

Nikos Laskaris
ENTEP



“Reflections of learning at the University of Patras and opportunities to discover at BSI/RIKEN ”



PATRAS UNIVERSITY HOSPITAL & SCHOOL OF HEALTH SCIENCES




RIKEN - BRAIN SCIENCE INSTITUTE



Electronics Laboratory
Εργαστήριο Ηλεκτρονικής

ELLAB

University of Patras
Πανεπιστήμιο Πατρών



an ERASMUS POSTGRADUATE COURSE on BIOMEDICAL ENGINEERING

ACADEMIC YEAR

IKY

A unique opportunity to attend a European Course of multinational character in a beautiful Mediterranean environment

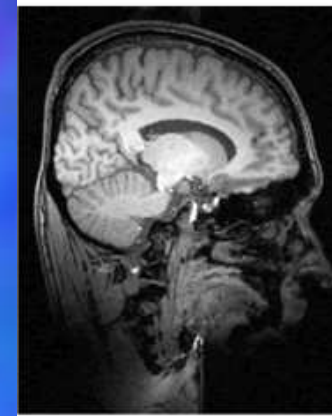
INFORMATION
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E-mail: info.med.upatras.gr
<http://www.med.upatras.gr>

MEDICAL PHYSICS
School of Medicine



Biomedical Engineering ✨
Dept. of Medical Physics - University of Patras





Understanding the Brain

- Protecting the Brain
- Creating the Brain
- Nurturing the Brain
- Advanced Technology Development Group

Understanding the Brain

What does it mean to be human?

- Neuronal Circuit Mechanisms Research Group
- Cognitive Brain Science Research Group**
- RIKEN-MIT Neuroscience Research Center

**Understanding begins
by elucidating basic brain mechanisms.**

This area of research is concerned with making new discoveries about the functional and information processing attributes that are unique to the brain

Cognitive Brain Science Research Group

Group Director
Keiji Tanaka, Ph.D.

Group Laboratories

Laboratory for Cognitive Brain Mapping

Keiji Tanaka, Ph.D.
Laboratory Head

Laboratory for Human Brain Dynamics

Andreas A. Ioannides, Ph.D.
Laboratory Head

Laboratory for Integrative Neural Systems

Manabu Tanifuji, Ph.D.
Laboratory Head

Laboratory for Cortical Organization and Systematics

Kathleen Rockland, Ph.D.
Laboratory Head

HBD-laboratory

(lab. head: **Dr. Ioannides**)

理化学研究所 脳科学総合研究センター

認知脳科学研究グループ

脳機能ダイナミクス研究チーム 研究員

理学博士

ニコラオス・ラスカリス

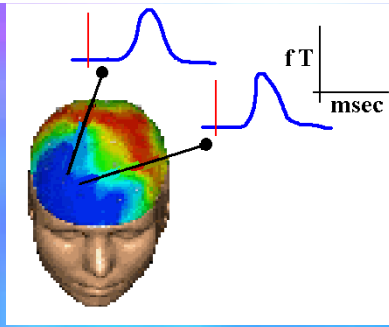
〒351-0198 埼玉県和光市広沢 2-1
電 話 (048) 462-1111 (内線 7185)
FAX (048) 467-9731
e-mail Nikos@brain.riken.go.jp

A Magnetoencephalographic unit

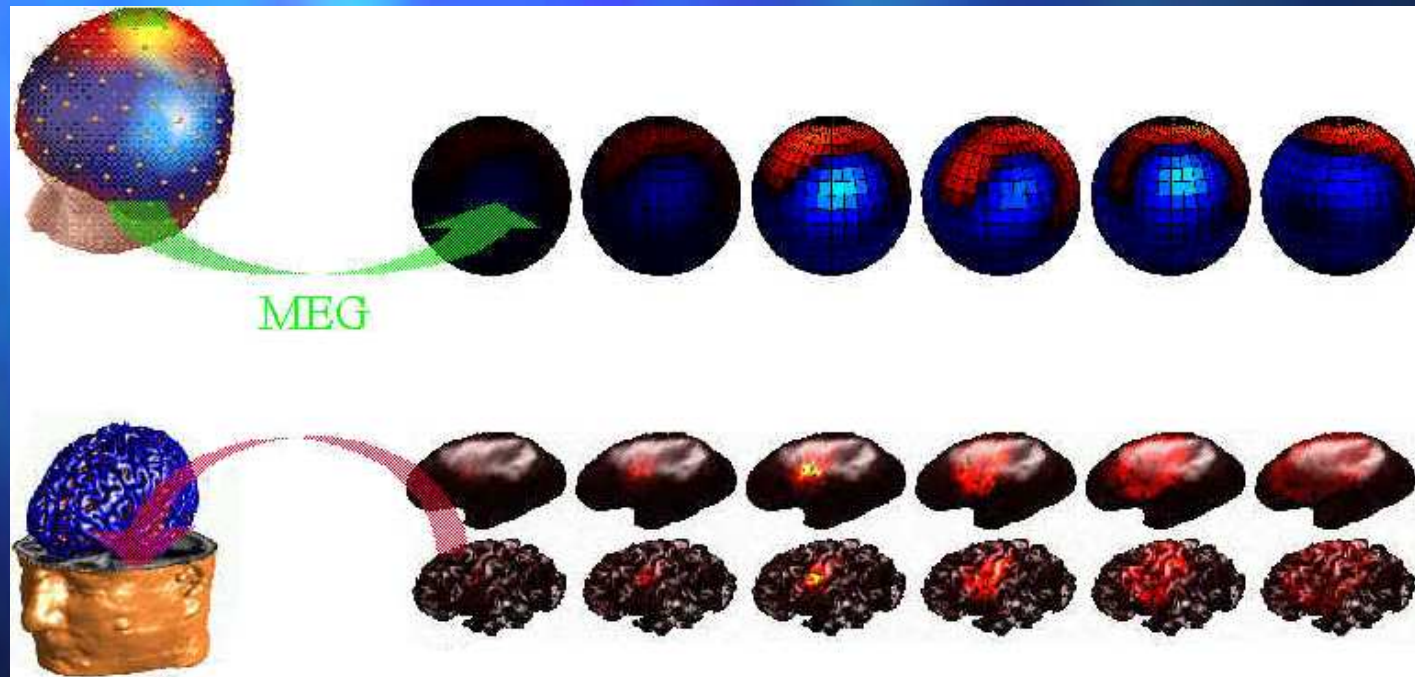
MEG is the measurement of very weak magnetic fields outside the head that are produced by electrical activity in the brain.

MEG is an ideal non-invasive method for tracking changes in brain activity with high temporal resolution and very good spatial resolution

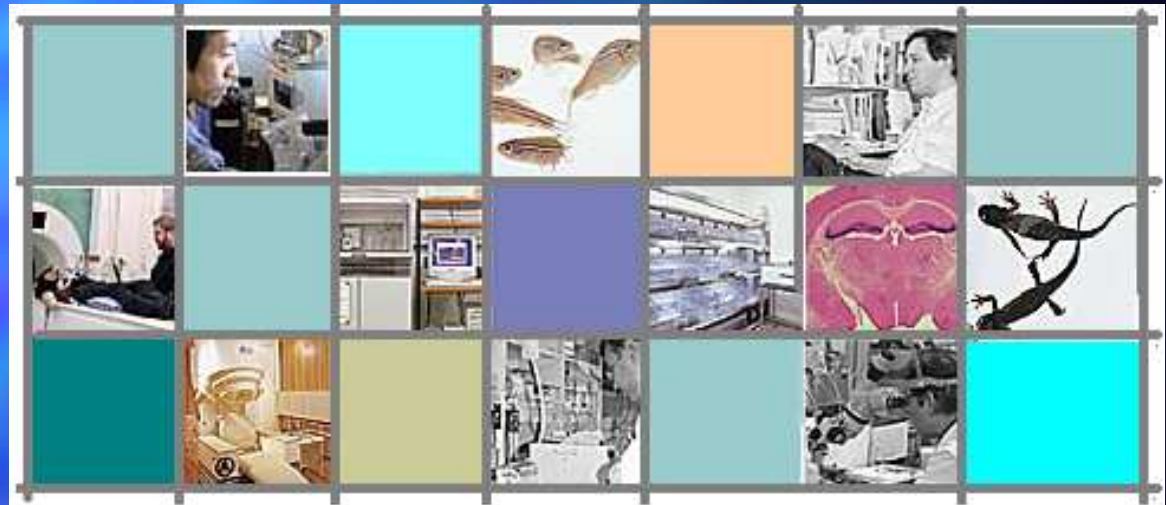




Understanding brain's function
by characterizing and explaining
the recorded MEG signal



Working at RIKEN-BSI



- ① Infrastructure
- ② Organization
- ③ Researchers' devotion
- ④ Unique opportunities

Working at HBD-lab



Fuji-Q Highlands

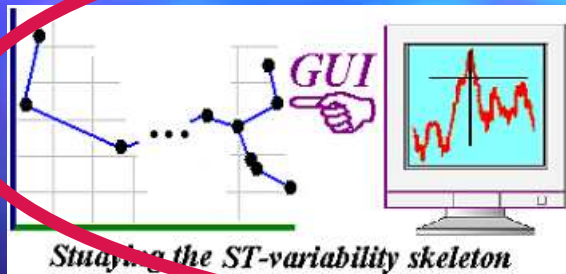
Speed : 106 mph !!!

after ~4 years....



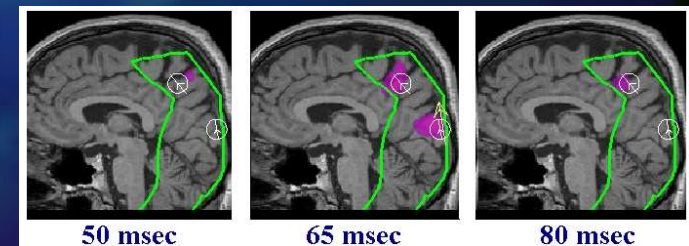
In summary :

① sleep studies

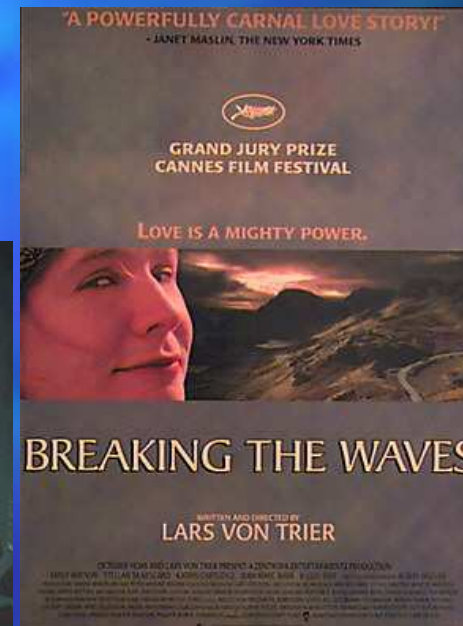


② single-trial analysis
of MEG signal

③ single-trial analysis
of tomographic solutions

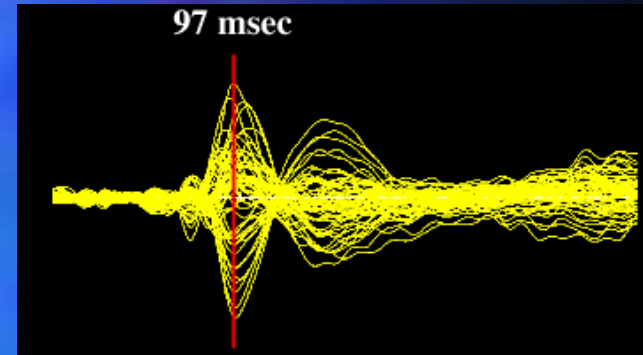


Breaking the (Brain) Waves



[HBD-lab, 2000-3]

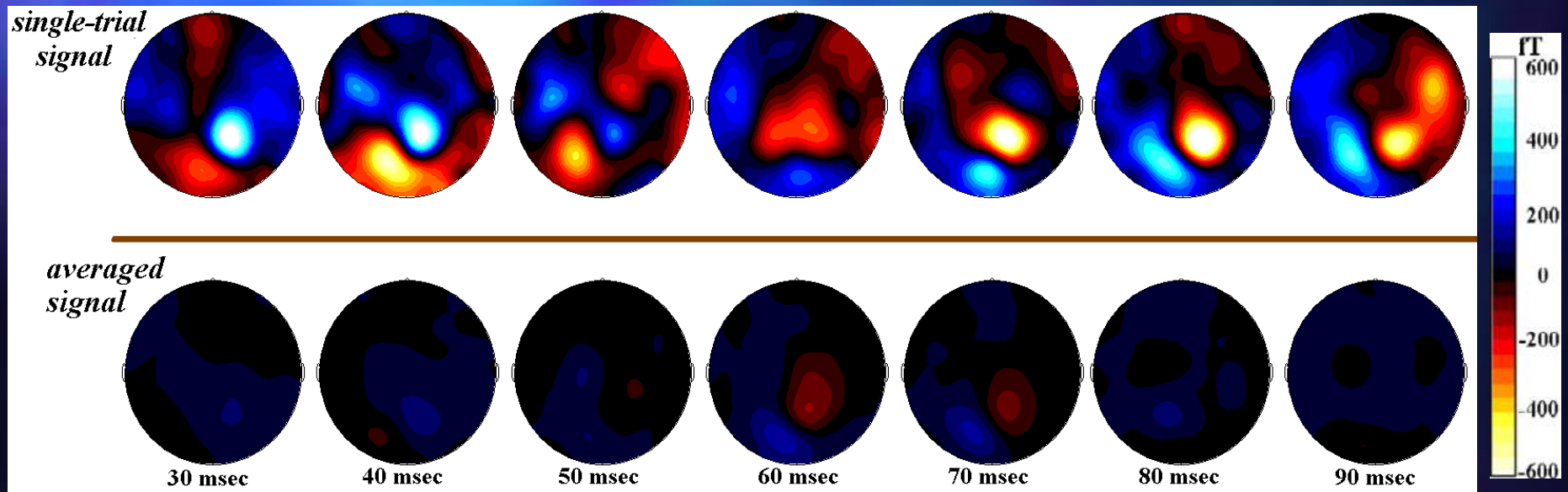
In repeated stimulation paradigms
the averaged signal indicates
a transient response



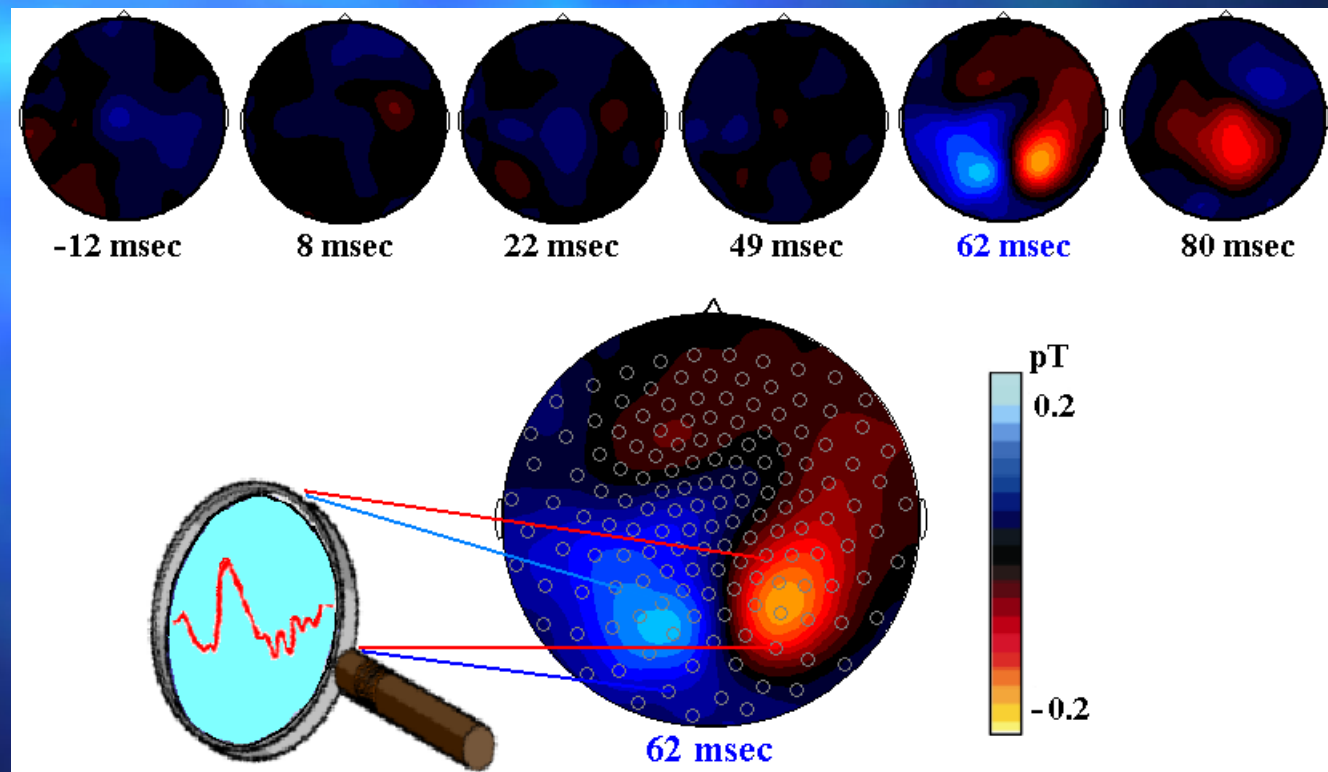
- ① How the averaged signal is formed ?
- ② Is “signal + noise” a valid model ?
- ③ Does rhythmic brain activity play any role ?
- ④ Can we break the code of the Brain Waves ?

Our approach

Pattern Analysis of MEG signal

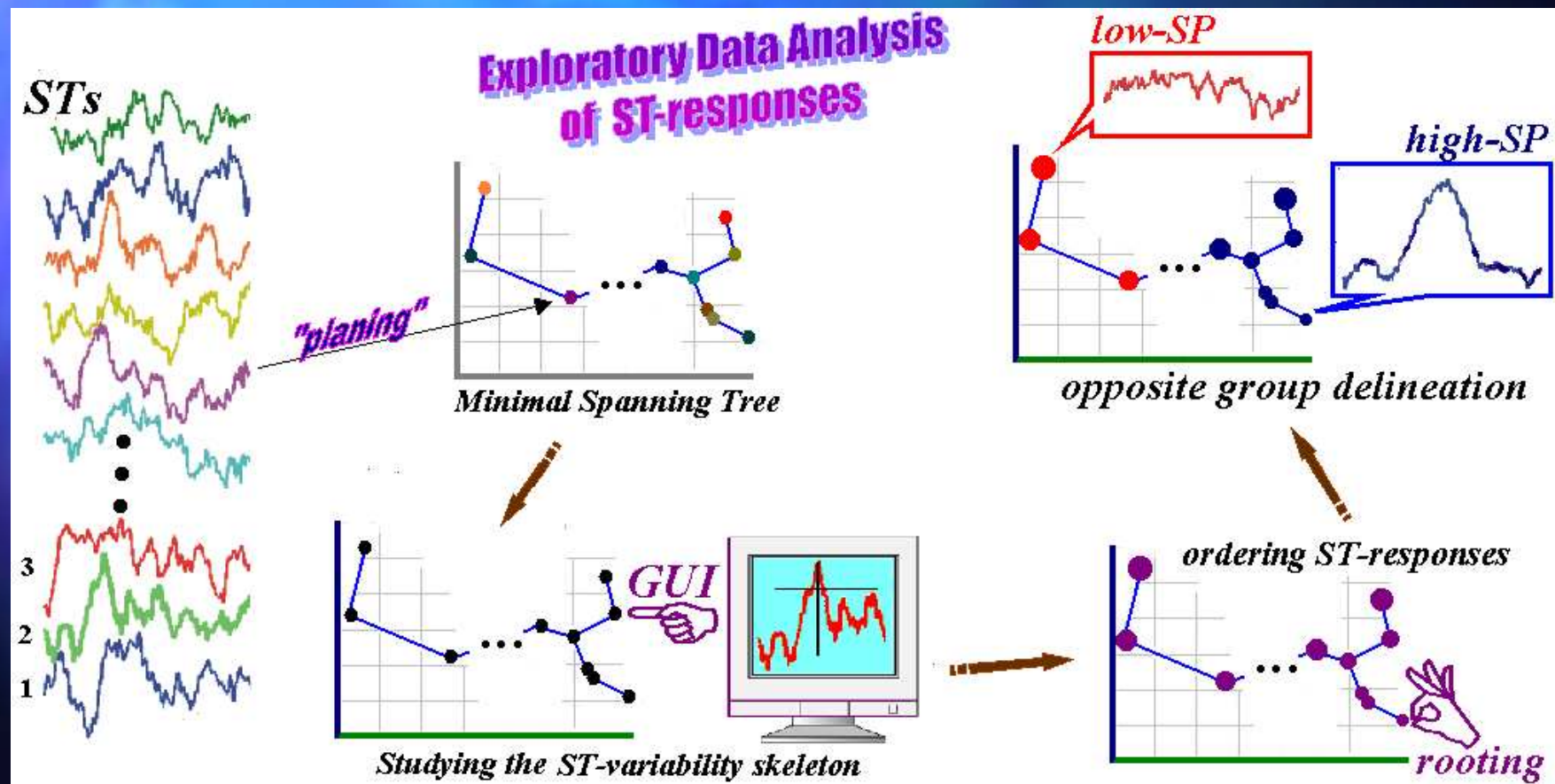


Decomposition of the event-related spatiotemporal dynamics



Forming a spatial operator for extracting **temporal patterns**

Handling the temporal patterns of regional neural activity



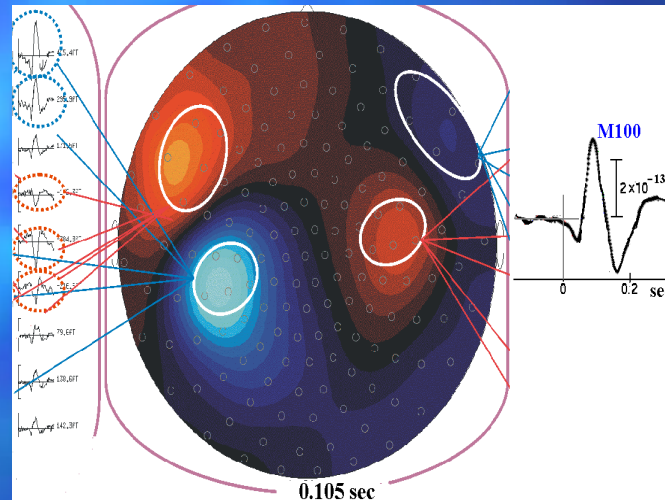
Repeated stimulation

I)

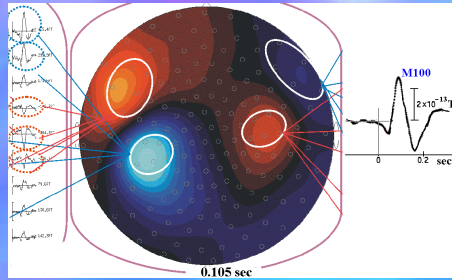
Observations from auditory stimulation paradigms

[Laskaris & Ioannides, Clin. Neurophys., 2001]

120 trials,
binaural-stimulation
[1kHz tones, 0.2s, 45 dB],
ISI: 3sec, passive listening

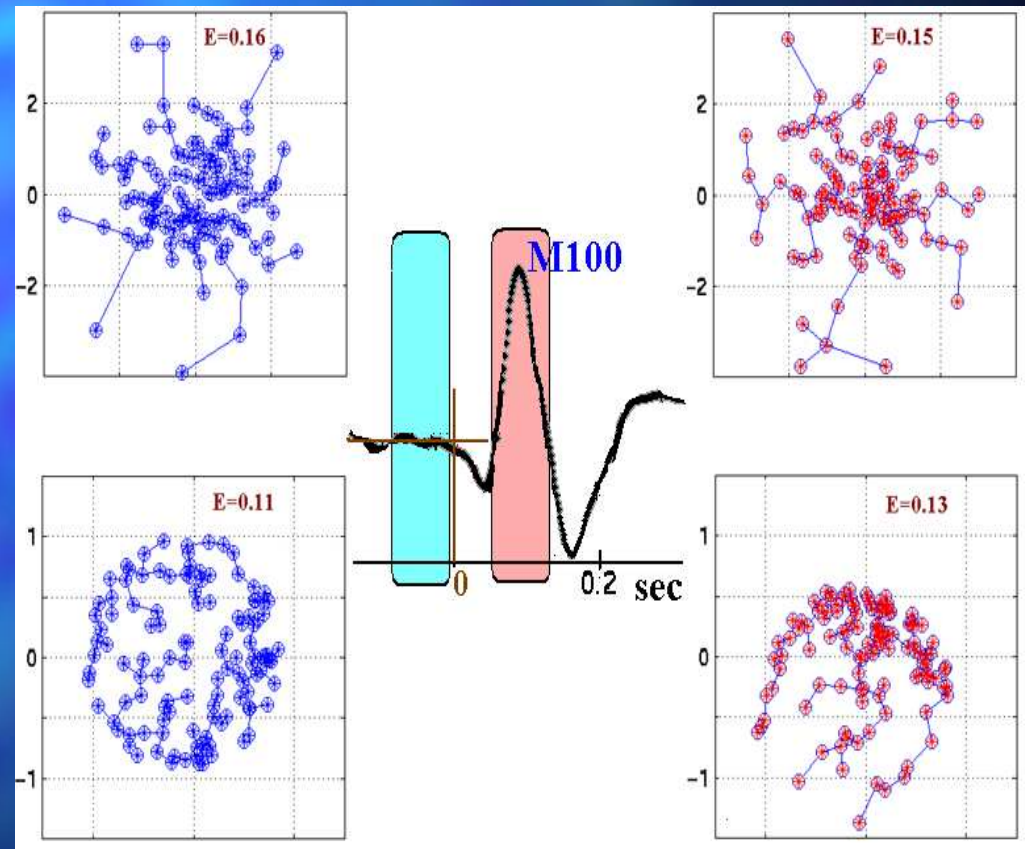


Explaining the averaged
M100-response



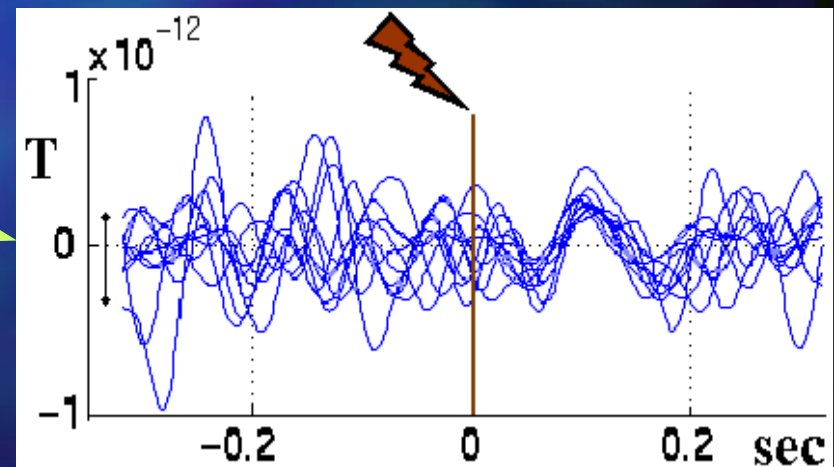
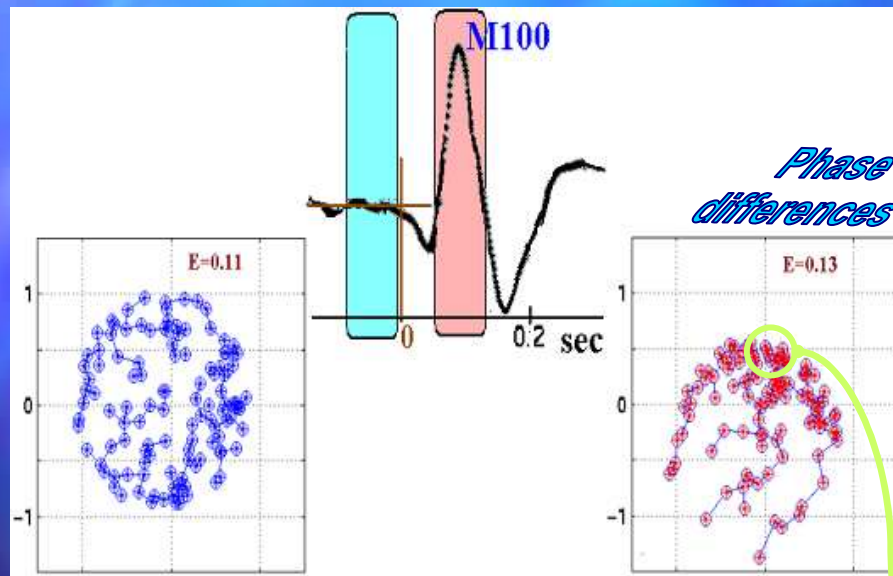
*Amplitude
differences*

*Phase
differences*



The M100-peak emerges from the stimulus-induced phase-resetting

Phase reorganization of the ongoing brain waves



Repeated stimulation

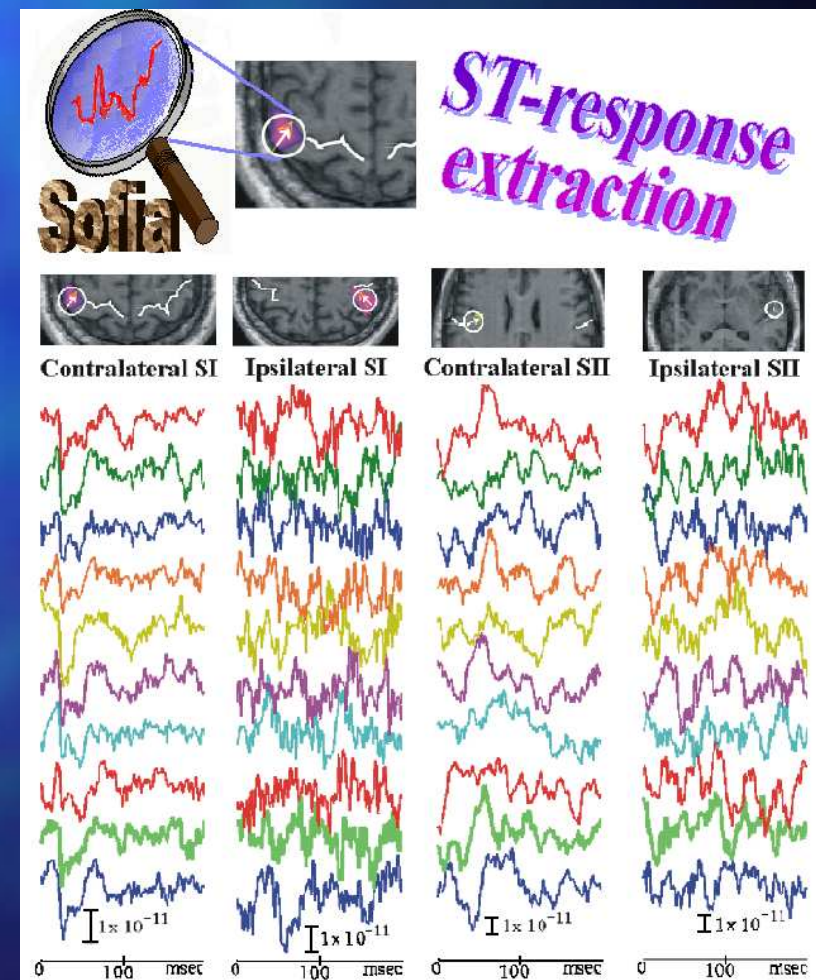
II)

**Information processing
during
somatosensory stimulation**

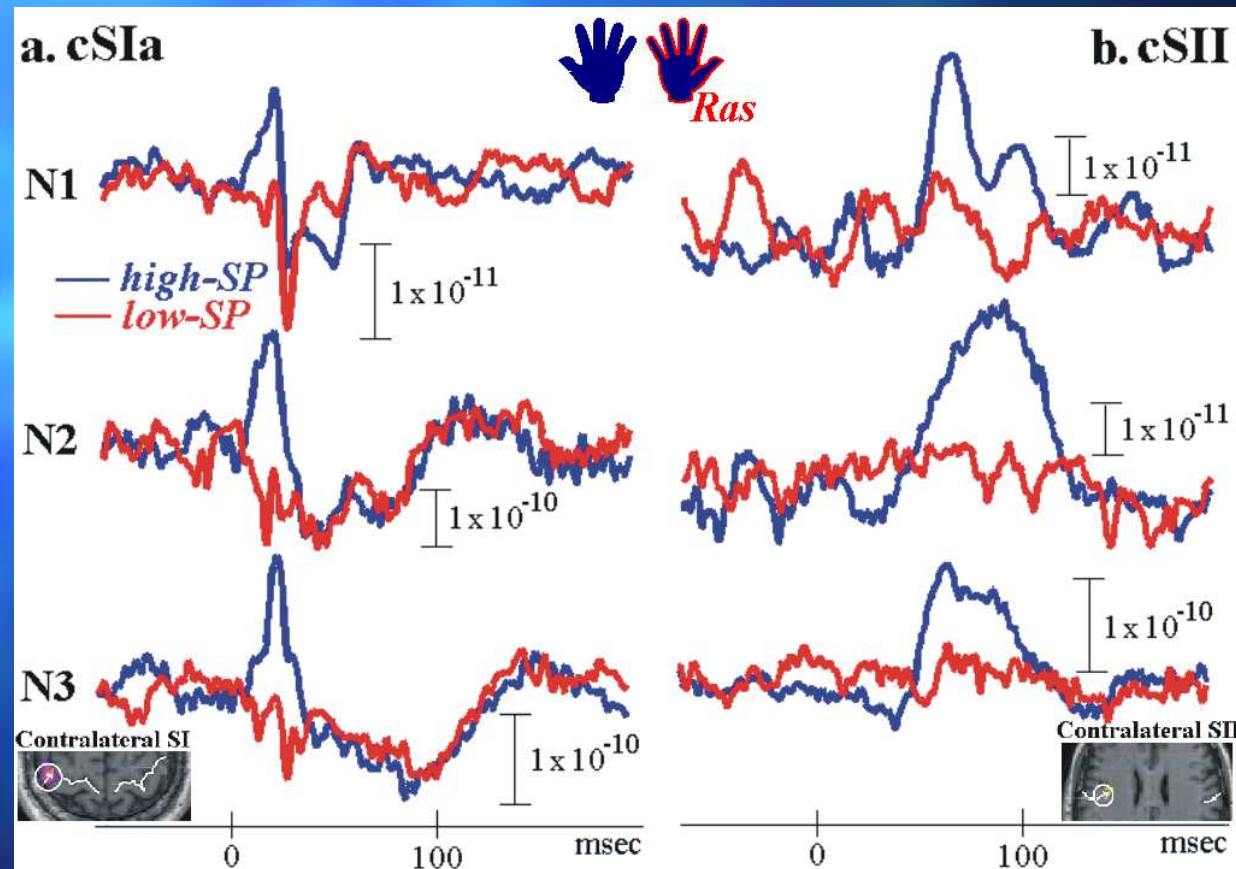
[Ioannides et al., HBM, 2002]

100 trials of
median nerve stimulation
(ISI: 1sec)

A systems approach
for understanding the interactions
between the waves of excitation
produced by a single stimulus

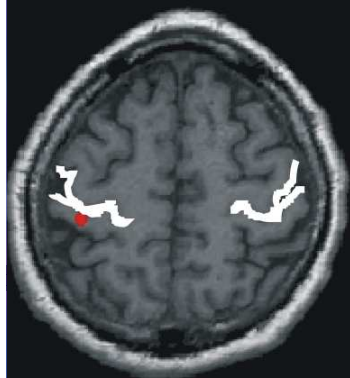


Somatosensory responses are highly variable



Different classes of response
can be identified in both SI and SII

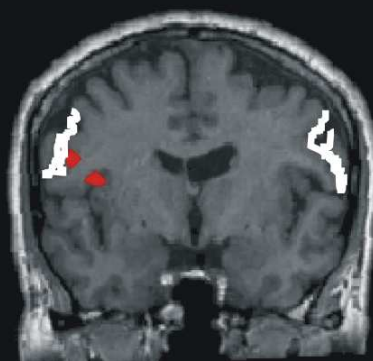
a. high-SP(cSIa)



L R

15-25 msec

b. high-SP(cSII)



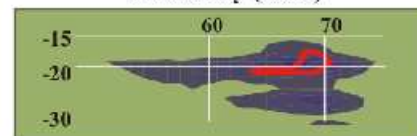
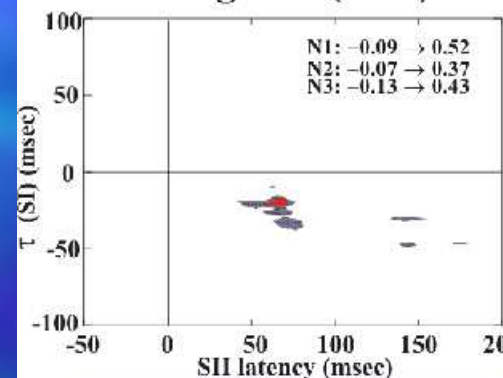
L R

73-83 msec

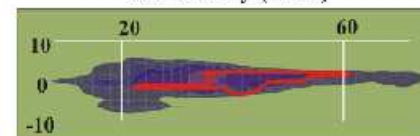
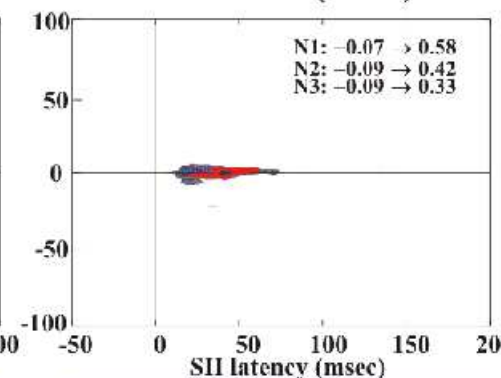
These classes
correspond
to different modes
of coactivation

and
different modes
of interaction

c. high-SP(cSII)



d. low-SP(cSII)



Serial vs. Parallel
processing

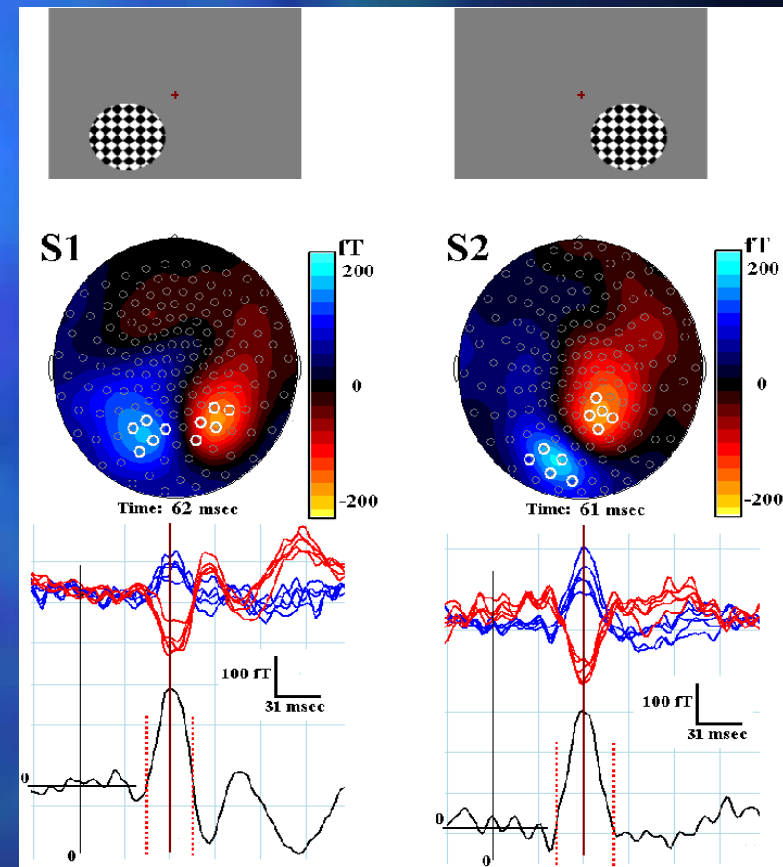
Repeated stimulation

III)

**Quantization of
stimulus-related Brain Waves
from a visual paradigm**

[Laskaris et al., NeuroImage, 2003]

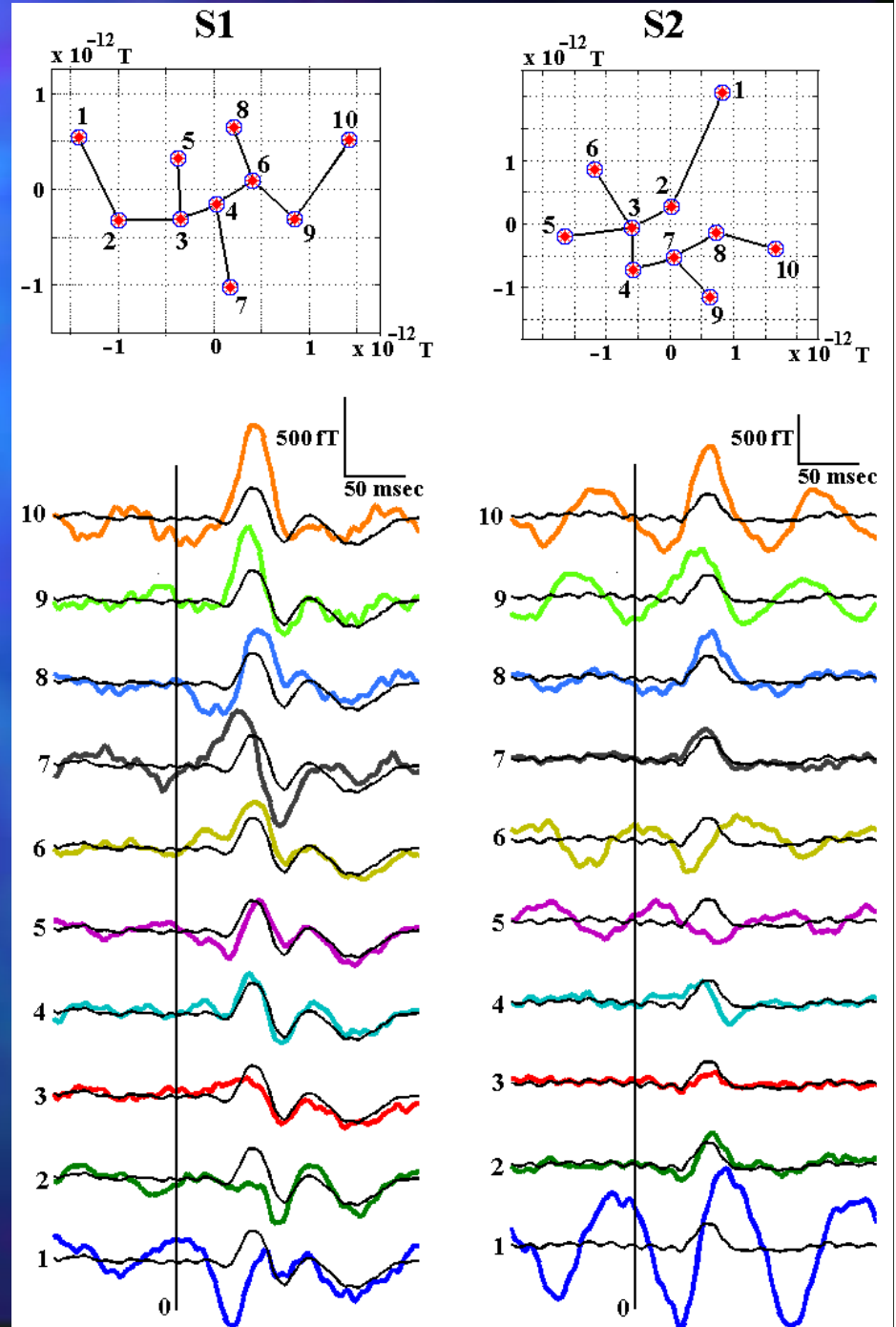
240 trials, pattern reversal,
4.5 deg , ISI: 0.7 sec,
passive viewing



Restoring the Brain Waves
from the averaged response

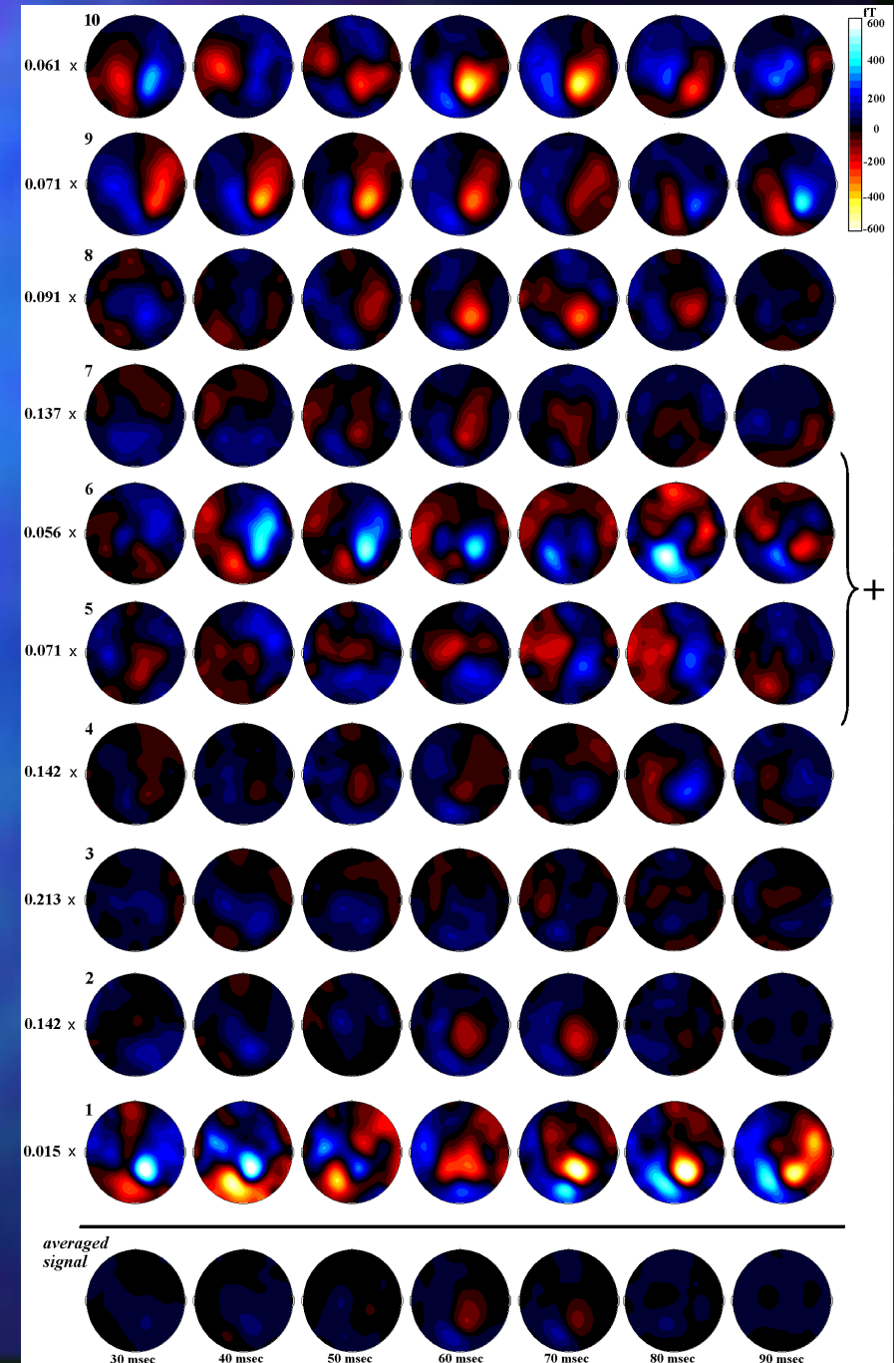
The ordered prototypes of regional response dynamics

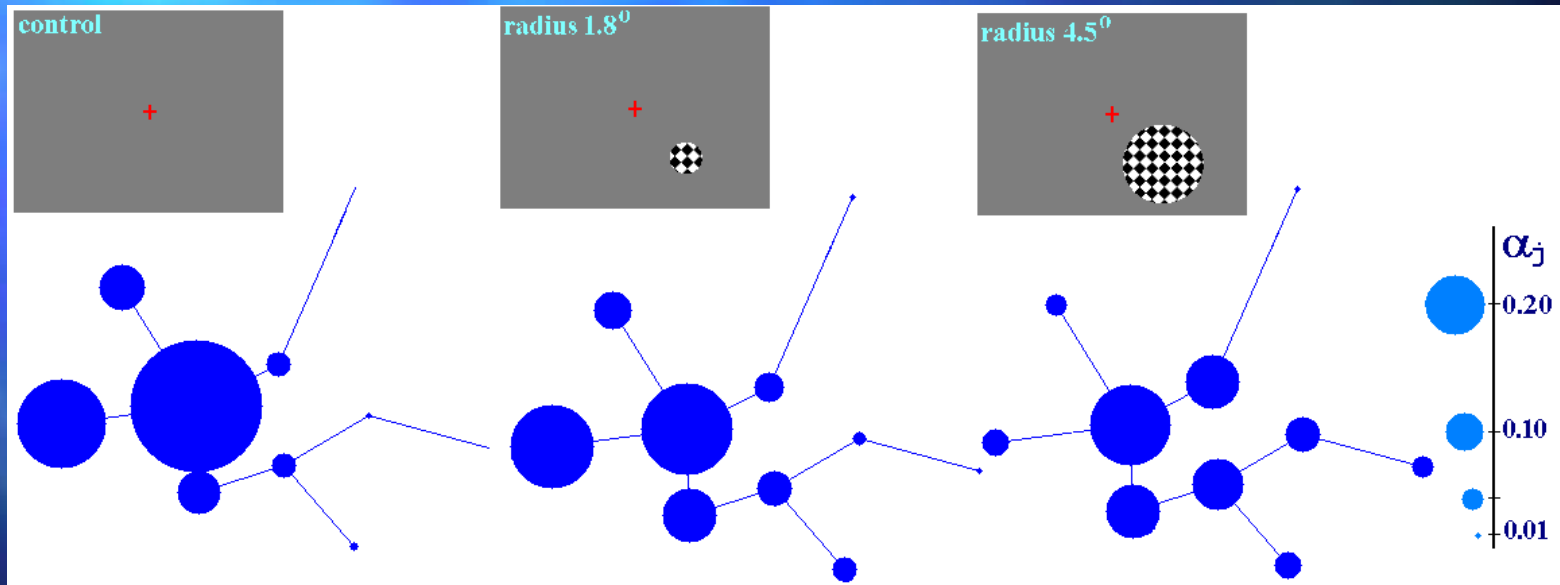
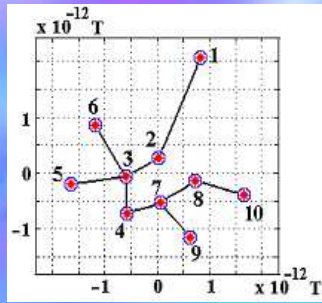
The ongoing activity
before the stimulus-onset
is functionally coupled
with the subsequent regional response



The failure of “signal+noise” model or how we are washing out the Brain Waves

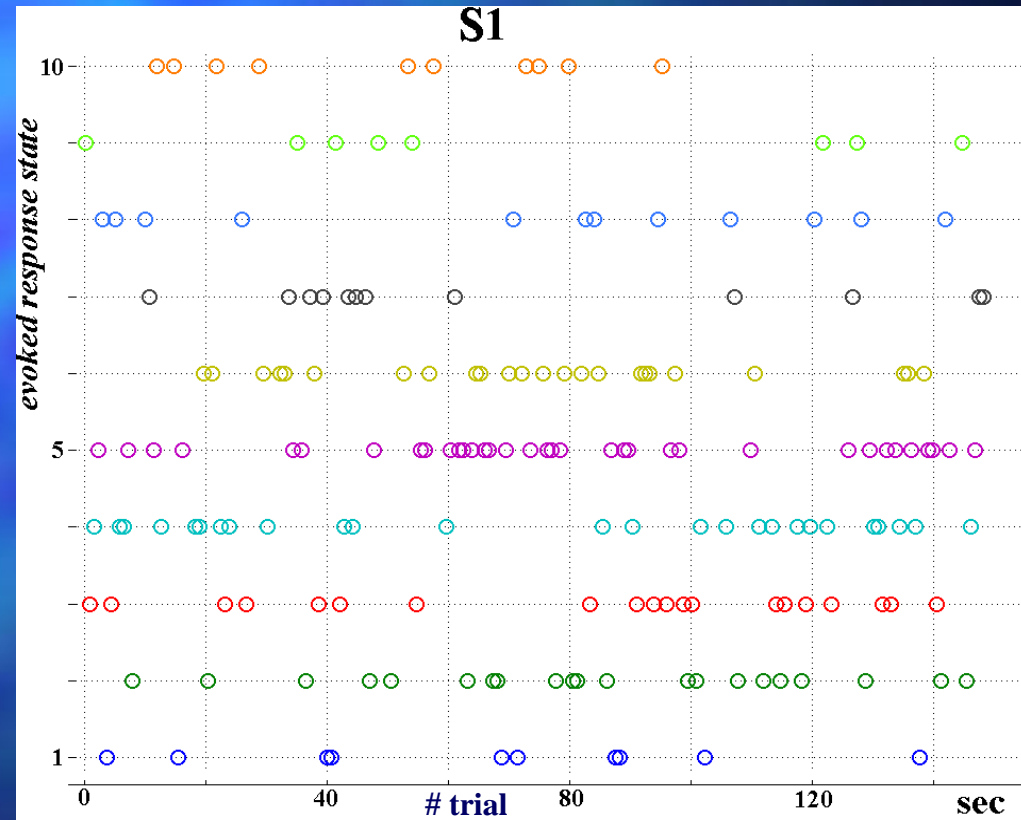
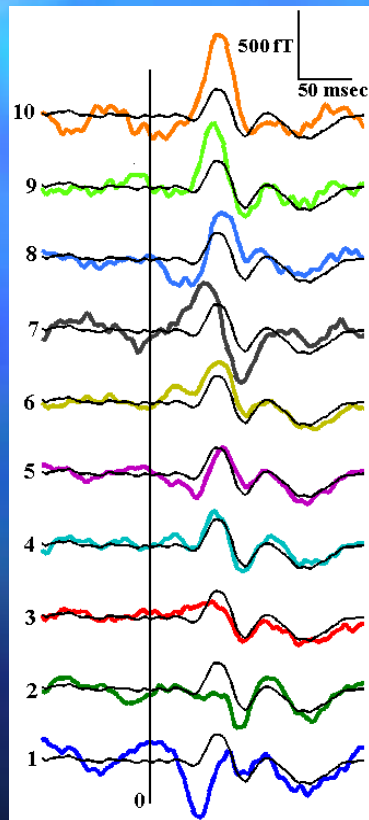
Distinct response dynamics
are fused into
a single timecourse



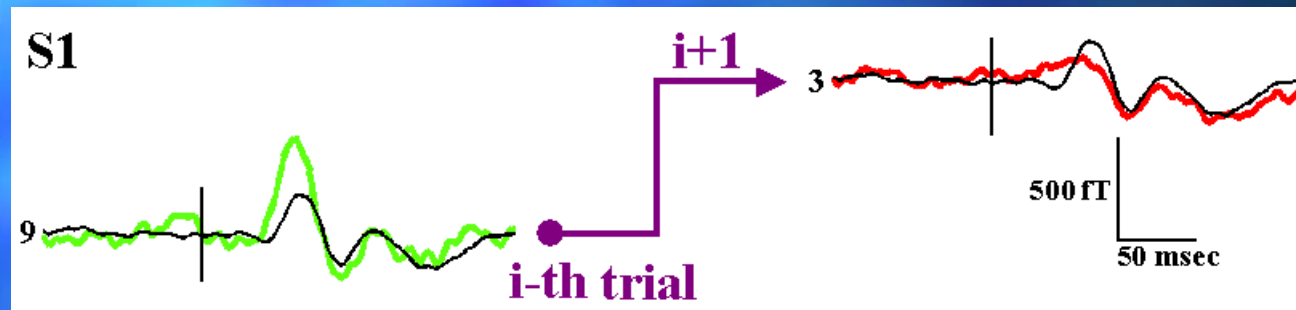


The stimulus is reflected in the shape of Brain Waves

There are systematics
hidden behind
the **trial-to-trial non-stationarity**



Using Markovian analysis :



The transition from
a high-responsiveness state
to a low-responsiveness state
is the most important “law”
governing the sequence of responses

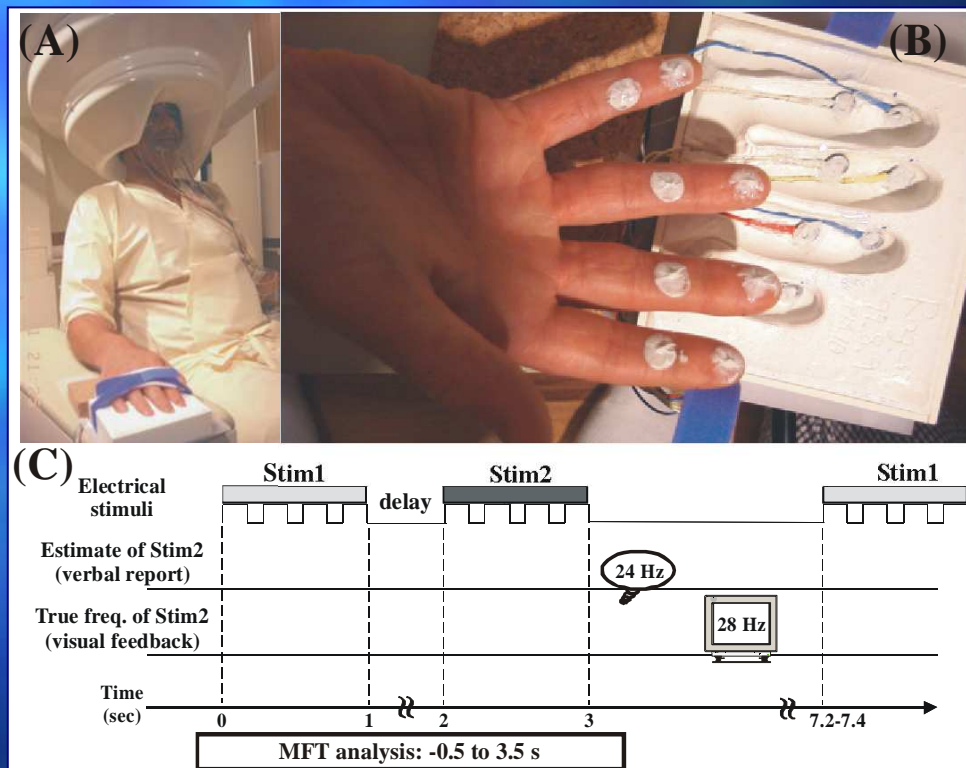
**tactile stimulation
&
behavioral responses**

IV)

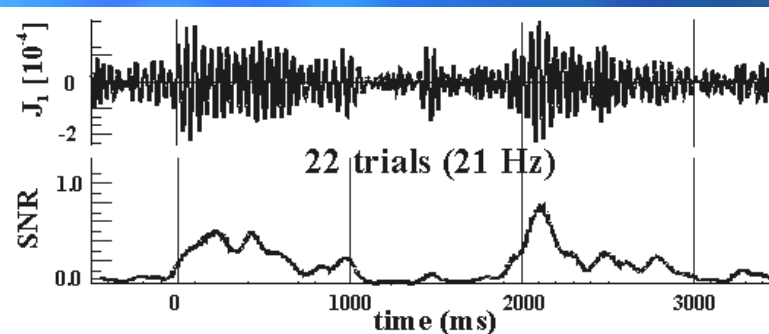
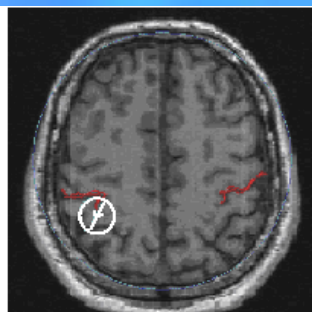
Deciphering the Brain Waves in a frequency discrimination task

[Liu et al., Neuroscience, 2003]

We correlated
the Brain Waves
with the subject's perception

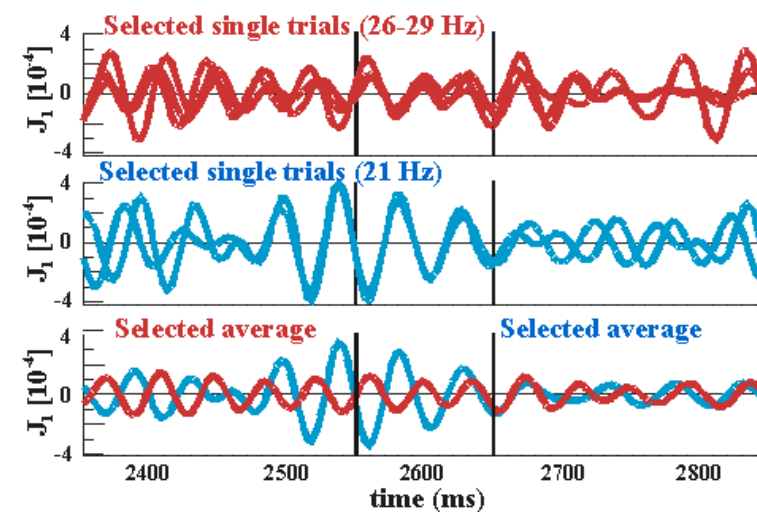
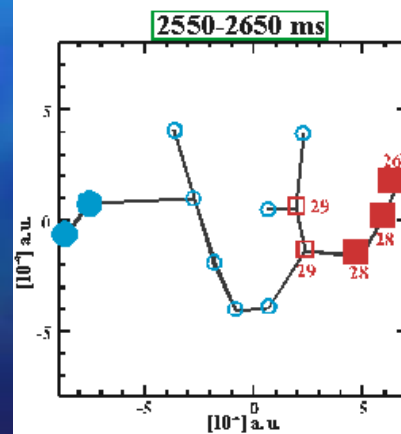


(A)
Subject 1:
(-35 -34 49)

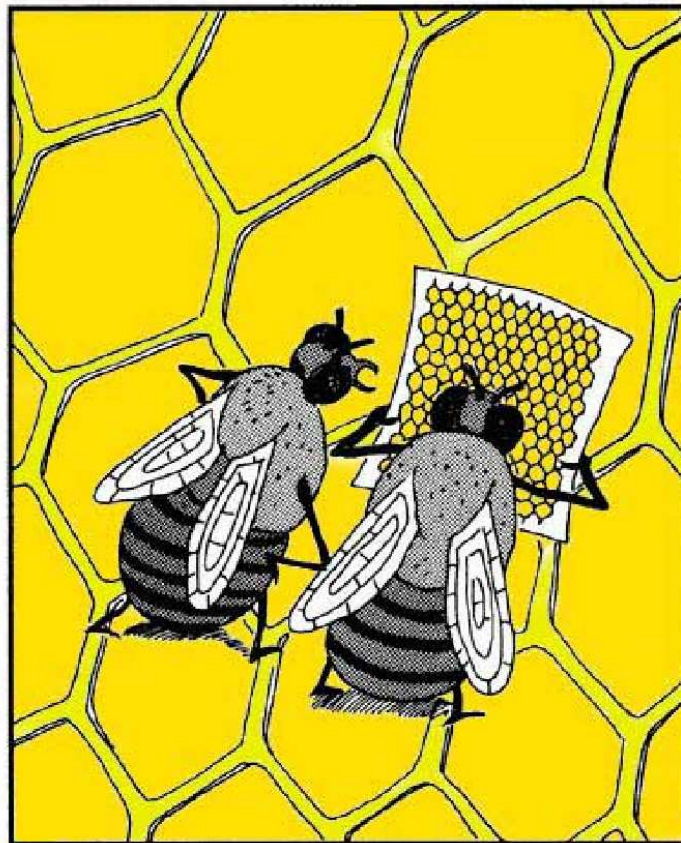


Correct, 21 versus 26-29 trials (subject 1-3)

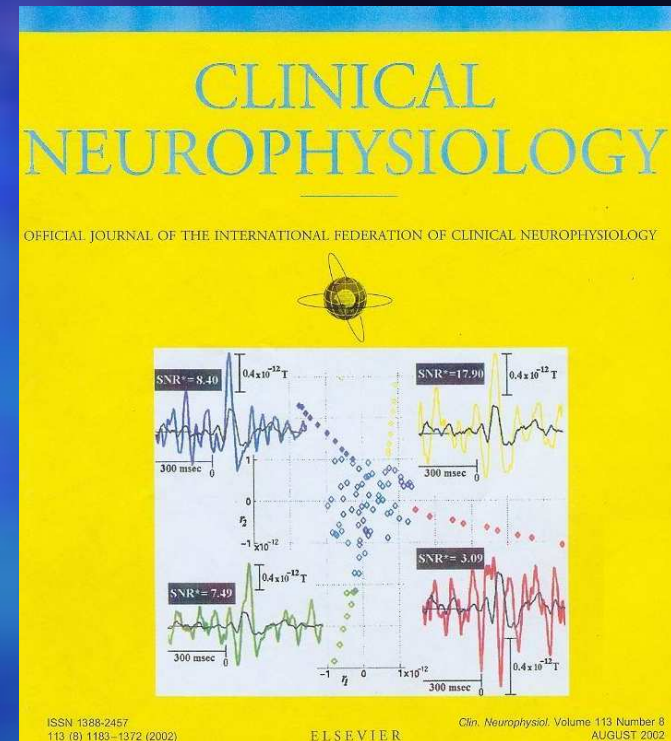
(A) Subject 1:



prospect



So, Where are we exactly?

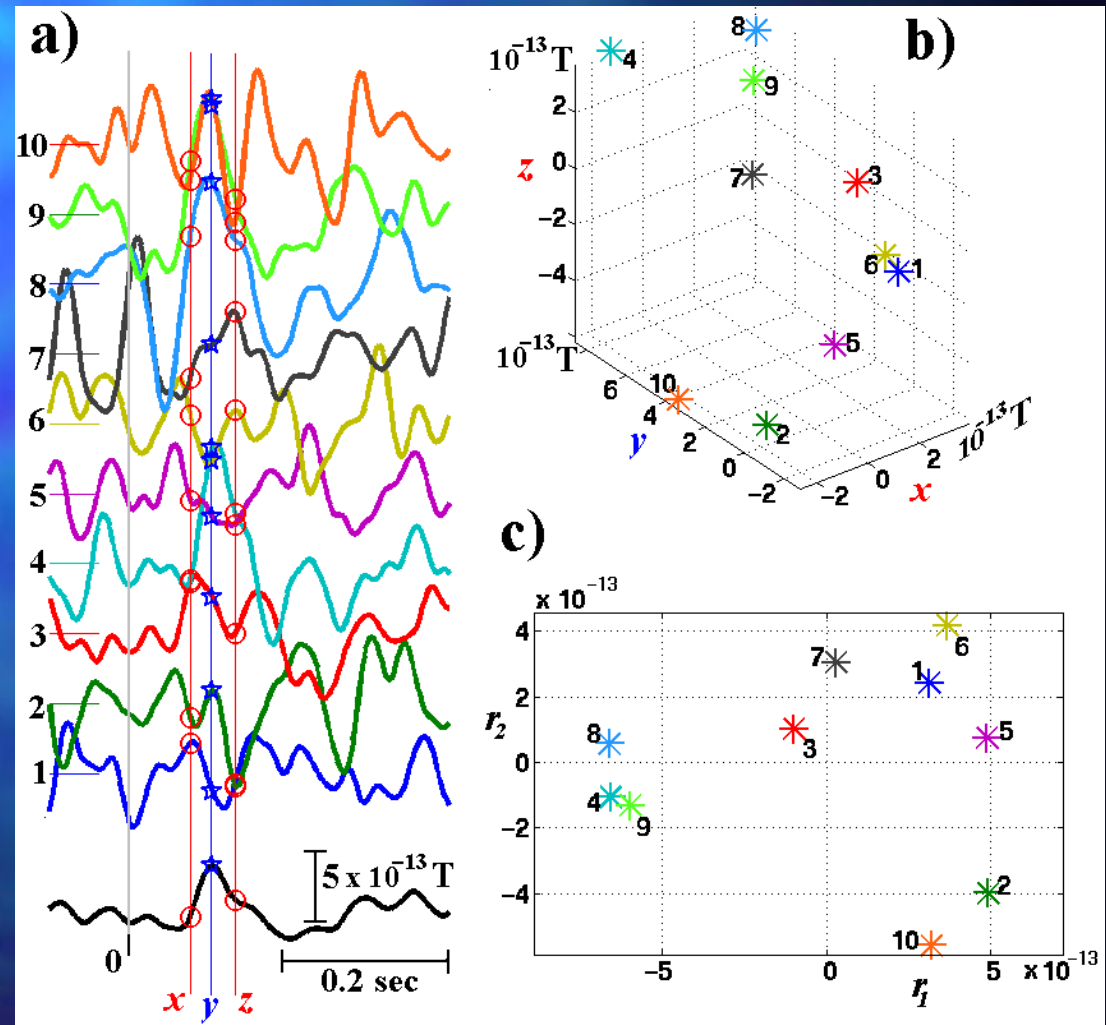


[Laskaris & Ioannides, Clin. Neurophys., 2002]

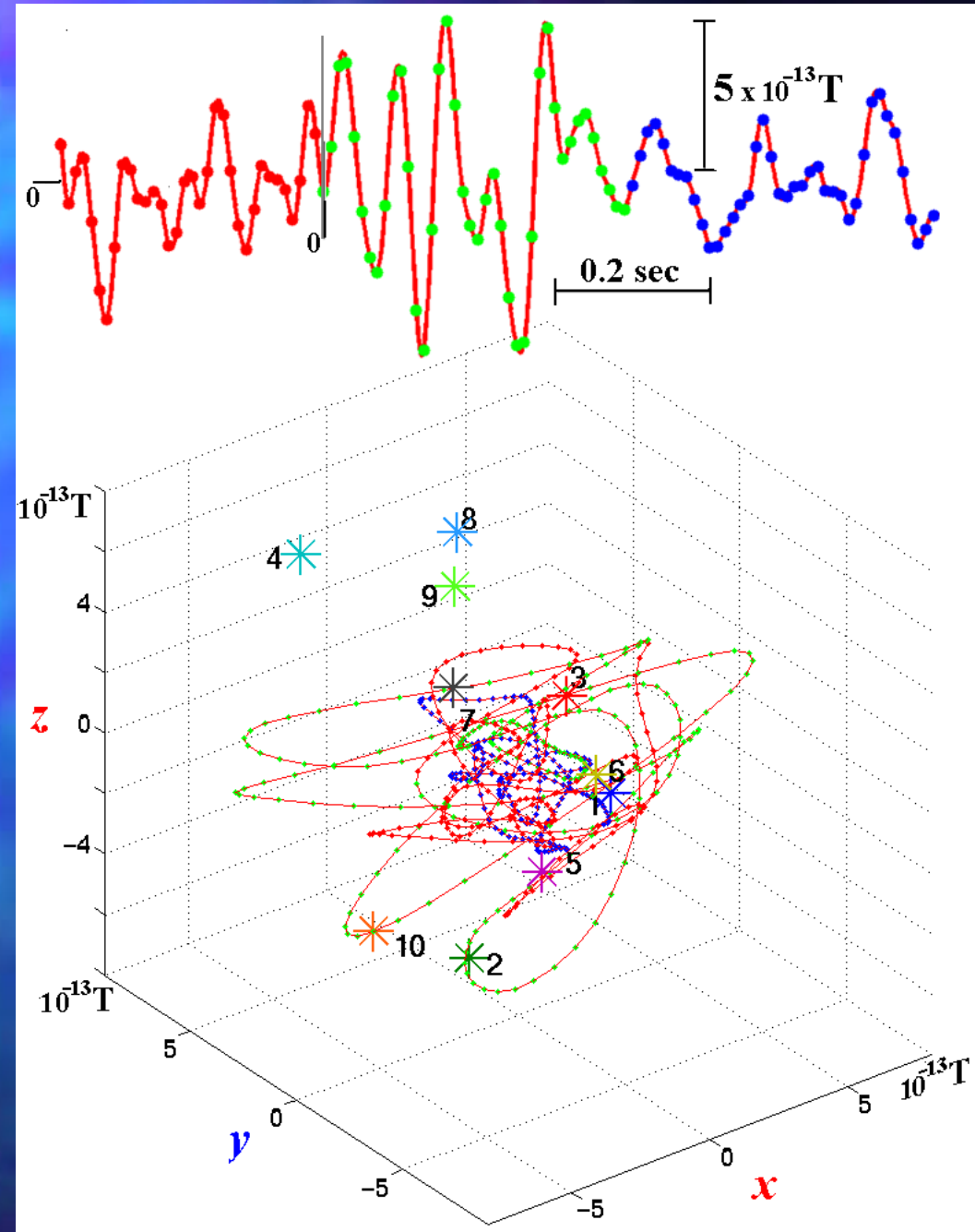
Semantic Maps :

A unifying geometrical approach
for studying event-related dynamics

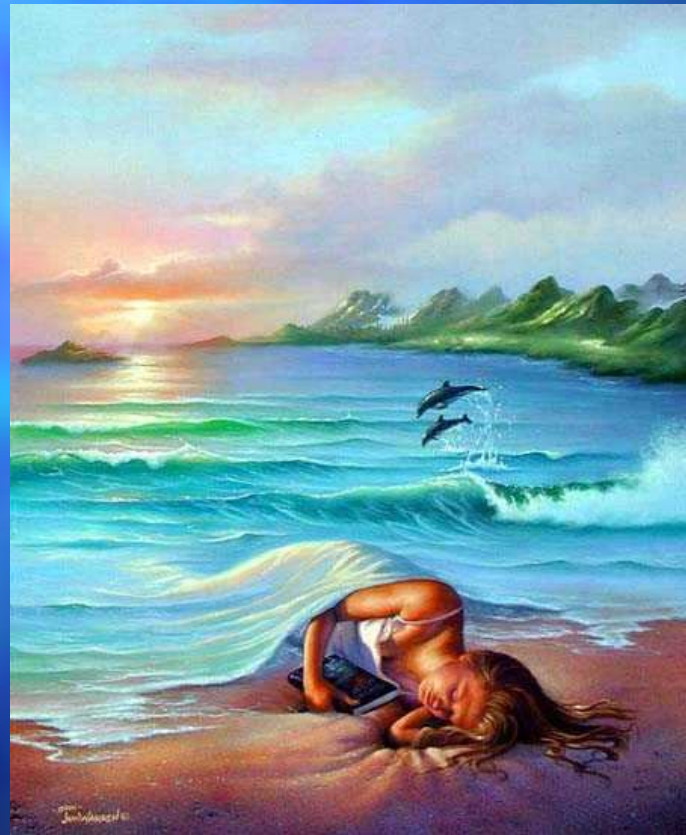
The structural description of *response dynamic manifold*



is combined with the
dynamical description
of a single-trial response



With many thanks



And great expectations

