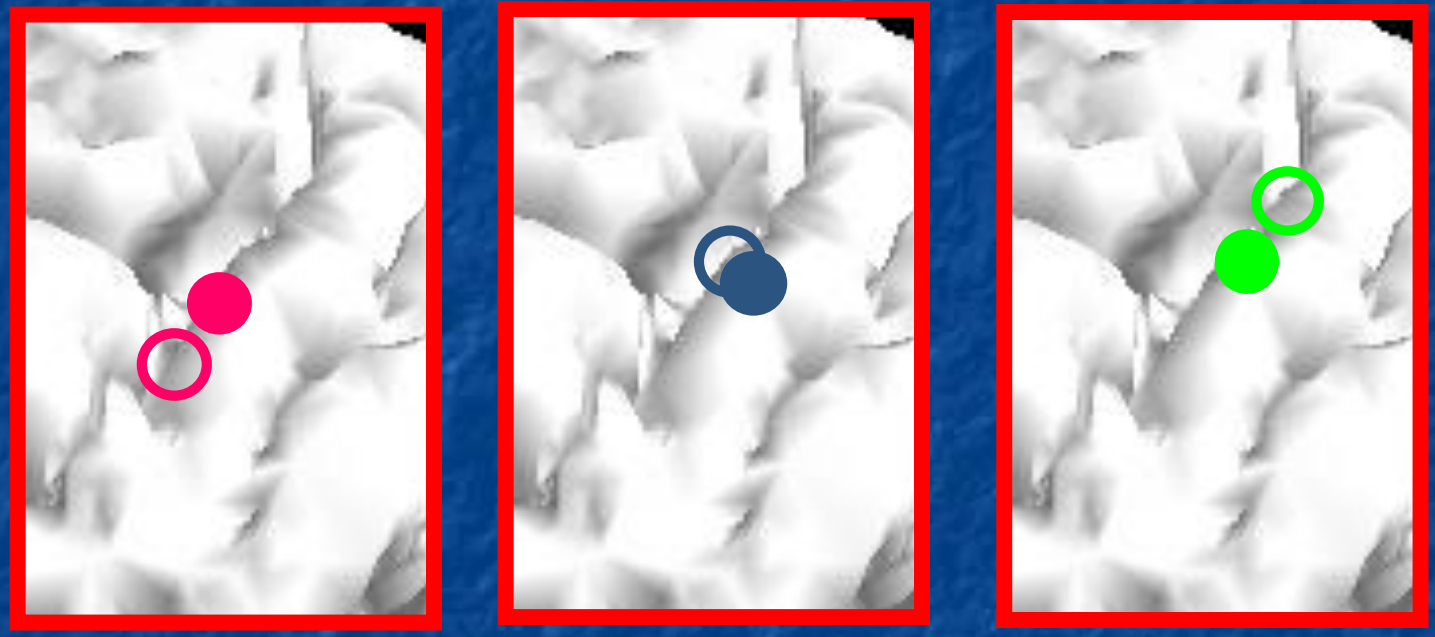
Plastic changes of cortical representation: 'spared' territories invade 'deprived' ones

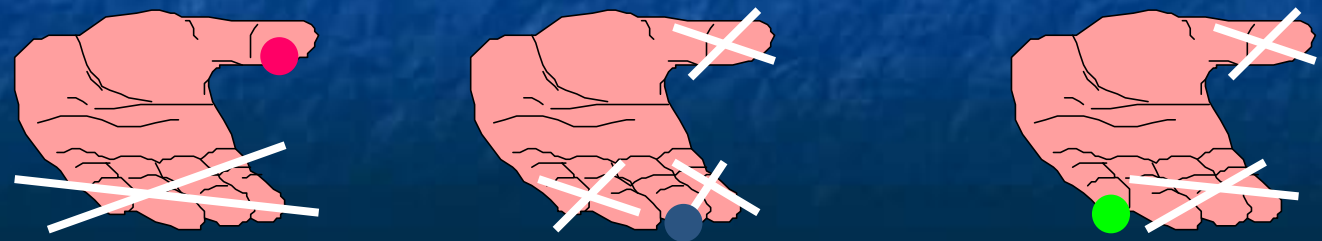


PRE *POST*

anesthesia

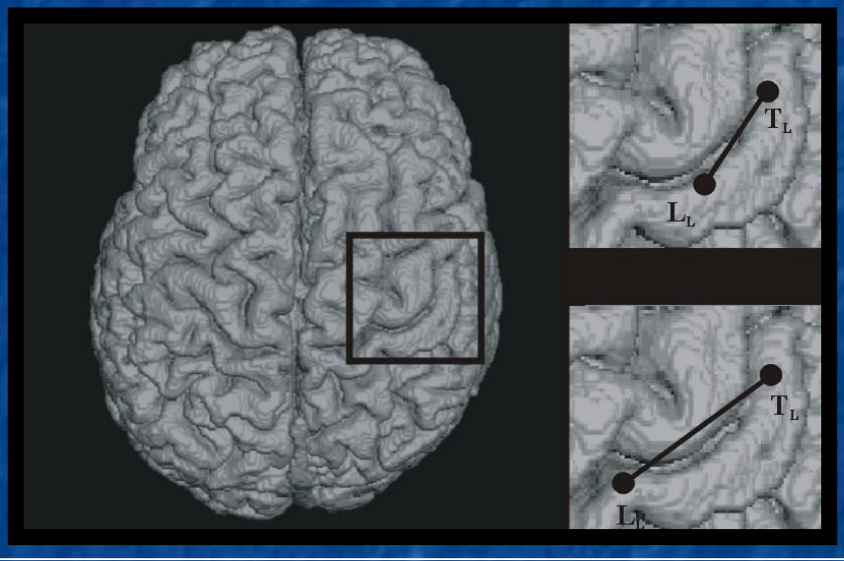
Rossini et al ClinPh 1994
10 subjects





Plastic changes of cortical representation:
hand representation depends on how we perceive it

Hand representation in carpal tunnel syndrome



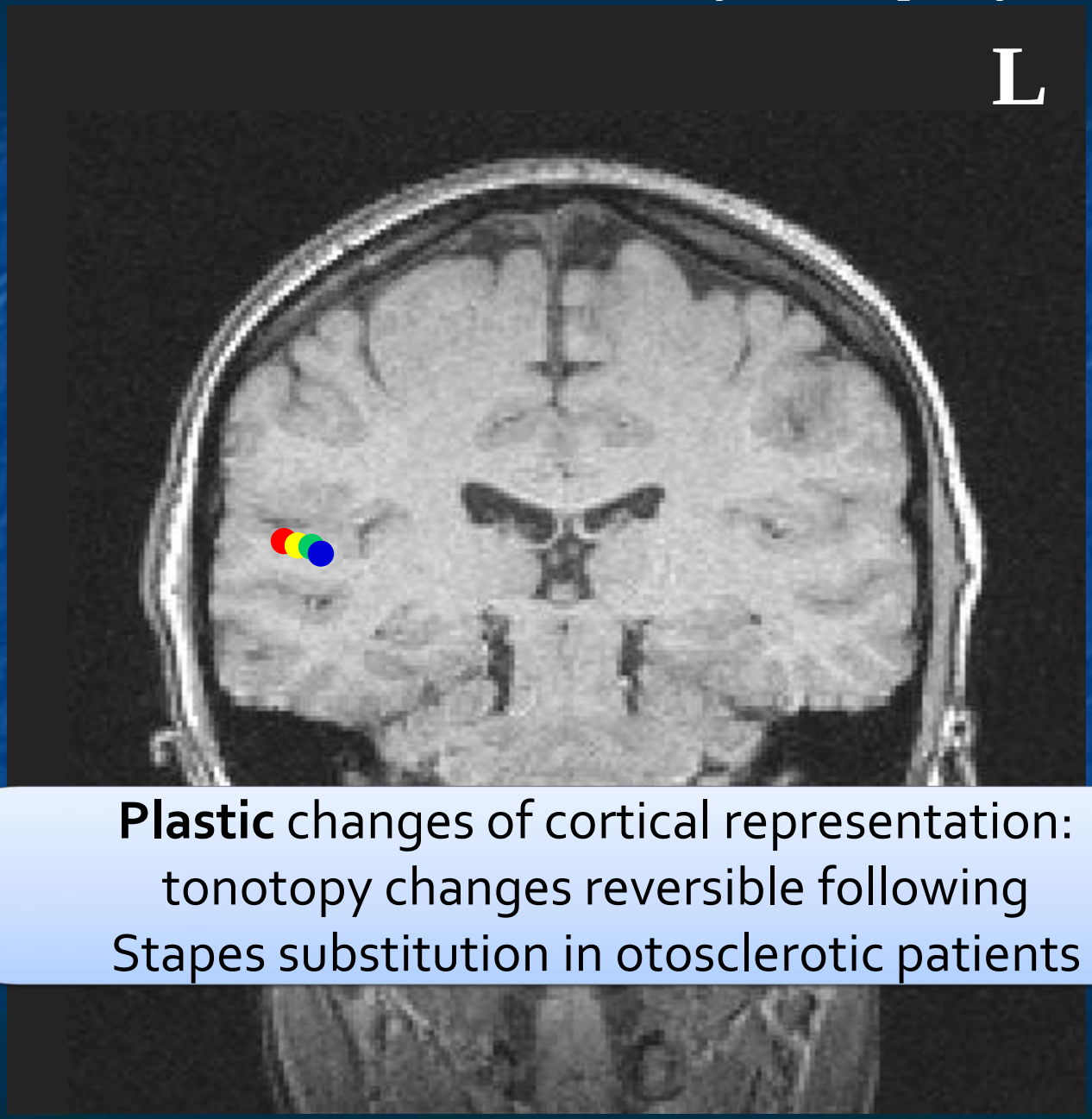
Prevailing symptom
(referred from the person)

pain

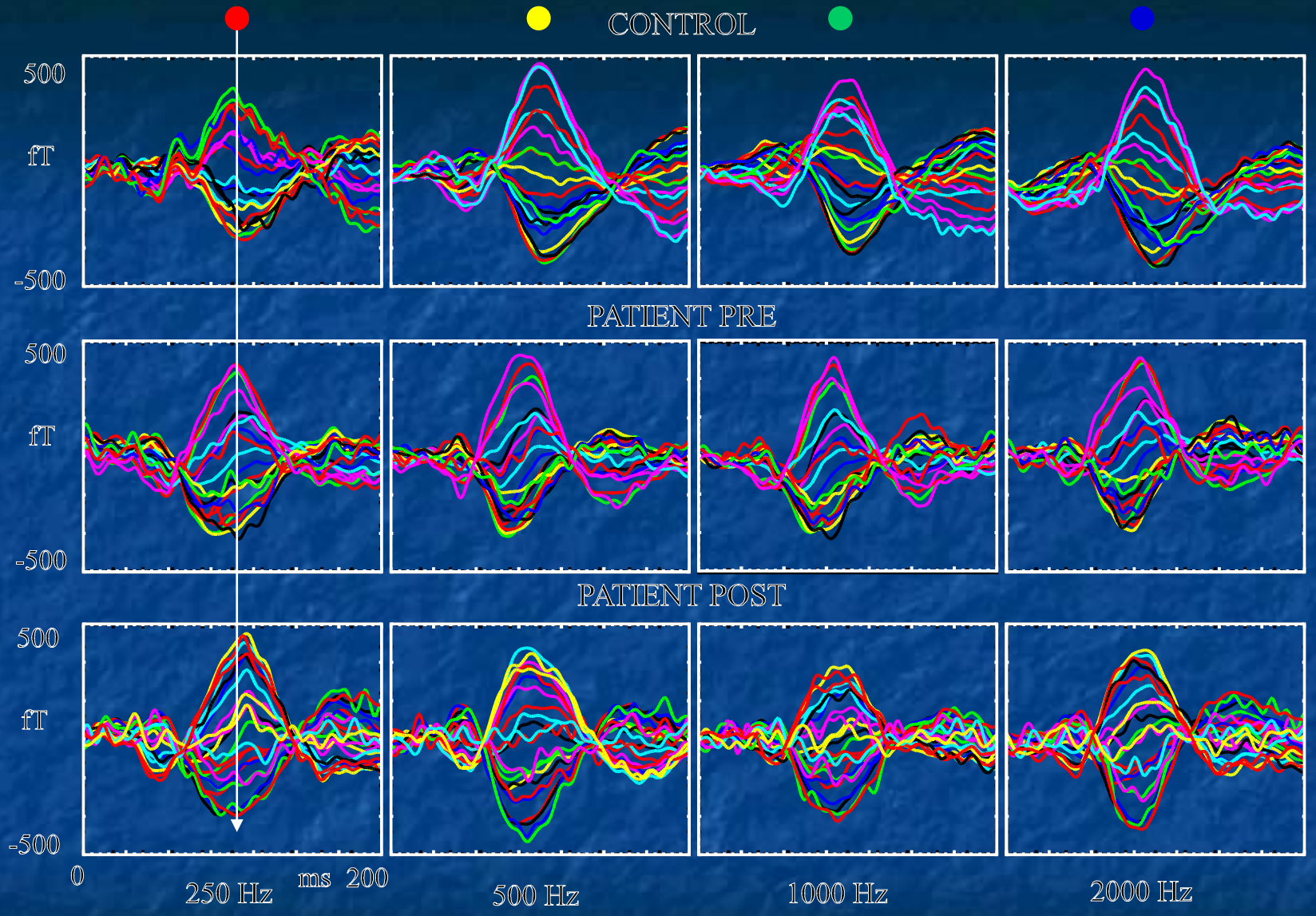
paresthesia

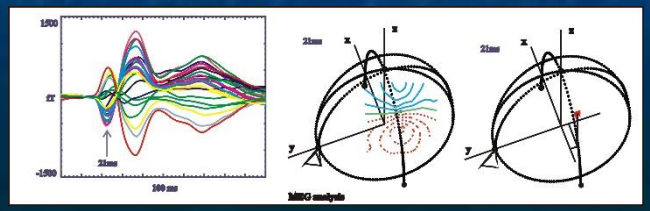
Tecchio et al. HBM 2002
14 carpal tunnel patients - 10 controls

MEG discriminates auditory tonotopicity



Plastic changes of cortical representation:
tonotopy changes reversible following
Stapes substitution in otosclerotic patients



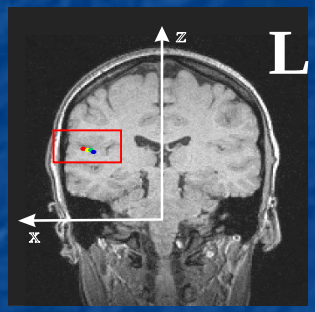


Tecchio et al. HBM 2000
10 otosclerotic patients - 10 controls

Plastic changes of cortical representation: tonotopy changes reversible following Stapes substitution in otosclerotic patients

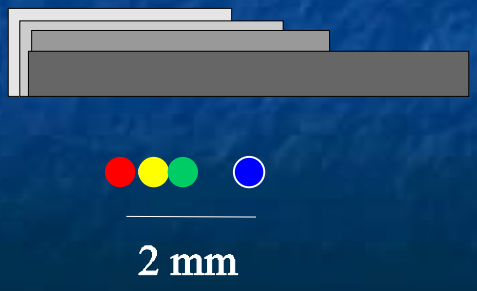
1) peripheral alteration: reduction - LONG term/ reversible

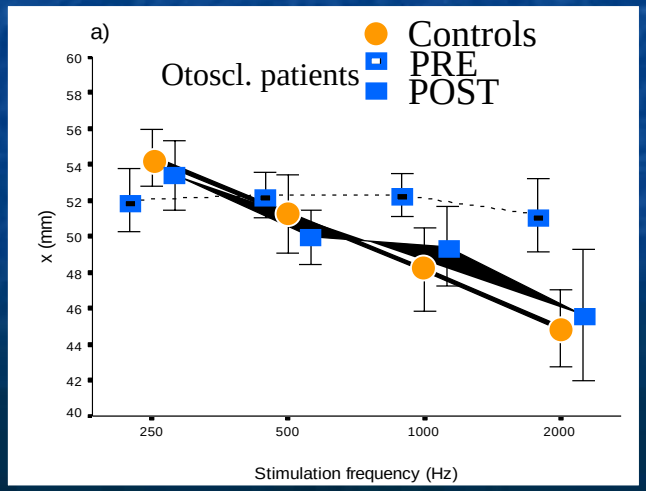
Normal-hearing

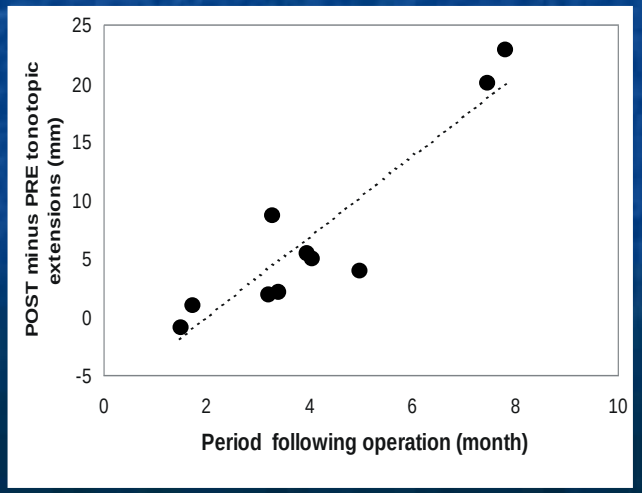


Tecchio et al. HBM 2000
10 otosclerotic patients - 10 controls

Otosclerotic







The organization of the 'Body and Brain' system determines its communication language

Feedback, **Synchrony**, **Plasticity**

The feedback of actions creates synchrony among the nodes of dedicated functional networks that, in turn, engage in plastic adaptations.

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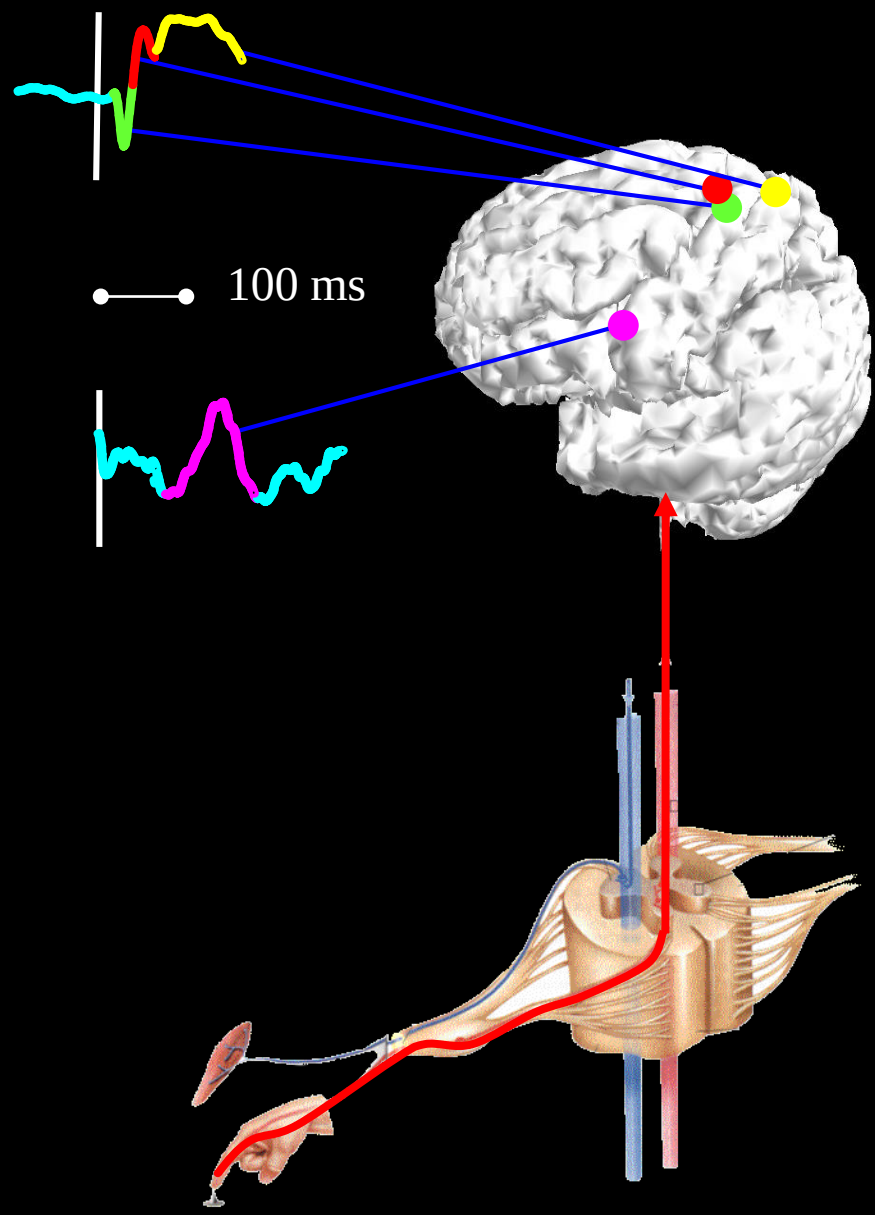
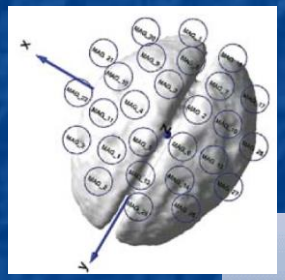
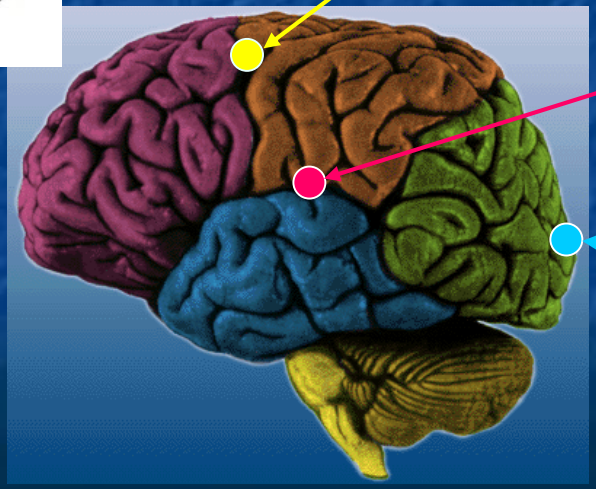
EEG/MEG allow following the temporal evolution of the brain processing

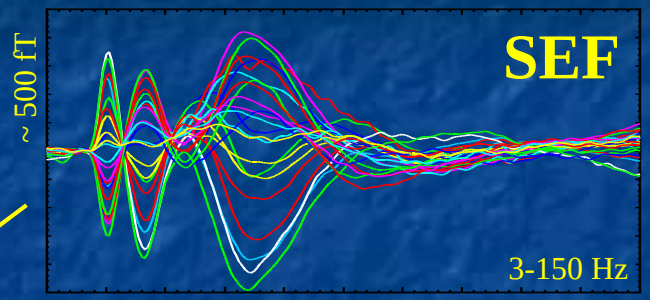


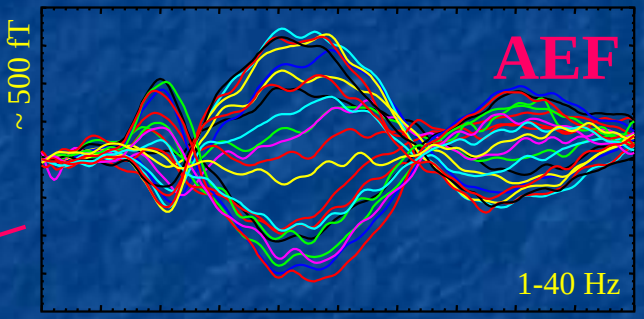
Neuronal Network
response shape → ← recruited pattern

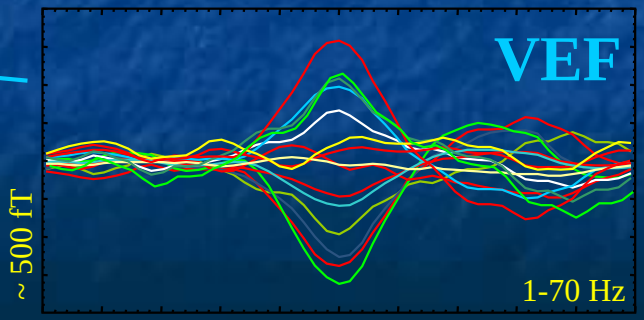
The cortical area answering to
a **light beam**, a **sound**, a **pat**,
presents a
typical *shape* of its answer











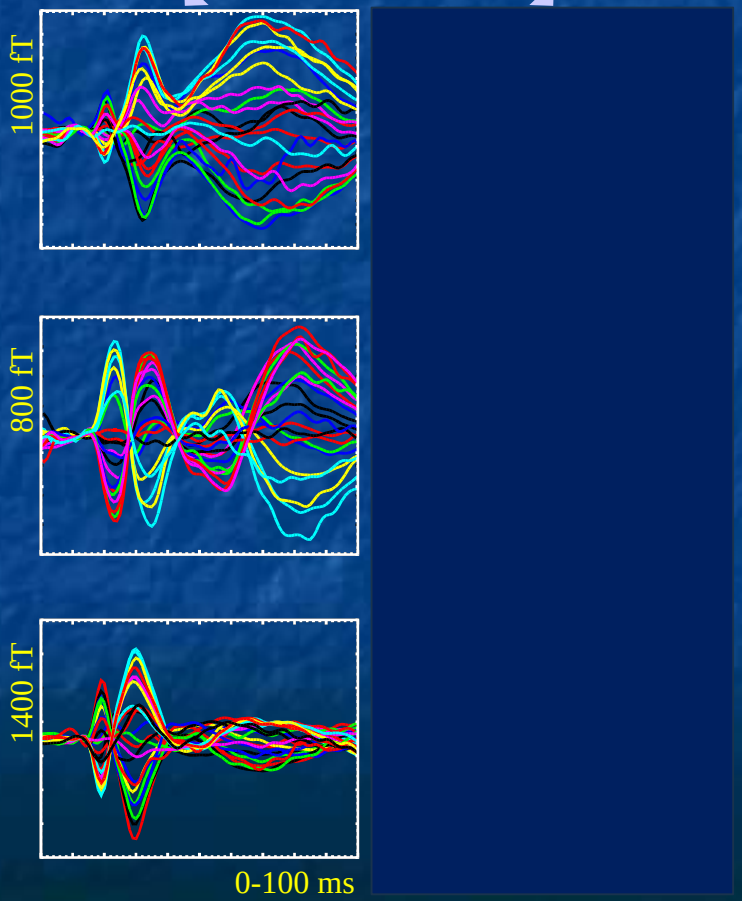
0-150 ms

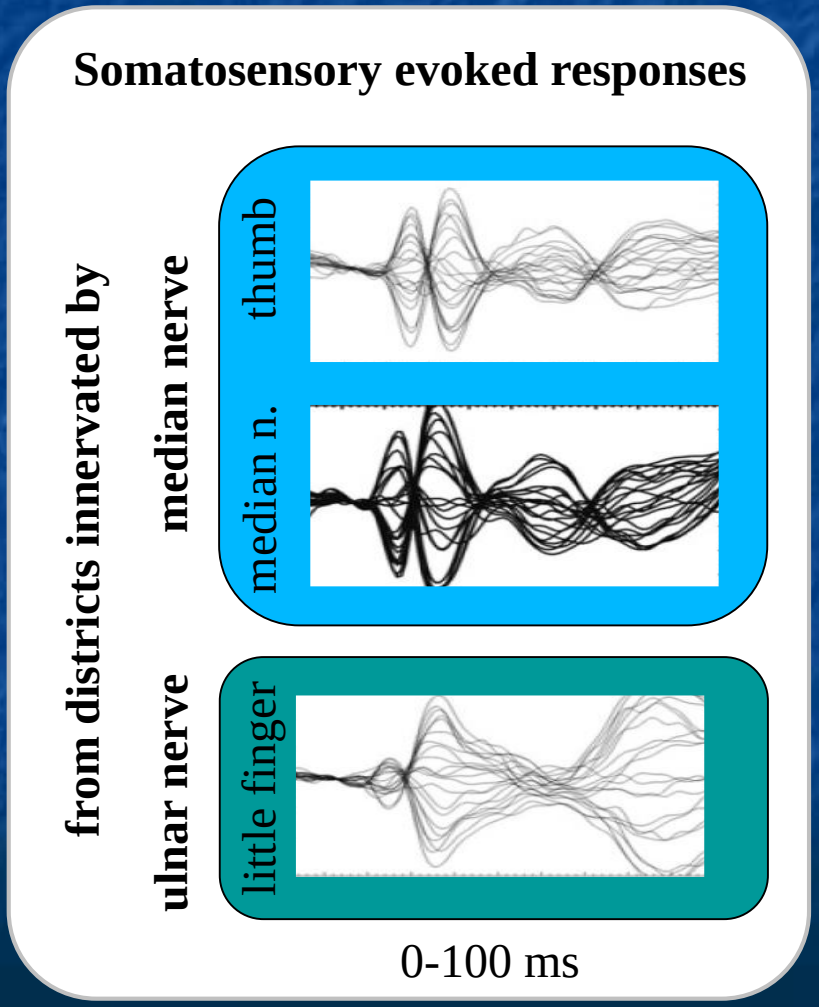
Neuronal Network
response shape → ← recruited pattern

Shape similarity
from hemispheric homologs

Tecchio et al NeurosciLett 2000

Shape variability
across subjects

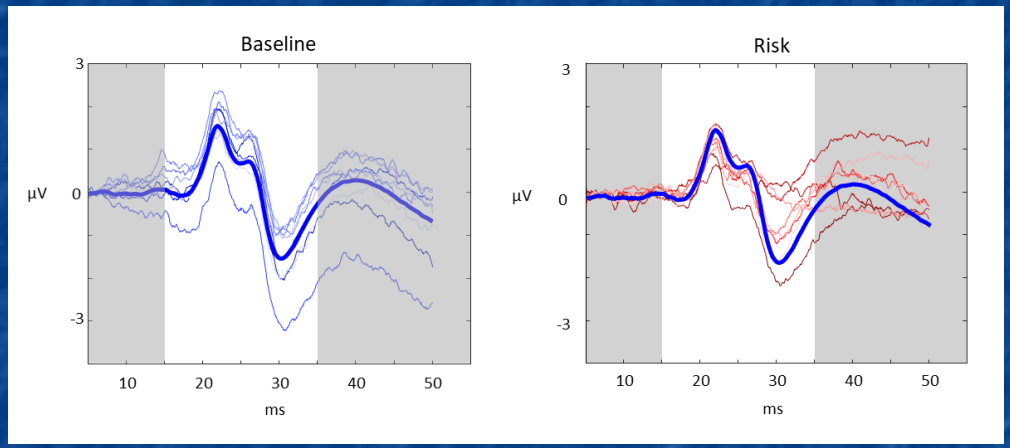




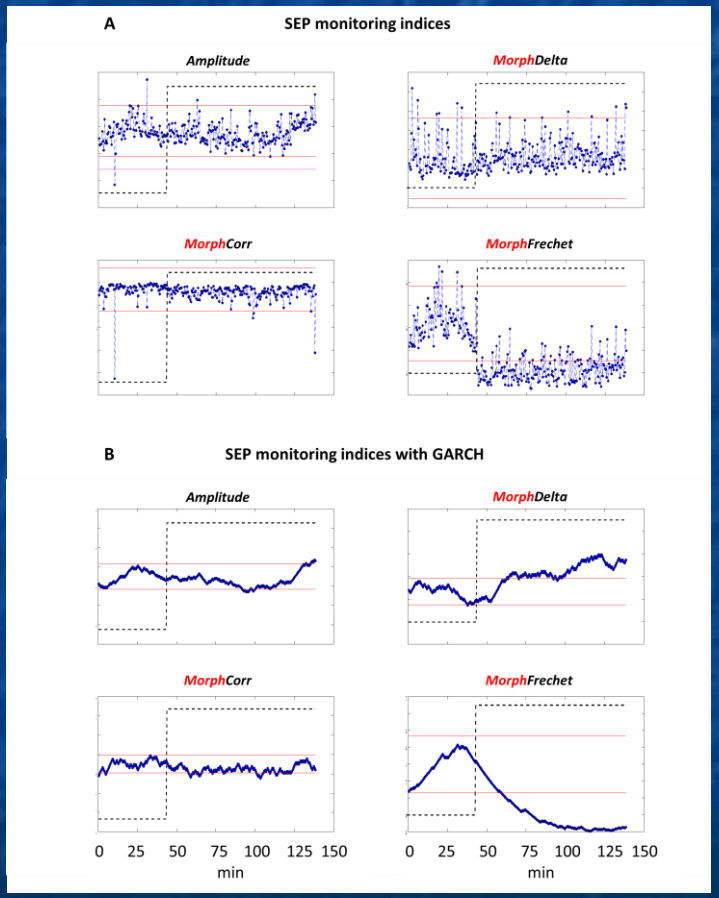
Tecchio et al HBM 2005

SEP morphology senses blood flow reduction

more than SEP amplitude



The higher sensitivity to blood flow reduction of SEP morphology than amplitude
promises to improve the effectiveness of intraoperative
monitoring during middle cerebral artery (MCA) aneurysm clipping procedures.



Tecchio et al. Clin EEG Neurosci 2019
16 patients MCA Aneurism Clipping

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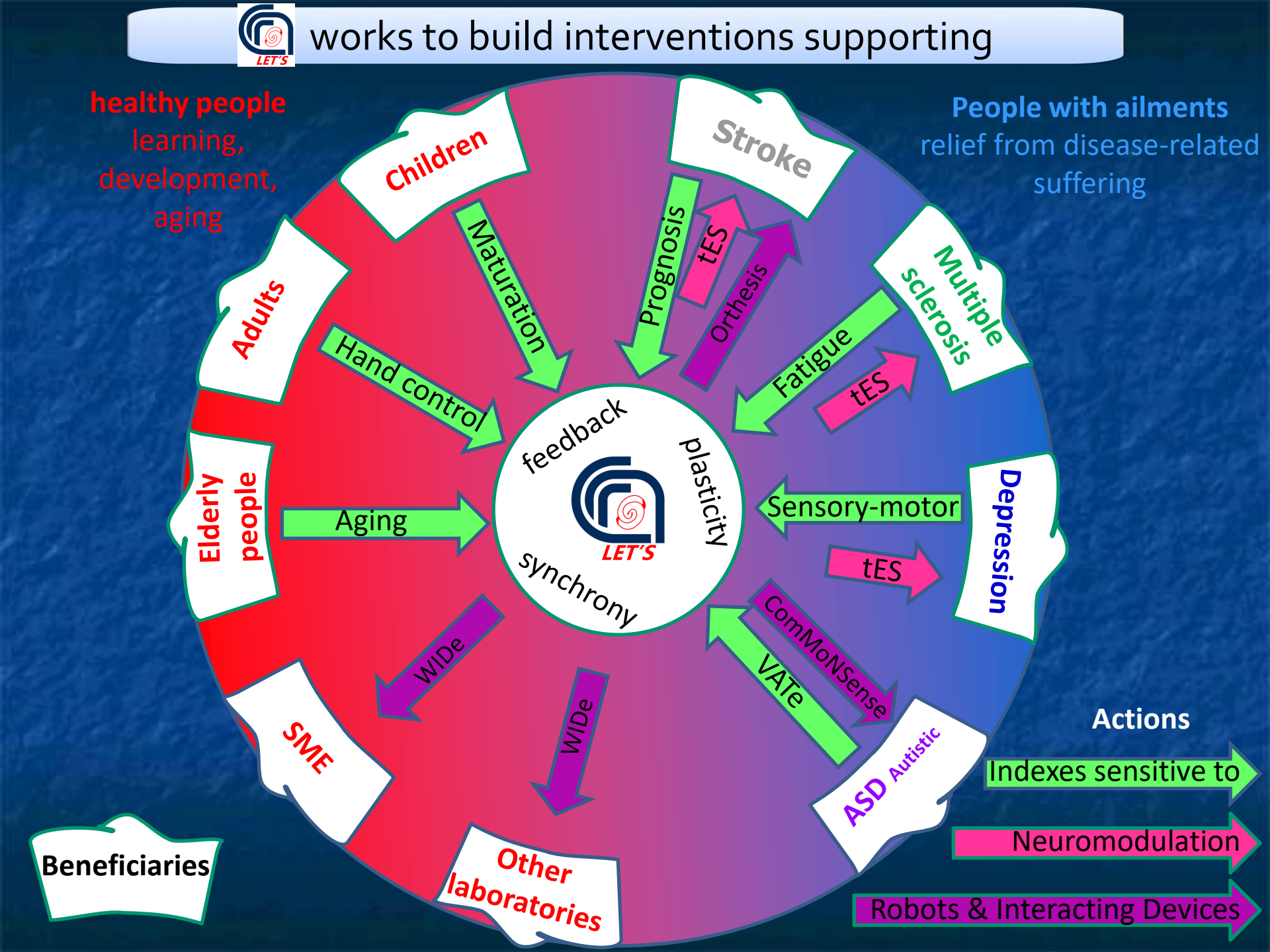
works to build interventions supporting
healthy people
learning, development, aging
People with ailments
relief from disease-related suffering
Children
Maturation
Stroke
Prognosis
tES
Orthesis
Multiple sclerosis
Fatigue
tES
Adults
Hand control
feedback
plasticity
synchrony
LET'S
Elderly people
Aging
Sensory-motor
tES
Depression
WIDe
WIDe
ComMoNSense
VATe
SME
Other laboratories
ASD Autistic
Beneficiaries
Actions
Indexes sensitive to
Neuromodulation
Robots & Interacting Devices

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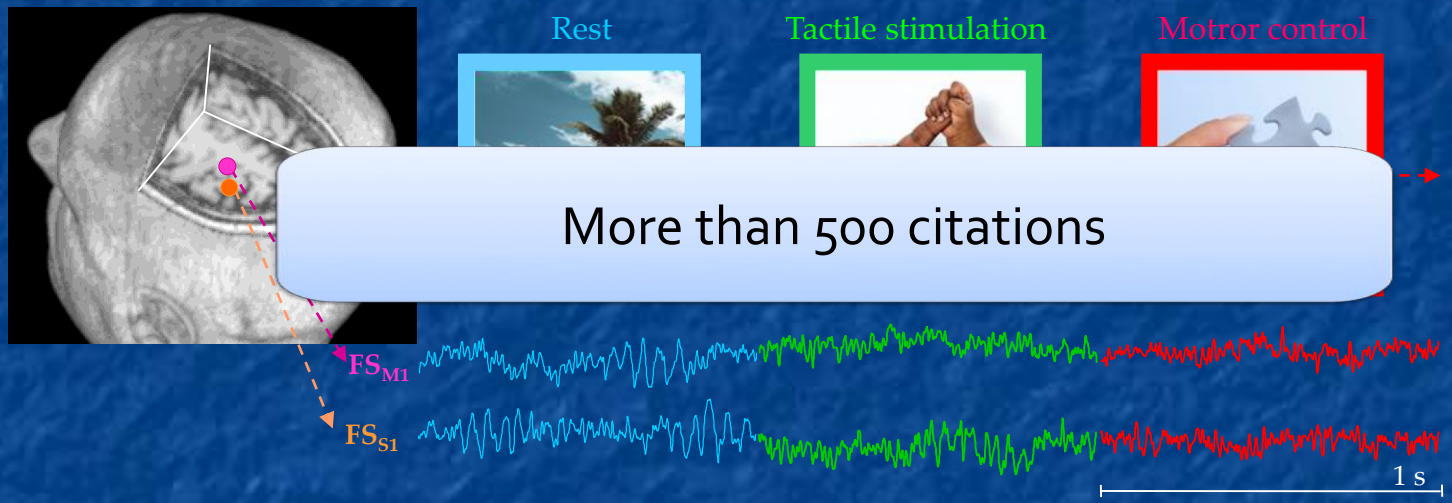
LET'S developed a new concept-source identification method with MEG/EEG/EMG: the

Functional Source Separation (FSS)

which exploits a

specific functional fingerprint of the source neurodynamics

-instead of the source's position-



Methods

Procaro et al IJNT 2017
Porcaro & Tecchio Book Chapter 2015
Porcaro et al Neuroimage 2010
Porcaro et al ClinPh 2009
Porcaro et al Hum Brain Mapp 2009
Porcaro et al Hum Brain Mapp 2008
Barbati et al Hum Brain Mapp 2008
Tecchio et al J Physiol 2007, Review
Barbati et al Hum Brain Mapp 2006

Investigation tool

Cottone et al JN 2017
Cottone et al Brain Struc Func 2016
Melgari et al Neurosci 2013
Procaro et al ClinPh 2013
Di Pino, Porcaro et al RNN 2012
Pellegrino et al RNN 2012
Porcaro et al Neuroimage 2011
Pittaccio et al Hum Brain Mapp 2011
Tecchio et al Brain 2009
Betti et al J Neurosci 2009
Tecchio et al Neuroimage 2008
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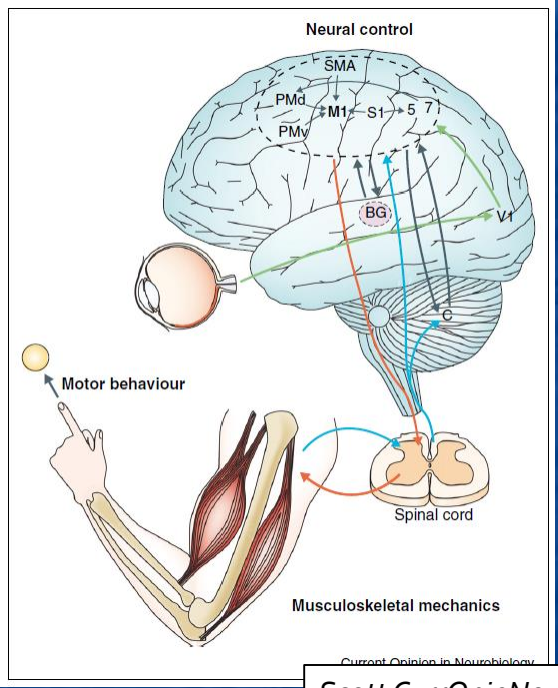
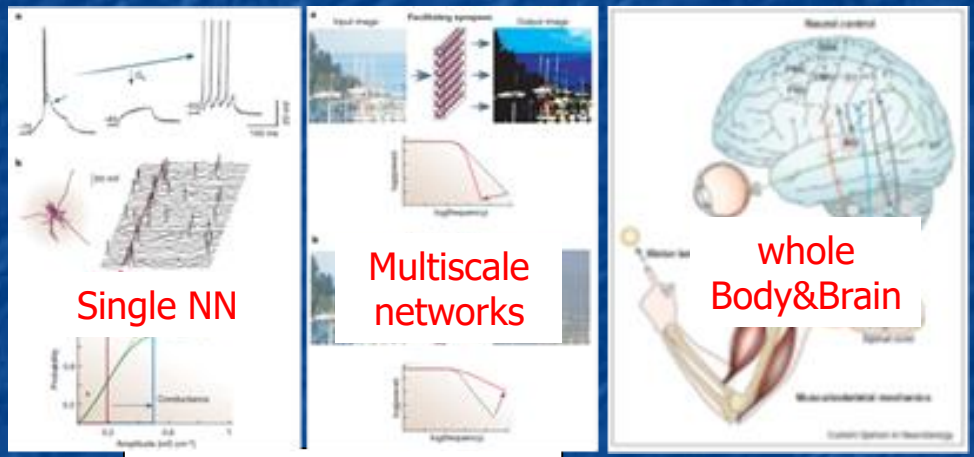
The **triadic principle**,
which governs the Body&Brain system,
modularly repeats at multiple scales.

Motor control: paradigmatic model

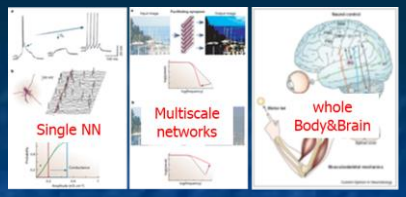


Scott CurrOpinNeurobiol 2017

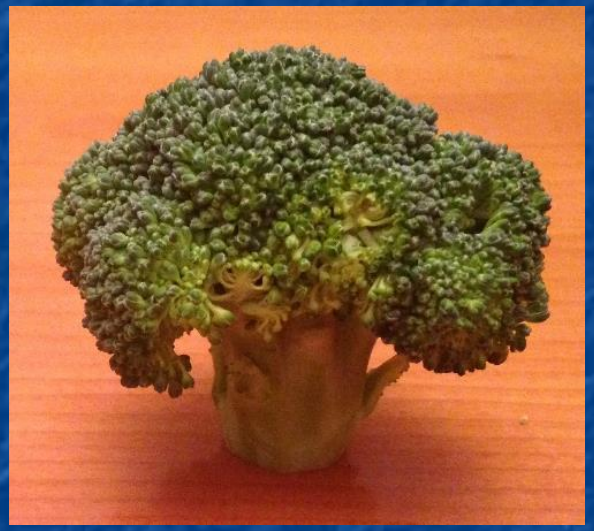


Destexhe&Marder Nature 2004

Feedback → Synchrony → Plasticity

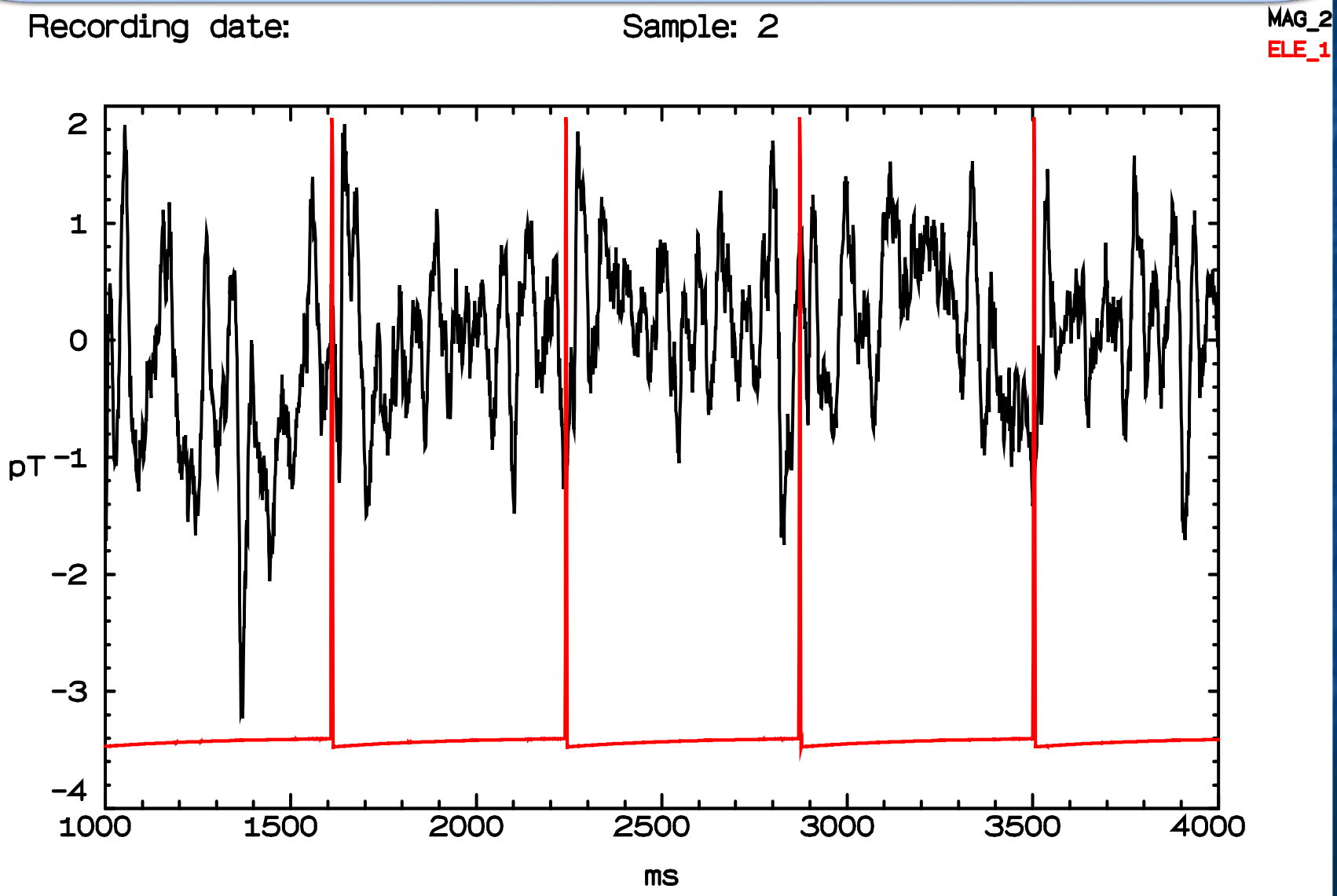


Modular multiscale triadic principle:
Feedback → Synchrony → Plasticity


Fractal structure

Neuronal electric activity dynamics [neurodynamics]: Is it fractal?



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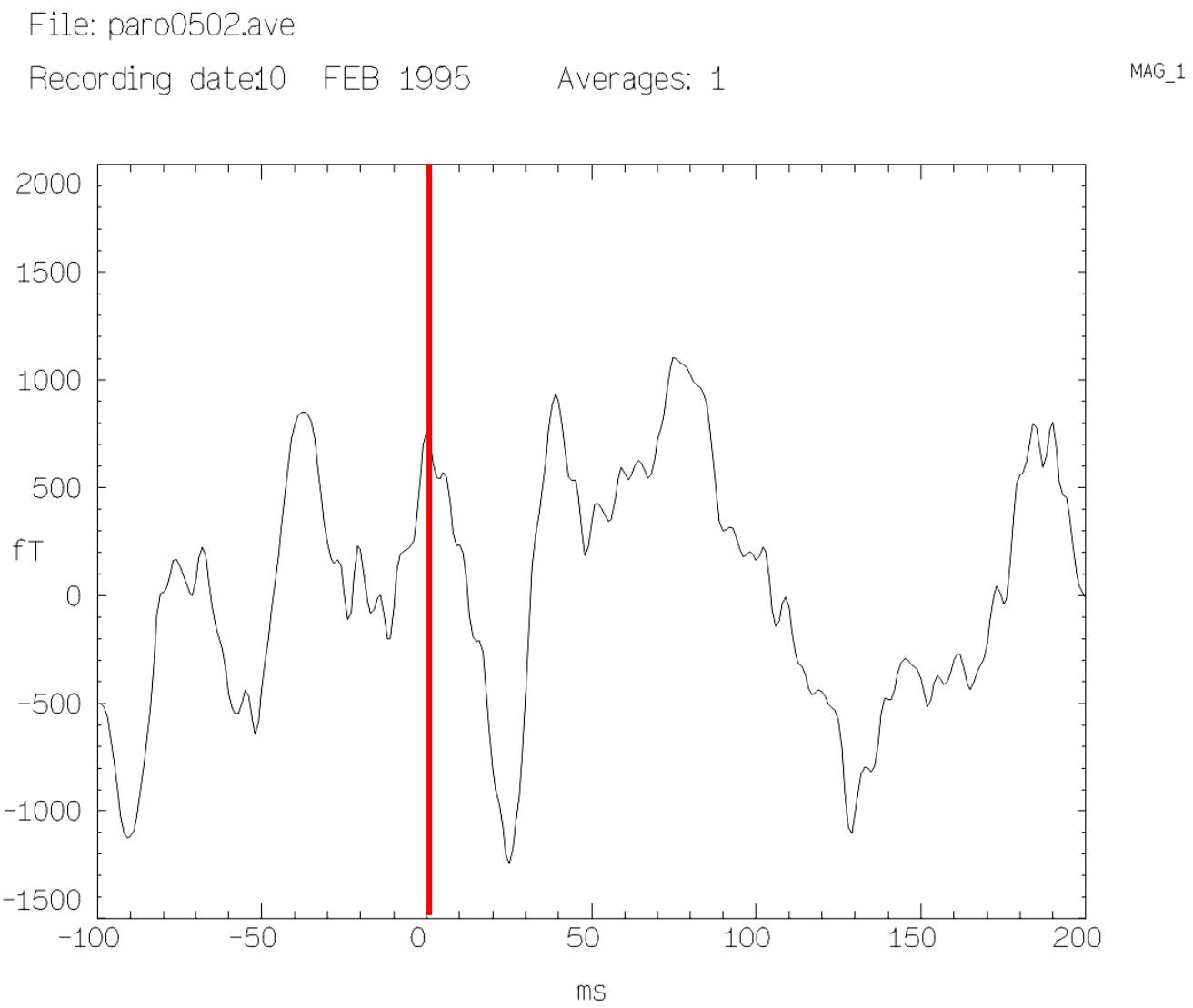

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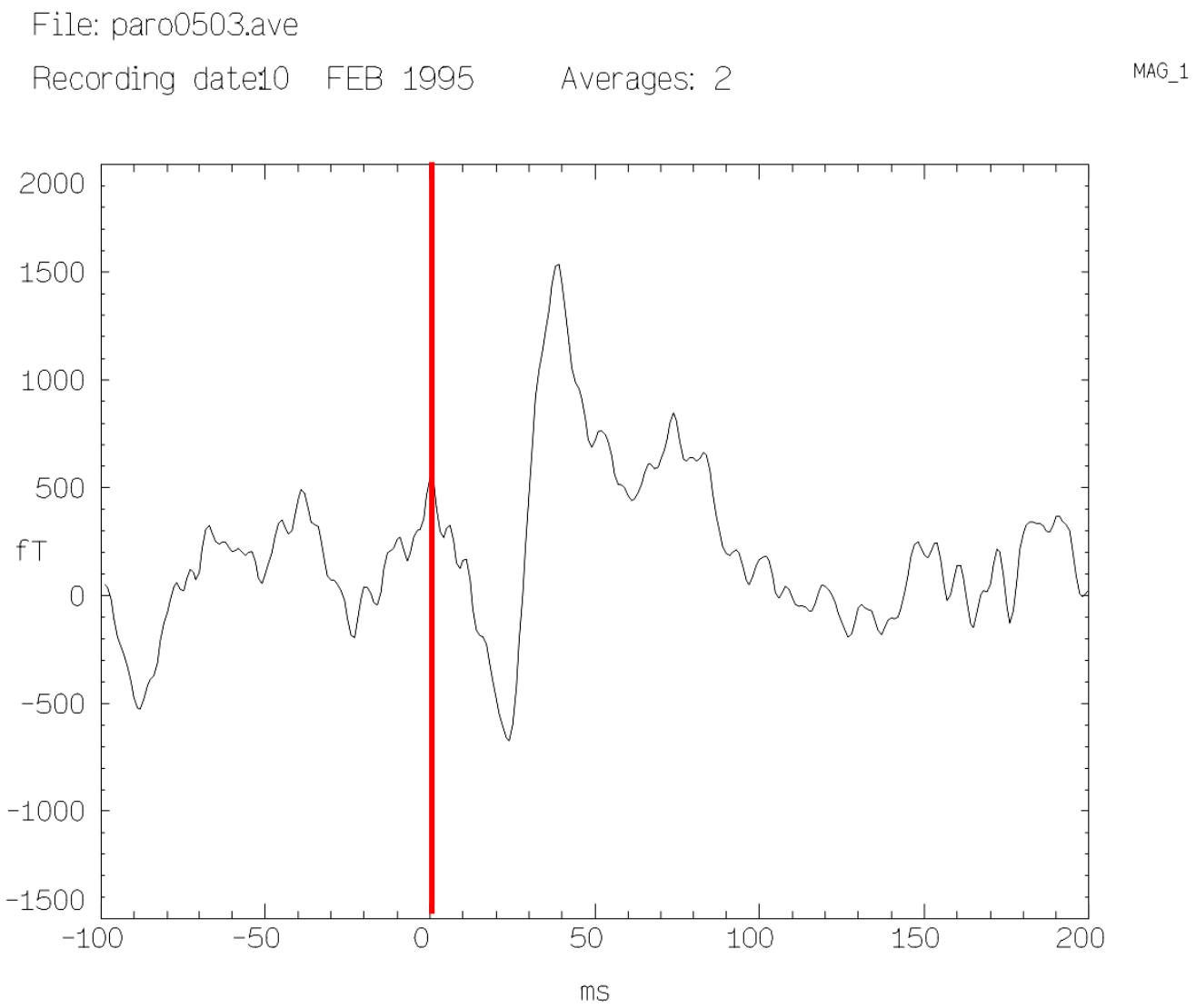

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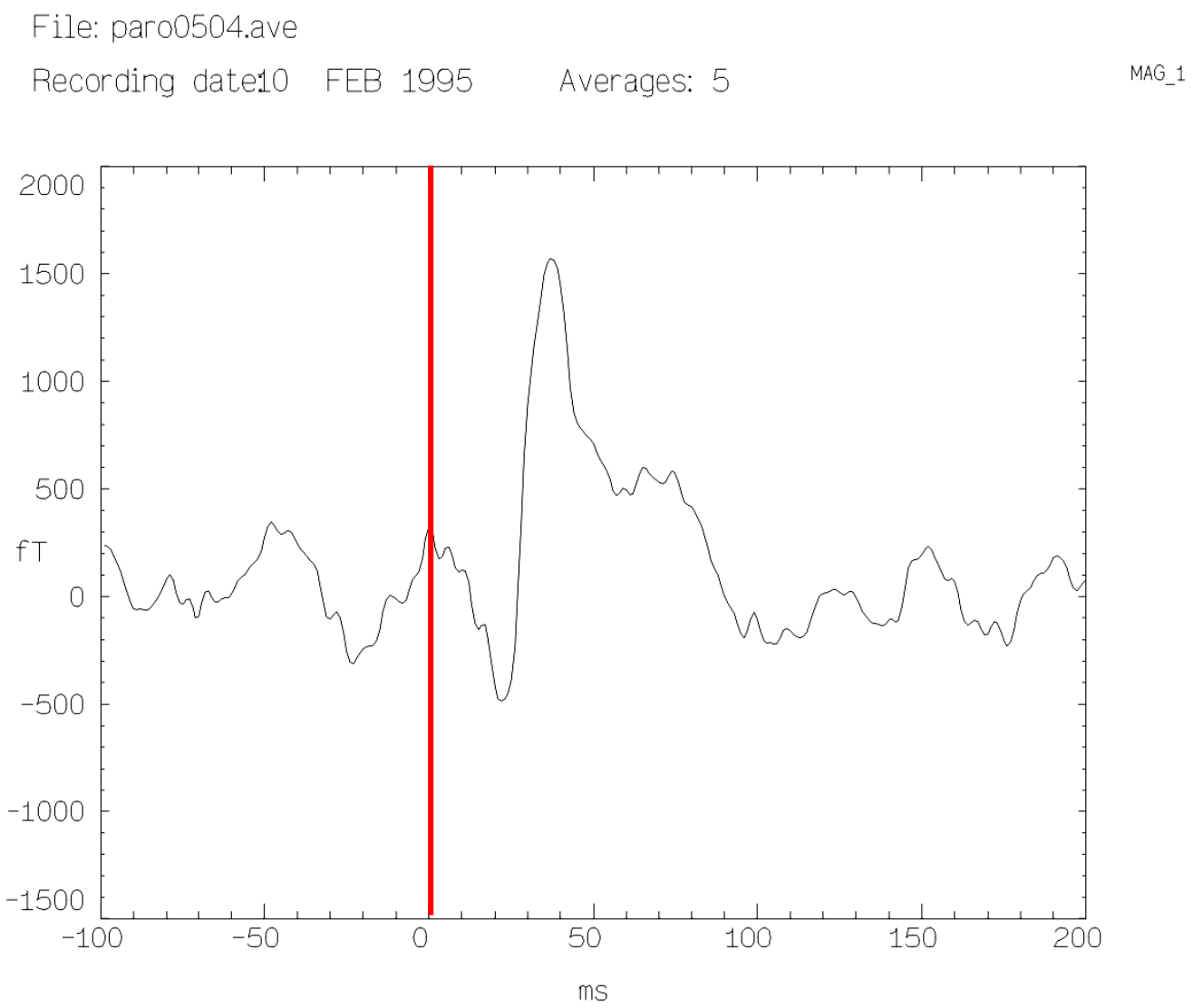

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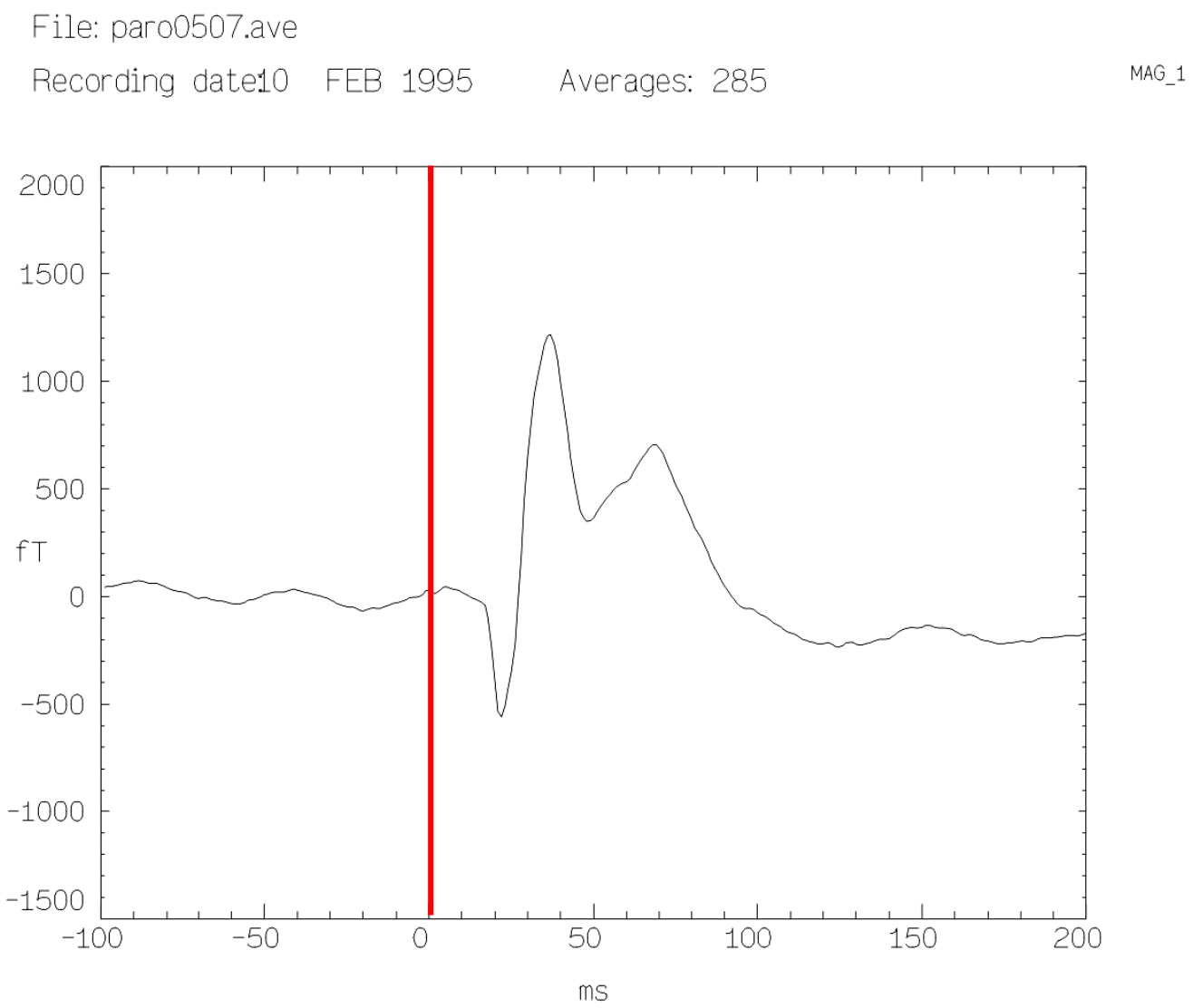
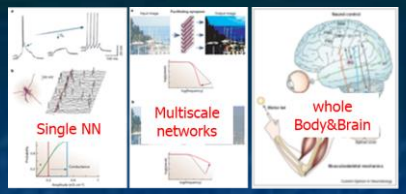
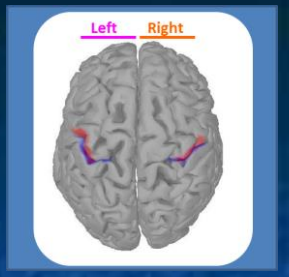
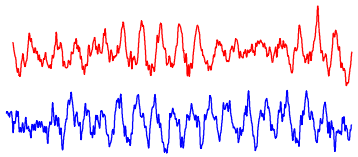
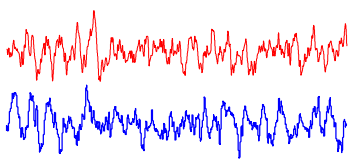
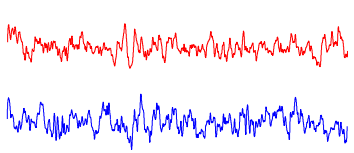
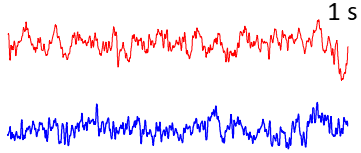




NeuroDynamics: local signature



fractal dimension of the neuronal electric activity

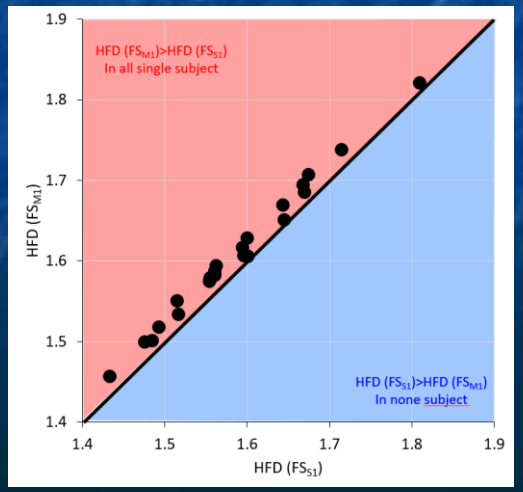
	Rest CE	Rest OE	Sensory right	Motor right
$M1^L(t)$ / $S1^L(t)$				
FD ($M1^L$)	*1.690*	*1.719*	*1.718*	*1.794*
FD ($S1^L$)	*1.427*	*1.469*	*1.432*	*1.503*

1 s

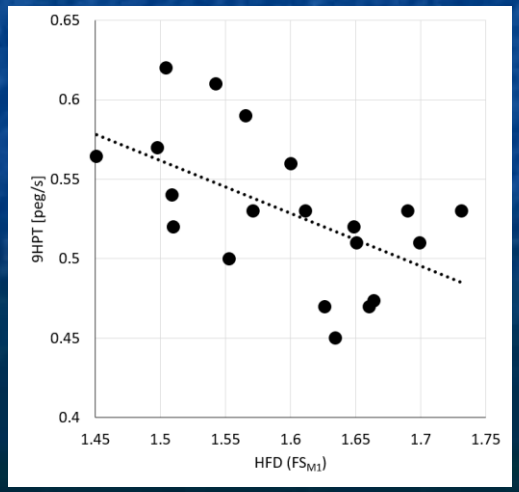
Cottone et al BSaF 2017
18 healthy people

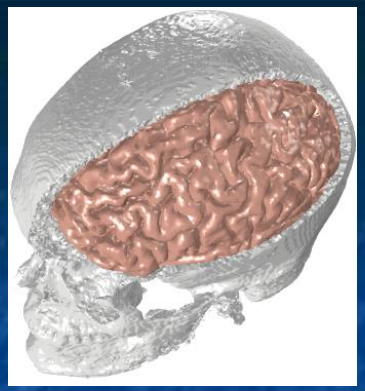
in single persons

the fractal dimension of M1 > S1

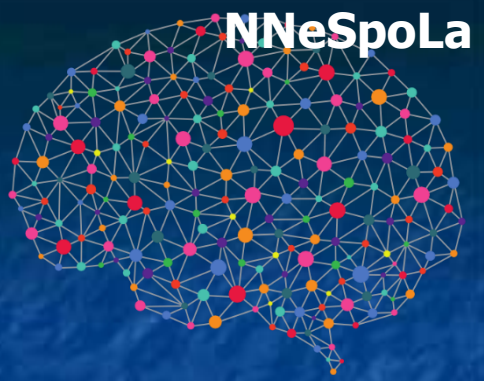


M1 fractal dimension correlates to fine hand motor skill





Neural **Ne**twork **Spo**ken **La**nguage [**NNeSpoLa**]



Definitions:

1. **a Neuronal Network [NN]** is made up of **nodes** and their **connections**
2. at least 1 NN node receives **input,** and 1 NN node produces **output**
3. **The connections are necessarely both negative and positive**
4. **a NN Node** is a neuron or a group of neurons or a group of diverse brain regions

Model:

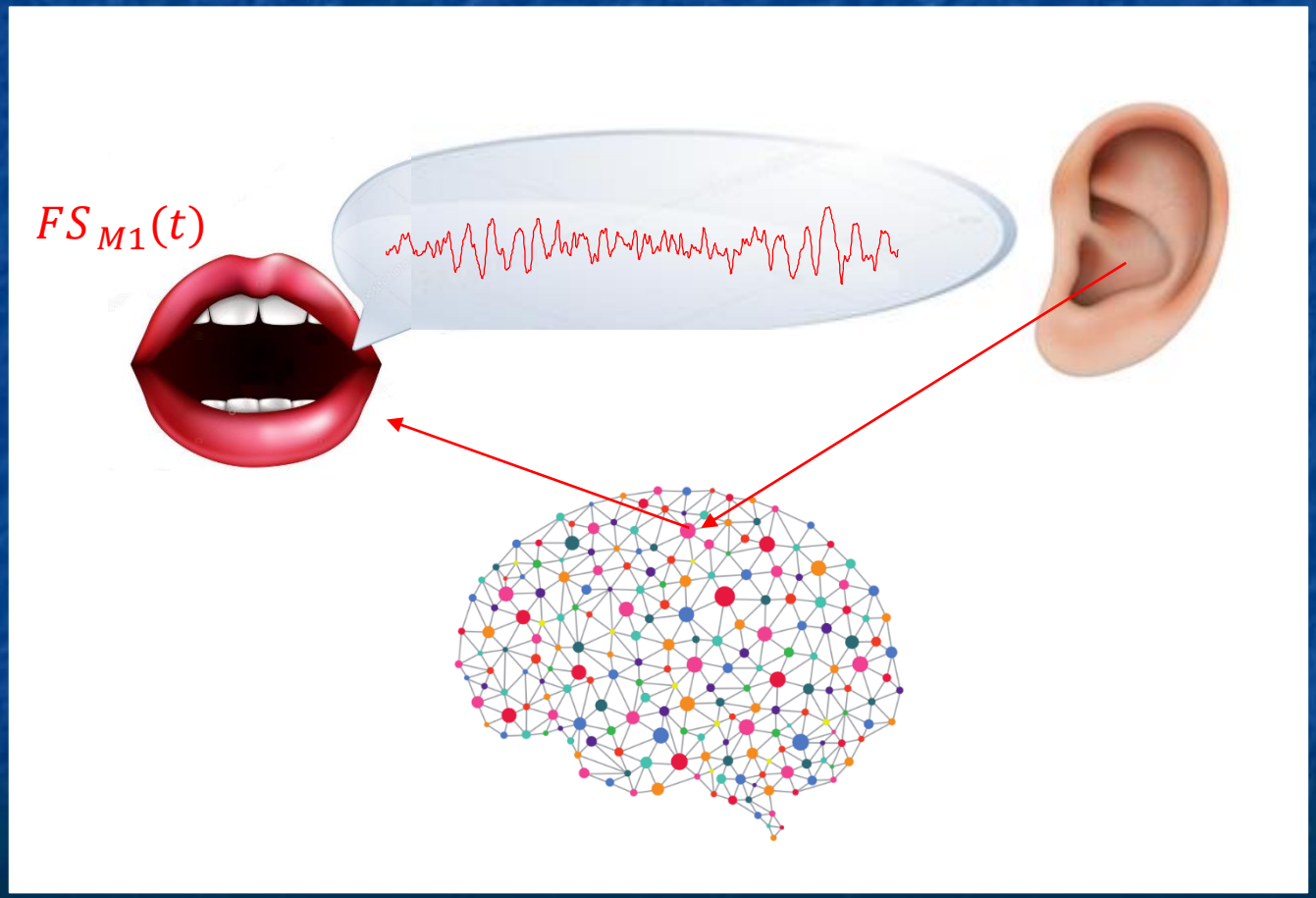
1. Every NN develops a **NN language** - shared by all NN nodes-
2. Every NN node '**necessarily' produces a word-OUT,** when the **word-IN** arrives.

Hypothesis:

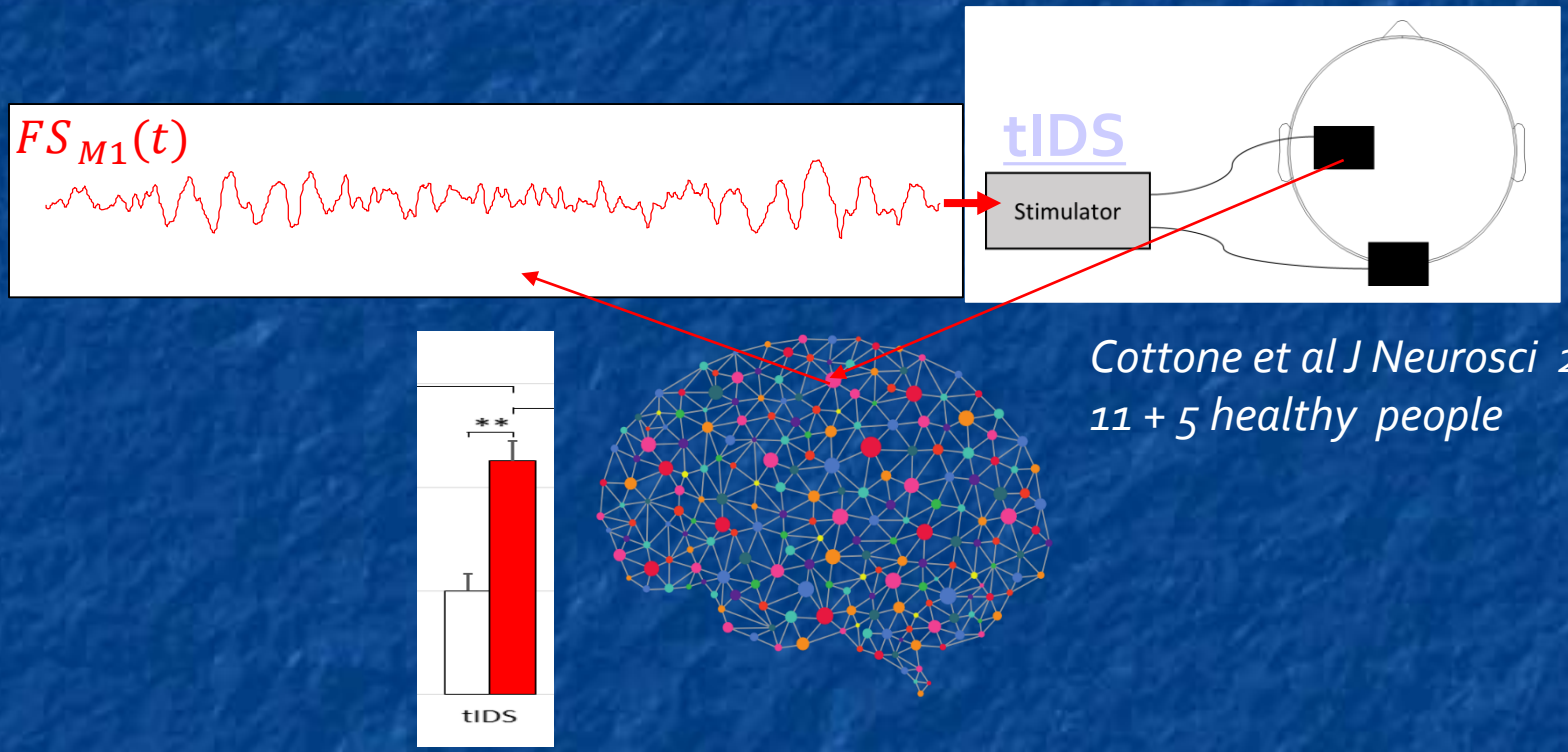
If via fluctuating tES we send a message 'typical' of the node's language,
the node increases the probability to produce its word-OUT
(i.e. it is more excitable).

The cortical area speaks its 'typical' language.

When it hears a similar message, it tends to speak.



transcranial **I**ndividual neuro**D**ynamics **S**timulation (**tIDS**)



Cottone et al J Neurosci 2018,
11 + 5 healthy people

Sustaining our hypothesis:
sending a message 'typical' of M1 language via tIDS
M1 increases the probability to produce 'its' word-OUT
(i.e. it is more excitable).

The organization of the 'Body and Brain' system determines its communication language

Triadic principle Feedback, Synchrony, Plasticity
fractal governing principles

Functional Source Separation (FSS)

Listening to intervene

transcranial Individual neuroDynamics Stimulation (tIDS)

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ISINP 31 July 2019 Como

ISINP

Thank the LET'S present and past collaborators





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and thank you for your attention!

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