Time/Frequency Analysis of Electrophysiological Data

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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)

Δ log power @ abs max deviation channel

S. Makeig, 2005
erpimage(): Alpha power in single trials

Load 3
Load 5
Load 7

Sorted Trials

µV

dB

ITCoh

Time (ms)

9.644 Hz

-27.8 dB

Onton & Makeig
Inter-trial Coherence (ITC)

(“phase-locking factor”)

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

INTER-TRIAL COHERENCE

NO AMPLITUDE INCREASE

400 SIM. TRIALS ...

ERP-IMAGE PLOT

µV

P = 0.02

P = 0.02

INTER-TRIAL COHERENCE

(phase resetting)
NO AMPLITUDE INCREASE

PHASE LOCKING

ERSP

dB

µV²

ITC

r

FREQUENCY

TIME
“True” PPR (visual ‘alpha ringing’)

Trial Index

ERP

ITC

Time / ms

10.0Hz

0.5
Where does the 15 dB ERP power increase come from? If the ERP is not produced by a stimulus-evoked energy increase, then by what?

Trial-to-trial event-related phase consistency produces the ERP.
Independent Component ERSP
Visual Selective Attention Task

15 subjects
31 channels
Westerfield & Townsend

S. Makeig (2001)
Baseline power spectral shifts with direction of attention.

Baseline Spectrum (1 s before stimulus)

S. Makeig 2/16/01
Example: frontal midline theta cluster

ERP image of 9.6-Hz alpha power

Load 3

Load 5

Load 7

Onton, Delorme & Makeig, 2005.

erpimage()
Event-Related Coherence (ERCOH)

- Significant consistency of local phase difference between two concurrent physiological waveforms.
TWO SIMULATED THETA PROCESSES

Event-related Coherence
Cortex

Two EEG channels

B

Coherence

C

Scalp channel coherence source confounds!
Two EEG channels

Coherence

Scalp channel coherence source confounds!
MANY EEG channels

Separate out Independent EEG Components

ICA Component coherence source dynamics!
Distributed Field Phenomena
- Spectral Phase Coherence
Brain Dynamic Events

You Win
You Lose!
You Lose!
Latency re button press (ms)

Frequency (Hz)

Typical Subject

All Subjects

ERSP

ITC

Δ ERC

Latency re button press (ms)
Frontal Midline Theta Sources
Visual Selective Attention Task

15 subjects
31 channels

Westerfield & Townsend

S. Makeig (2001)
Baseline power spectral shifts with direction of attention.

Baseline Spectrum
(1 s before stimulus)
Brain rhythms during juggling

Hiroyuki Kambara & S. Makeig, 2018
Dipole density
Event-Related Brain Dynamic State Space

Makeig et al., TICS 2004
Goal: To cluster equivalent ICs across subjects