

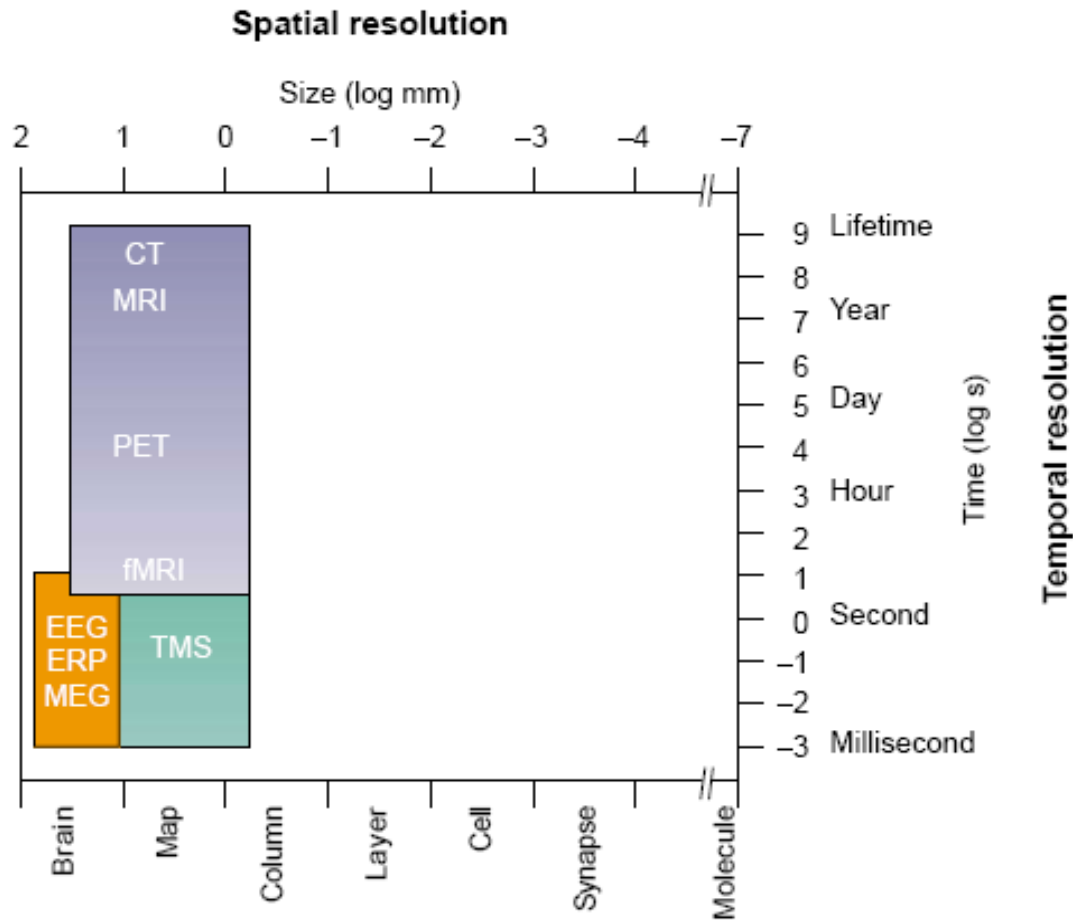
Micro-state analysis of EEG

Gilles Pourtois

Psychopathology & Affective Neuroscience (PAN) Lab

<http://www.pan.ugent.be>

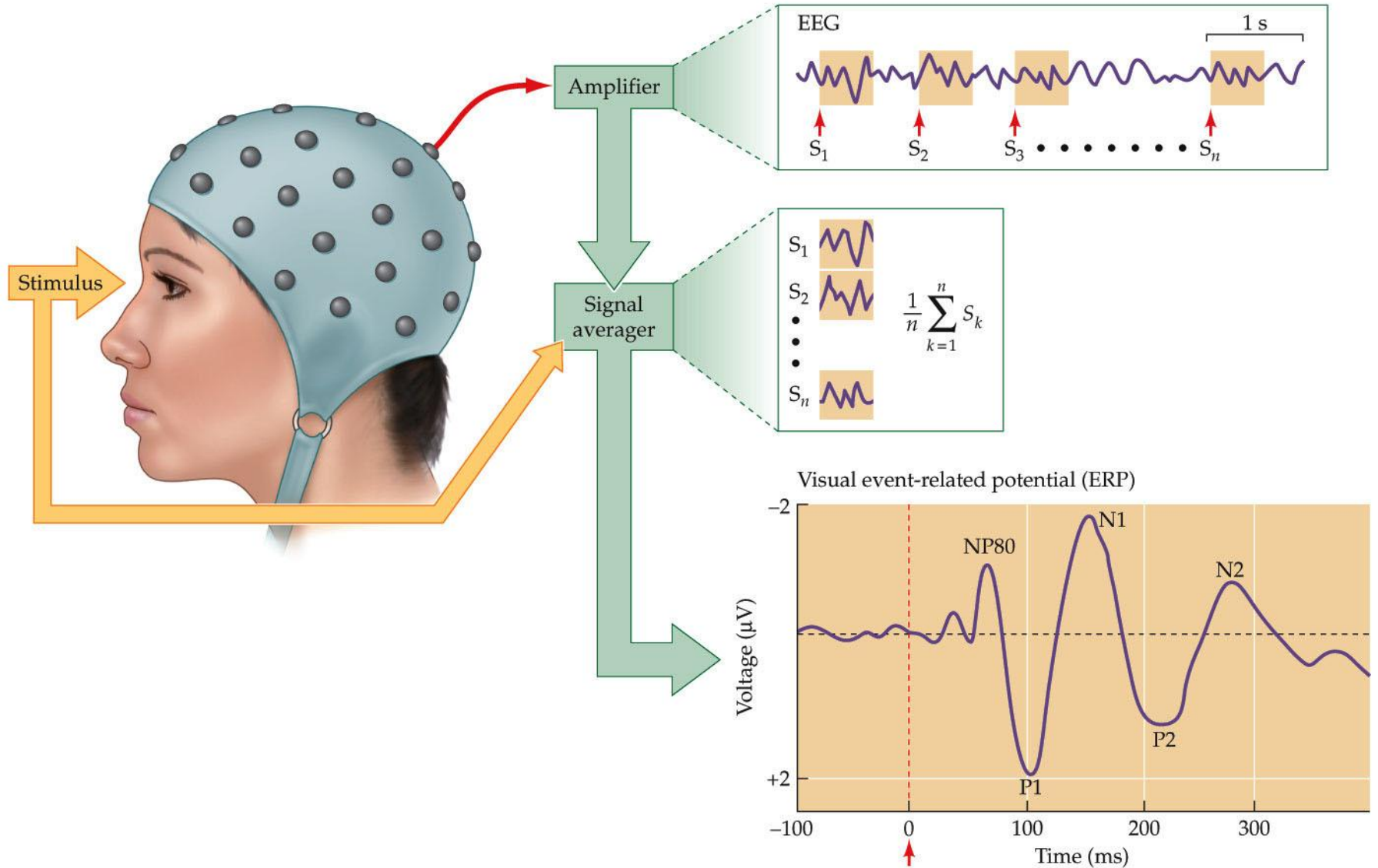




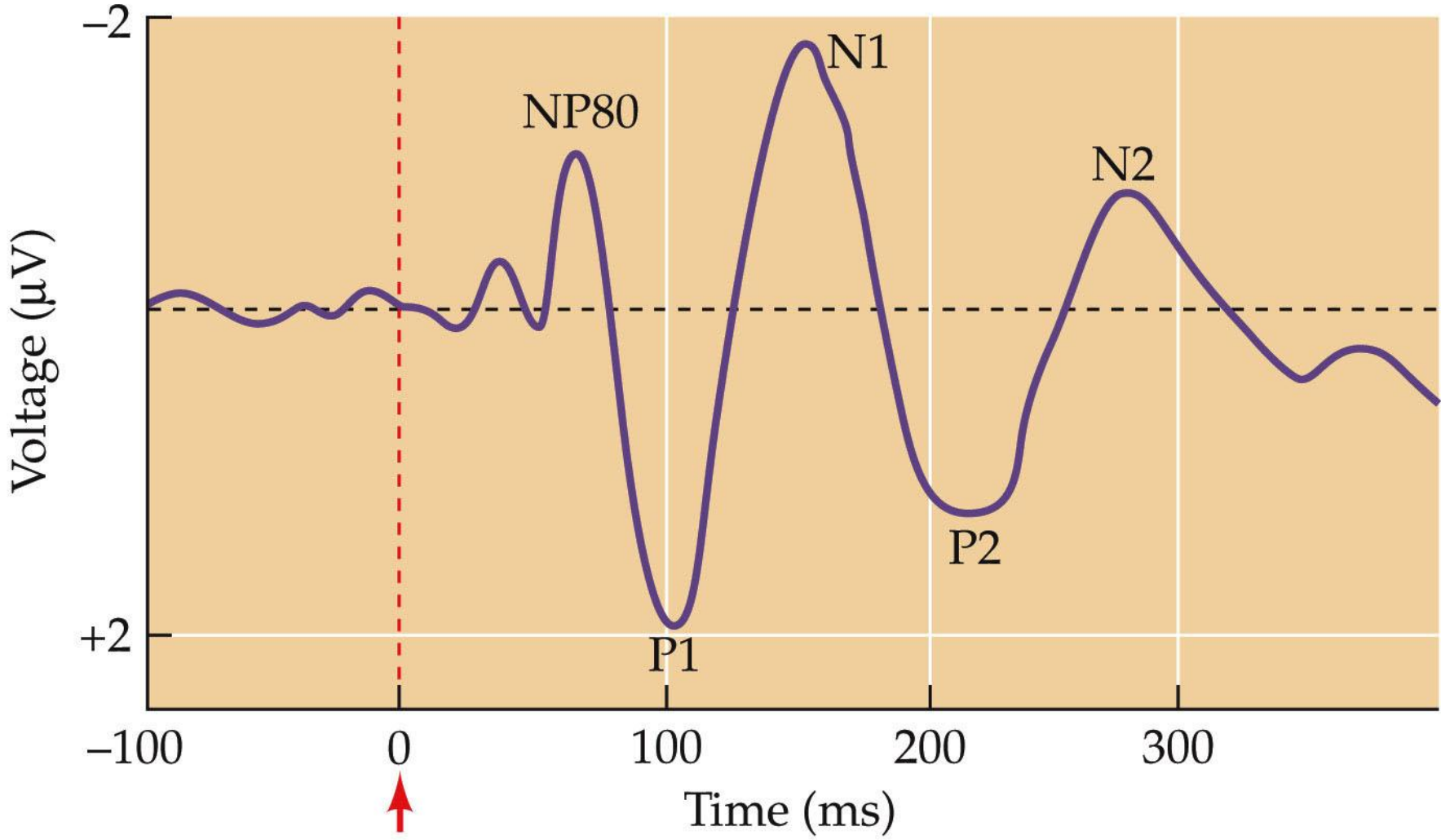
A shared opinion on EEG/ERP: excellent temporal resolution (ms time-scale) but poor spatial resolution (scalp recording and inverse solution problem)

Stewart & Walsh, 2000

ERP = Event Related Potential



Visual event-related potential (ERP)



What is a peak?

“The simplest approach is to consider the ERP waveform as a set of waves, to pick the peaks (and troughs) of these waves, and to measure the amplitude and latency at these deflections.”

Caveat

.....C1.....P1/N1.....N2.....P3.....

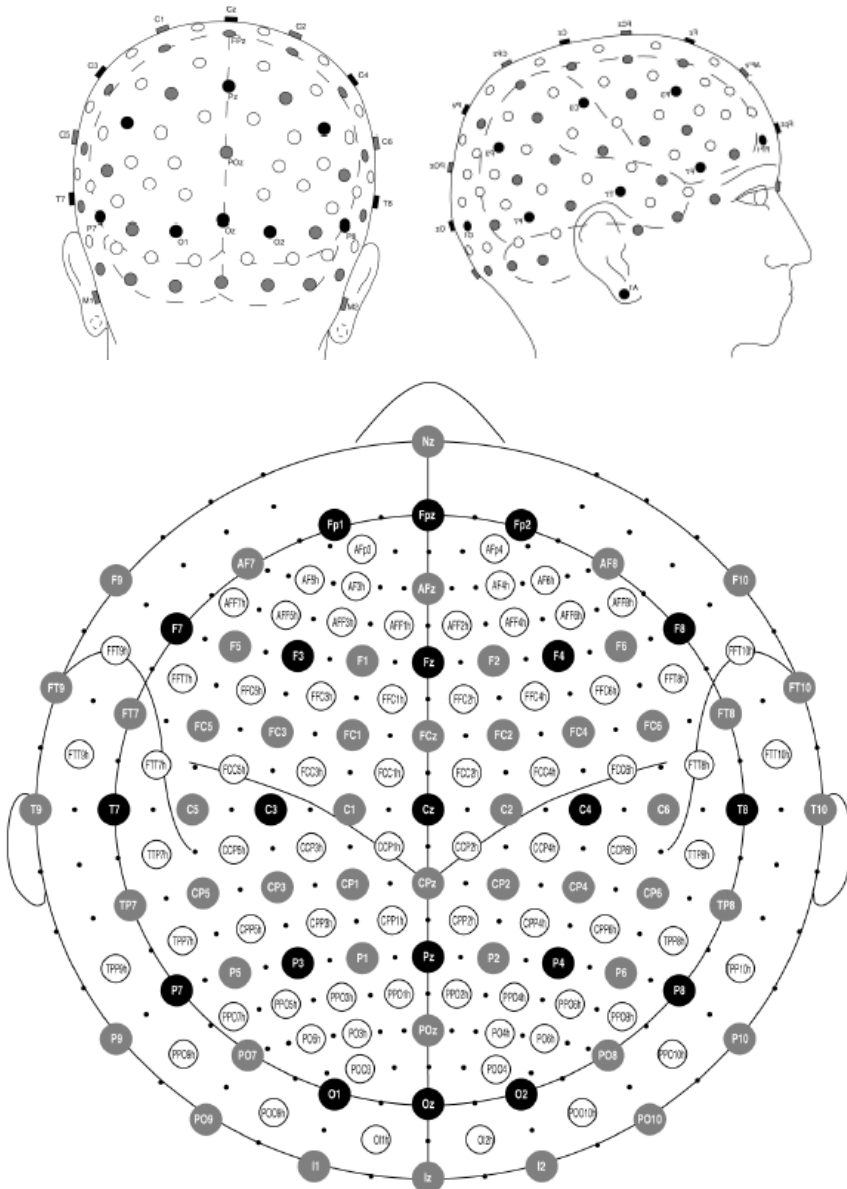
exogenous
ERP components
(sensory)

endogenous
ERP components
(cognitive)

(Visual)
stimulus
onset

Response/
Decision
making



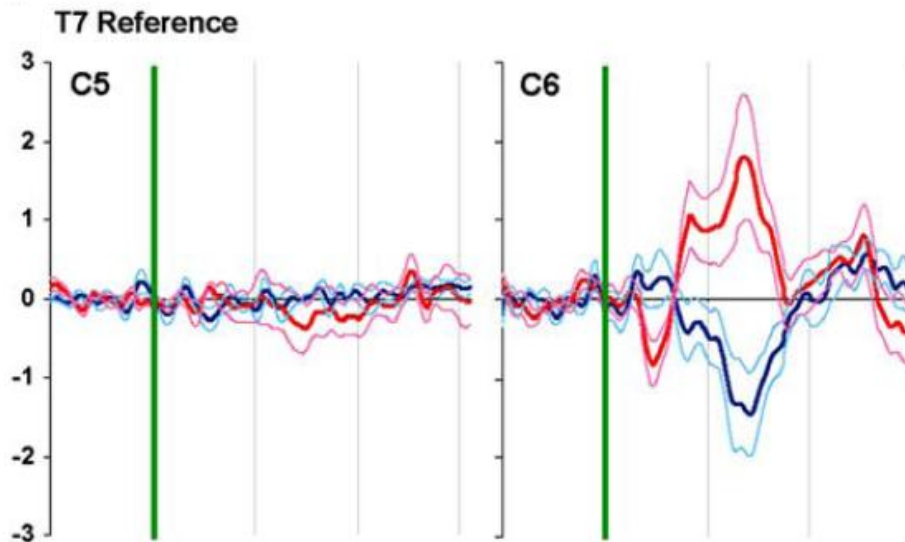
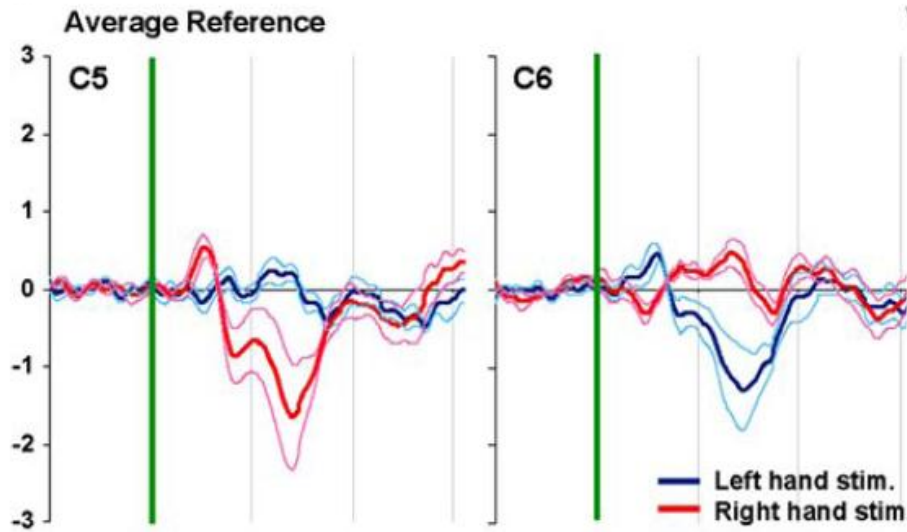


10-20 EEG system (Jasper, 1958, 20 electrodes).....up to 128 electrodes (high density ERP mapping)

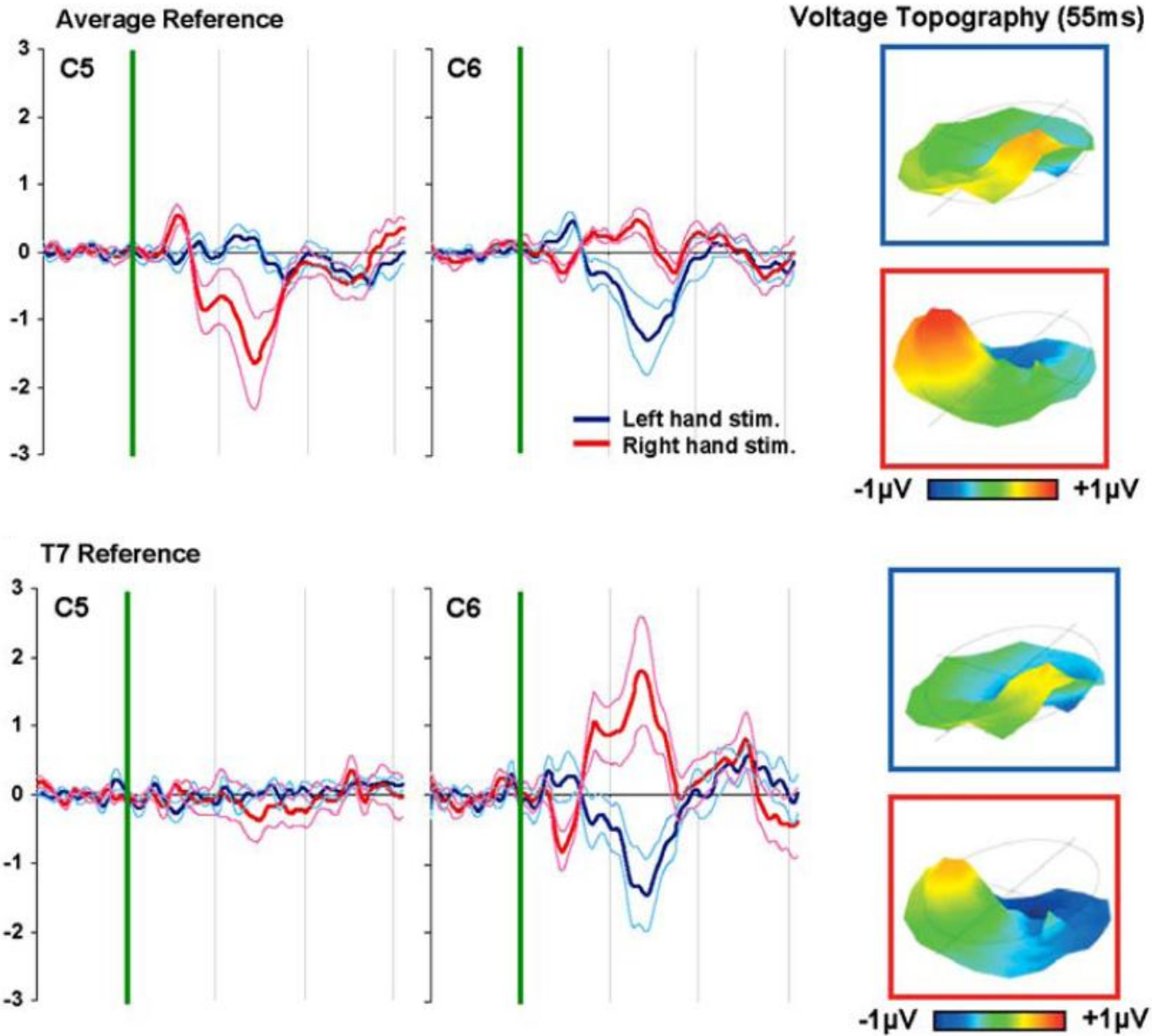
When peaks hurt...

- What does an ERP (peak) actually mean?
(synchronization, time and phase-locking but...)
- What about inter-peaks electric activity (meaningless)? Really true that only high amplitude (peak) is worth investigating?
- EEG is oscillatory in nature: maxima/peaks alone mean little.
- Worse: what about the landscape? (cf. tree and forest)
- Drawback/problem: reference! ERPs (amplitude) are strongly dependent on the reference!
- Wish: to analyze ERP data with less priors (and more power).
Time (time-frames) and spatial (electrode positions) domains.
+ to get rid of the reference problem.

Topography enables a reference free measure!

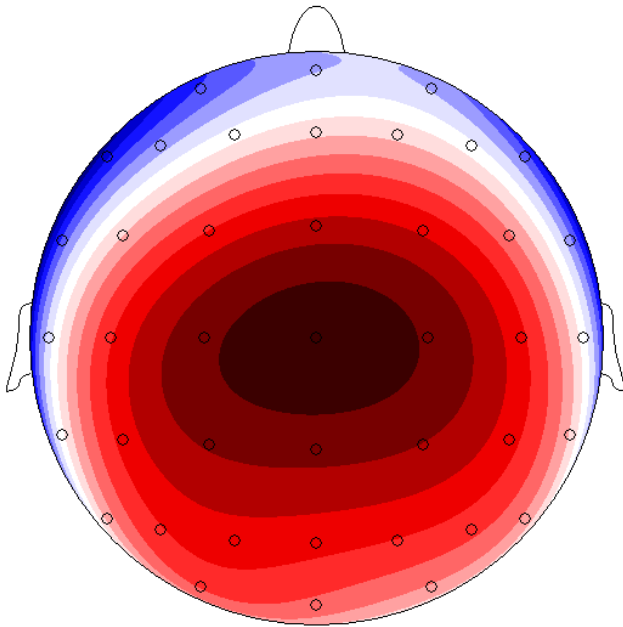


Topography enables a reference free measure!



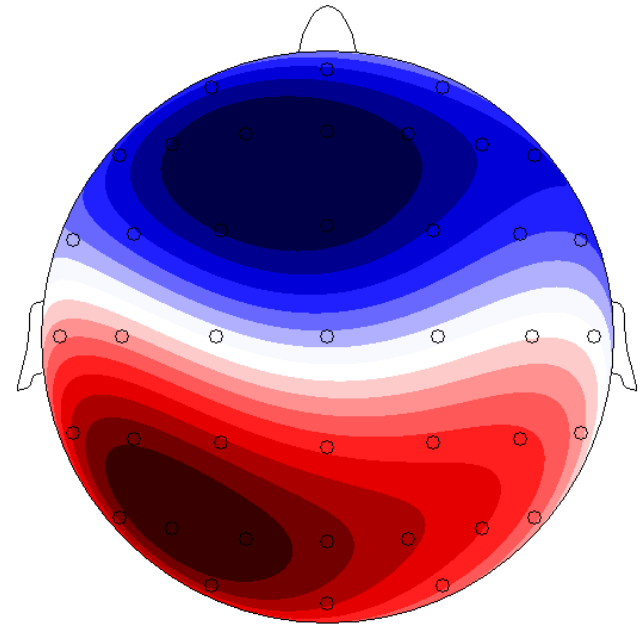
Topography matters!

Condition 1



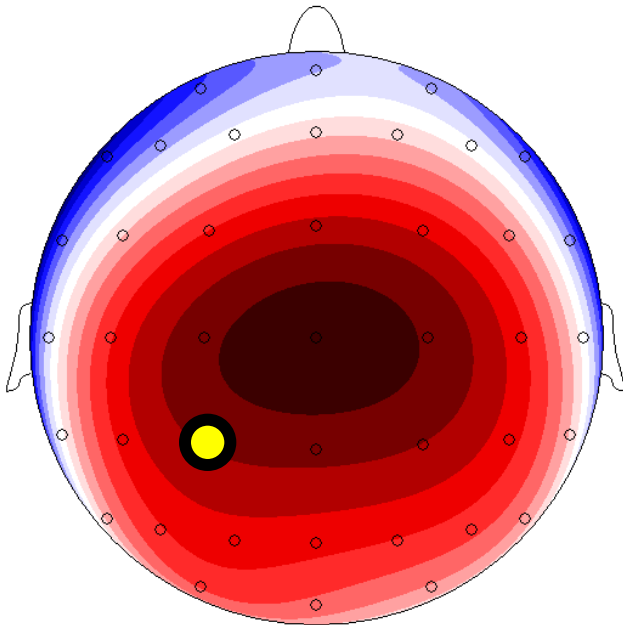
\neq

Condition 2



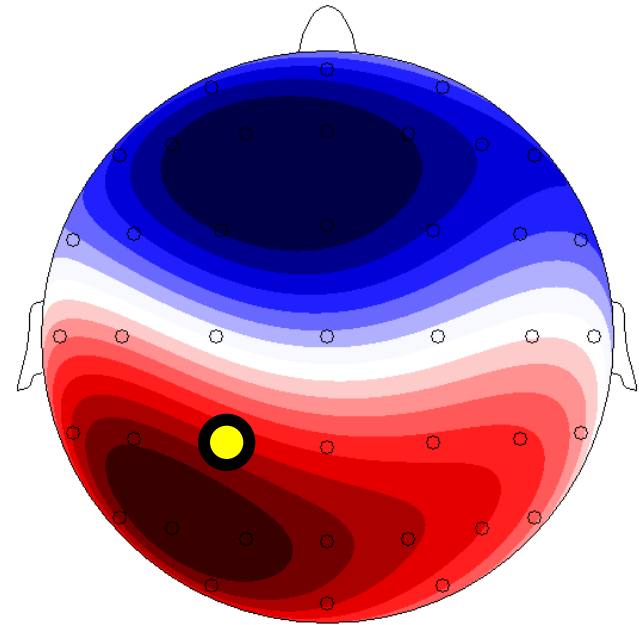
Topography matters!

Condition 1



≠

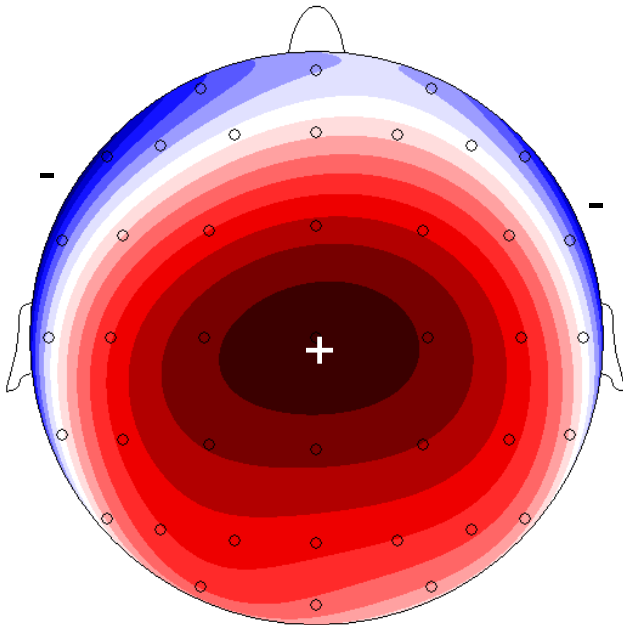
Condition 2



Read methods section (“acquisition: 32 or 64 channels; analyses: 1 or 2 channels”)
For this channel: same effect! At best a significant amplitude difference...
Tree hiding the forest...

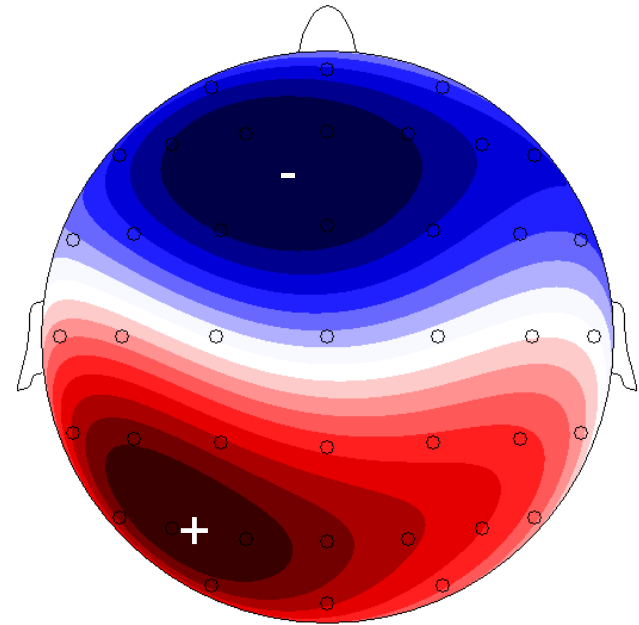
Topography matters!

Condition 1



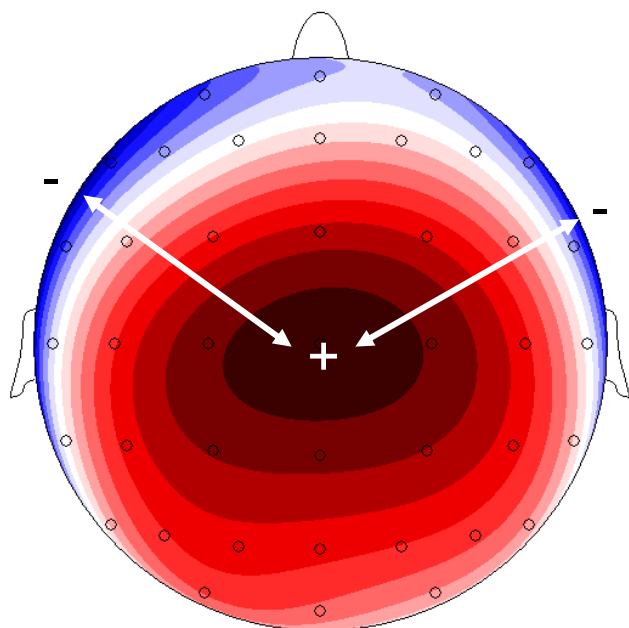
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Condition 2



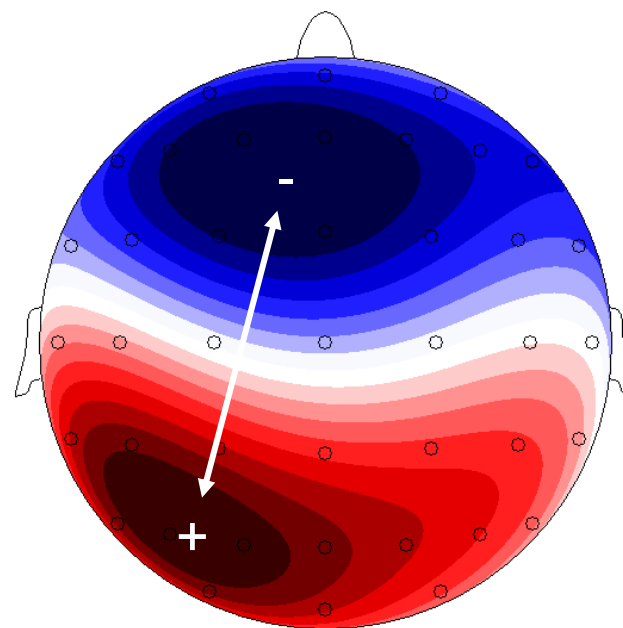
Topography matters!

Condition 1



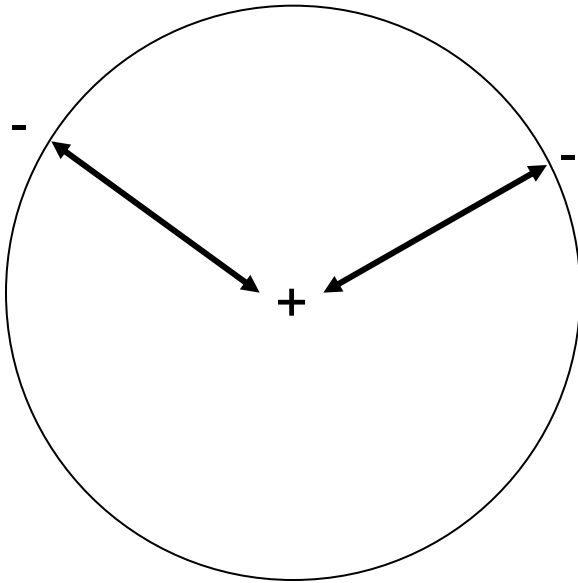
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Condition 2



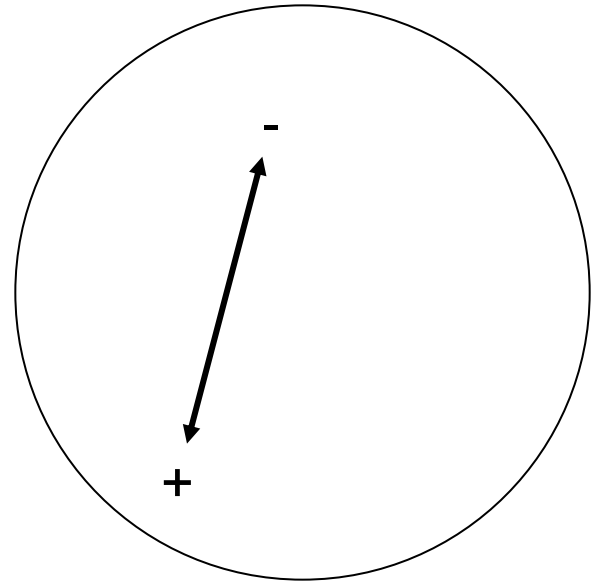
Topography matters!

Condition 1



\neq

Condition 2



Key assumptions

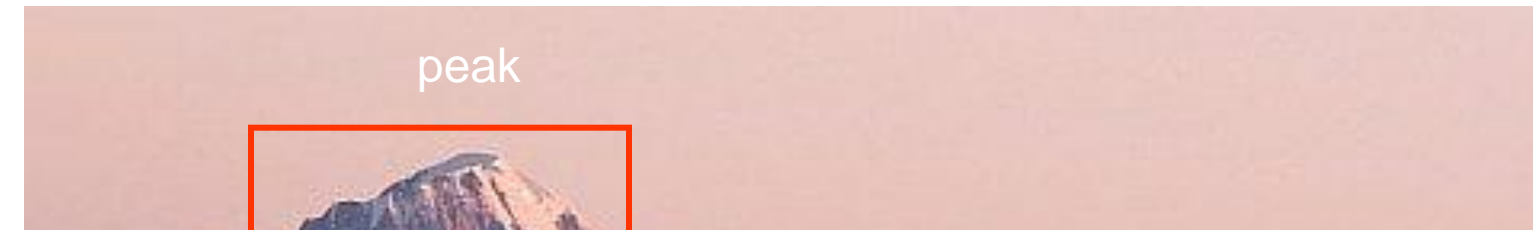
(Lehmann & Skrandies, 1980)

- If two topographic maps are different, one can be sure (demonstrated using maths) that the underlying configuration of intracranial generators is not the same (different brain networks involved!).
- However, the reverse assumption is not true. If the same topographic map is obtained in two conditions, it does not mean that the configuration of intracranial generators is the same (cf. 2 different networks leading to the same scalp map are feasible)!

Conventional analysis

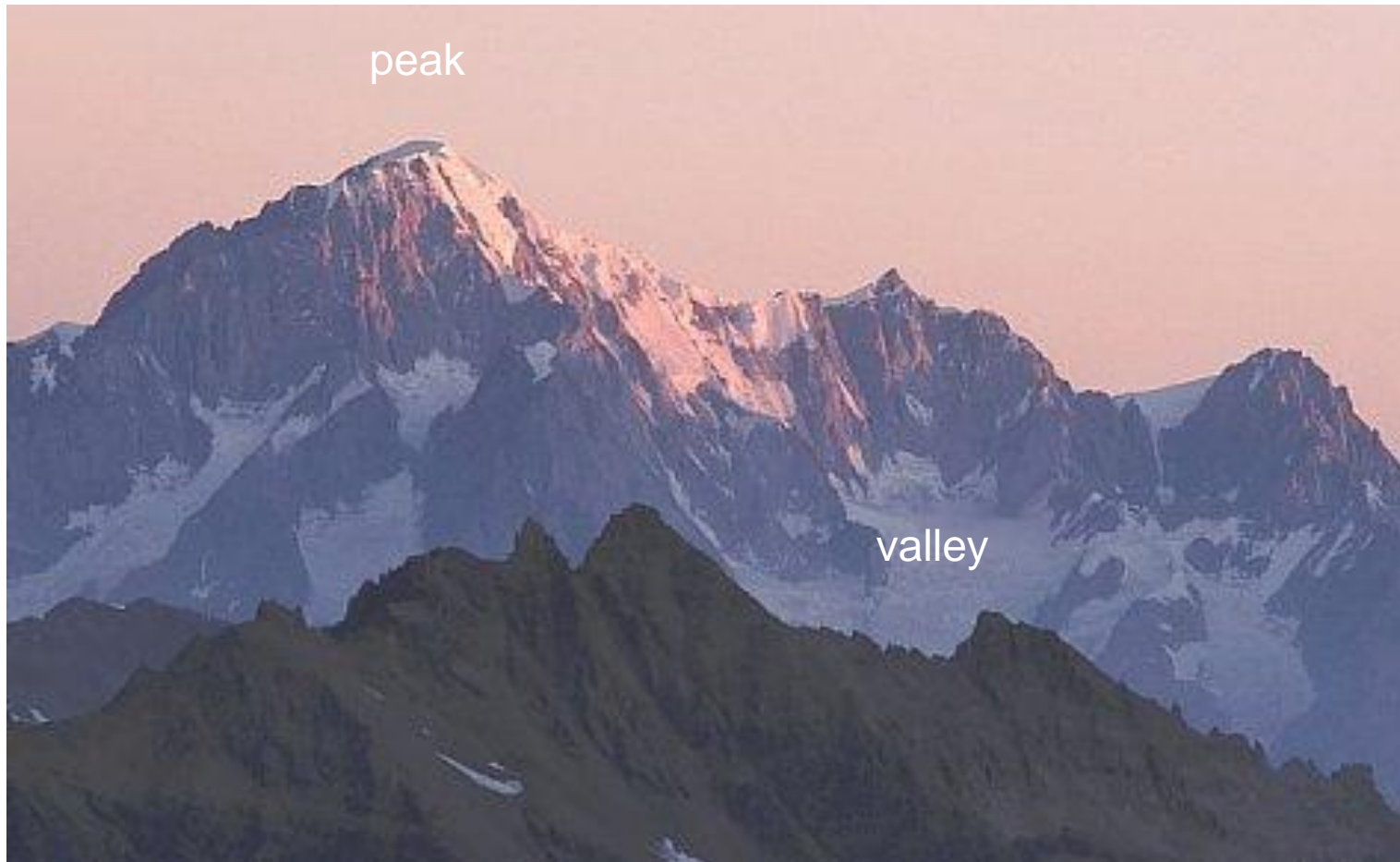


Conventional analysis

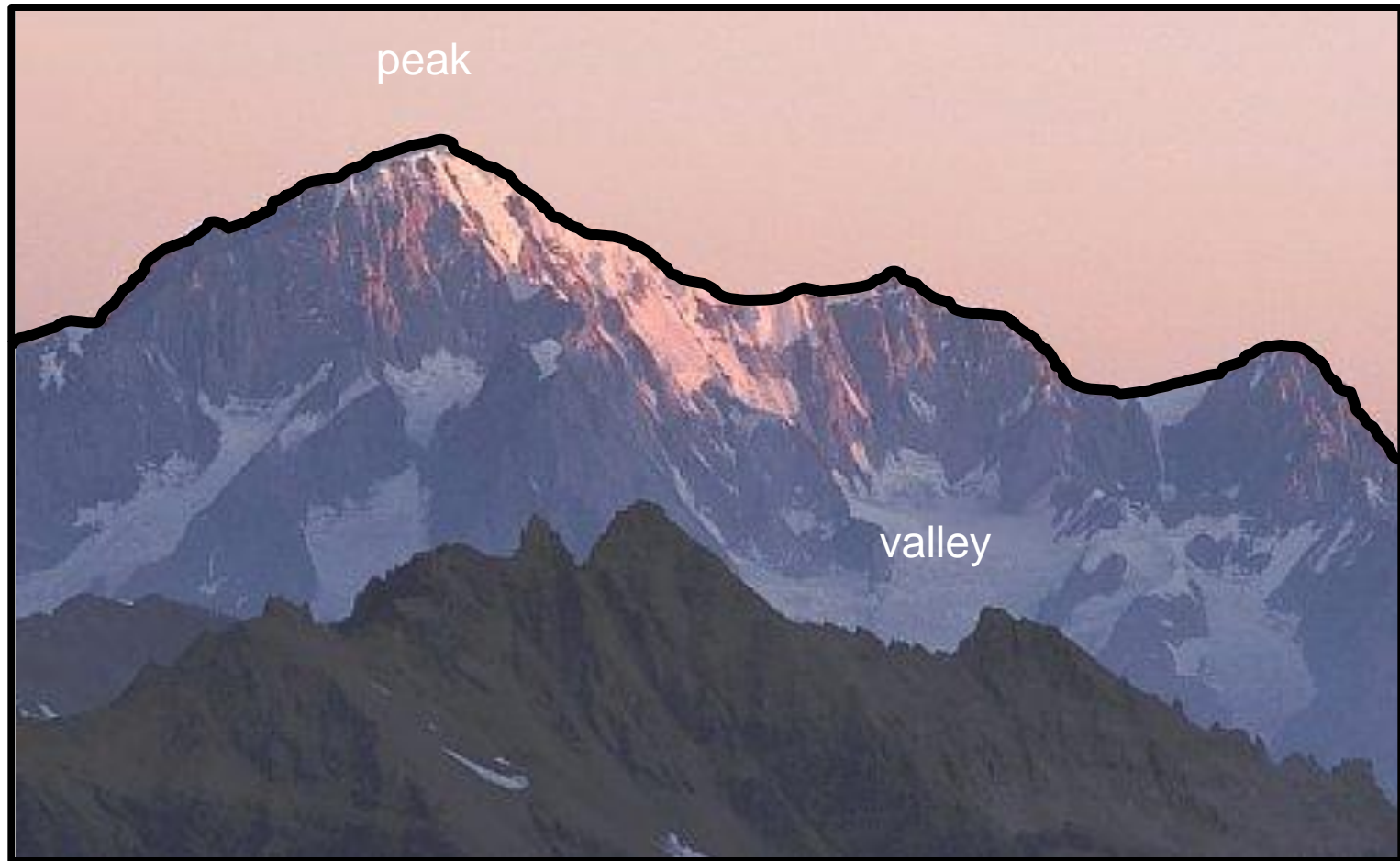


(Statistical) Thresholding

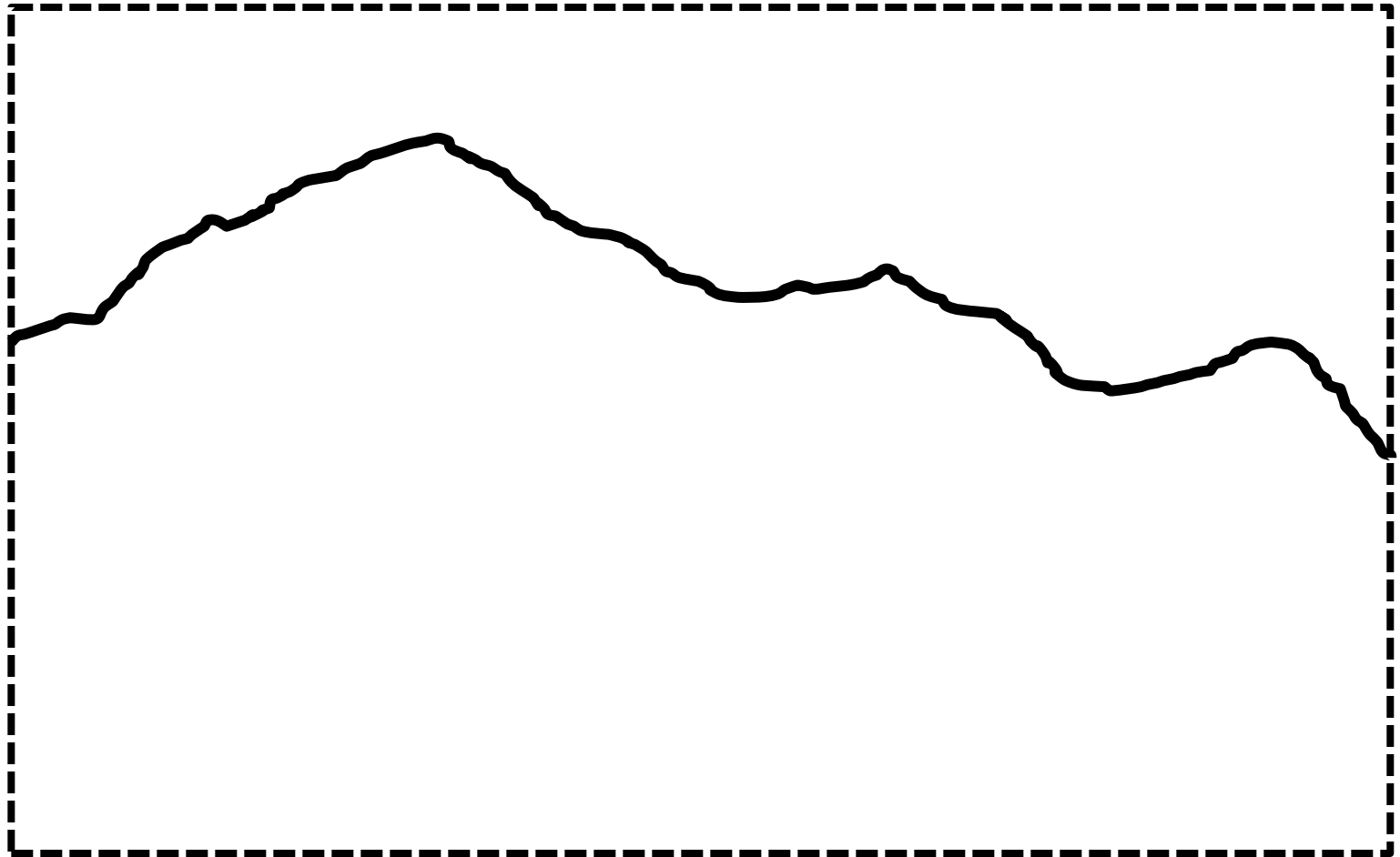
“Pattern” analysis



“Pattern” analysis

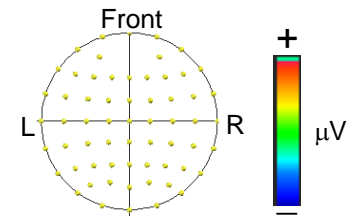
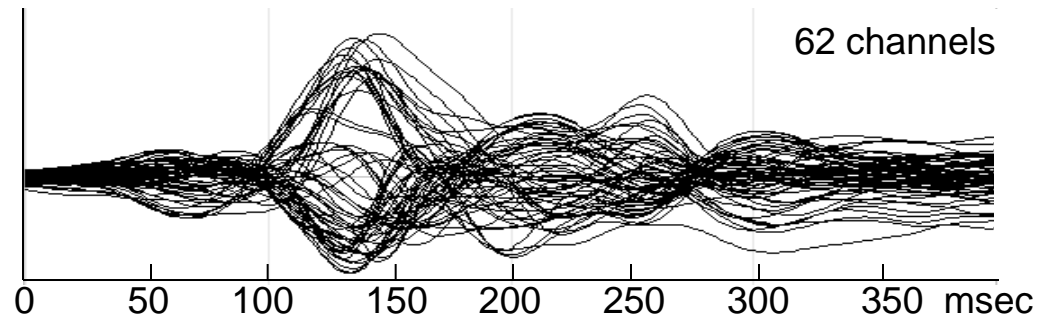


“Pattern” analysis



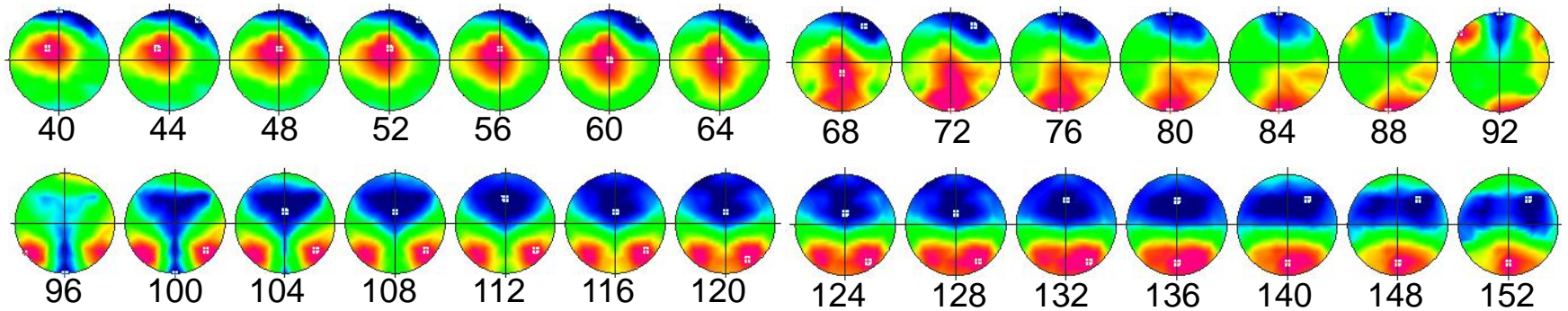
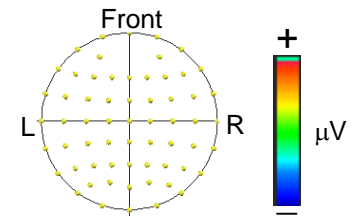
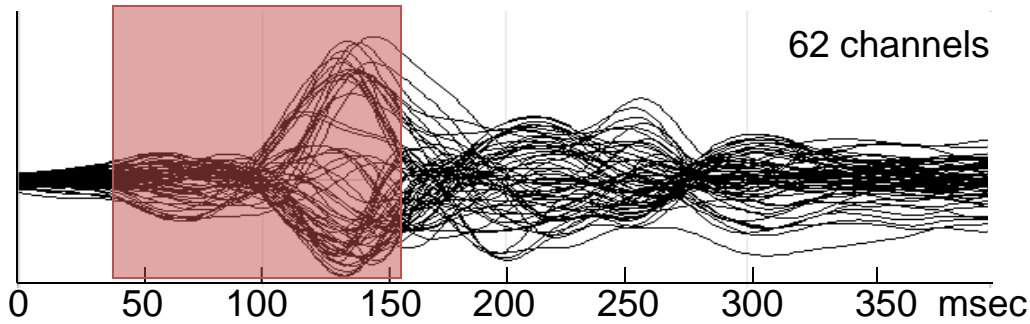
How to define/identify a
topographic map?

Spatial cluster analysis *(Michel et al., 1999, 2001)*



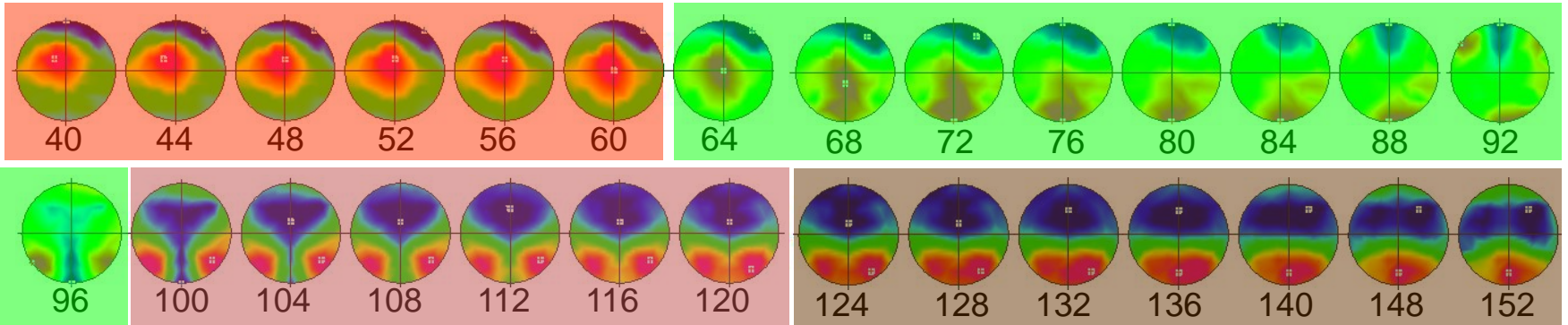
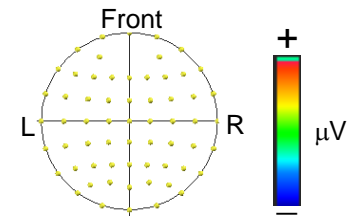
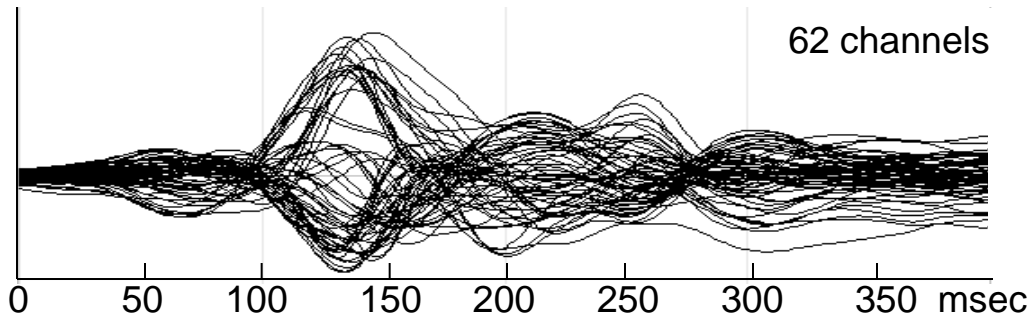
Spatial cluster analysis *(Michel et al., 1999, 2001)*

Map series



Spatial cluster analysis *(Michel et al., 1999, 2001)*

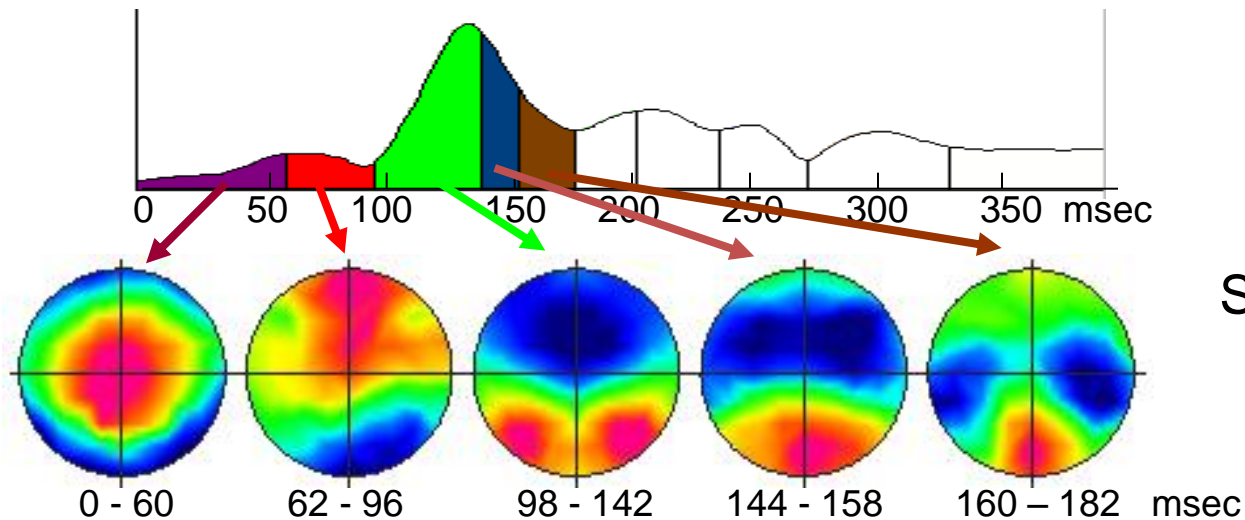
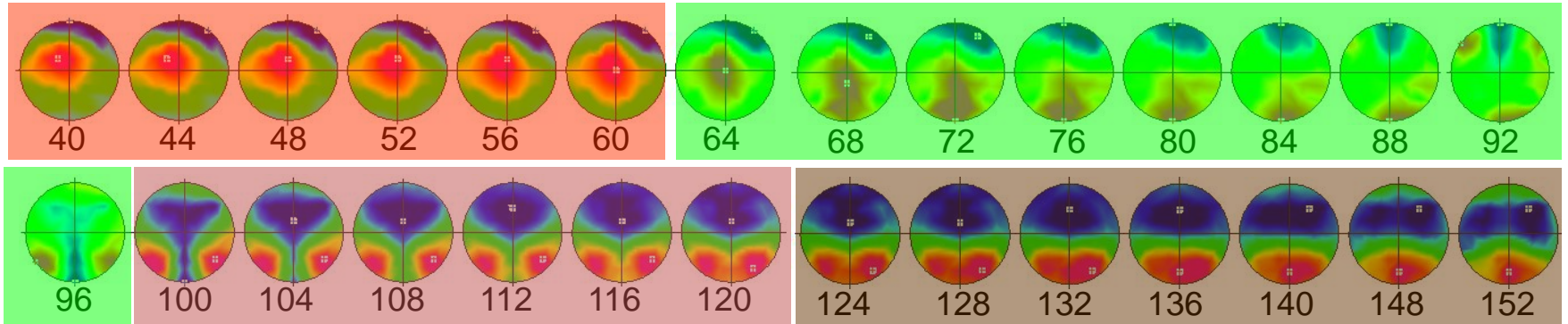
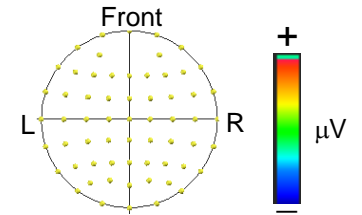
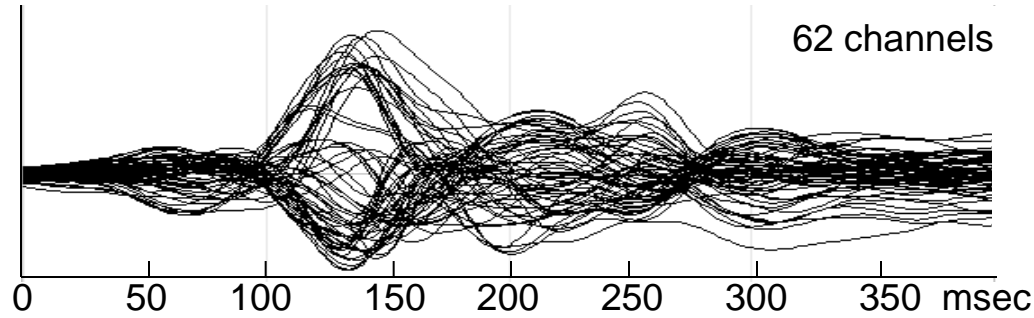
Map series



FUNCTIONAL MICROSTATES
(obtained regardless of local amplitude changes)

Spatial cluster analysis *(Michel et al., 1999, 2001)*

Map series



Spatial correlation (C)

$$C_{u,v} = \frac{\sum_{i=1}^n u_i \cdot v_i}{\|u\| \cdot \|v\|}$$

$$\|u\| = \sqrt{\sum_{i=1}^n u_i^2}, \quad \|v\| = \sqrt{\sum_{i=1}^n v_i^2}$$

(C is equivalent to the Pearson coefficient)

For each dominant map, one obtains then (after fitting) important indices not available with a peak analysis:

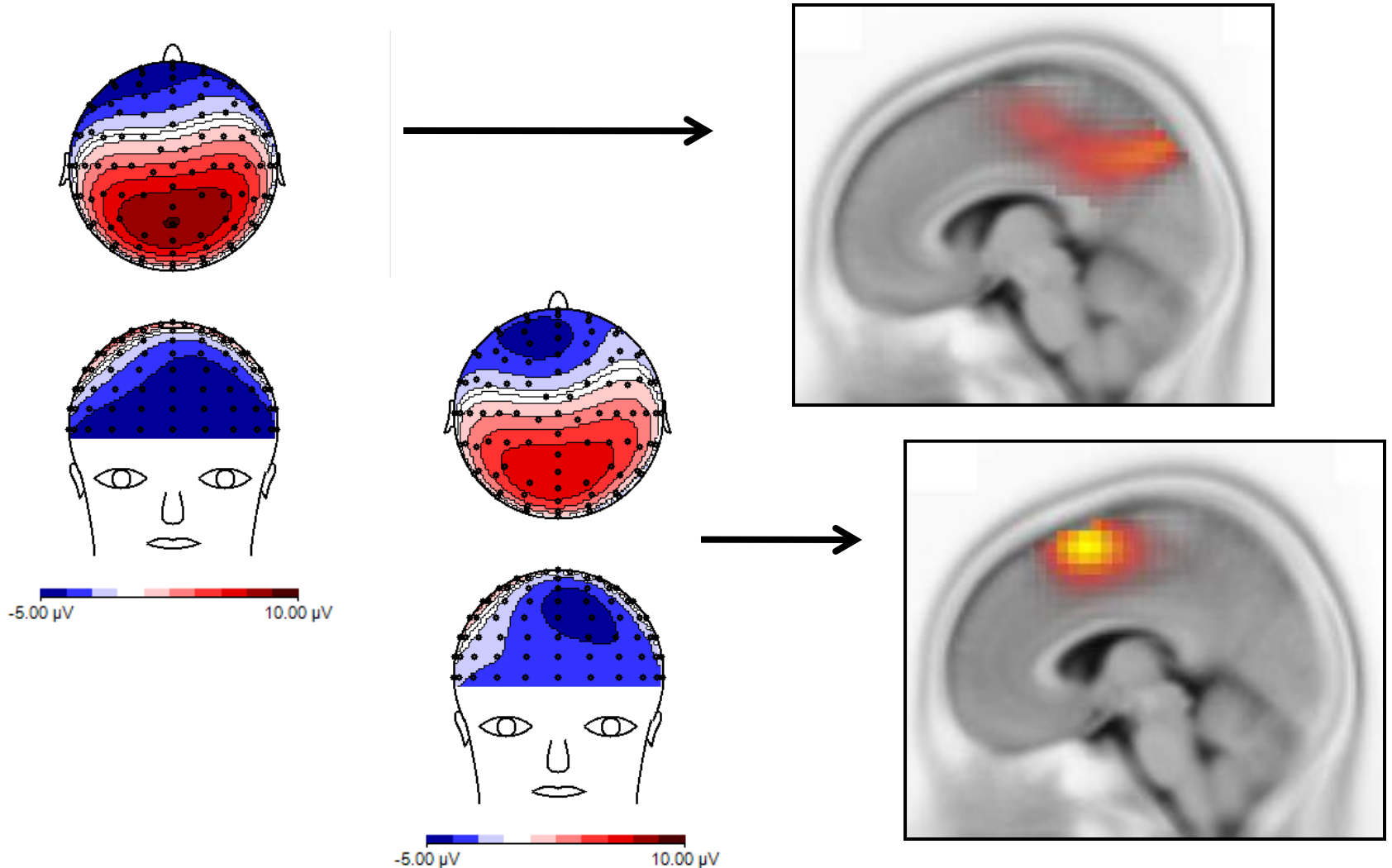
- ***Explained variance**
- ***Duration**
- ***Onset/Offset**
- ***Strength (GFP)**
- ***Best Correlation**

Use these indices to perform brain-behavior correlations!

Perform the tracking of a topographic map into raw (EEG) or epoched (ERP) data

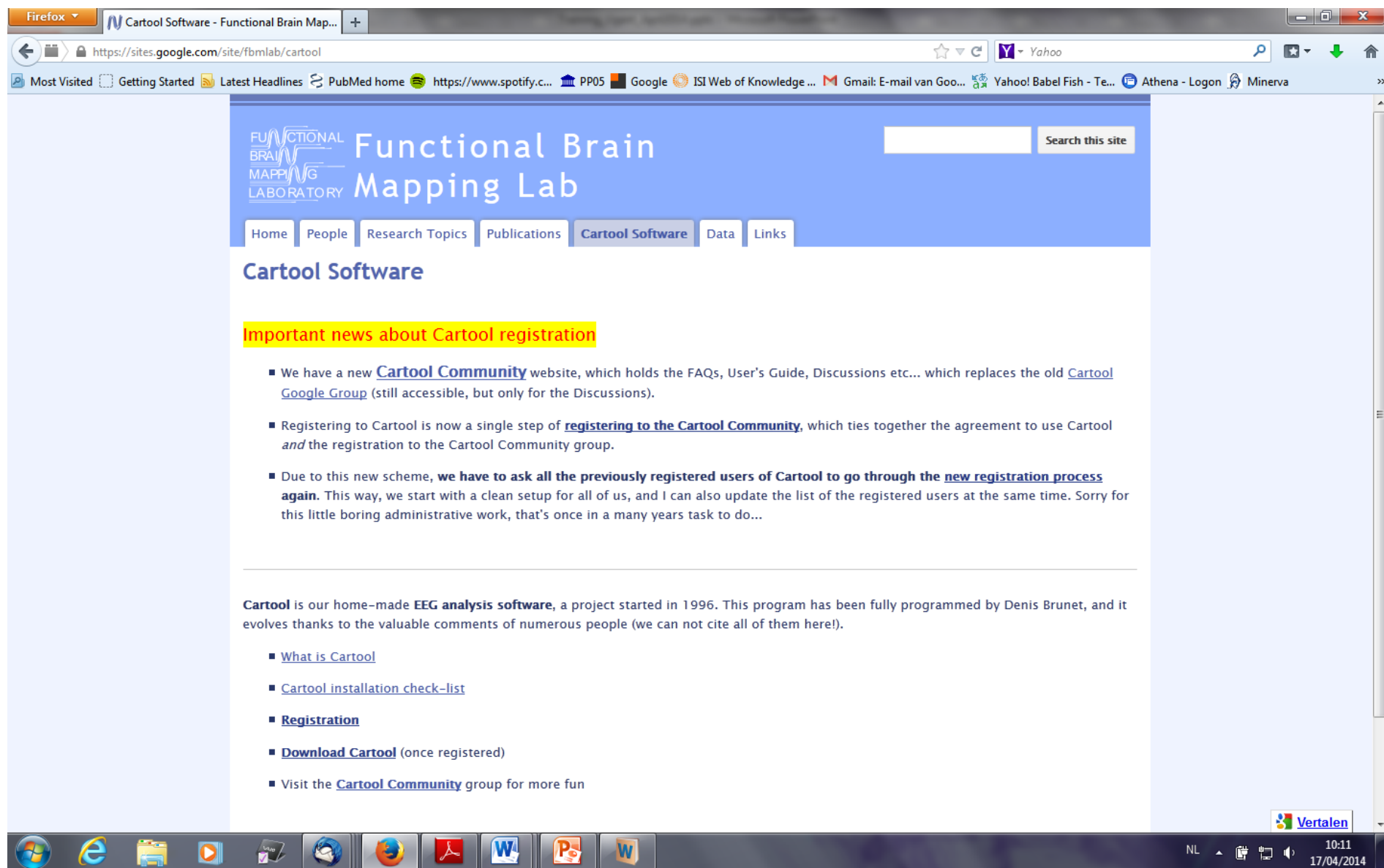
One of the advantages of topographic mapping over peak analysis:

Reduction of priors (time and space), and topographic maps can be used directly for Source Localization (inverse problem).



Easy solution: CARTOOL®

<https://sites.google.com/site/fbmlab/cartool>



The screenshot shows a Firefox browser window displaying the website 'Functional Brain Mapping Lab'. The browser's address bar shows the URL 'https://sites.google.com/site/fbmlab/cartool'. The website has a blue header with the lab's logo and name, and a search bar. Below the header is a navigation menu with links for Home, People, Research Topics, Publications, Cartool Software, Data, and Links. The main content area is titled 'Cartool Software' and features a yellow highlighted section for 'Important news about Cartool registration'. This section contains three bullet points: 1) A new 'Cartool Community' website has replaced the old 'Cartool Google Group'. 2) Registration is now a single step of 'registering to the Cartool Community'. 3) Existing users must go through a new registration process again. Below this, a paragraph describes 'Cartool' as home-made EEG analysis software from 1996. A list of links follows: 'What is Cartool', 'Cartool installation check-list', 'Registration', 'Download Cartool', and 'Visit the Cartool Community group for more fun'. The Windows taskbar at the bottom shows various application icons and the system clock indicating 10:11 on 17/04/2014.

Firefox Cartool Software - Functional Brain Map... +

https://sites.google.com/site/fbmlab/cartool

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FUNCTIONAL BRAIN MAPPING LABORATORY Functional Brain Mapping Lab

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Cartool Software

Important news about Cartool registration

- We have a new [Cartool Community](#) website, which holds the FAQs, User's Guide, Discussions etc... which replaces the old [Cartool Google Group](#) (still accessible, but only for the Discussions).
- Registering to Cartool is now a single step of [registering to the Cartool Community](#), which ties together the agreement to use Cartool and the registration to the Cartool Community group.
- Due to this new scheme, **we have to ask all the previously registered users of Cartool to go through the new registration process again**. This way, we start with a clean setup for all of us, and I can also update the list of the registered users at the same time. Sorry for this little boring administrative work, that's once in a many years task to do...

Cartool is our home-made **EEG analysis software**, a project started in 1996. This program has been fully programmed by Denis Brunet, and it evolves thanks to the valuable comments of numerous people (we can not cite all of them here!).

- [What is Cartool](#)
- [Cartool installation check-list](#)
- [Registration](#)
- [Download Cartool](#) (once registered)
- Visit the [Cartool Community](#) group for more fun

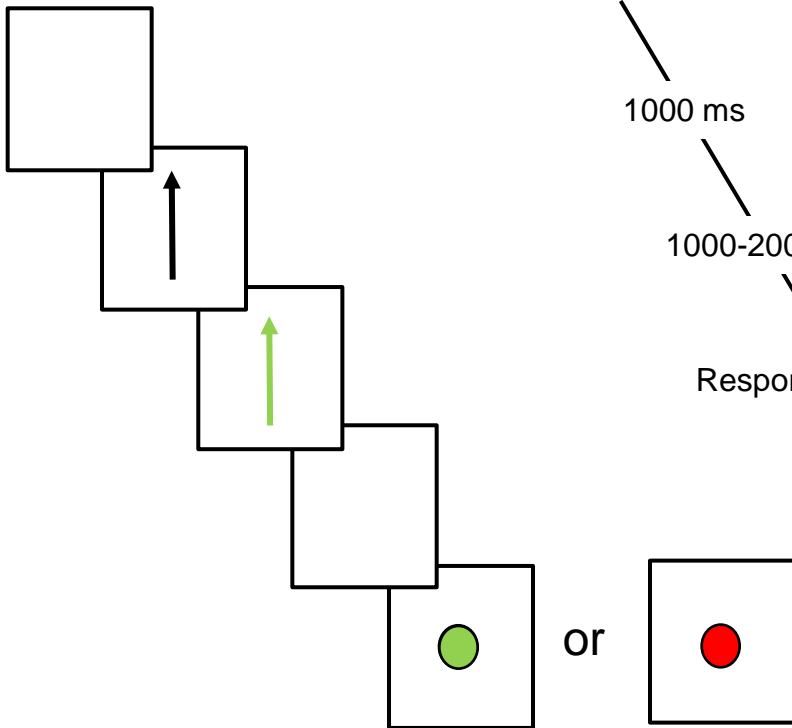
Vertalen

NL 10:11 17/04/2014

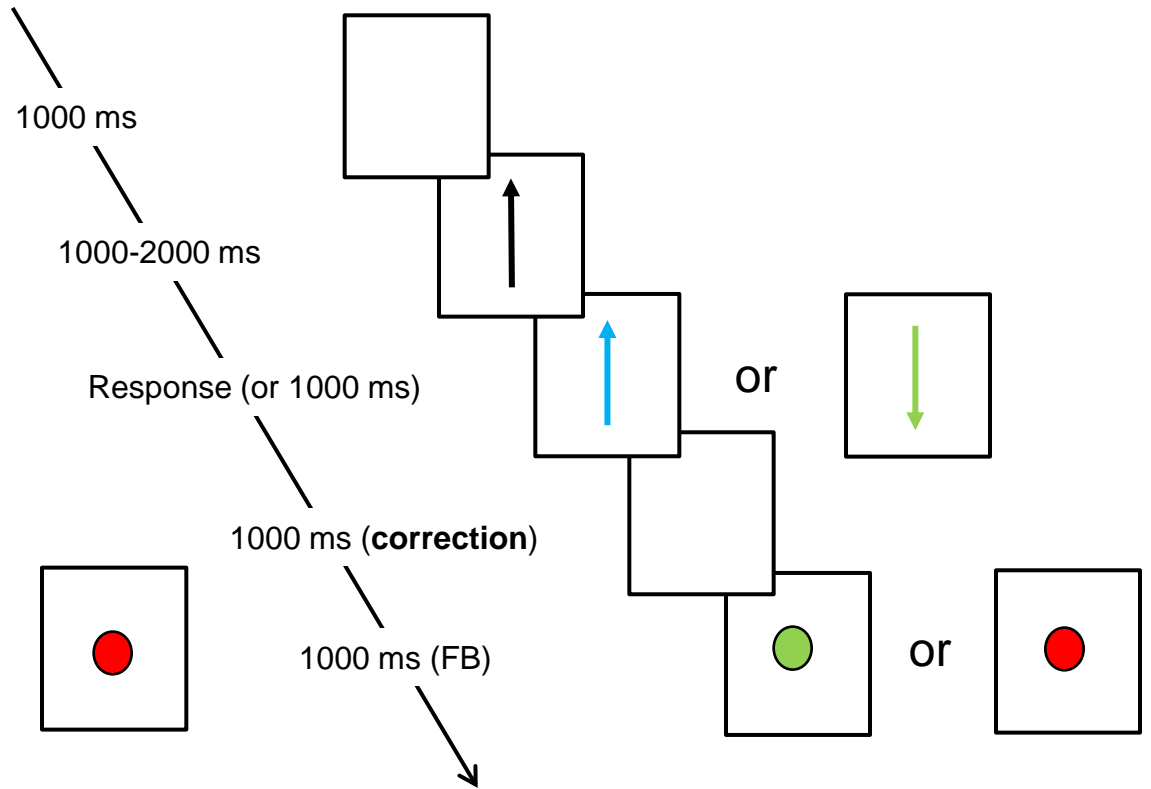
One example/application

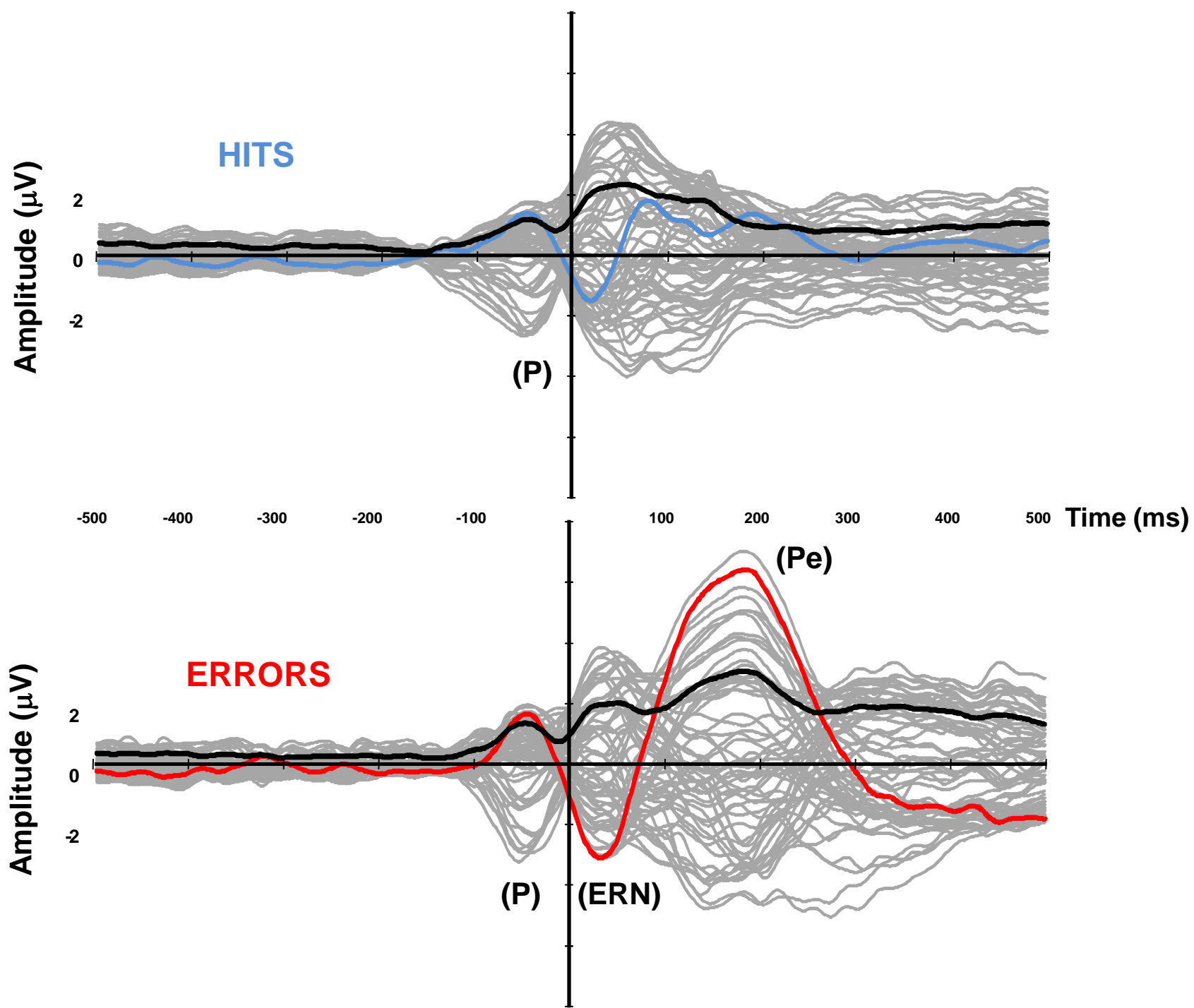
Go-NoGo task (color + orientation discrimination)

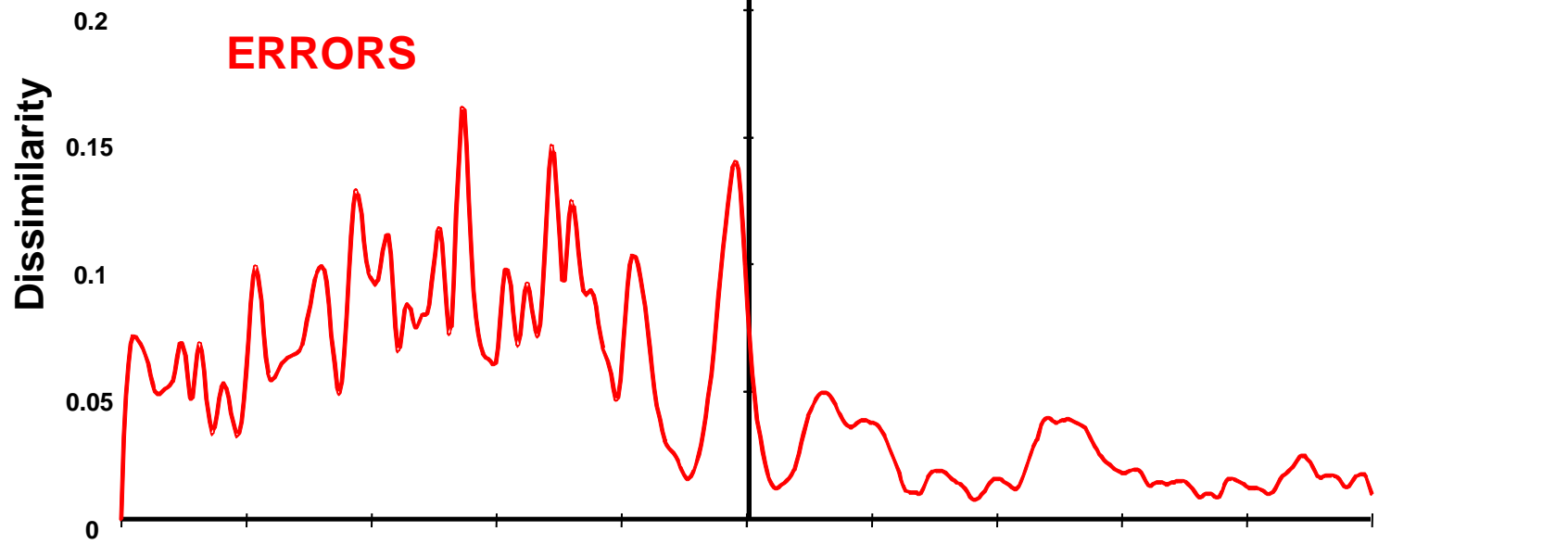
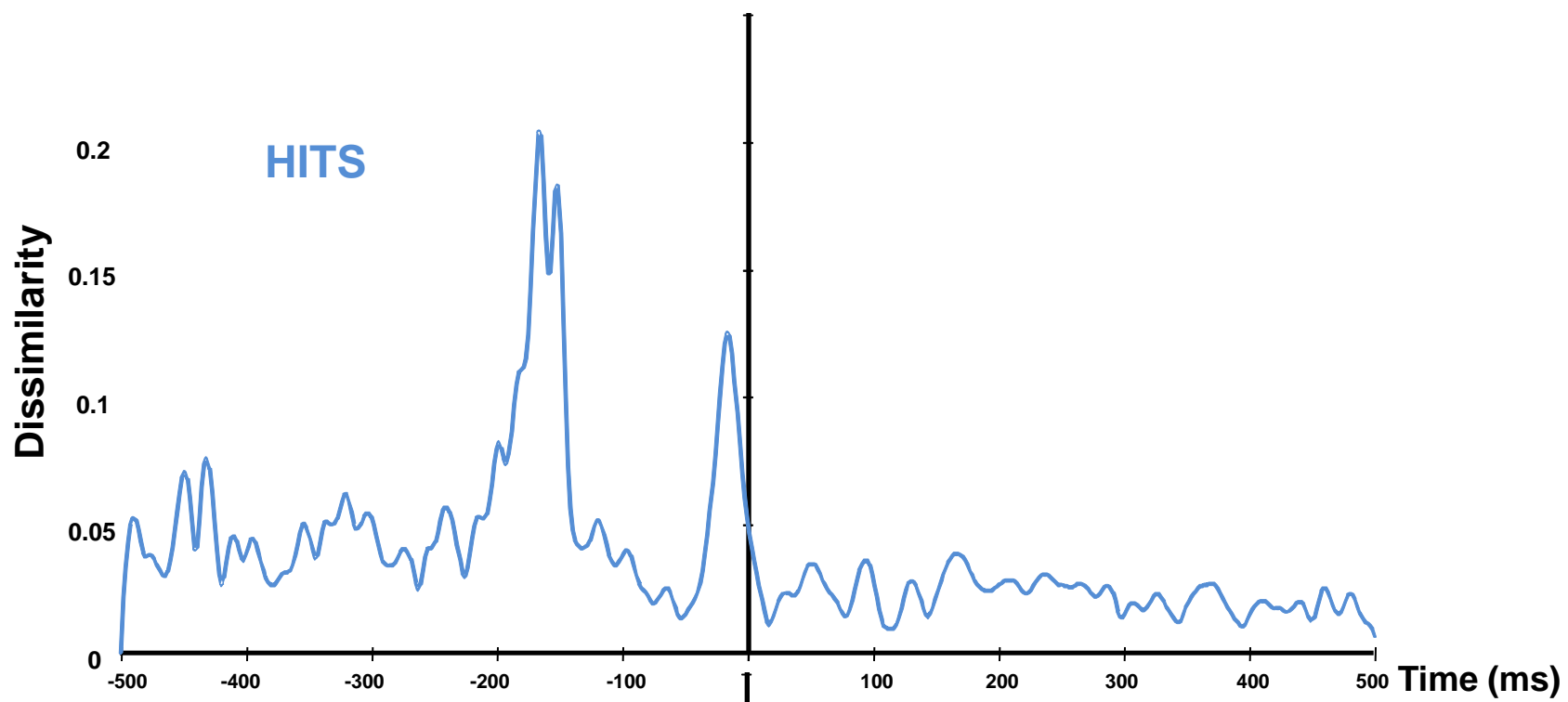
Go trial (2/3)



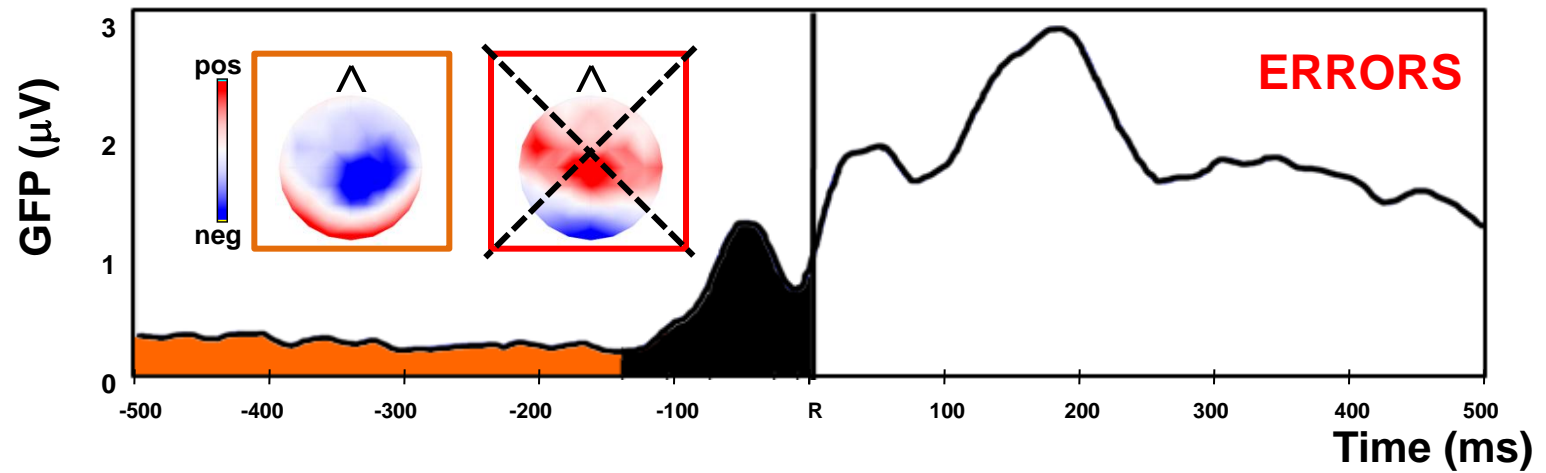
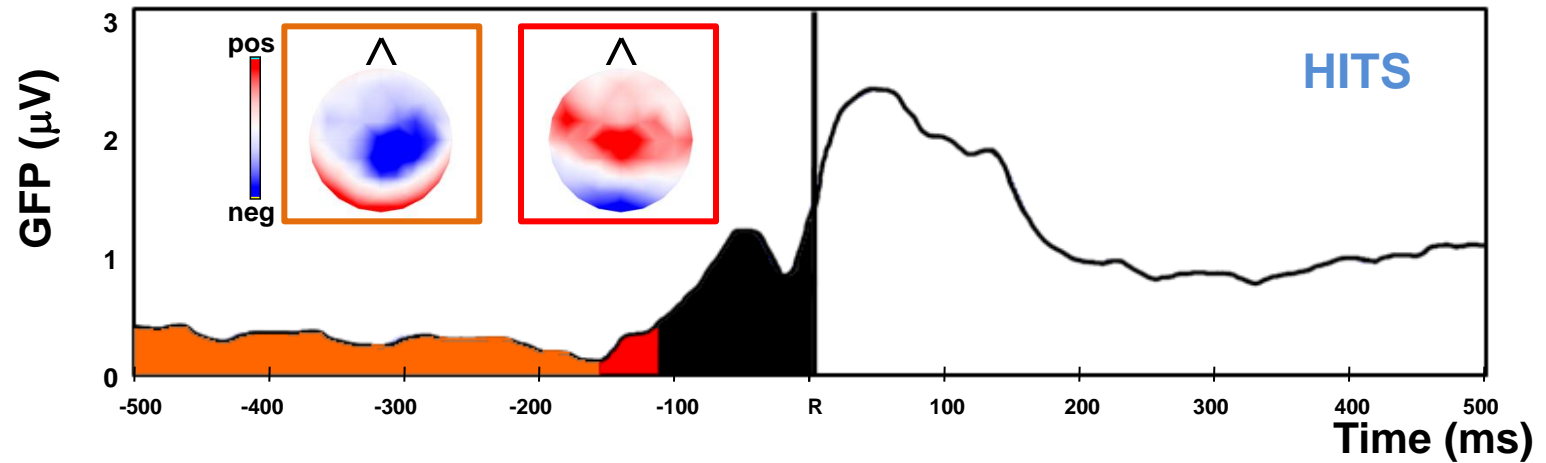
NoGo trial (1/3)

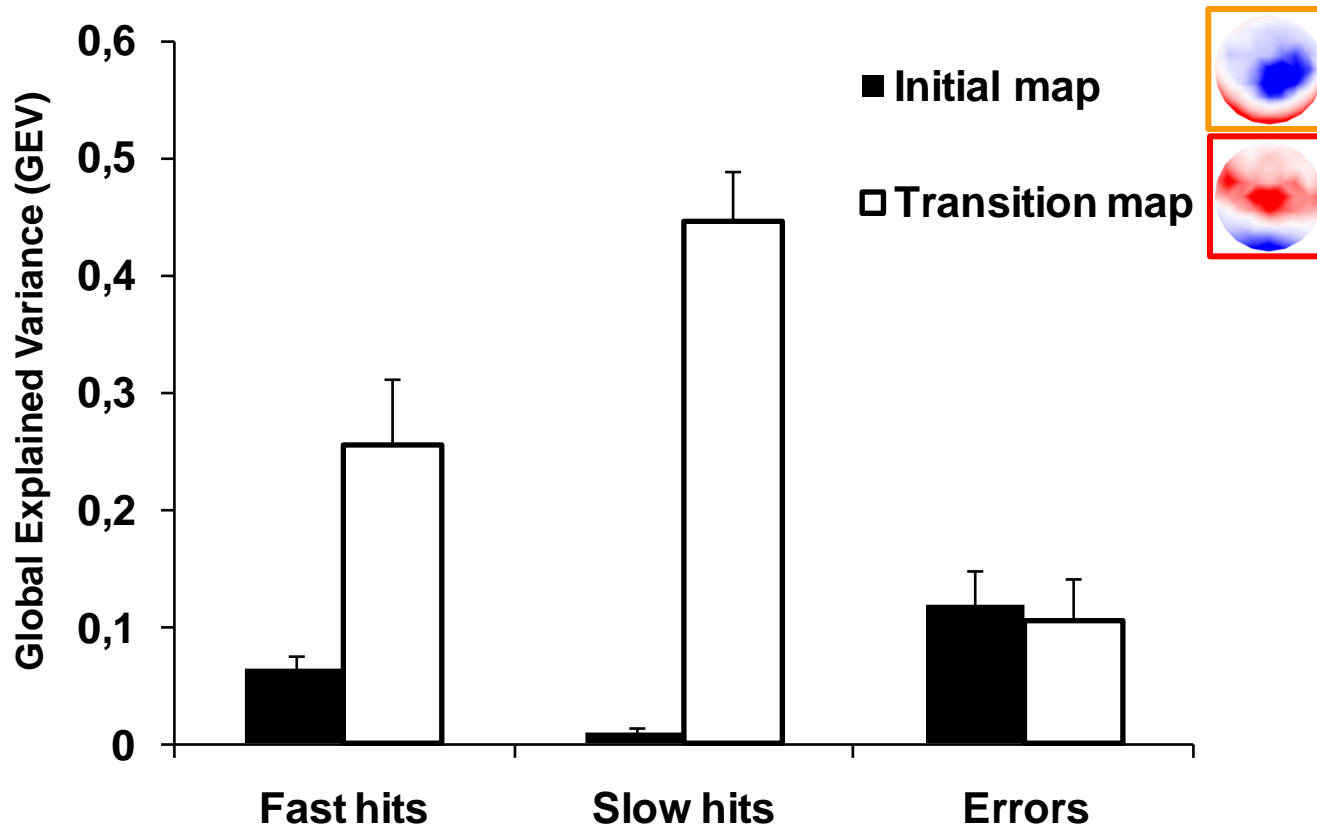




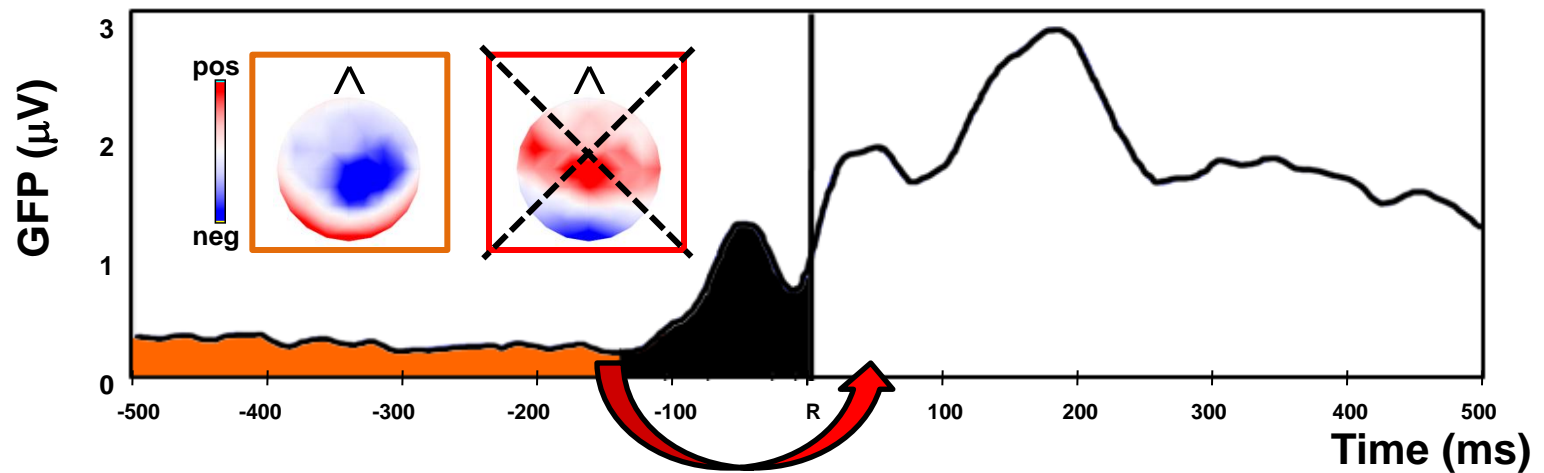
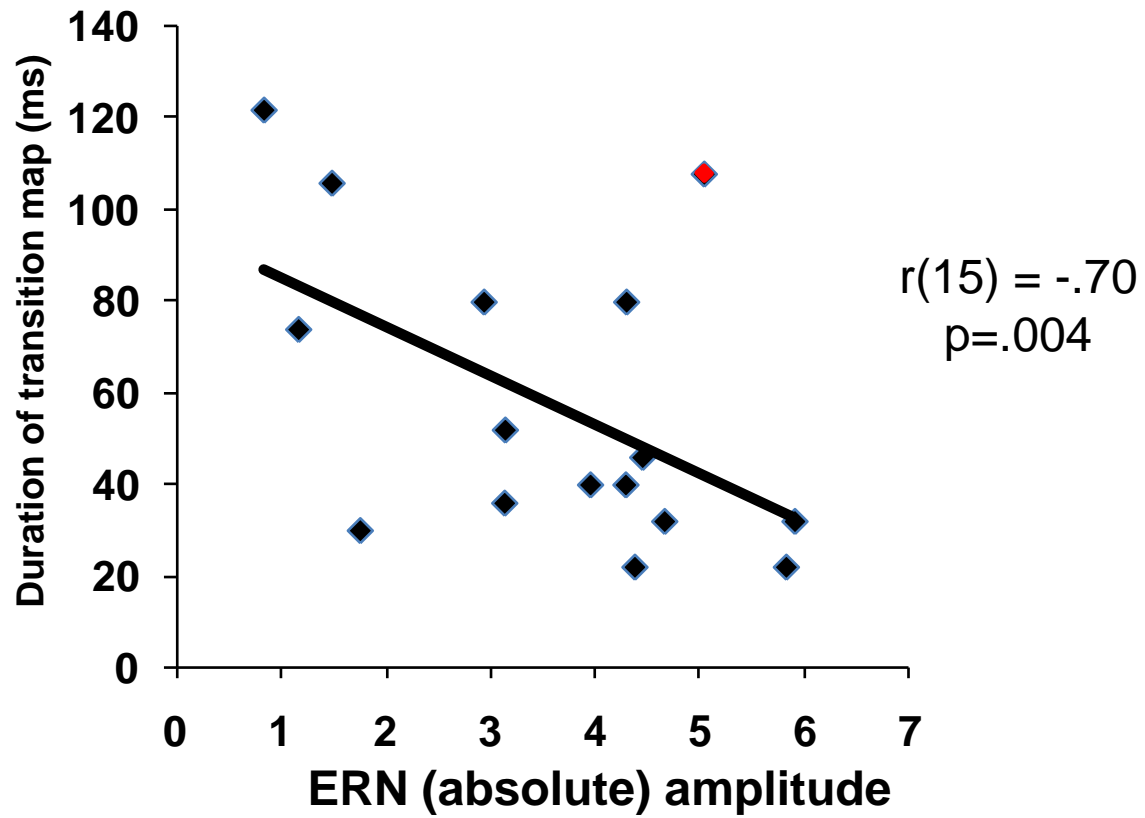


Topographic pattern analysis

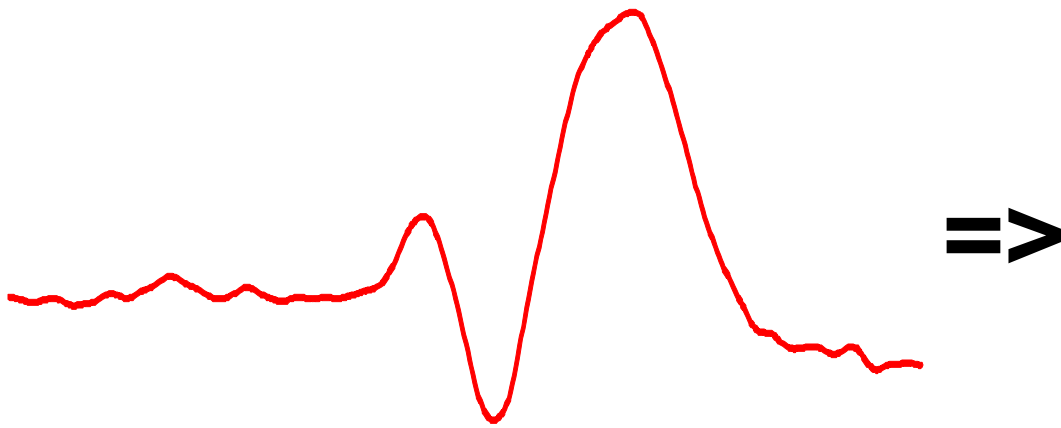




Map x Condition interaction; $F(2,30) = 27.58, p < .001$



Conclusions



\Rightarrow



Thank you for your attention!

Question?

=> Email me: gilles.pourtois@ugent.be