

Time/Frequency Analysis of Electrophysiological Data



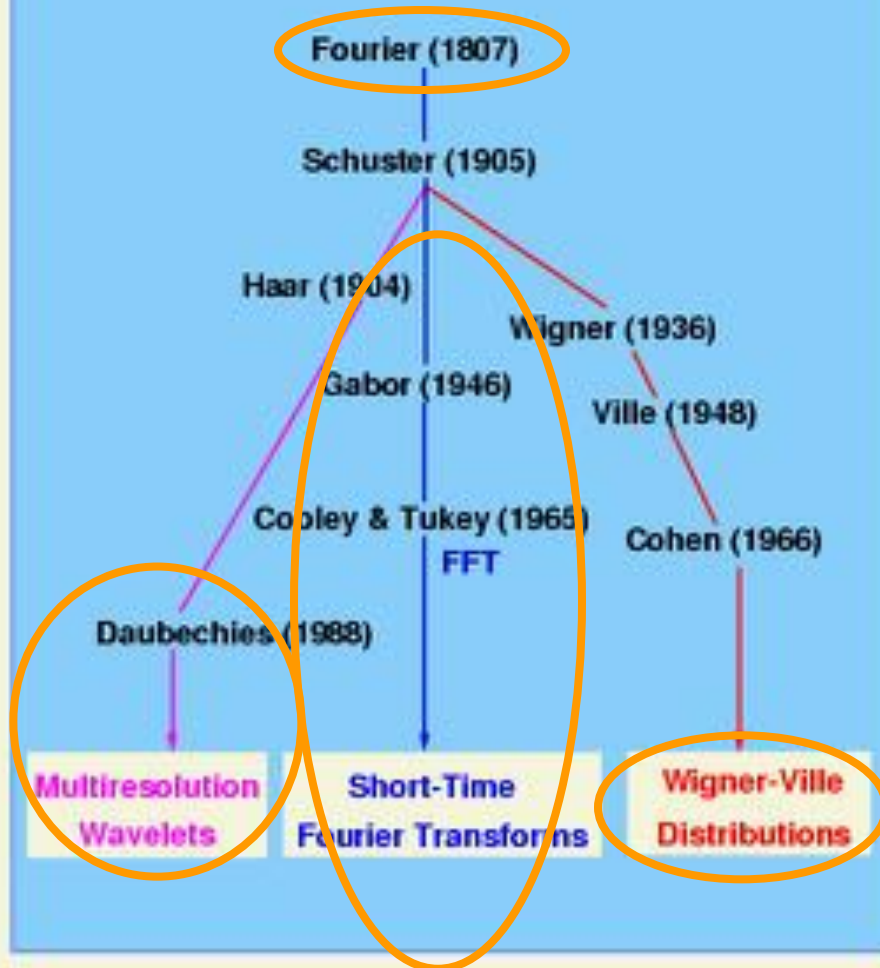
Scott Makeig

Institute for Neural Computation
University of California San Diego

27th EEGLAB Workshop
Pittsburgh, Pennsylvania

September, 2018

Time-Frequency Analysis

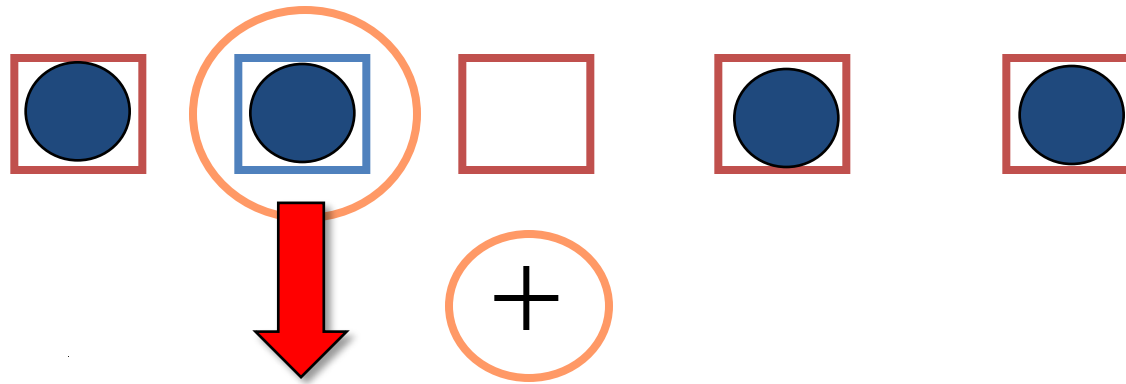


Event-related spectral perturbation (ERSP)

- Significant **consistency of local power** of a physiological waveform **across successive trials**.

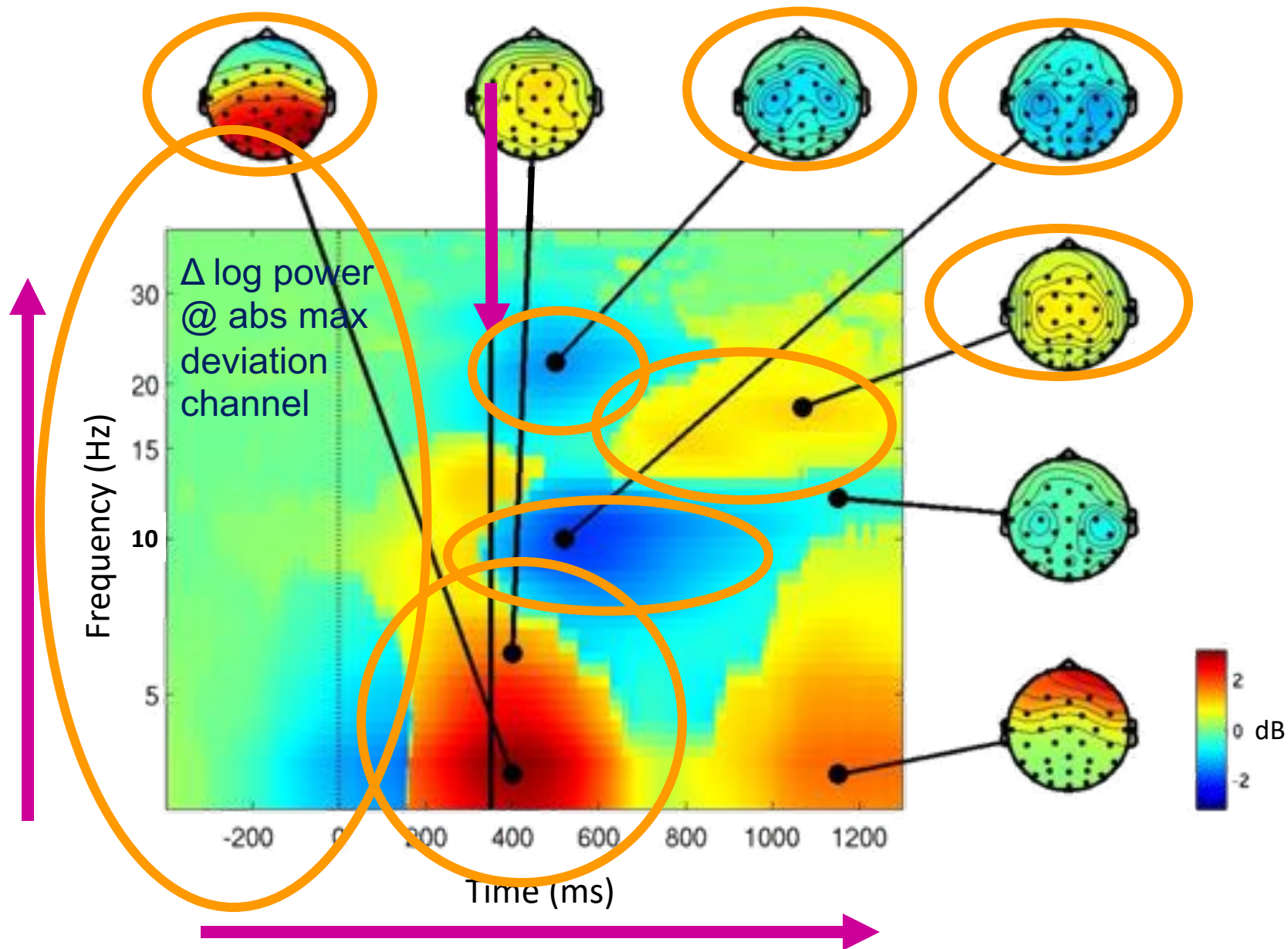


Visual Selective Attention Task

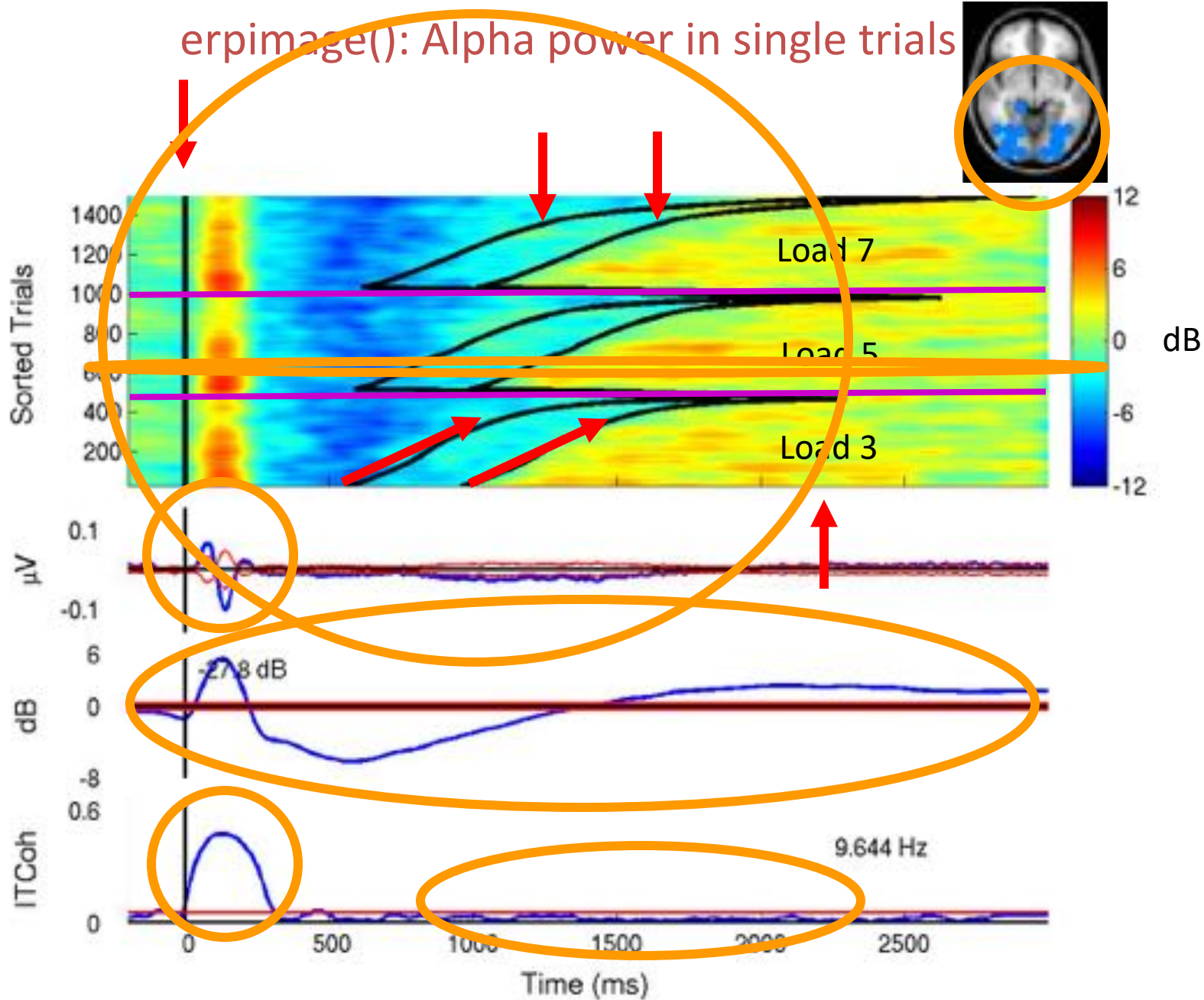


15 subjects

Event-Related Spectral Perturbation (ERSP)



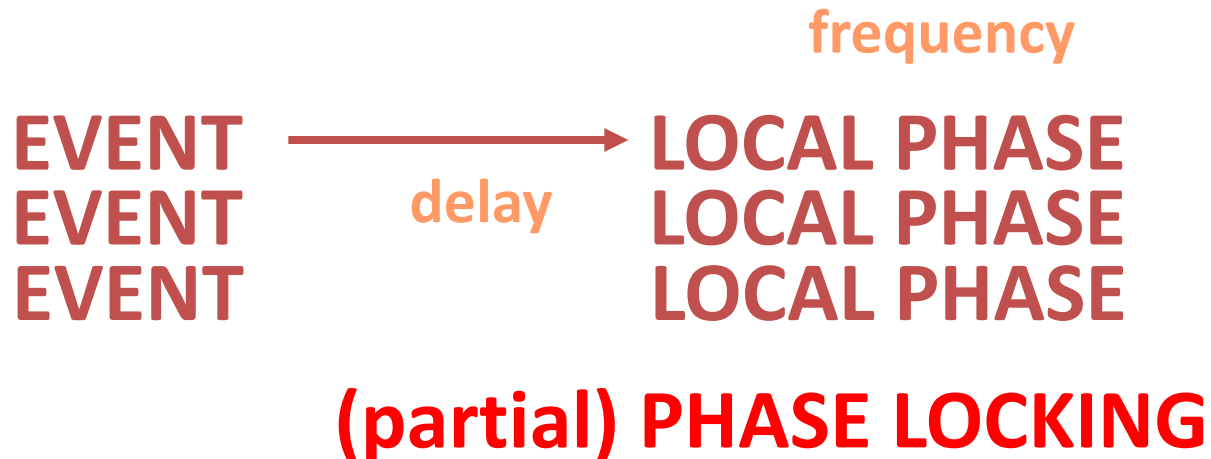
erpimage(): Alpha power in single trials



Inter-trial Coherence (ITC)

(“phase-locking factor”)

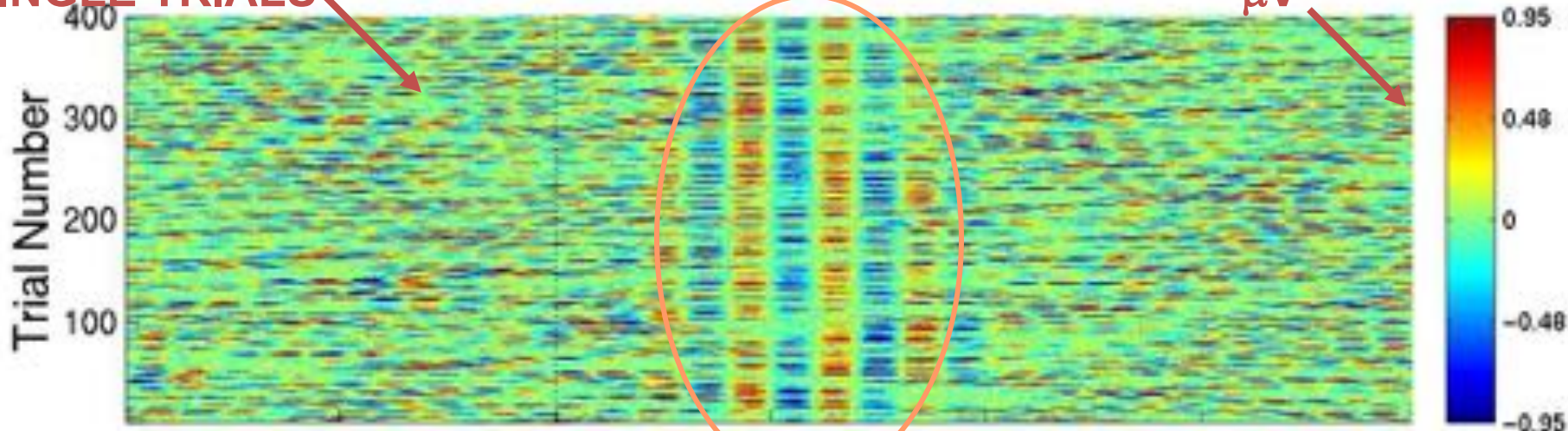
- Significant consistency of **local phase** of a physiological waveform across successive trials.



SINGLE TRIALS

ERP-IMAGE PLOT

μV



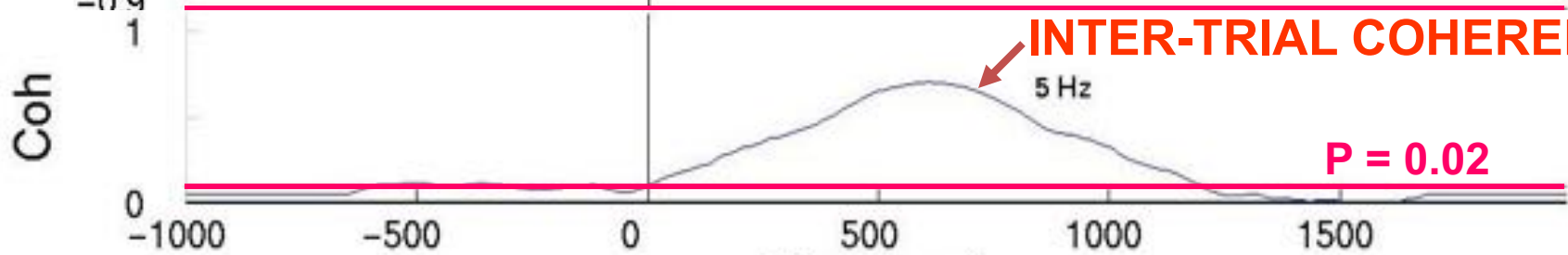
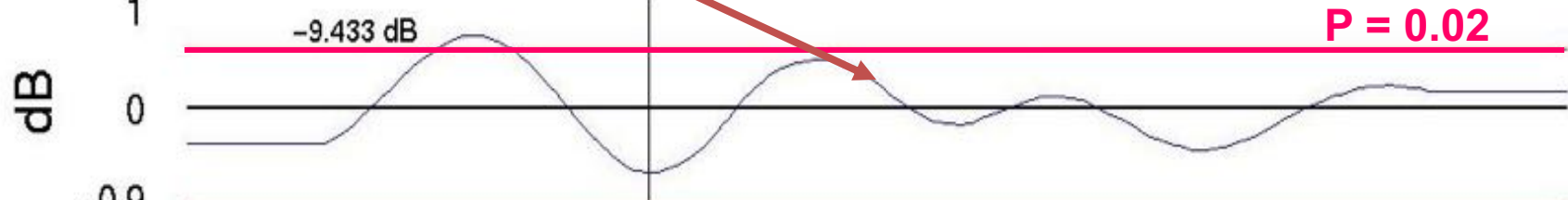
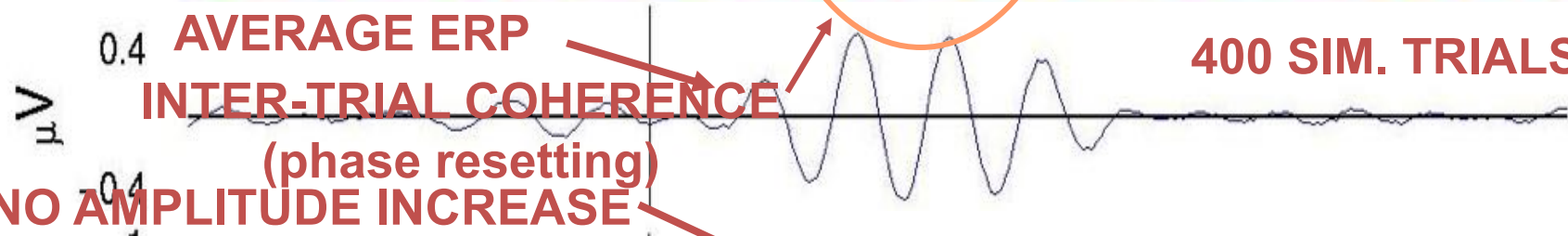
AVERAGE ERP

400 SIM. TRIALS ...

INTER-TRIAL COHERENCE

(phase resetting)

NO AMPLITUDE INCREASE

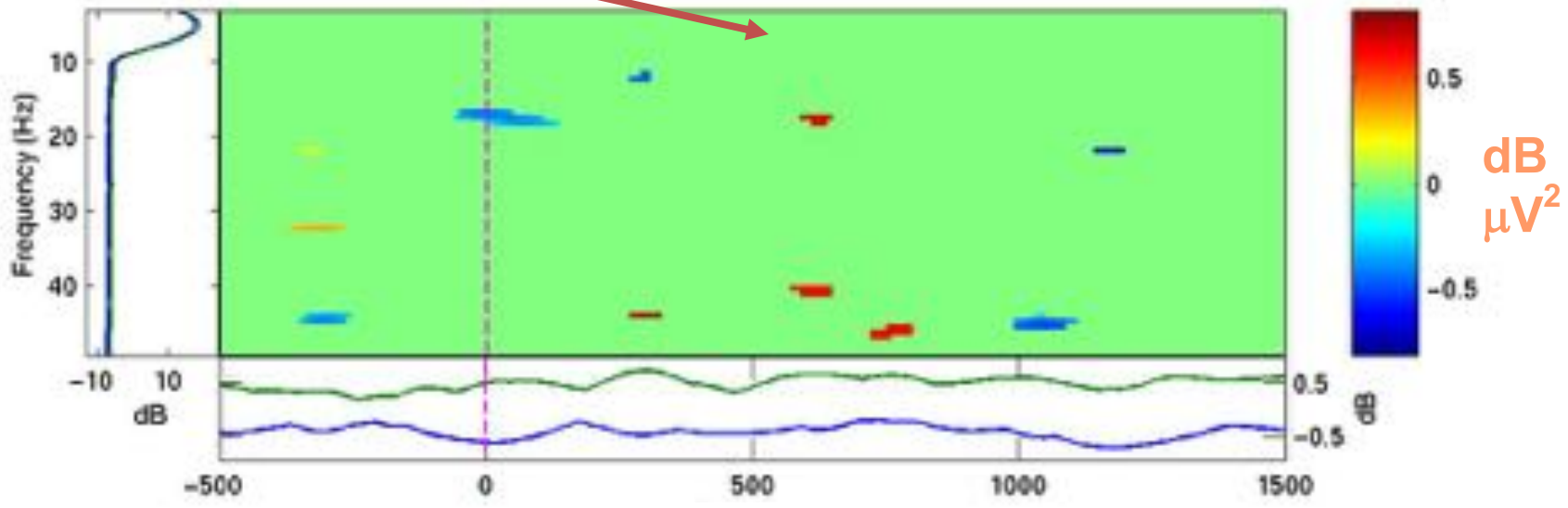


INTER-TRIAL COHERENCE

Time (ms)

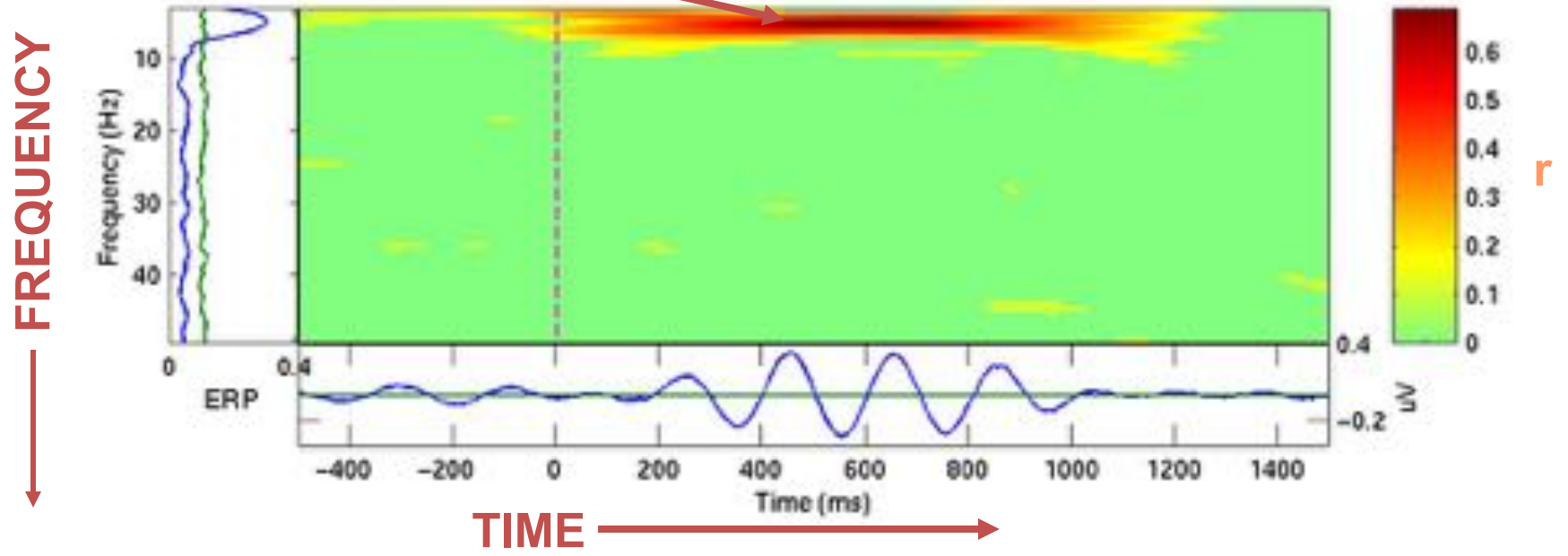
NO AMPLITUDE INCREASE

ERSP

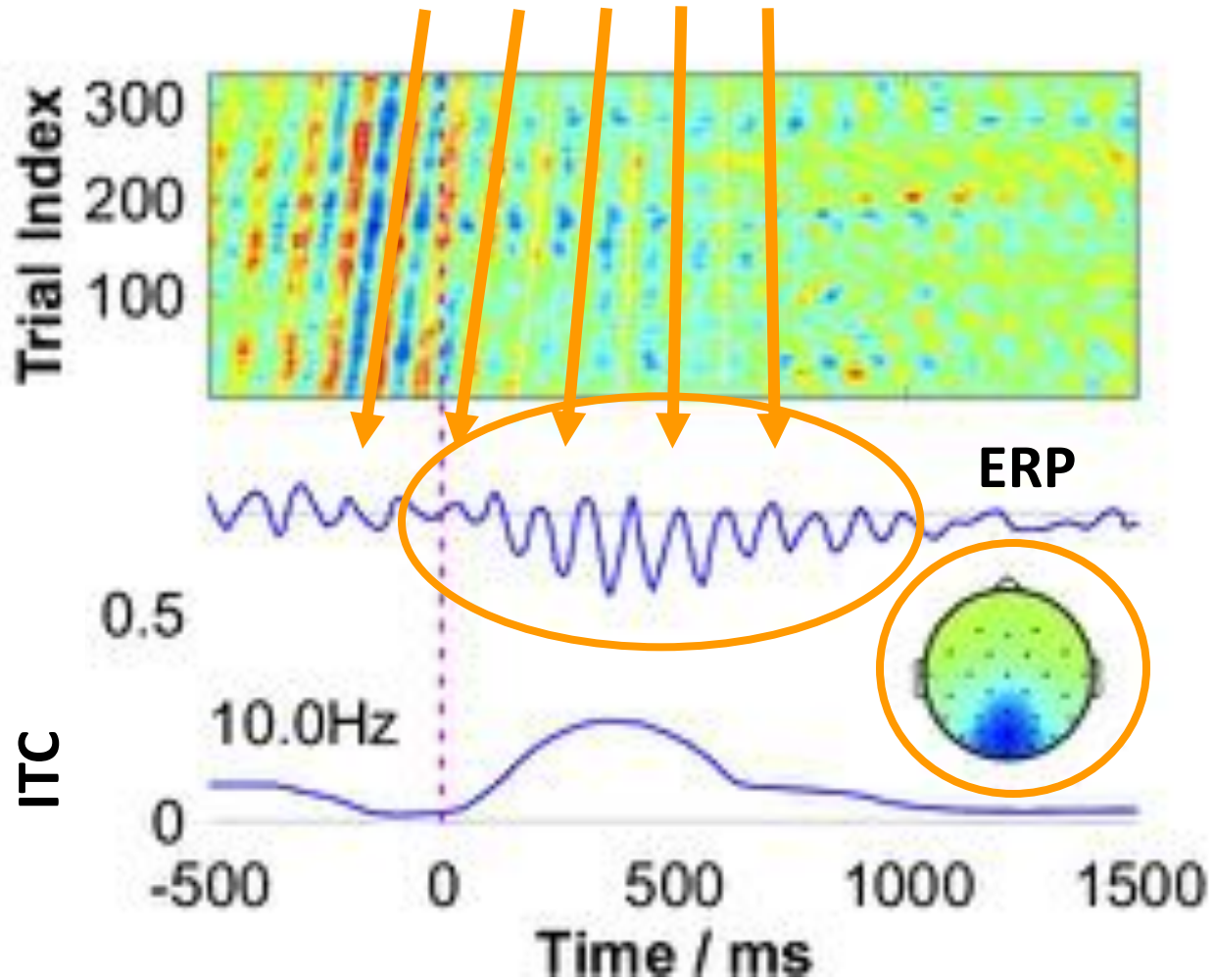


PHASE LOCKING

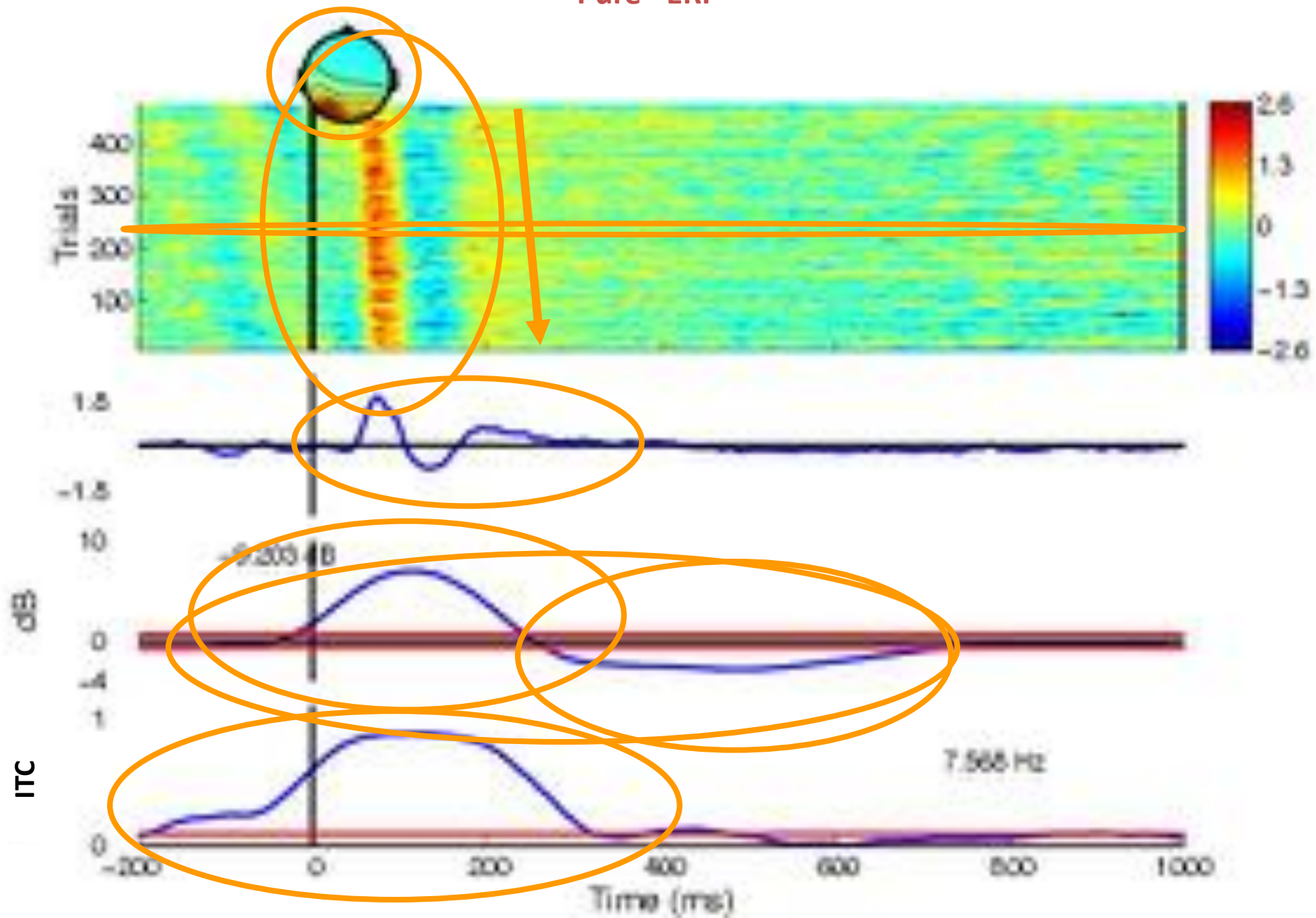
ITC

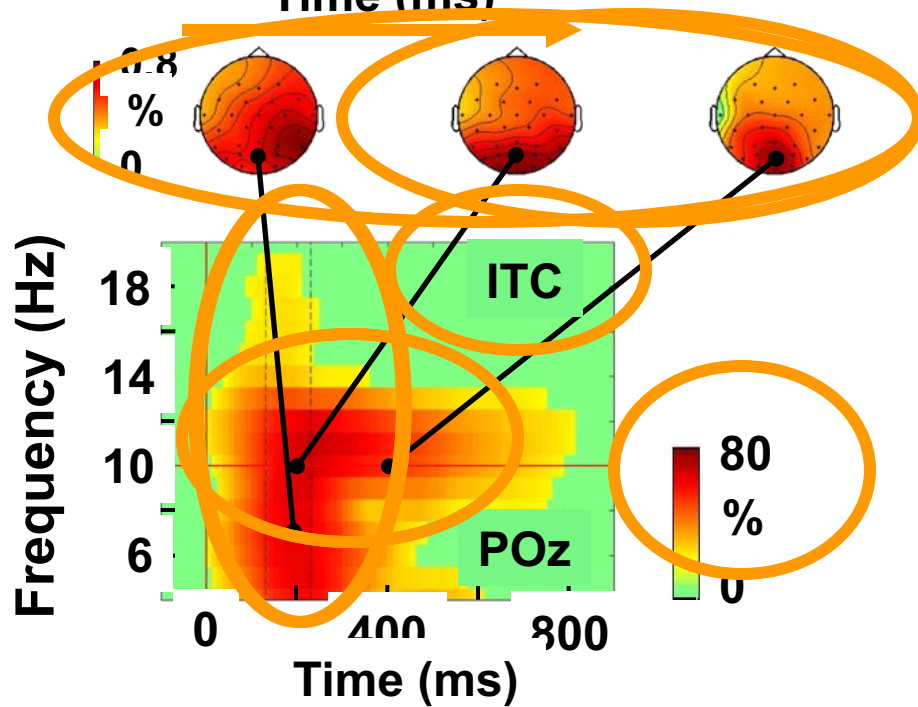
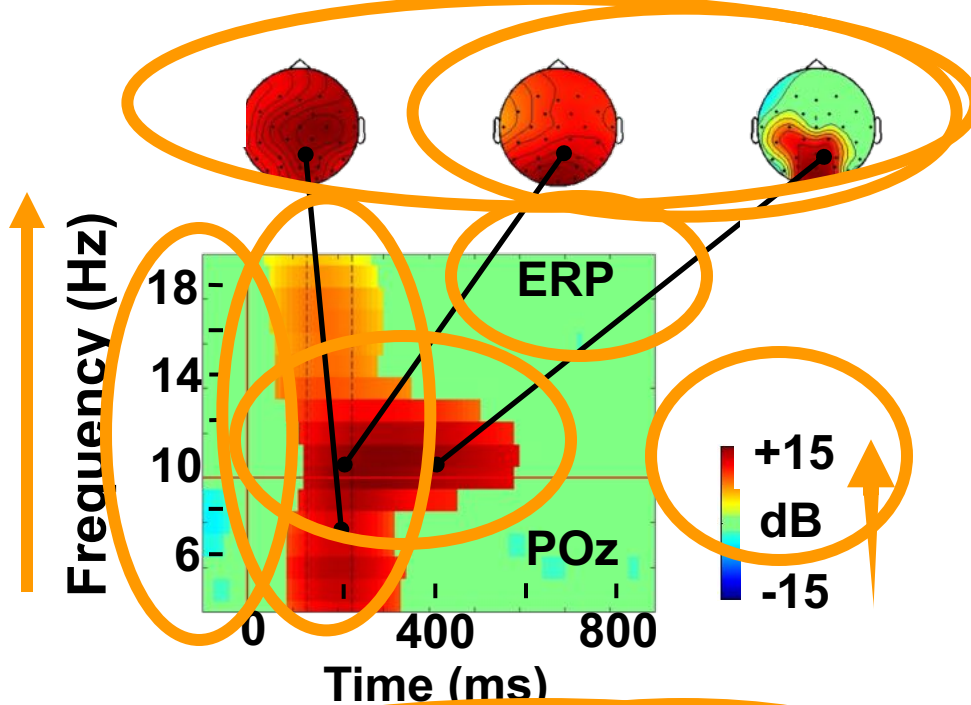


“True” PPR (visual ‘alpha ringing’)



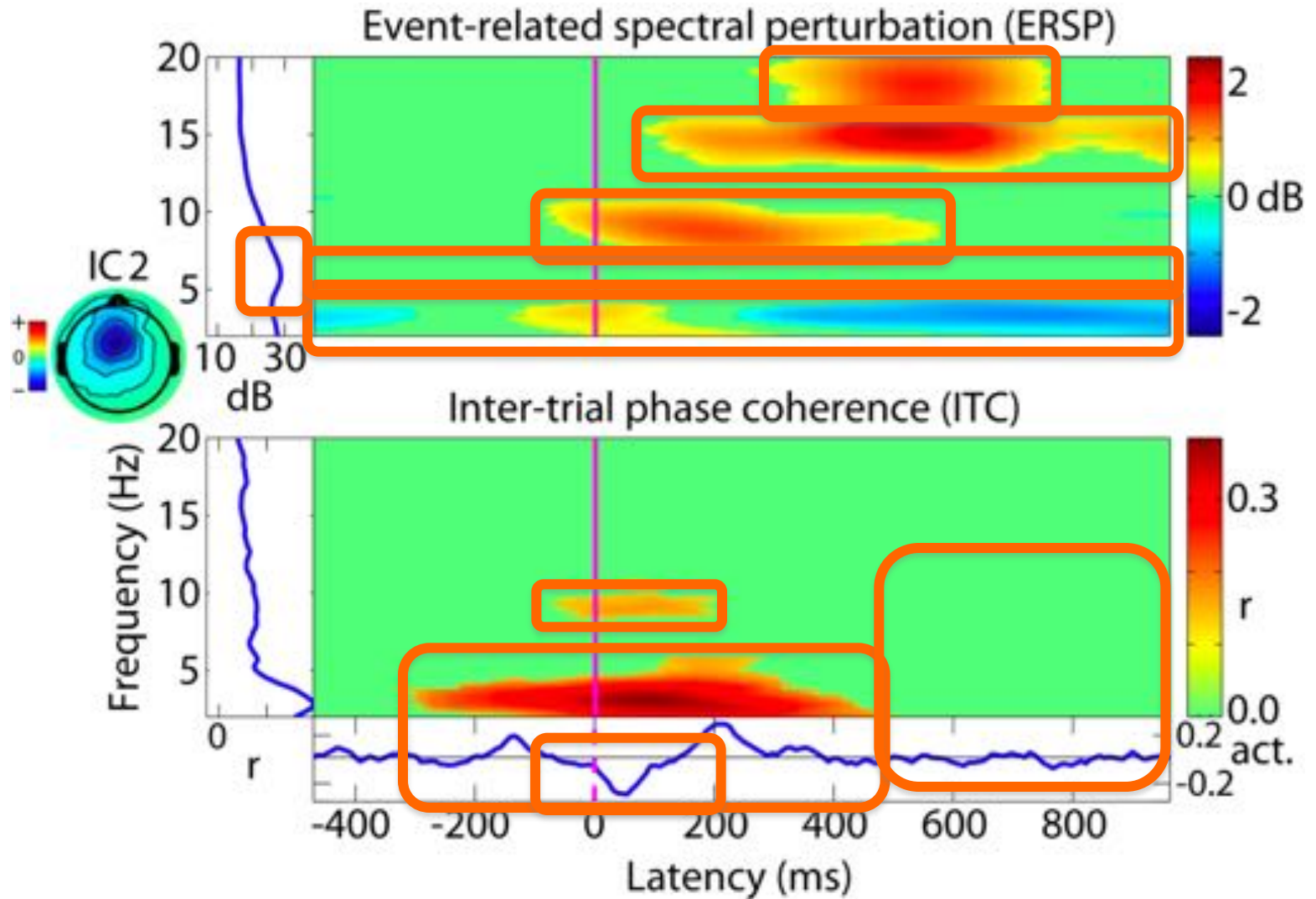
Pure ERP



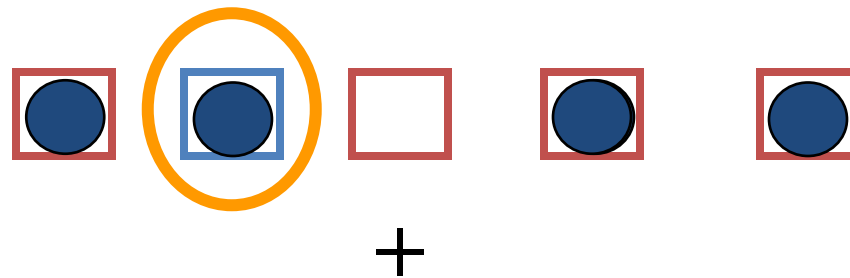


**Trial-to-trial
event-related
phase consistency
produces the ERP**

Independent Component ERSP



Visual Selective Attention Task

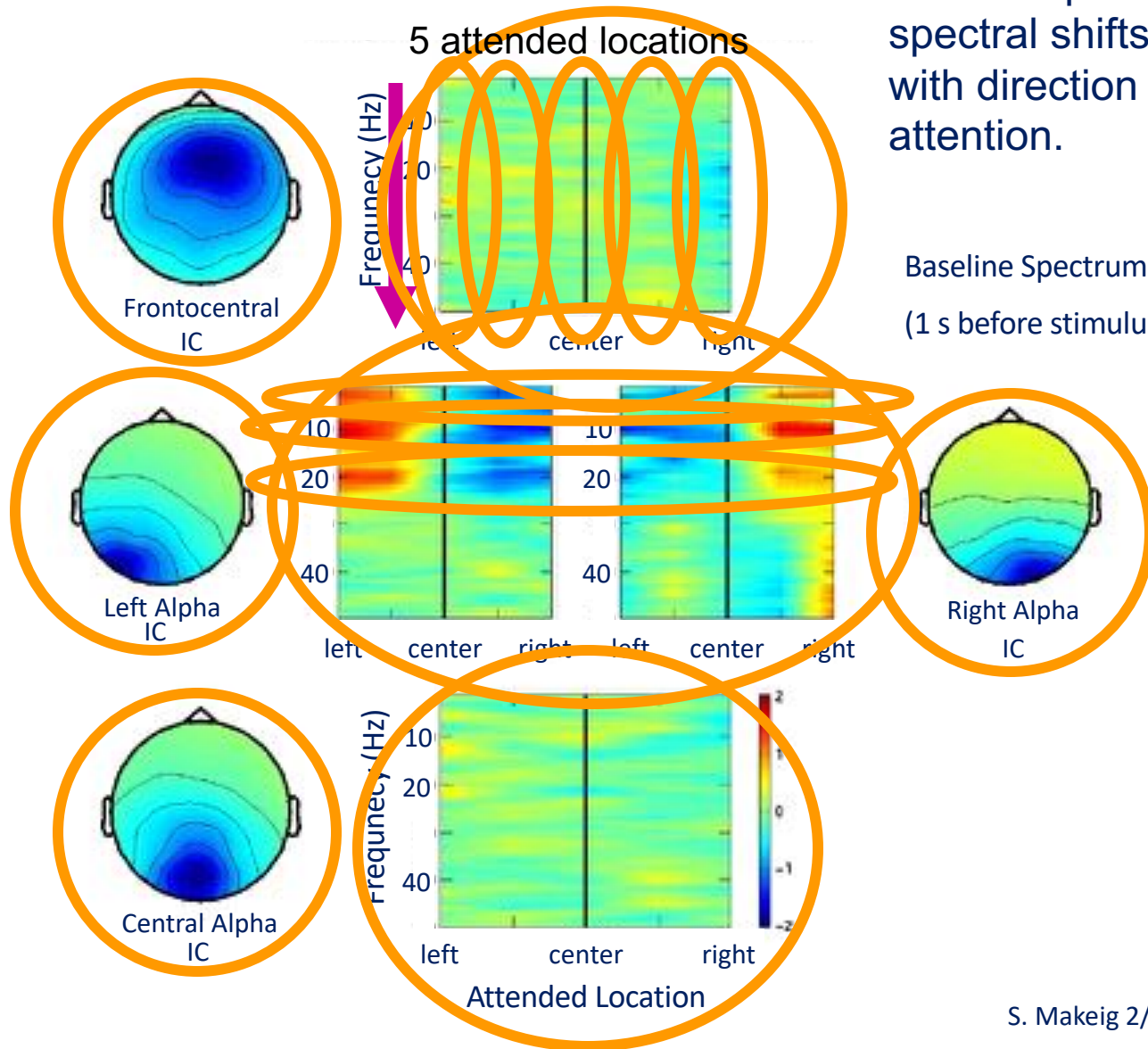


15 subjects

31 channels

Westerfield & Townsend

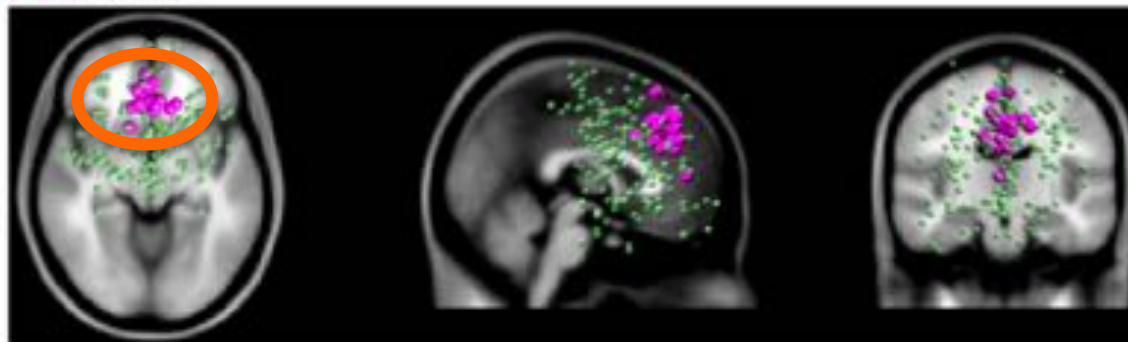
Baseline power spectral shifts with direction of attention.



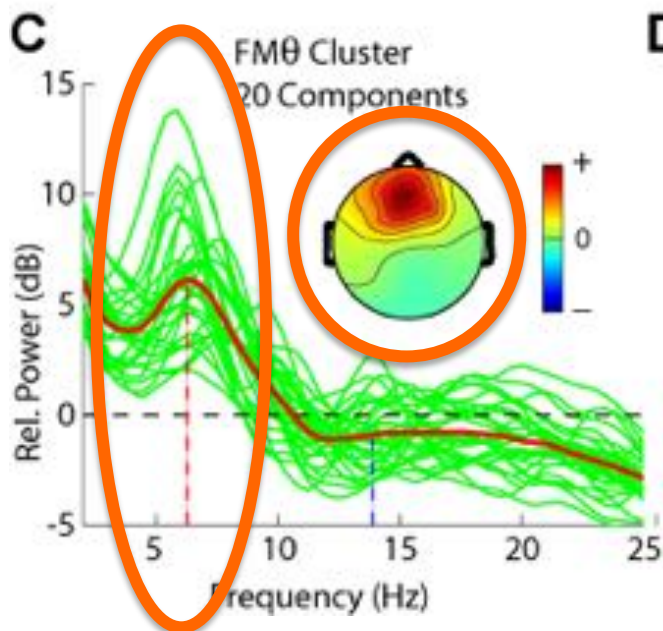
Example: frontal midline theta cluster

B

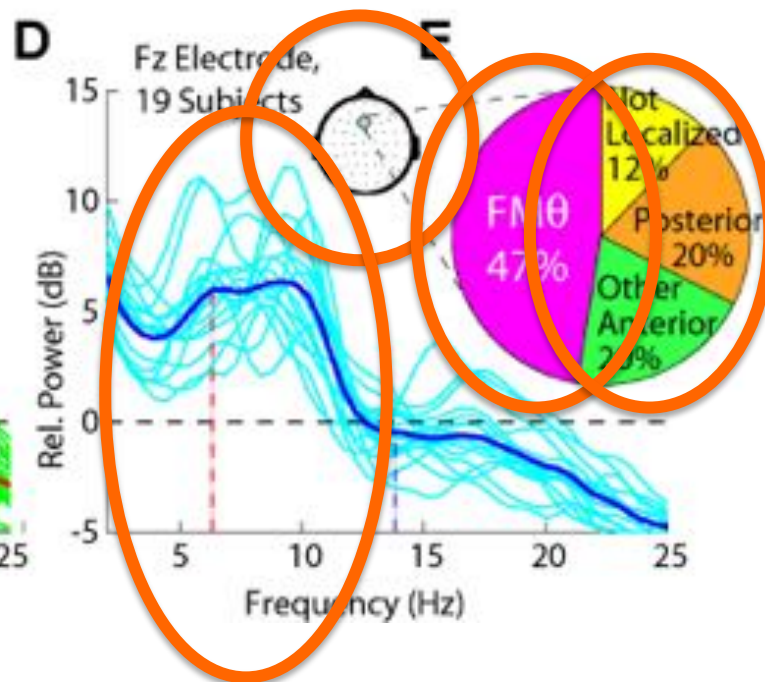
FM θ Cluster

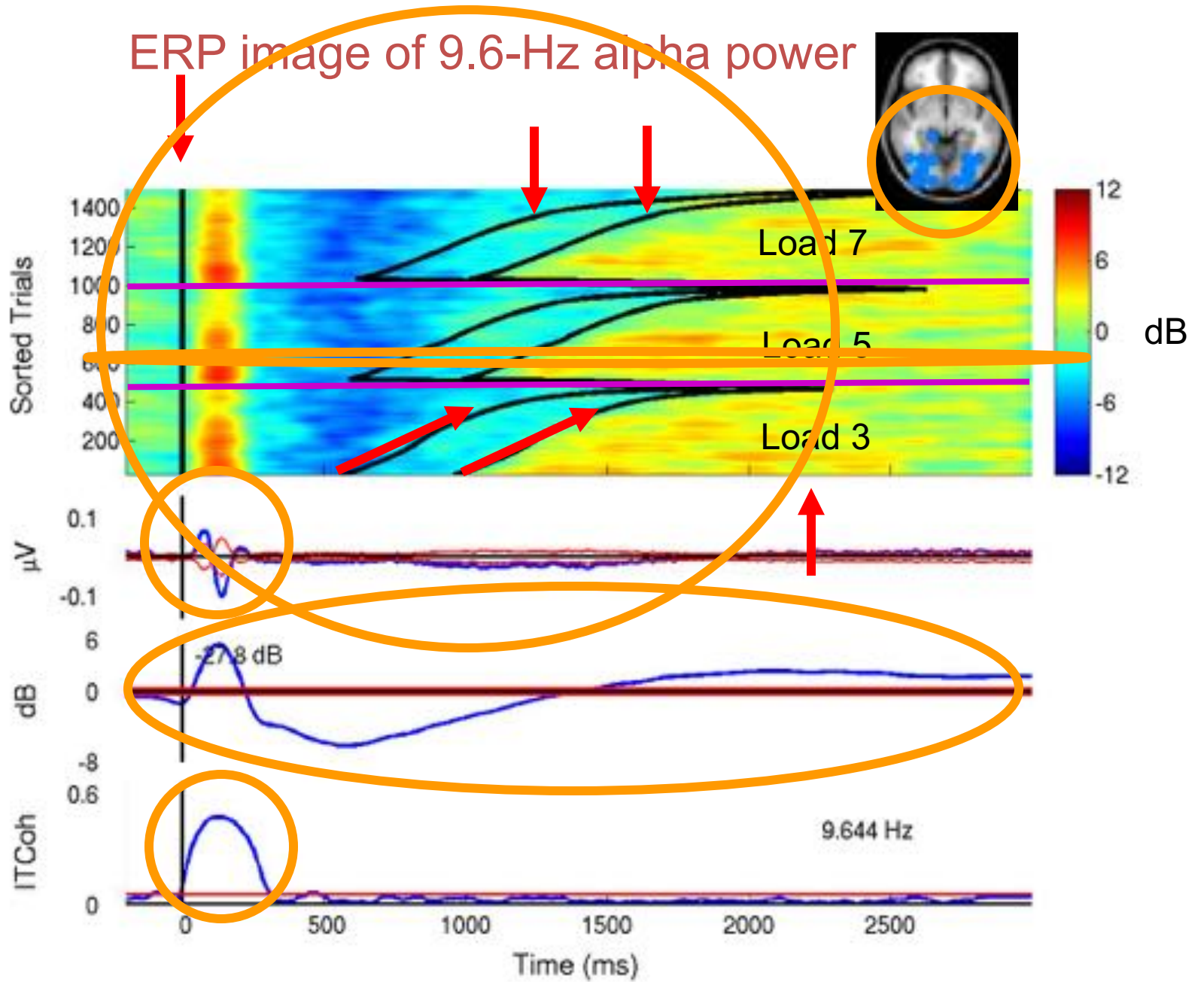


C



D



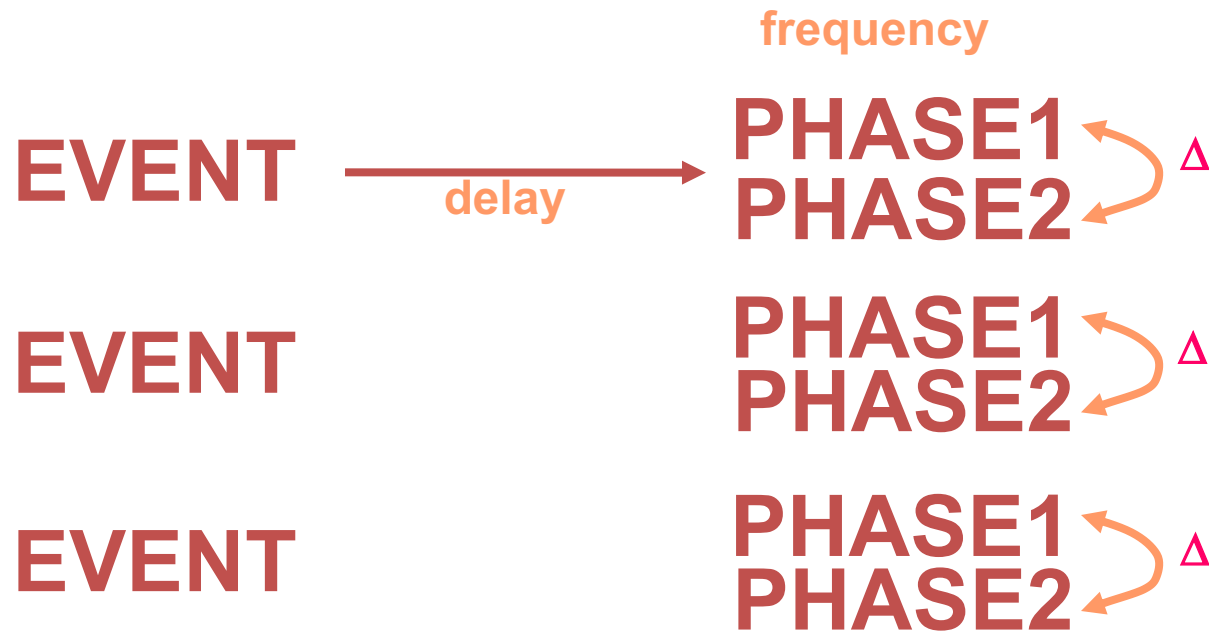


erpimage()

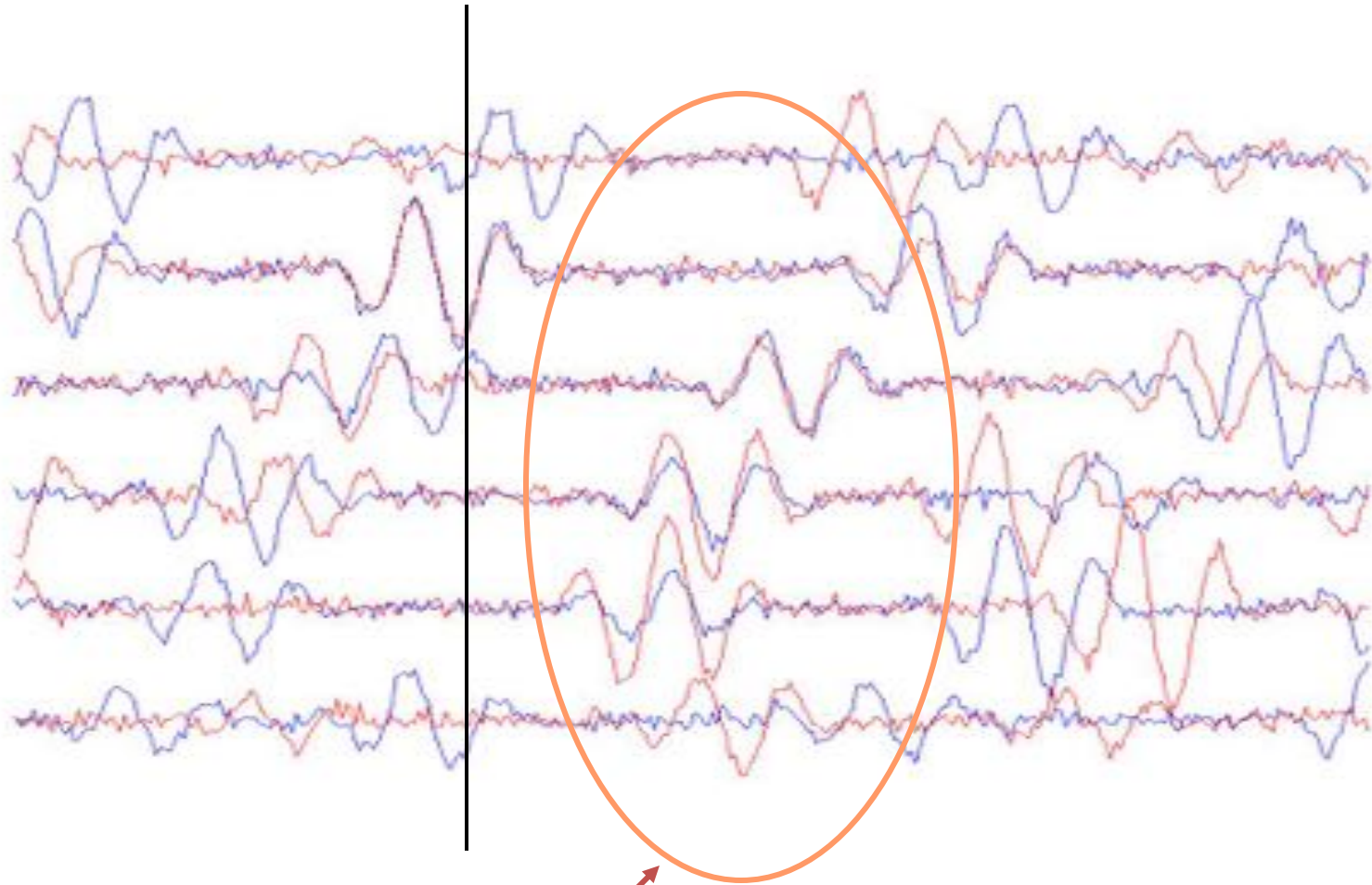
Onton, Delorme & Makeig, 2005.

Event-Related Coherence (ERCOH)

- Significant consistency of **local phase difference** between **two** concurrent physiological waveforms.



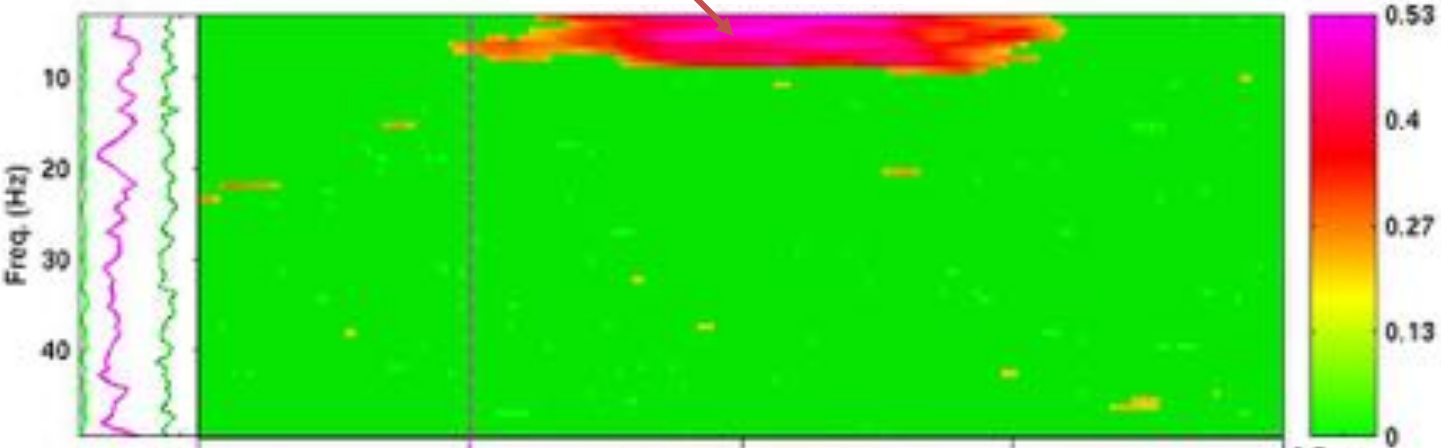
TWO SIMULATED THETA PROCESSES



Event-related Coherence

EVENT-RELATED COHERENCE

ERCOH



COHERENCE LAG

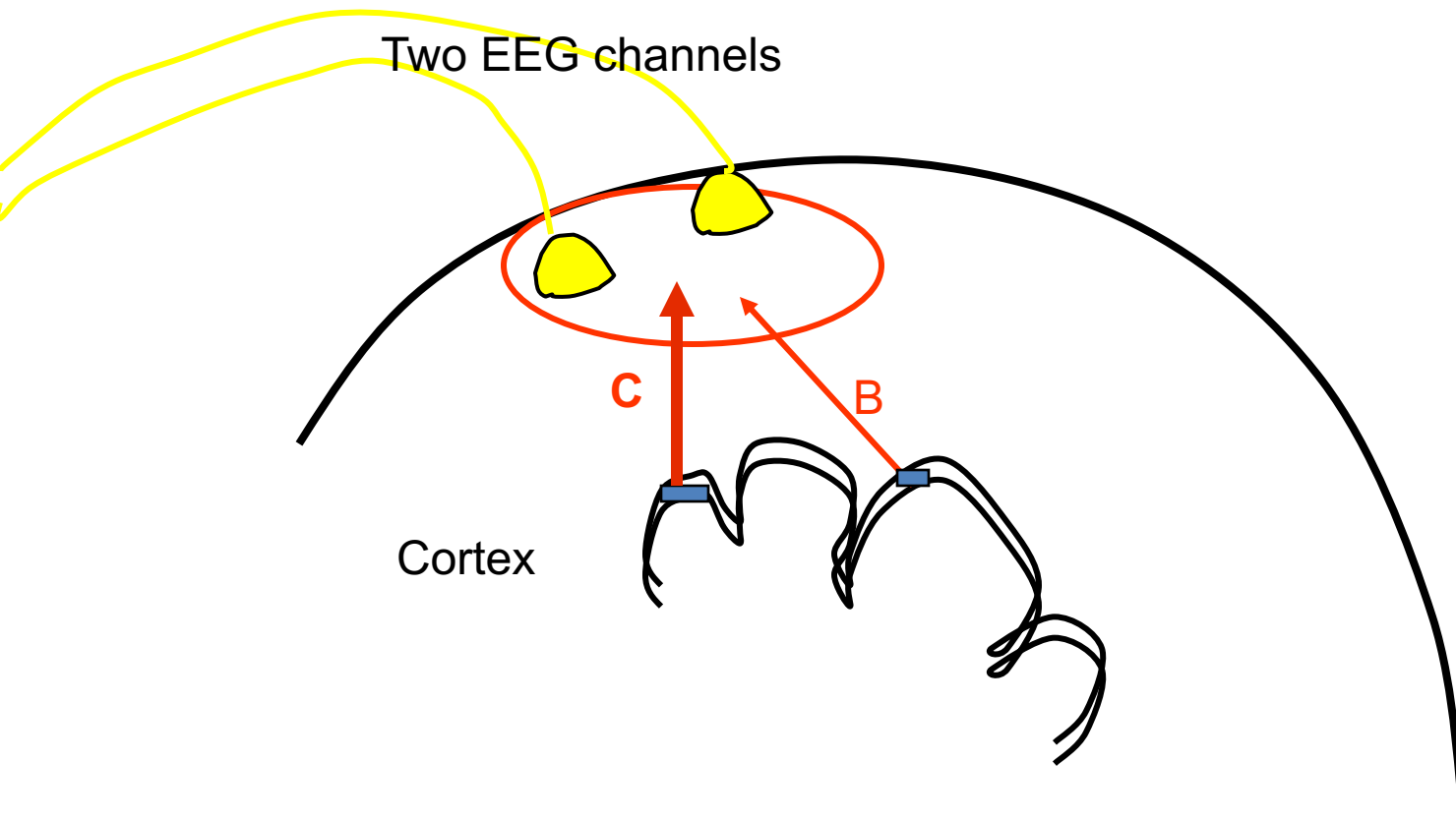


FREQUENCY

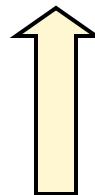
TIME

r

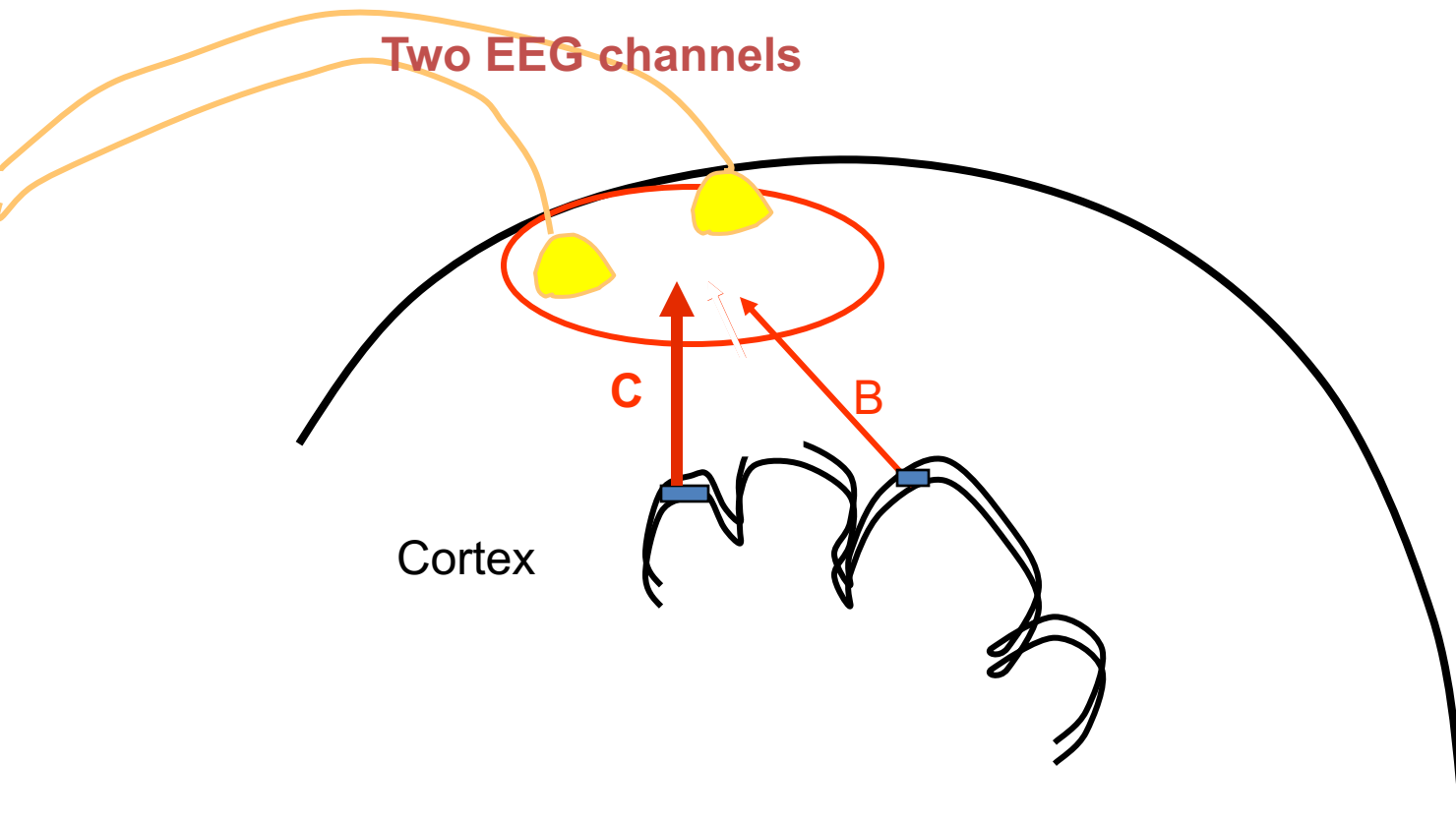
deg



Coherence



Scalp channel coherence → source confounds!

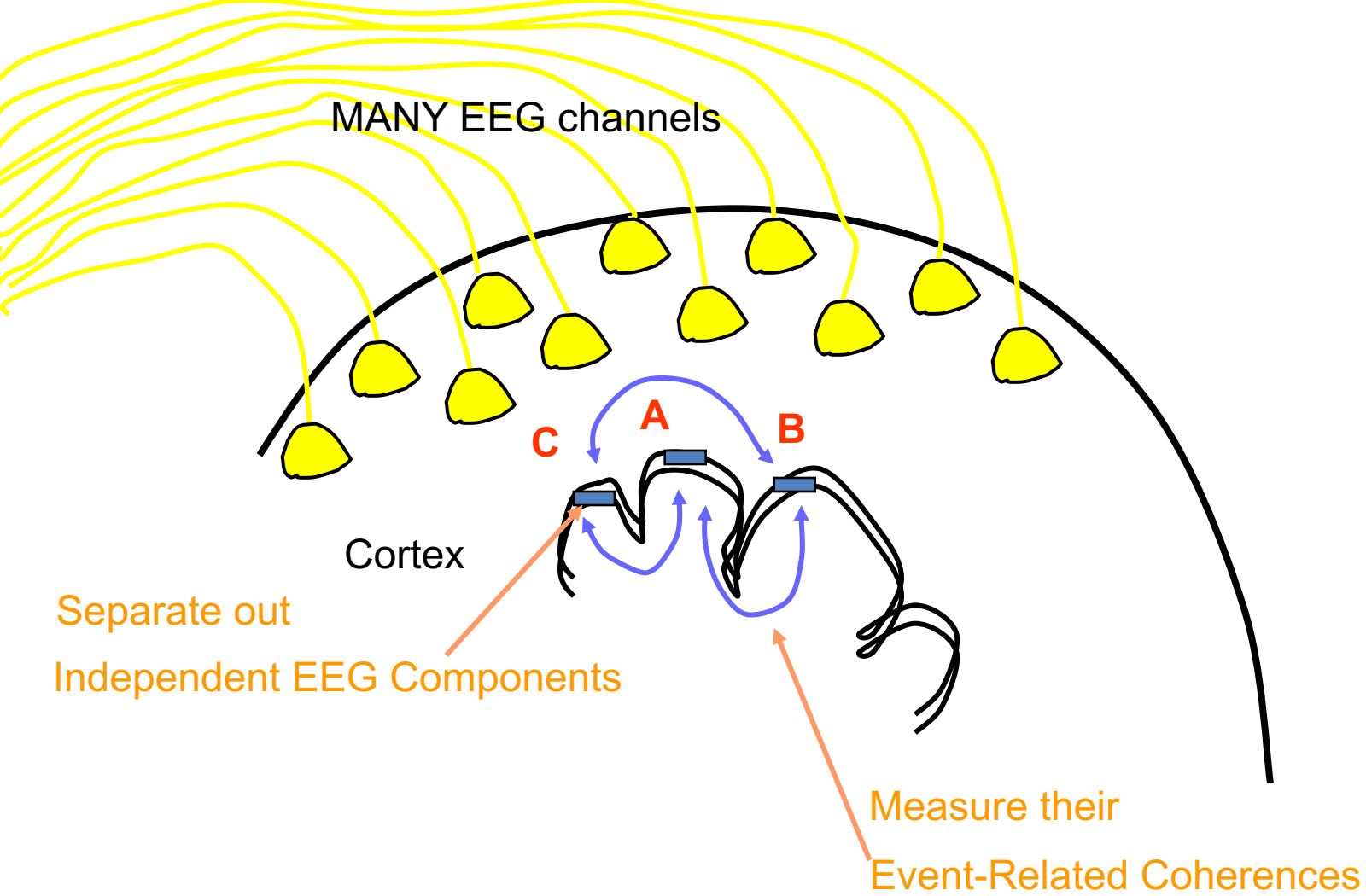


Cortex

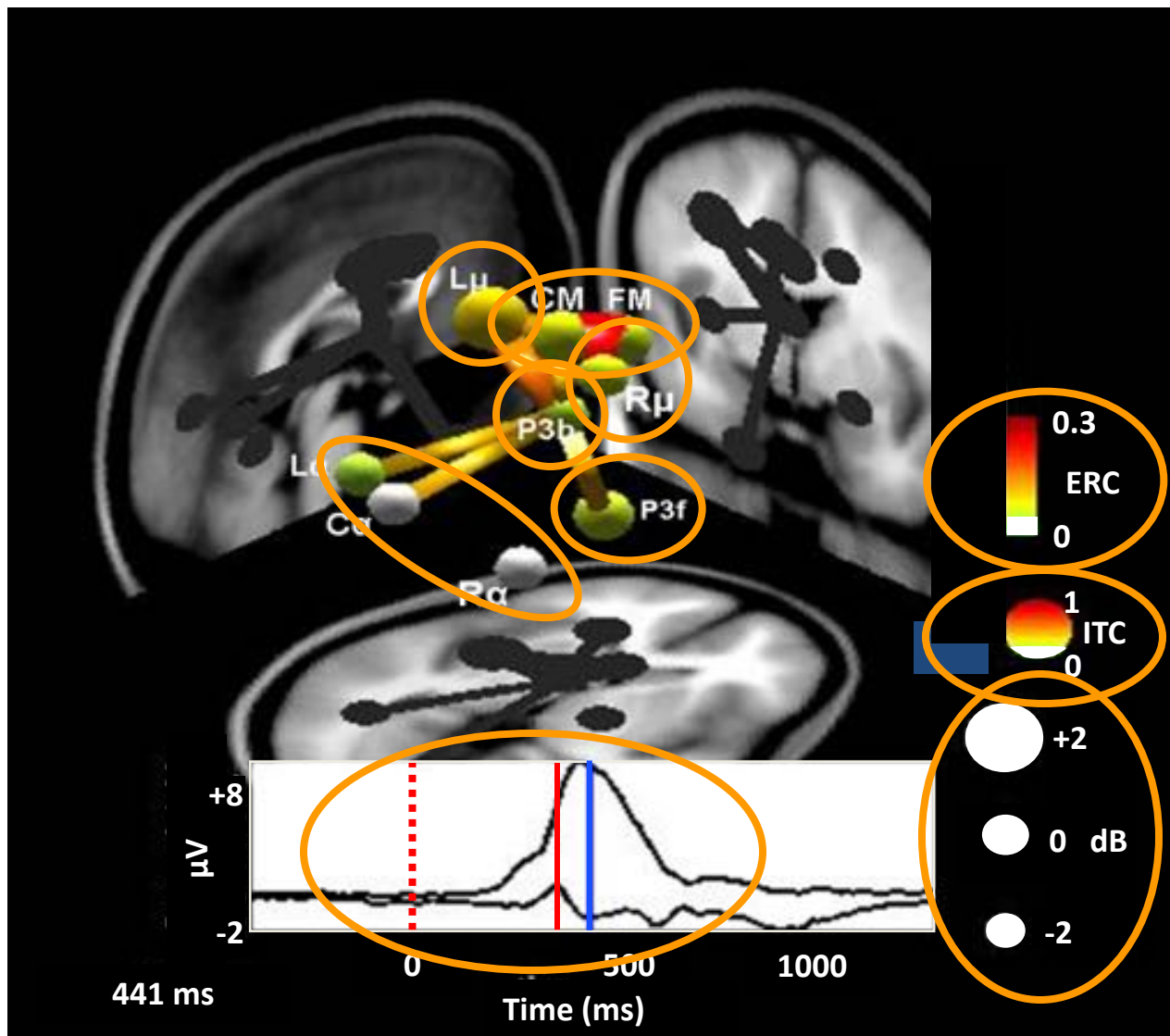
Coherence



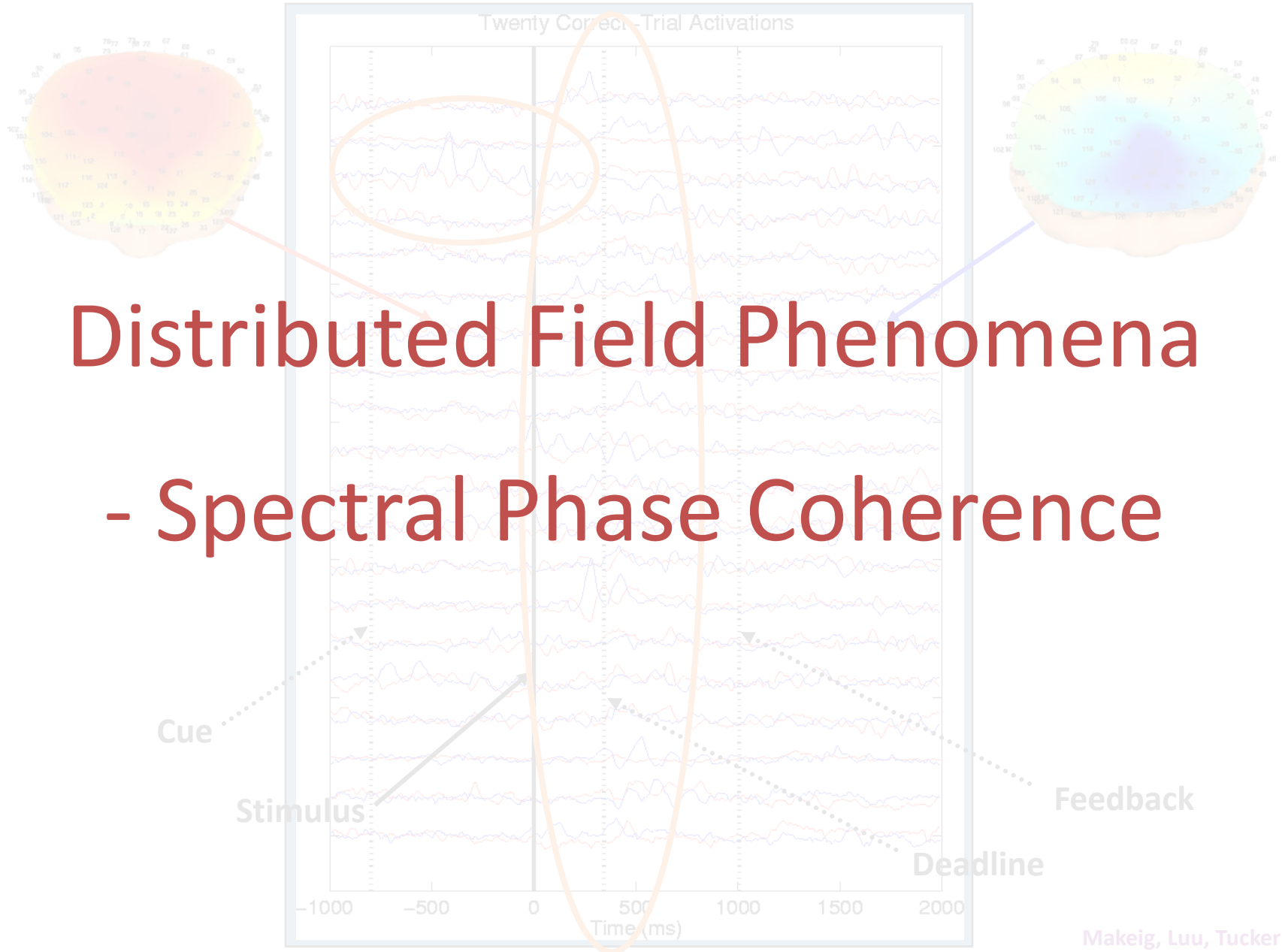
Scalp channel coherence source confounds!



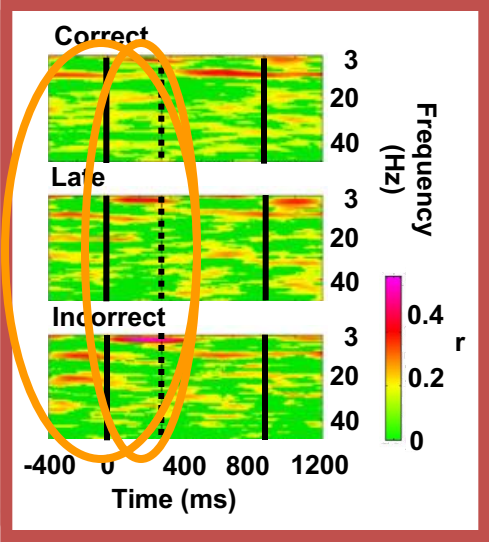
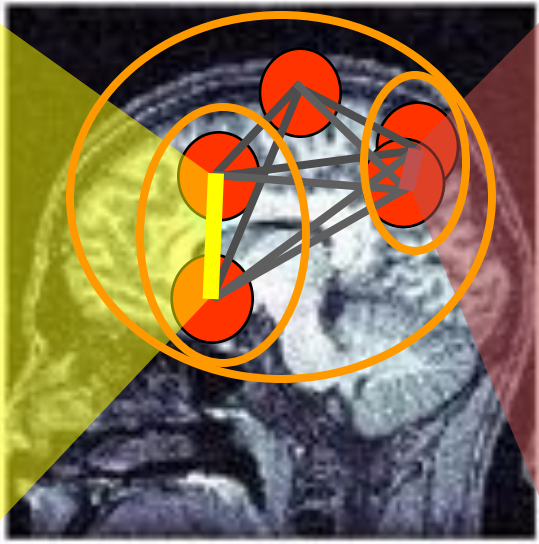
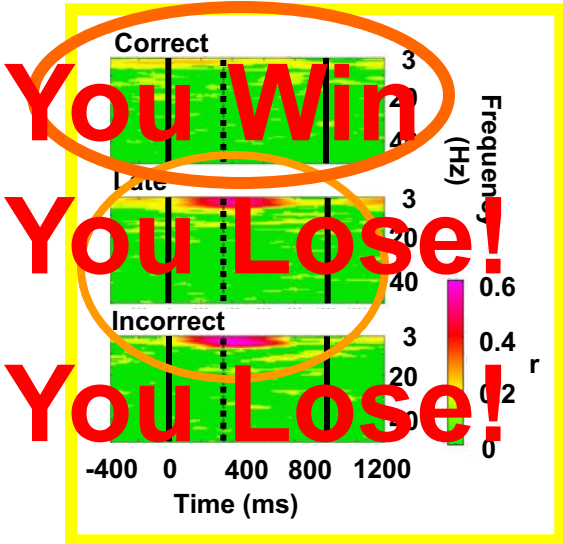
ICA Component coherence → source dynamics!

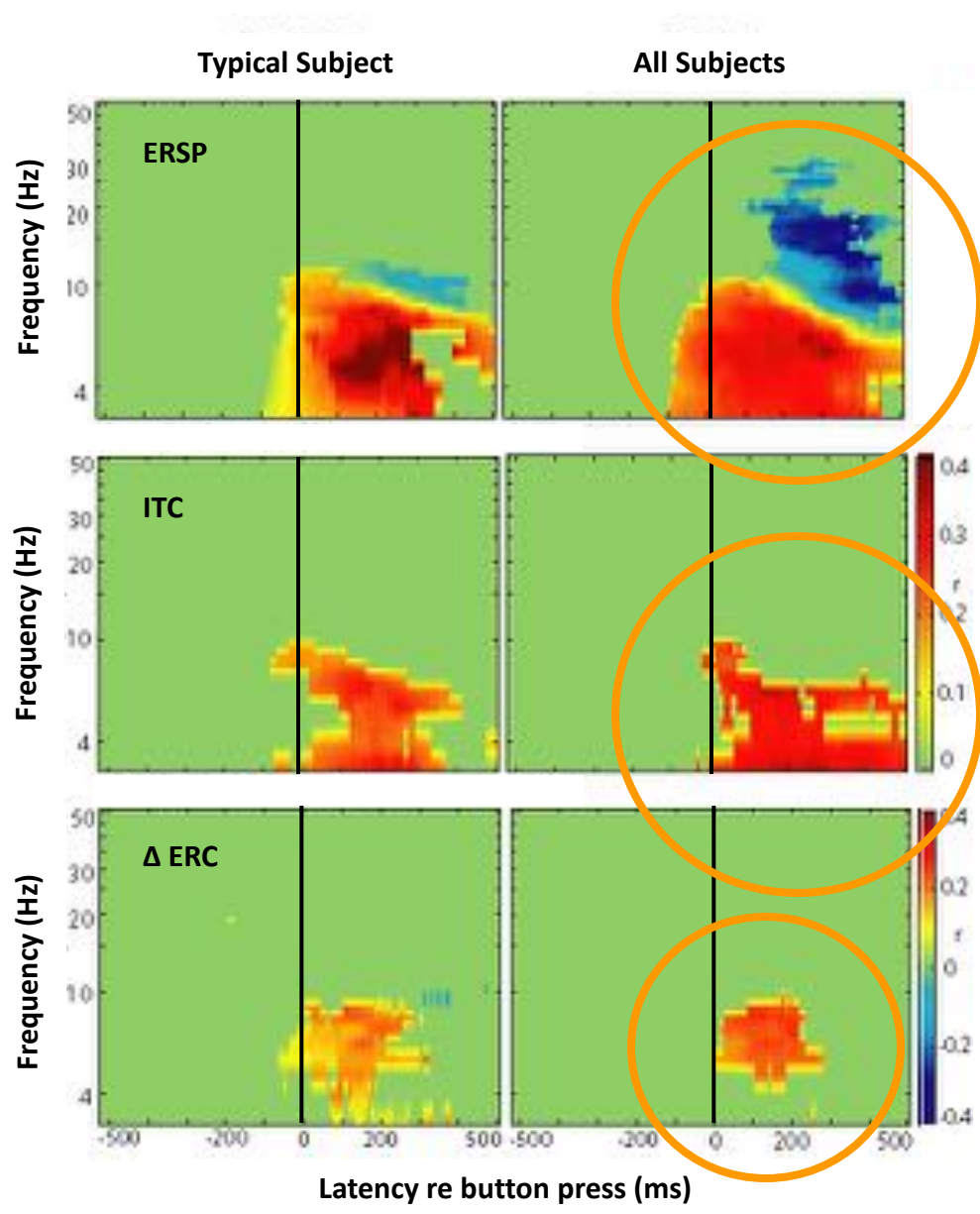


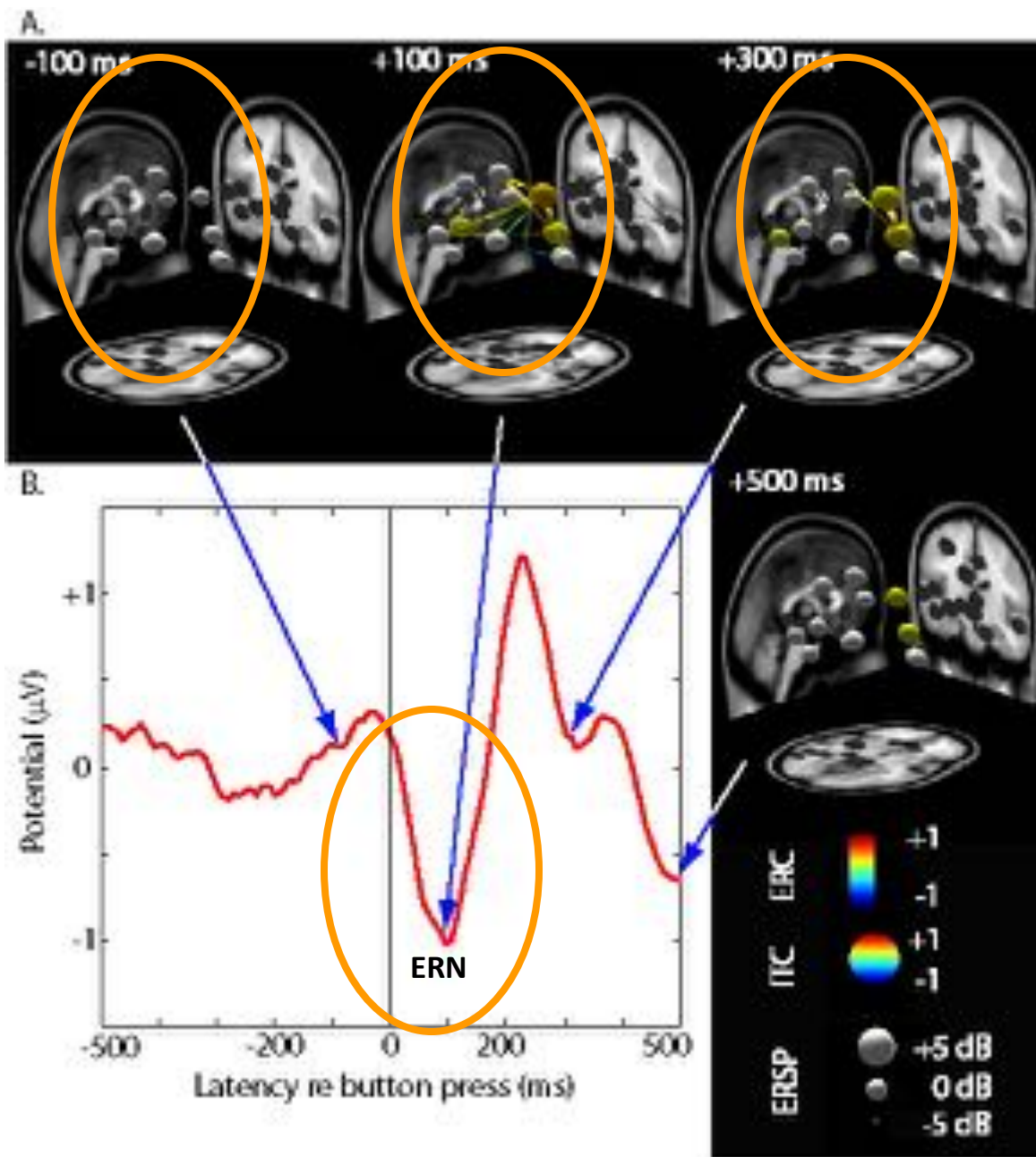
Theta Dynamics in Single Trials



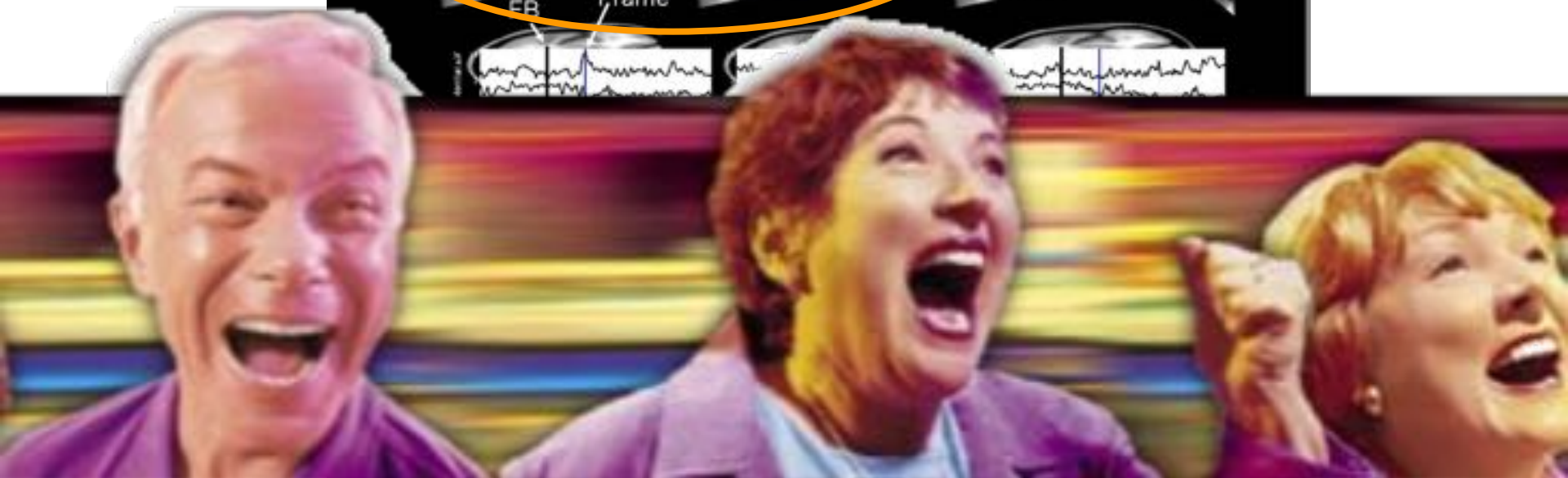
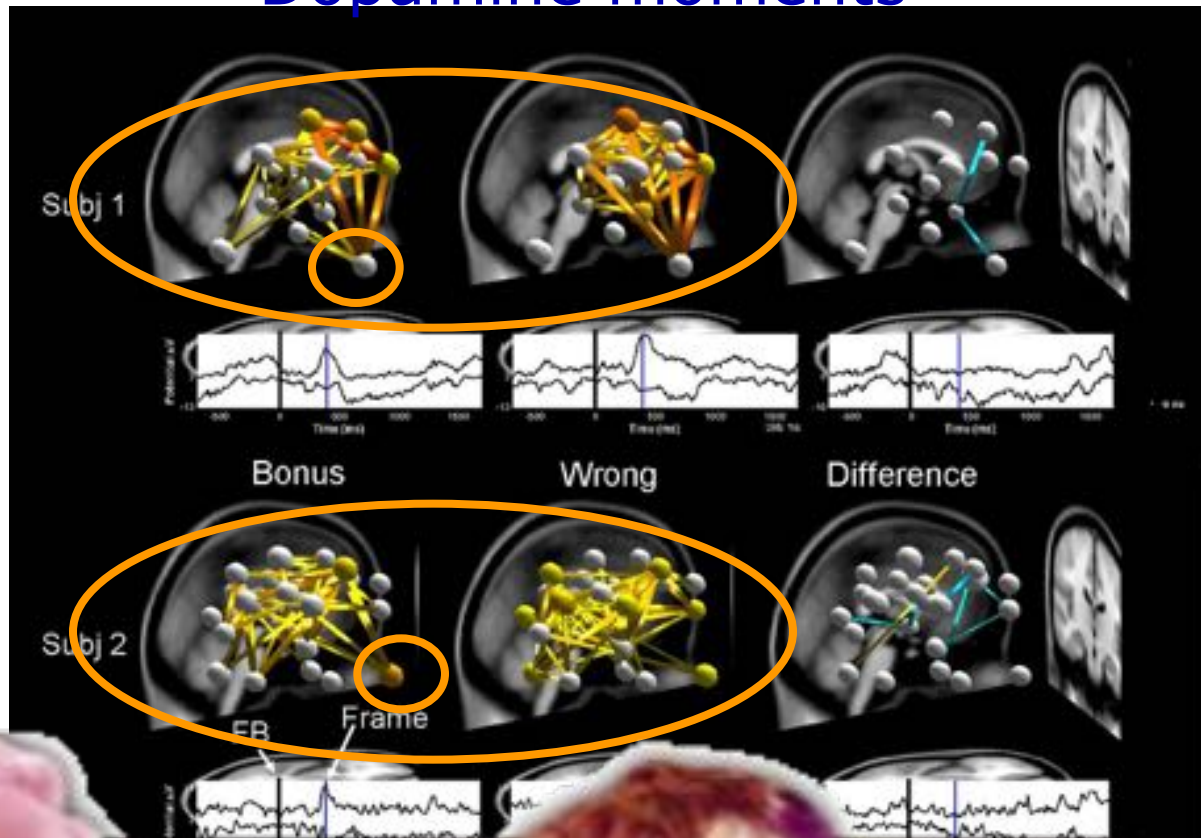
Brain Dynamic Events



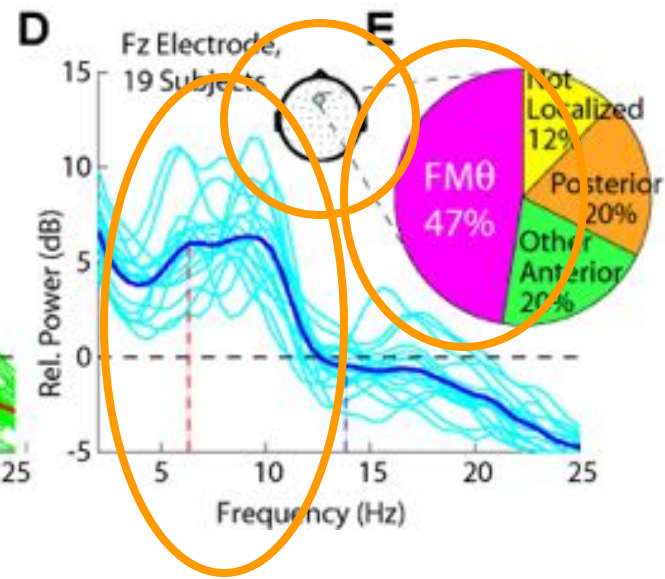
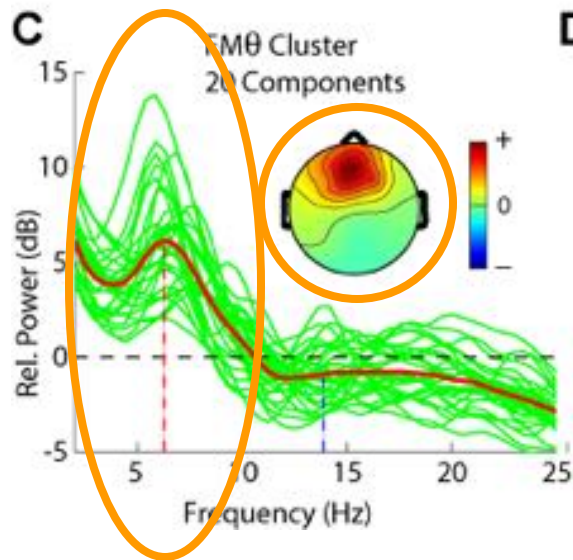
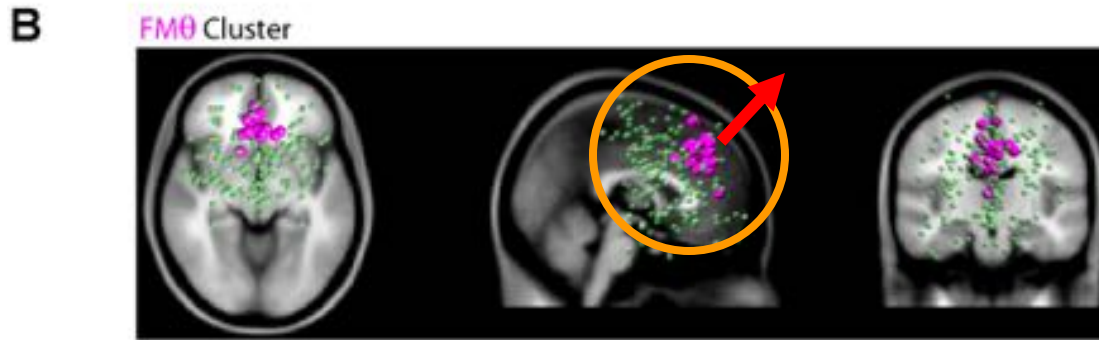
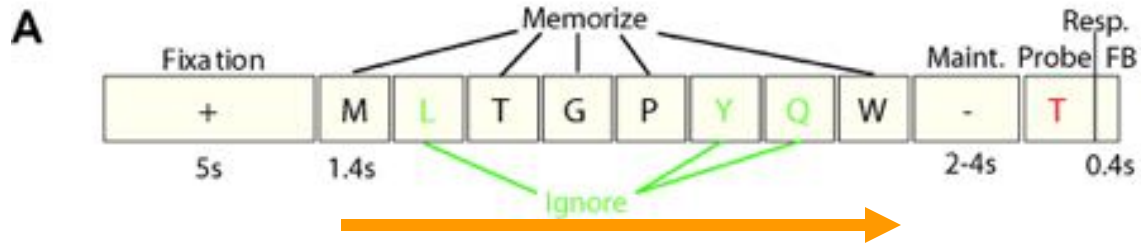




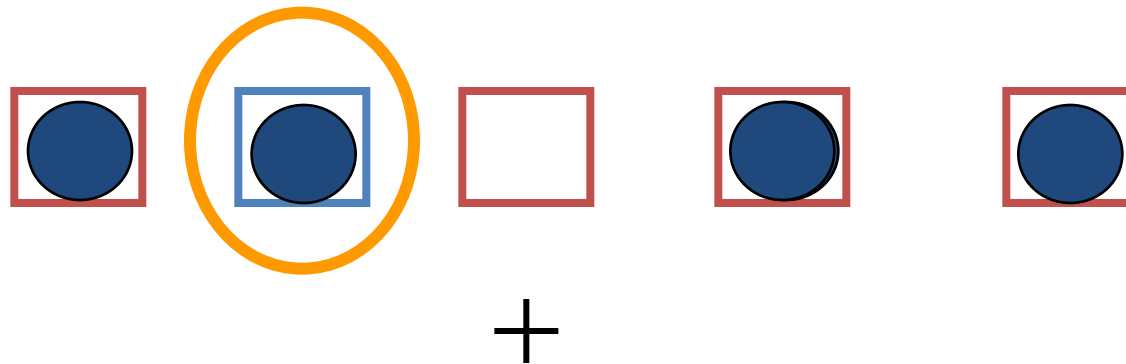
Dopamine moments



Frontal Midline Theta Sources



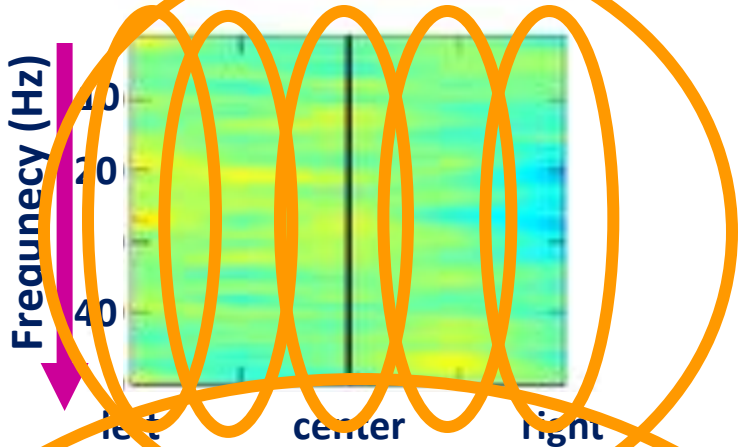
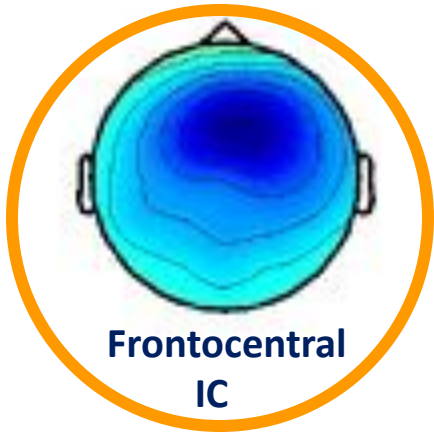
Visual Selective Attention Task



15 subjects

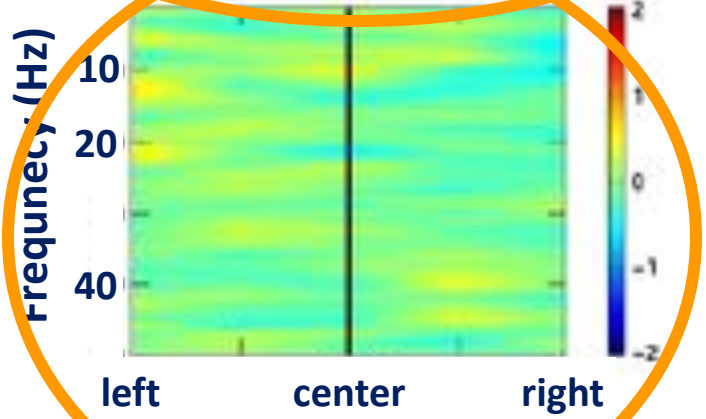
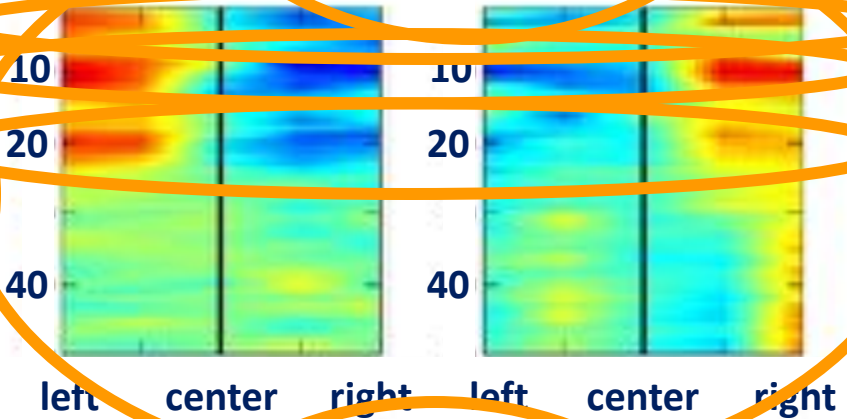
31 channels

Westerfield & Townsend



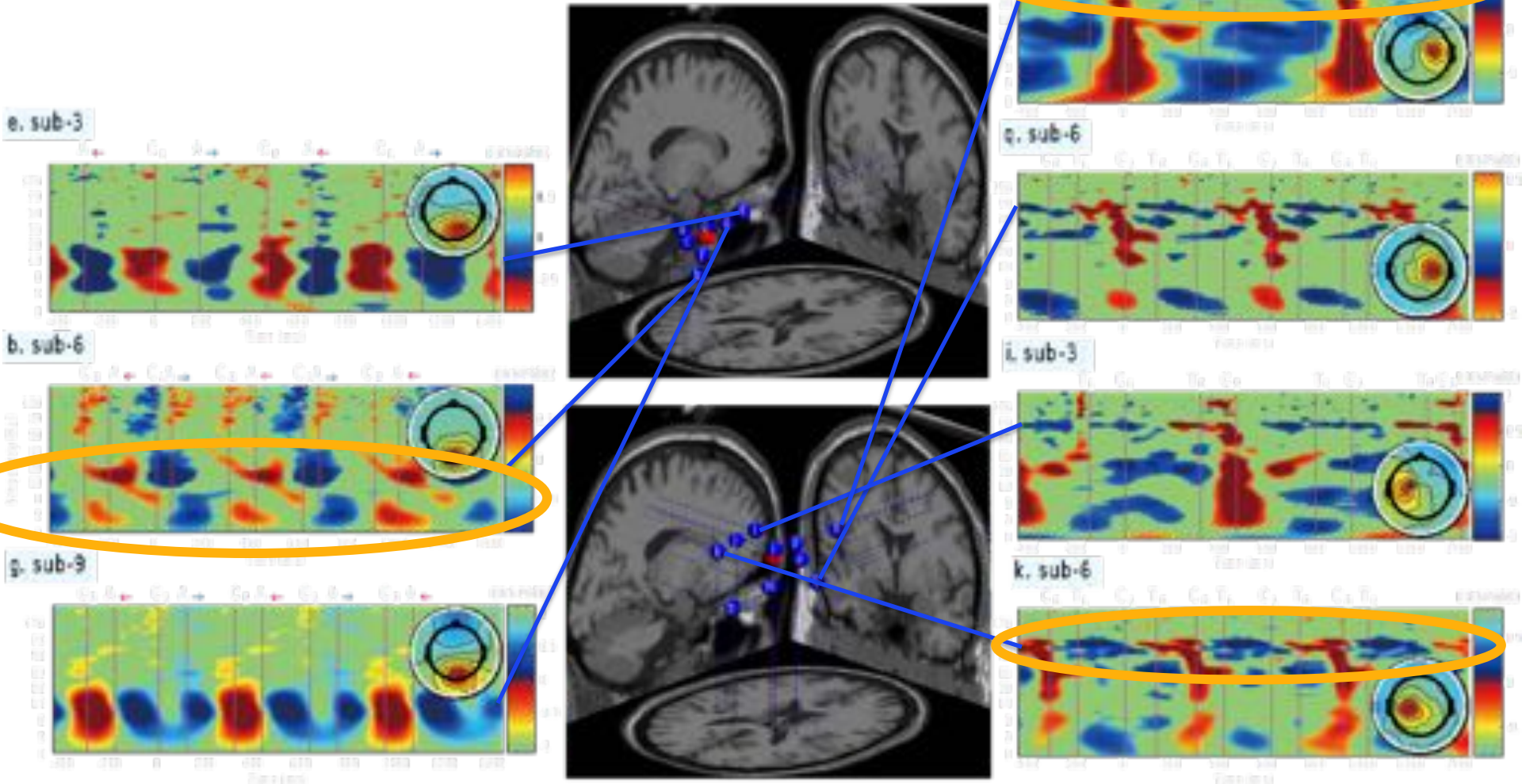
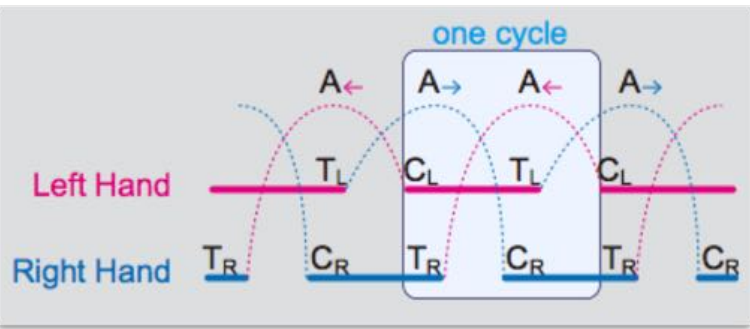
Baseline power spectral shifts with direction of attention.

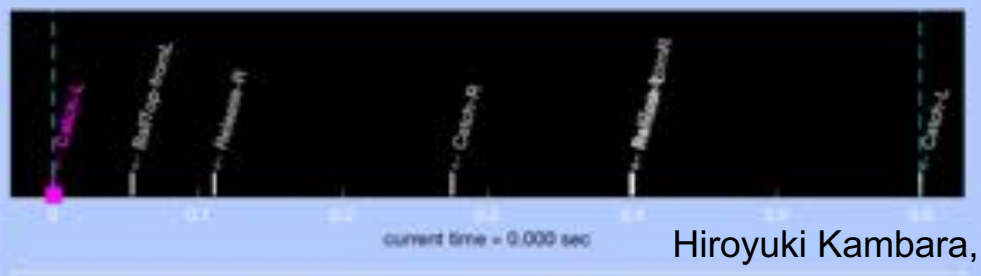
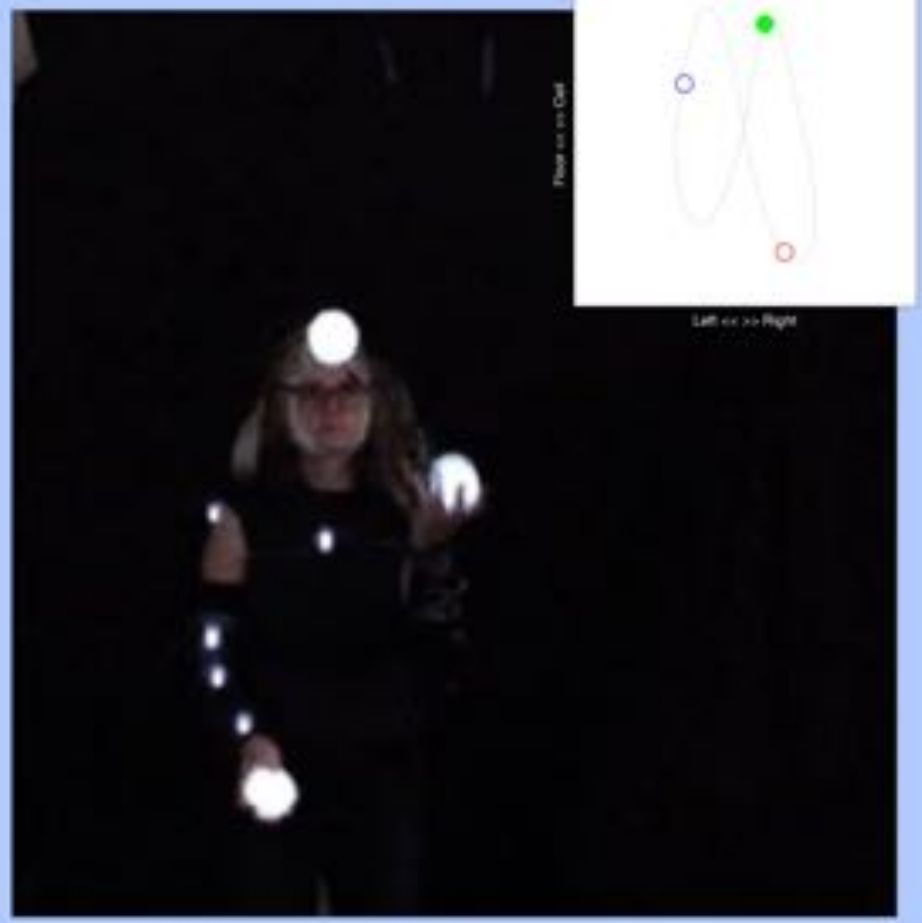
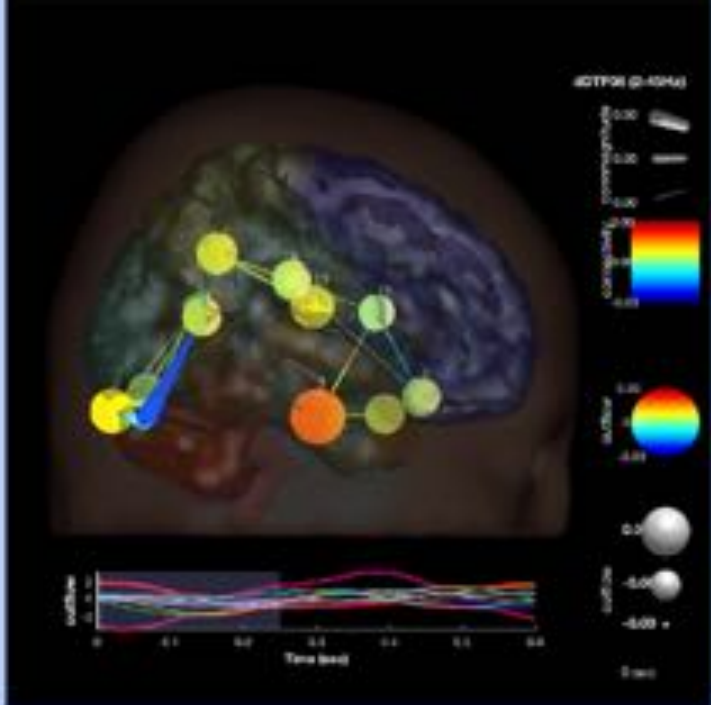
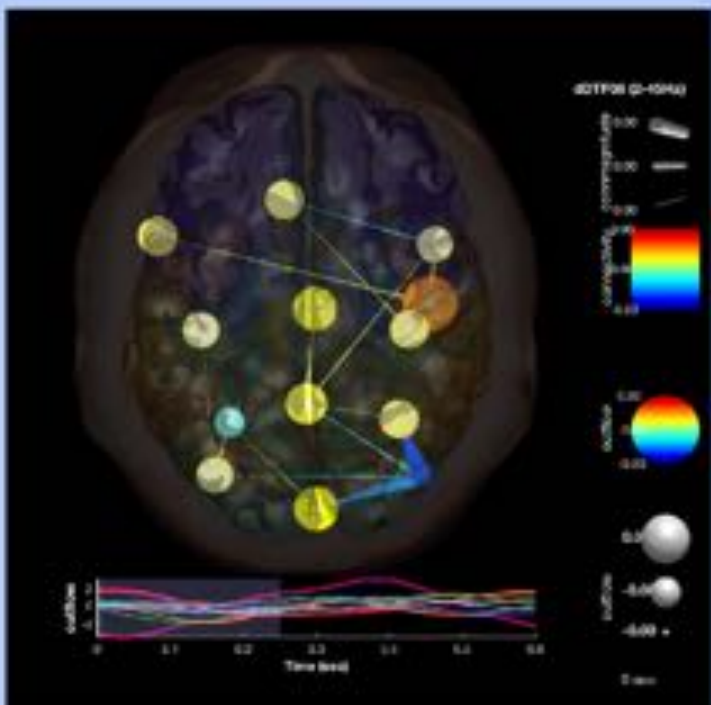
Baseline Spectrum
(1 s before stimulus)



Attended Location

Brain rhythms during juggling

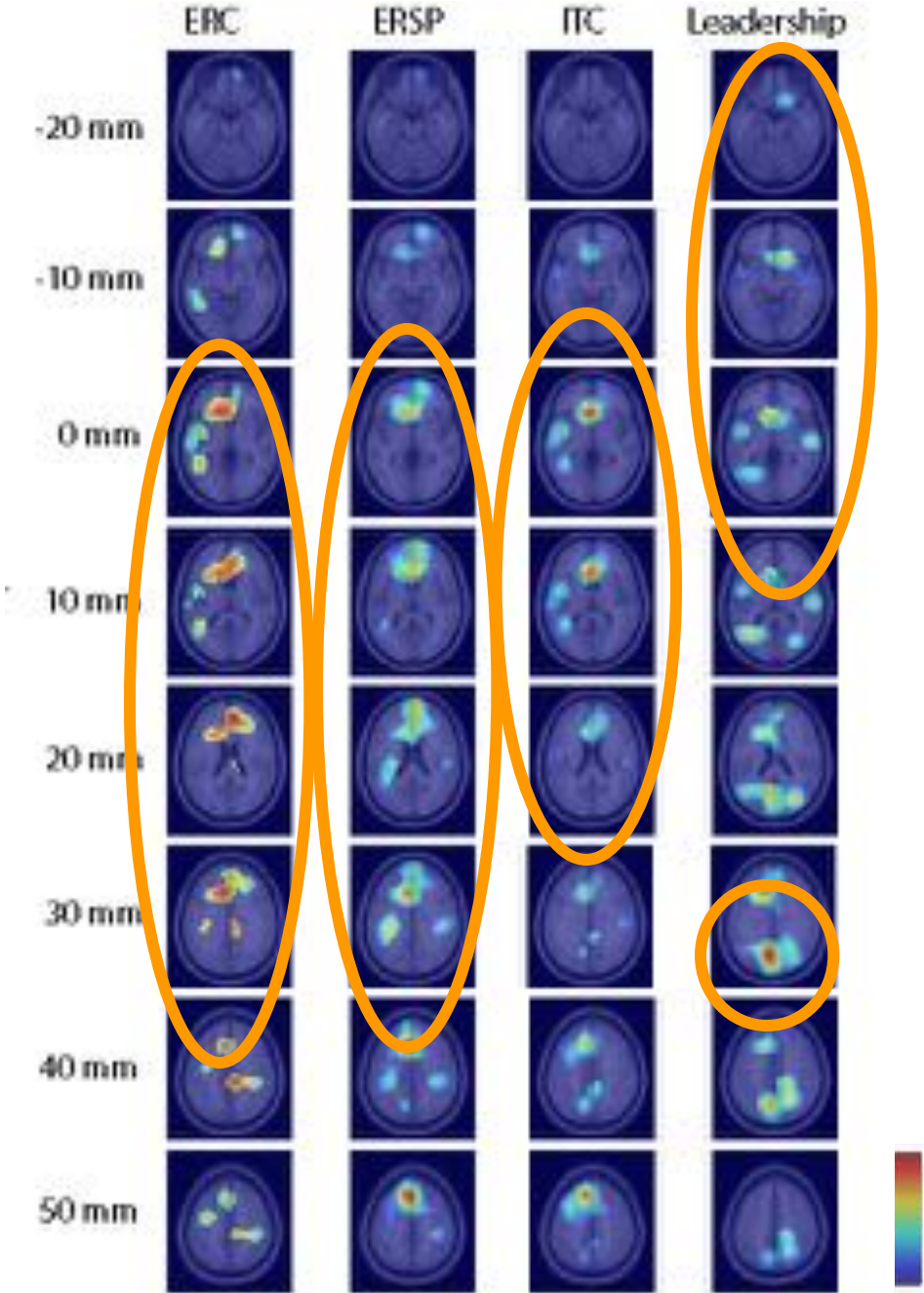




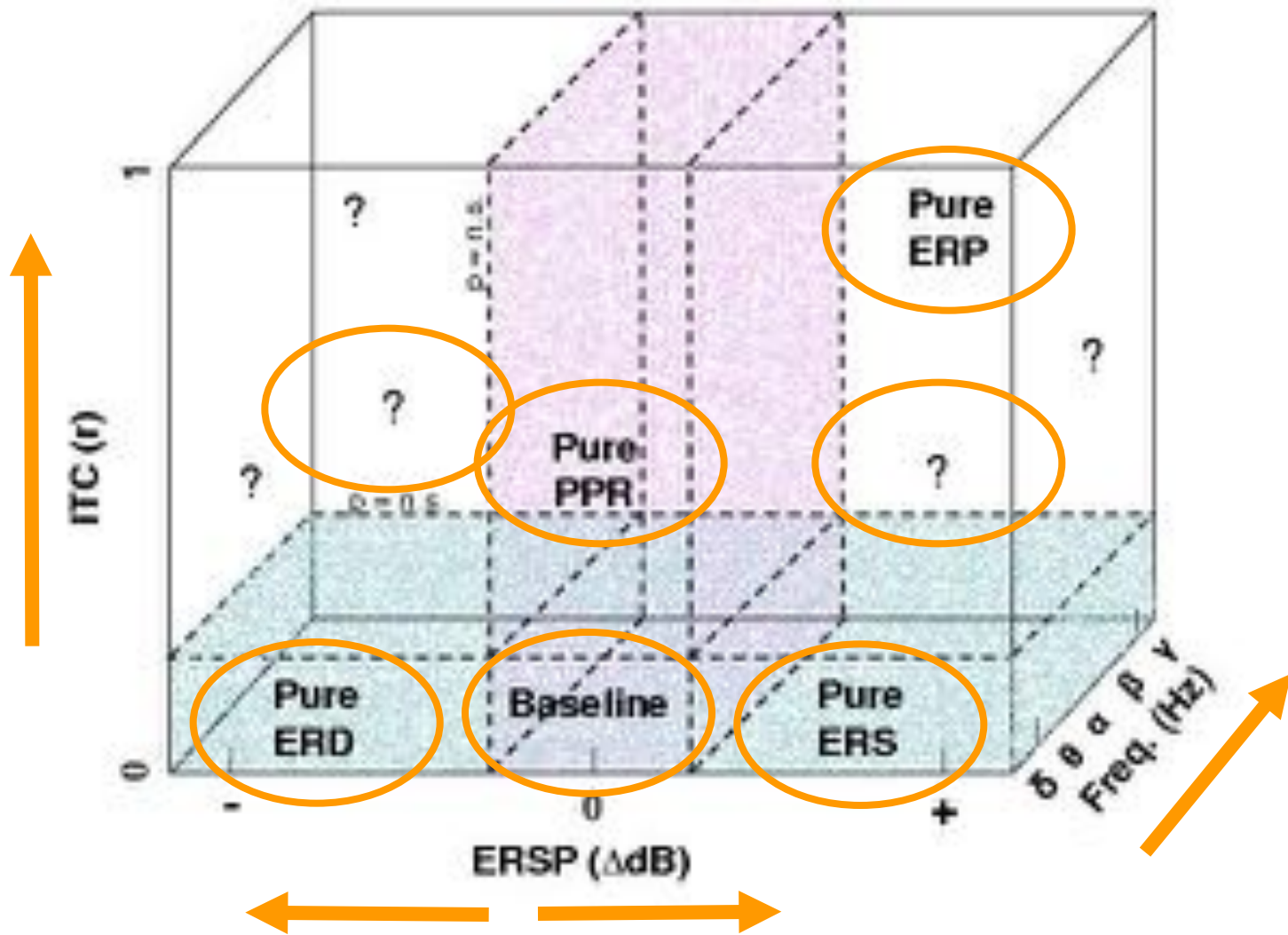
Control interface with buttons: Beginning, <<, <, Pause, >, >>, Prev Event, Next Event.

Hiroyuki Kambara, 2018

Dipole density



Event-Related Brain Dynamic State Space



Goal: To cluster equivalent ICs across subjects

