



EEG, ERPs, and Phase locking



Scott Makeig
Institute for Neural Computation
University of California San Diego

April, 2009
Indiana University,

The adequacy of blind response averaging

IF

- If 'equivalent' stimuli (passively) evoke the same macro field responses (with fixed latencies and polarities or phase) in **all** trials... and
- If **all** the REST of the EEG can be considered to be Gaussian noise sources that are **not** affected by the stimuli..

THEN ...

- The stimulus-locked average contains **all** the meaningful event-related EEG/MEG brain dynamics.

The inadequacy of blind response averaging



(Highly) questionable assumptions:

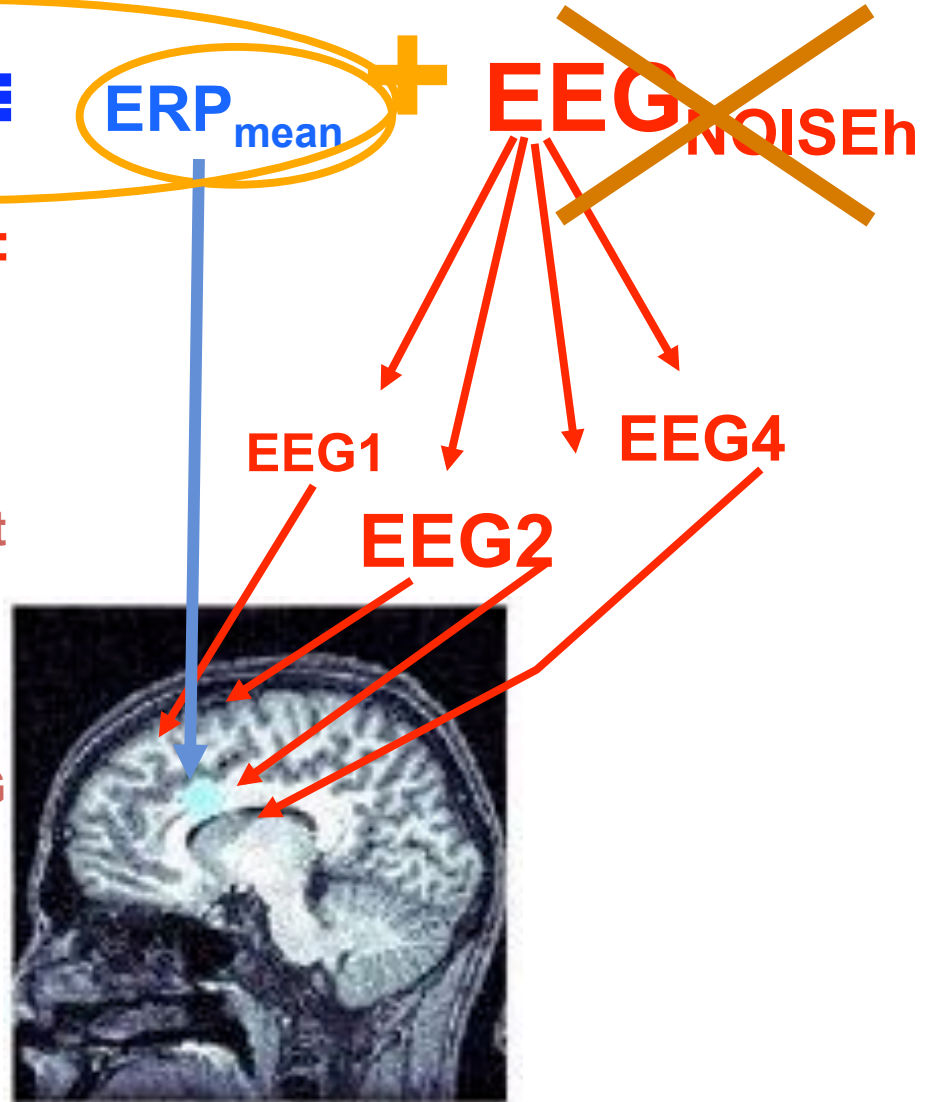
? The living brain produces *passive* responses ??????????????????????????????

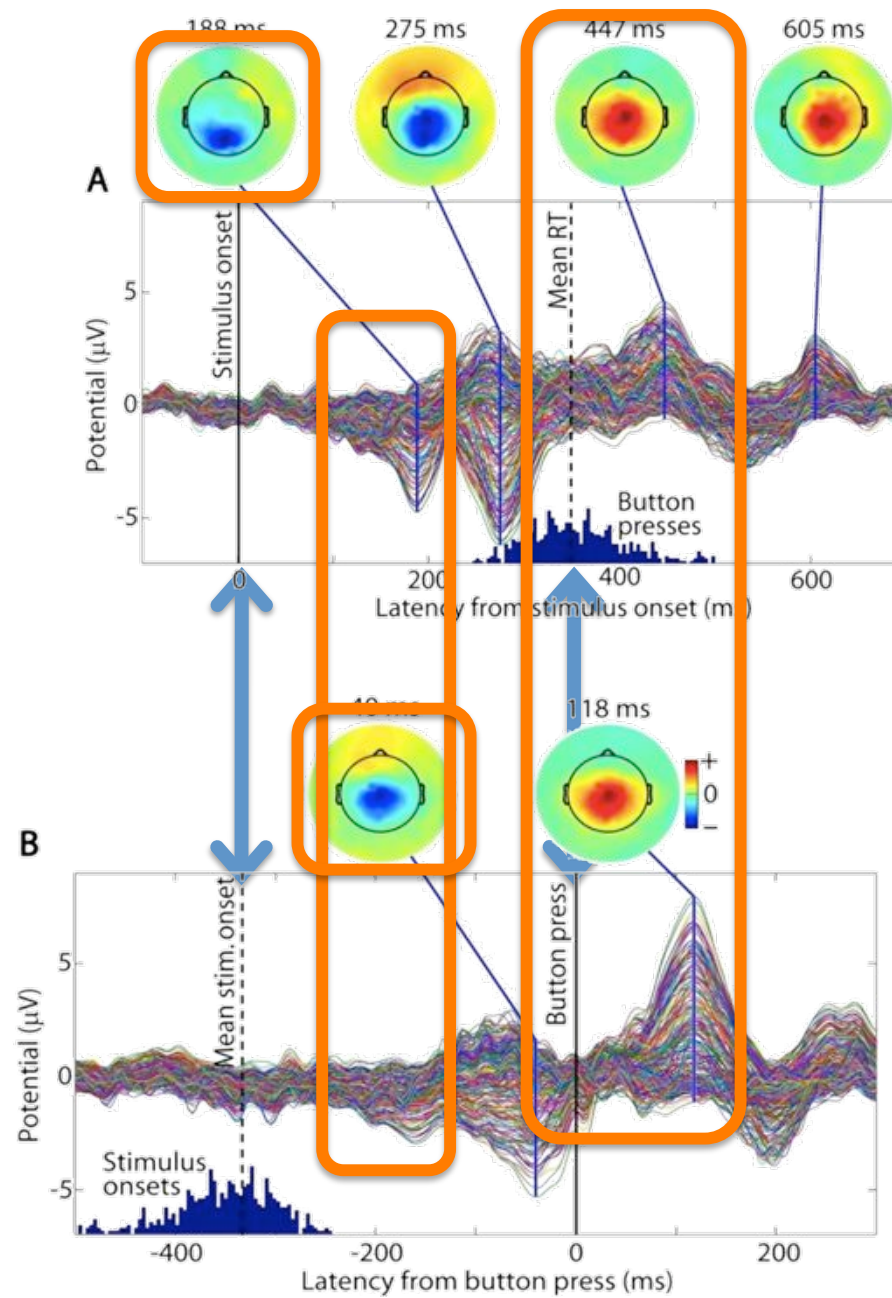
? Ongoing EEG processes are *not perturbed* by events – without transient phase locking → no ERP contributions from ongoing EEG processes.

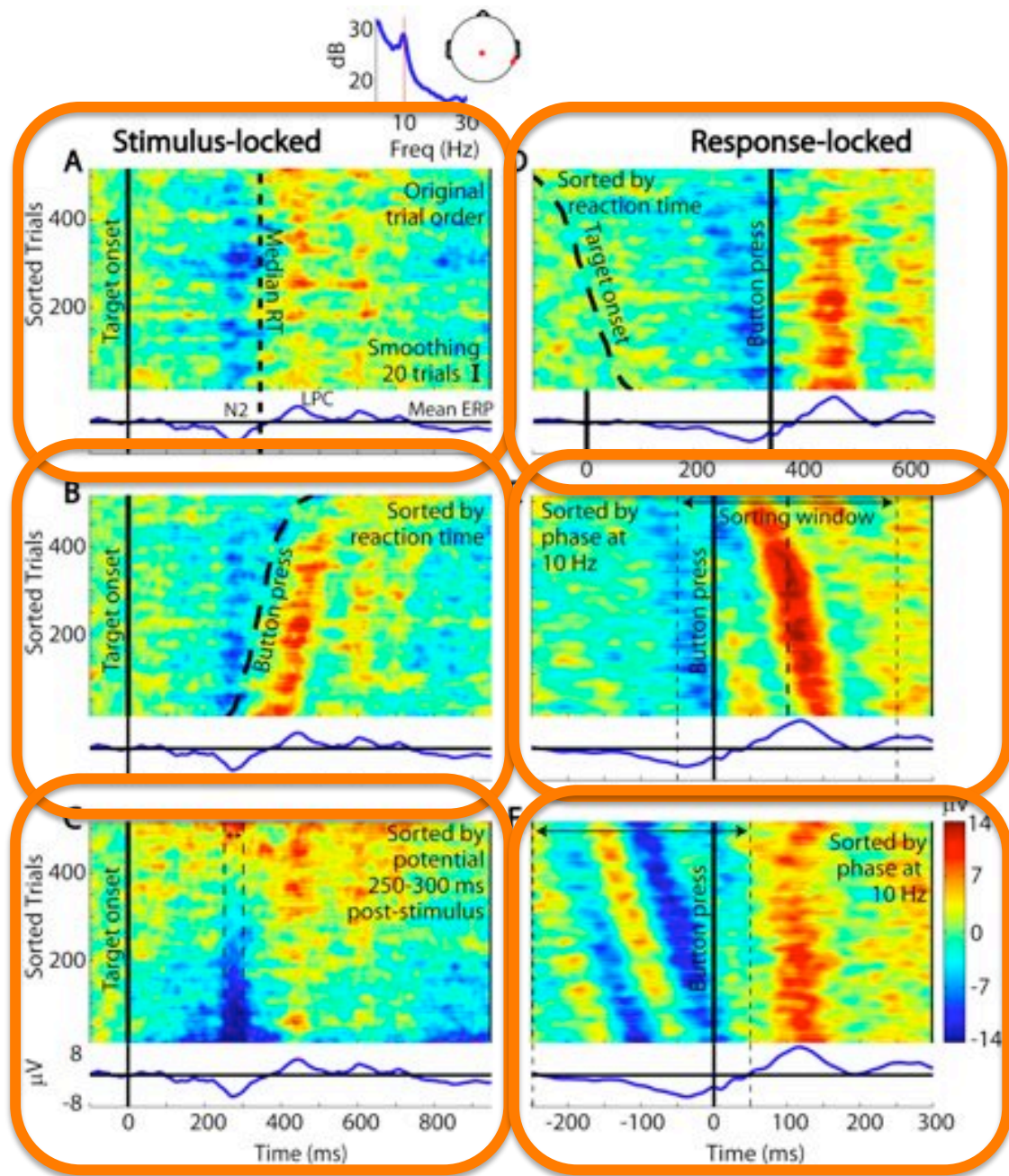
? Evoked response processes are *spatially segregated* from ongoing EEG processes.

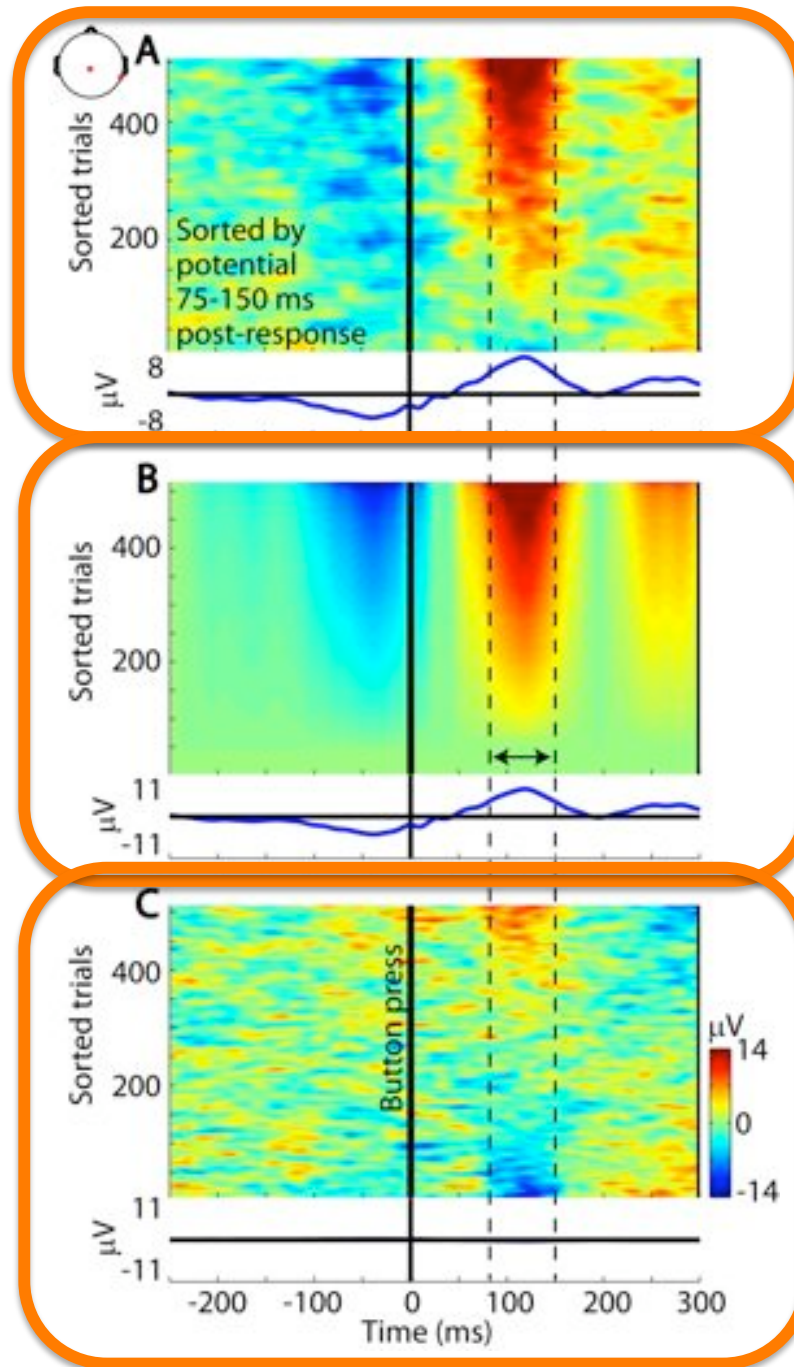
? The ‘true’ response baseline is *flat*.

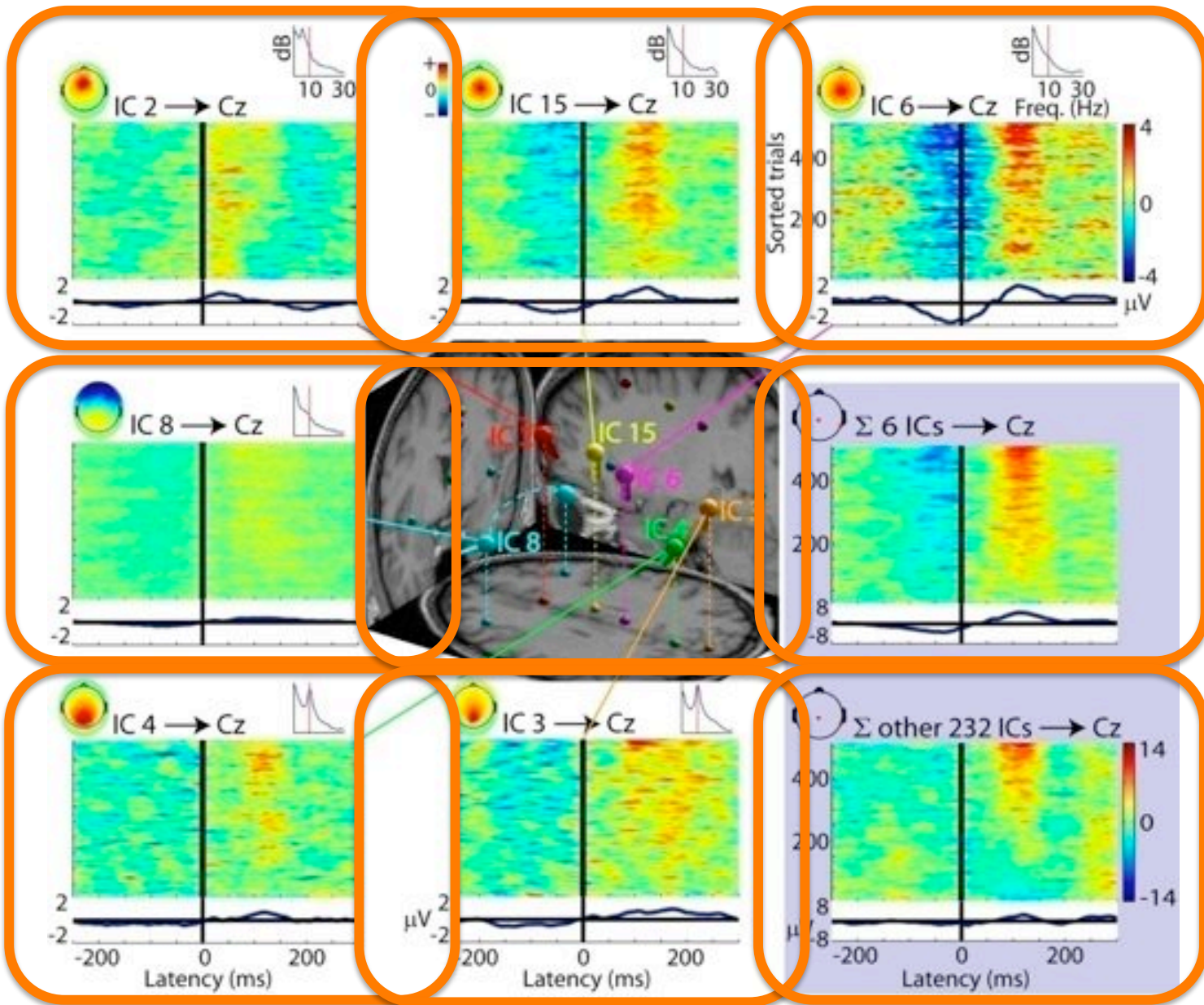
? ‘Equivalent’ stimulus events evoke *equivalent* brain responses → event-related brain dynamics are *stationary* from trial to trial.

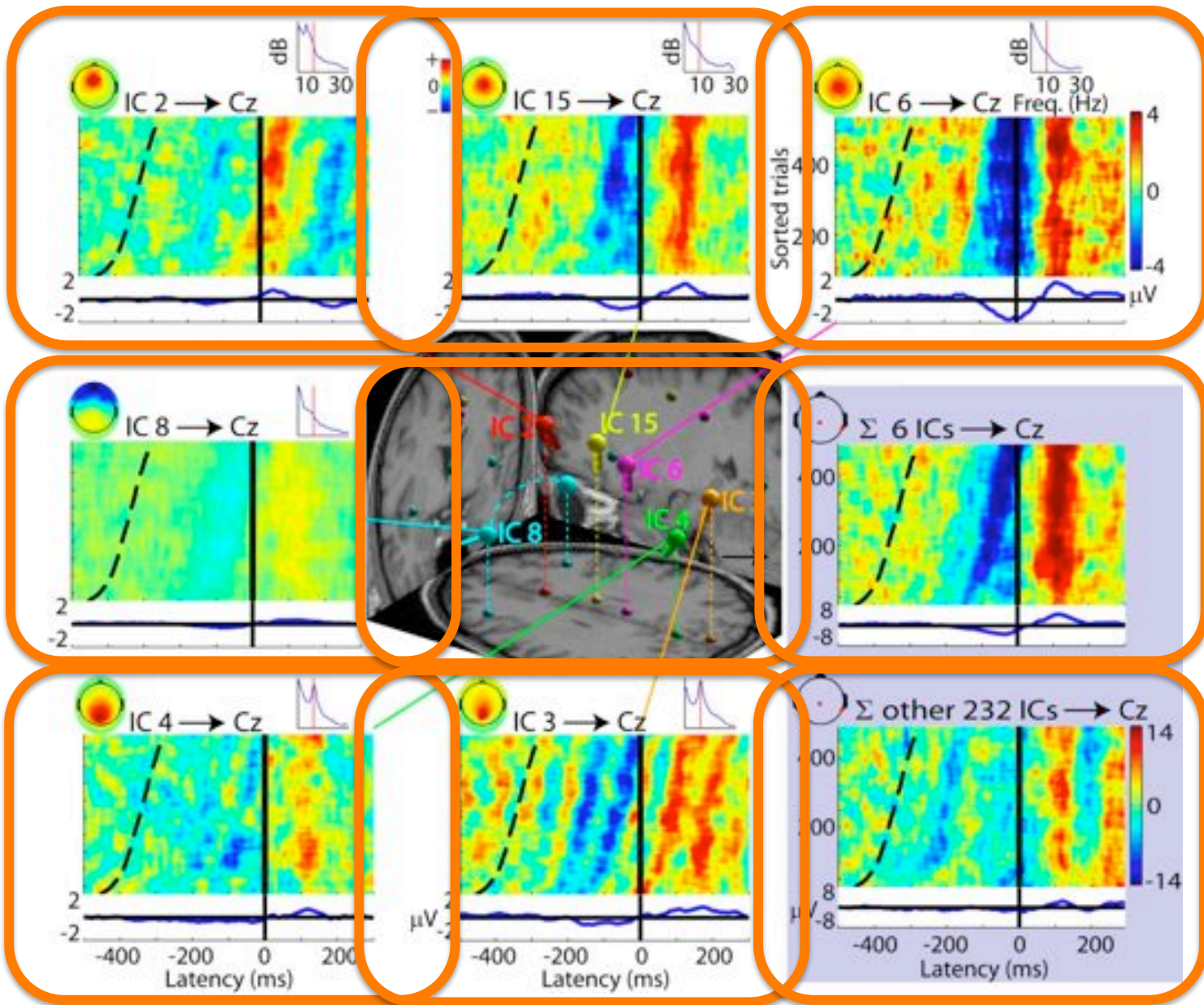












What produces event-related potential averages (ERPs)?

Inter-trial Coherence (ITC)

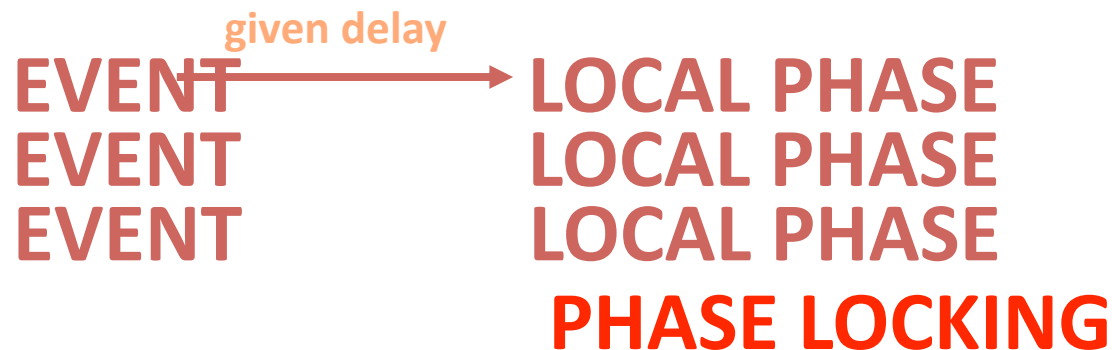
(“phase-locking factor”)

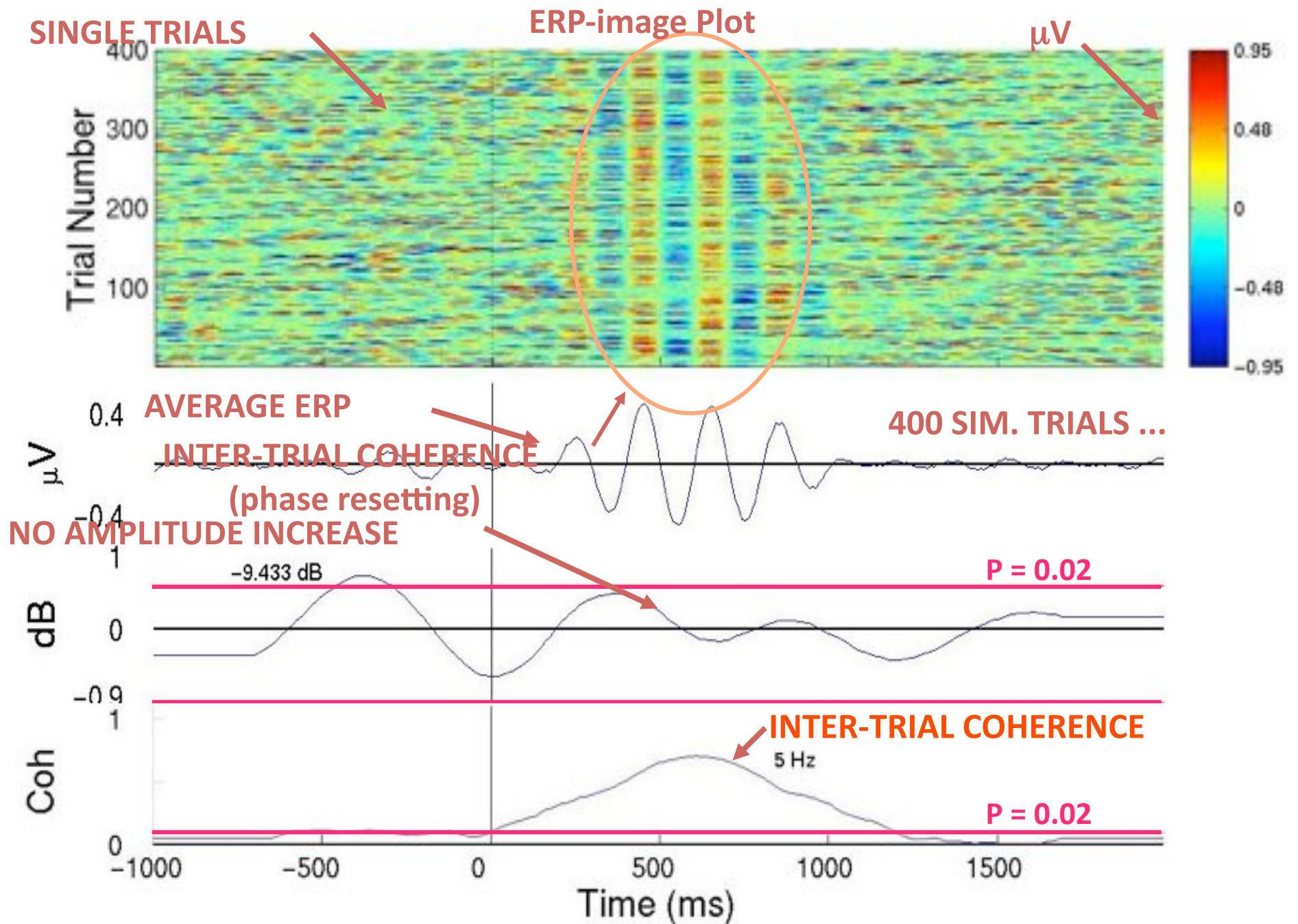
(“phase-

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

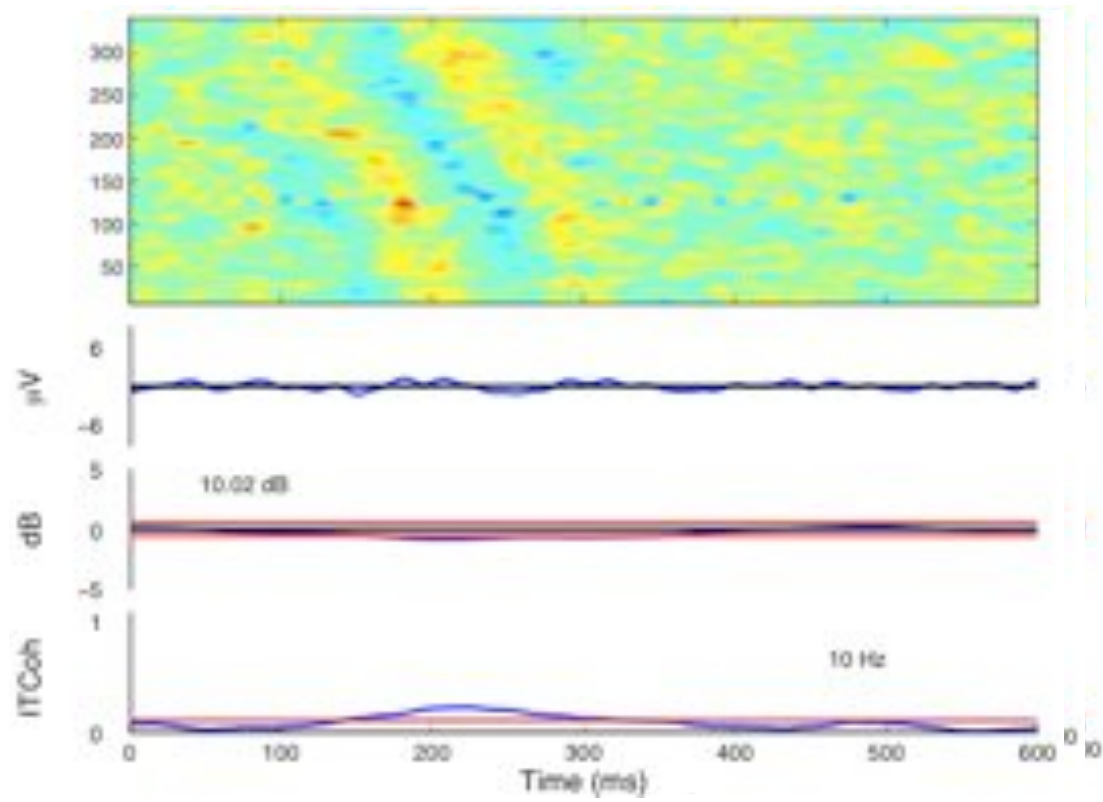
EVENTS

given frequency



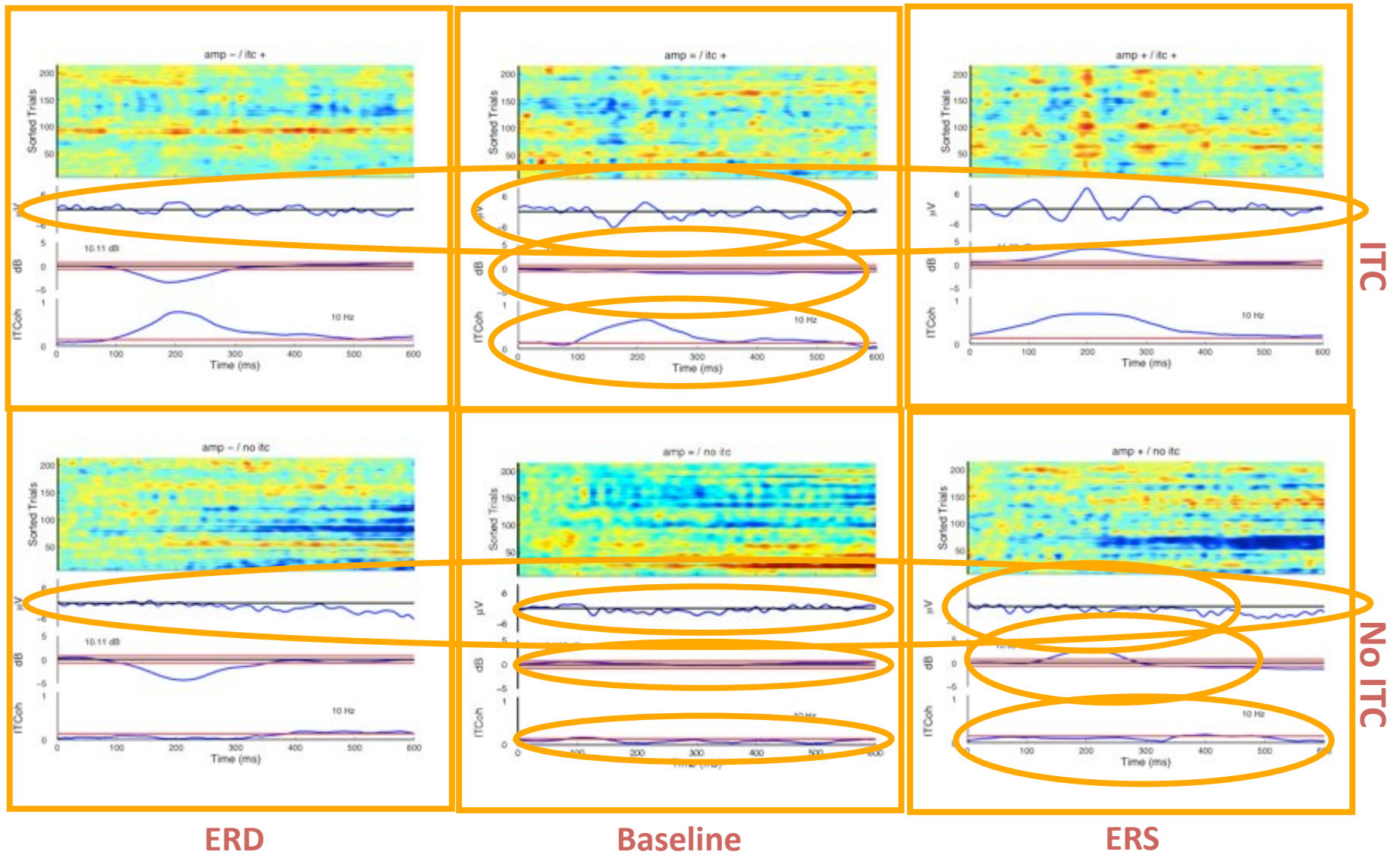


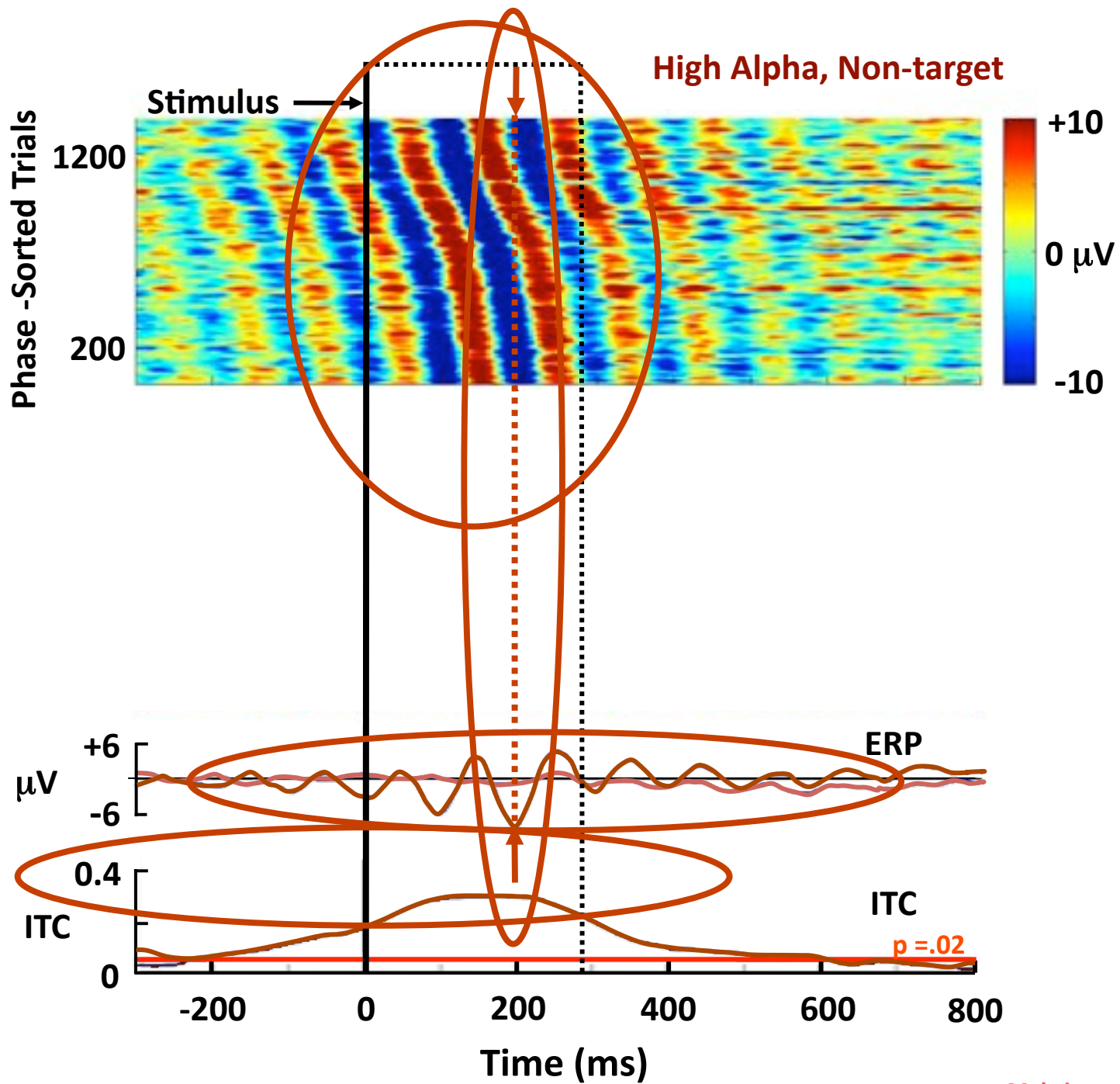
Phase-locking creates the ERP



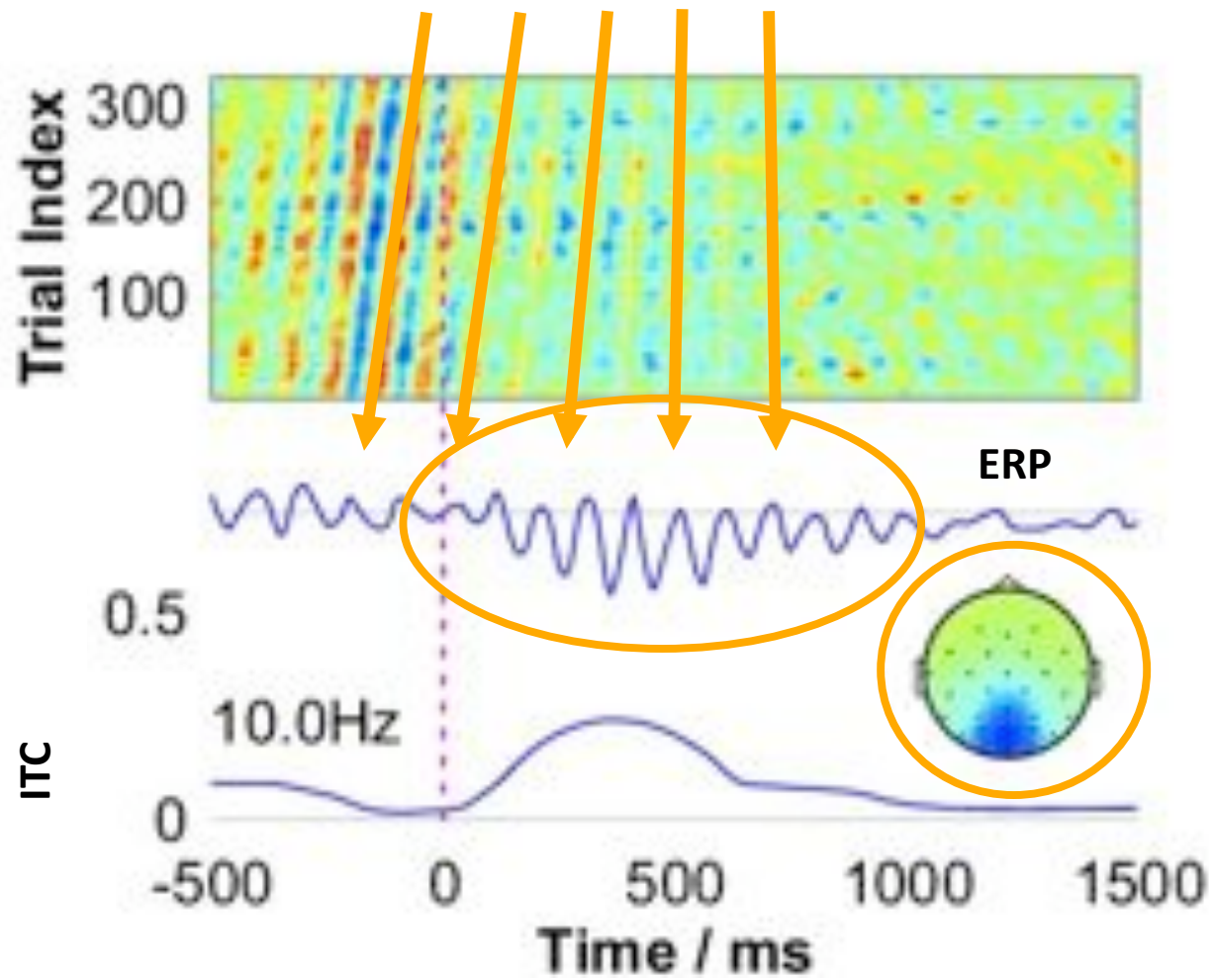
erpimage()

Simulation - Phase locking creates ERPs

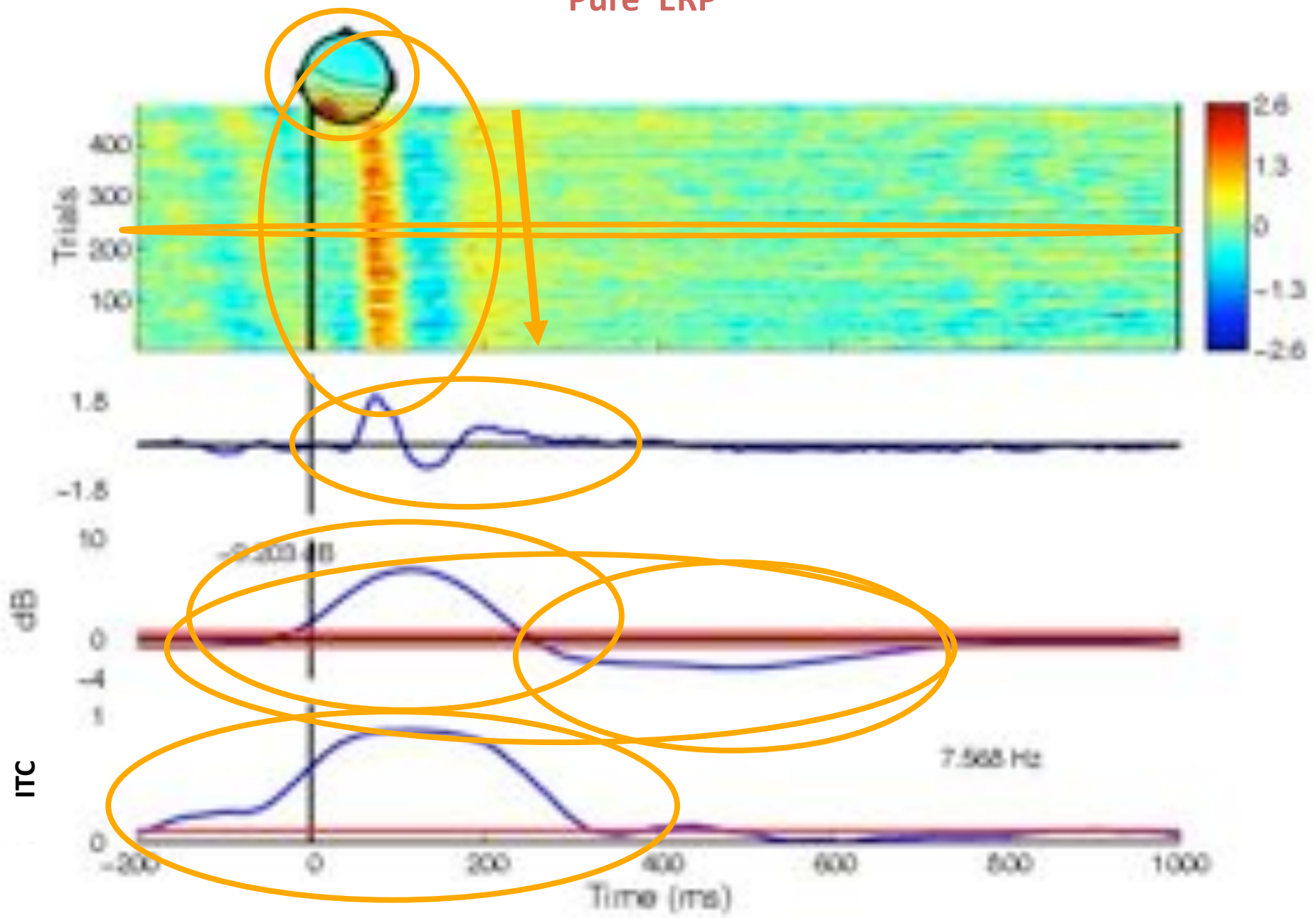




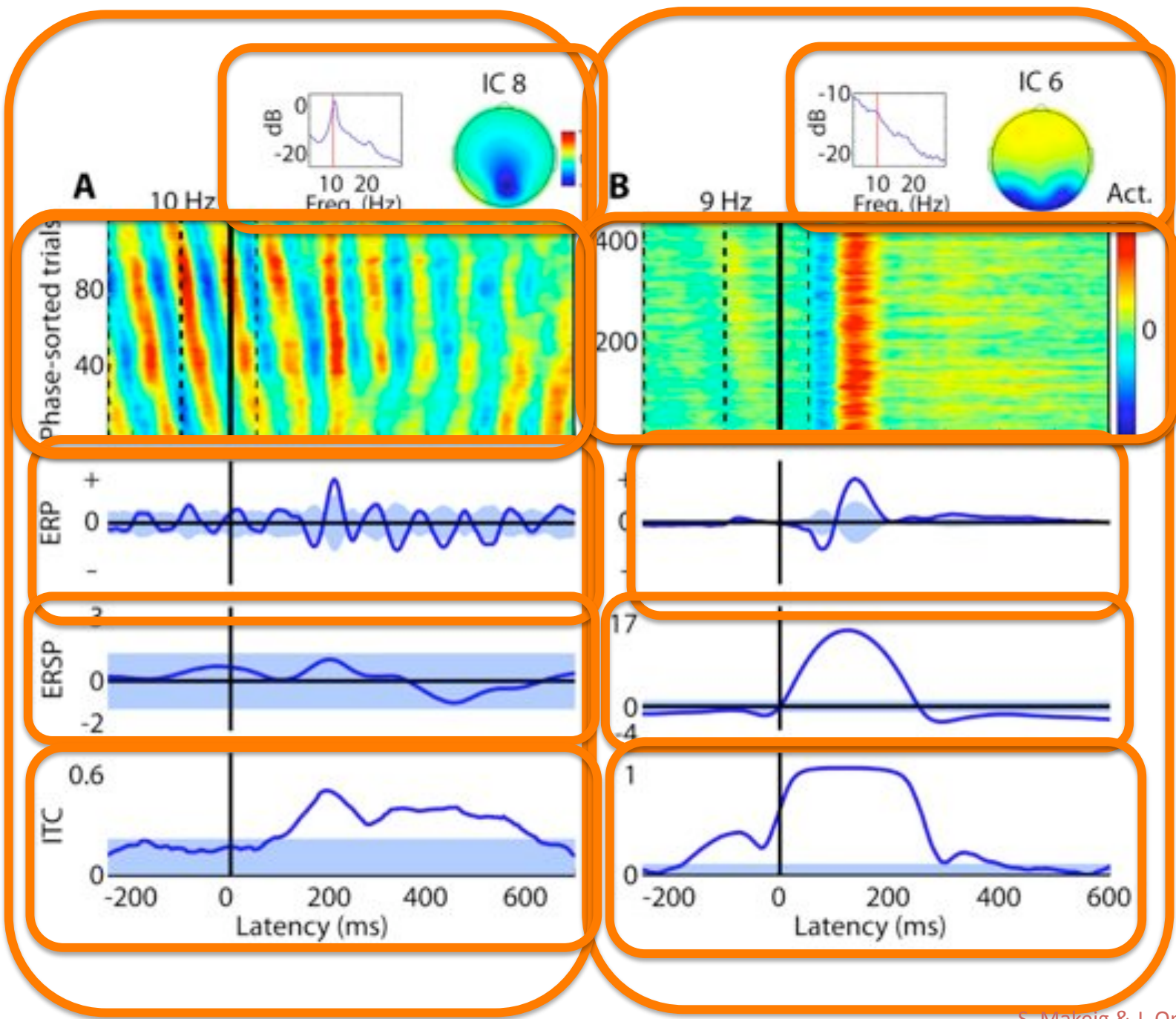
“True” PPR (visual ‘alpha ringing’)



'Pure' ERP



erpimage()



Are ERPS 'really' produced by phase locking?

- Give me three quarters.
- Now give me one more quarter.
- Are the four quarters in my hand

now still 'really' still $3 + 1$?

Or, are they 'really' $2+2$?

Or both? Or neither?

- Similarly, does my EEG data = EEG + ERP ?

Or does my EEG = (EEG with phase-locking) ?

Or both?

Or neither?

END of Phase-Locking Presentation

