Event-related EEG/MEG synchronization and desynchronization: Basic principles


Summarised by Yatin Mahajan
EEG is recording of electrical activity from the scalp produced by firing of neurons within the brain.

Refers to the brain's spontaneous electrical activity (resting) over a short period of time.
How EEG is produced?

Activity by EEG- electrical potential by post synaptic current

EEG is summation of firing from millions of neuron of similar orientation (radial)
EEG is outcome of oscillations of neuronal assemblies (firing) which occurs at different frequencies.

Commonly known as EEG Rhythms

- **Delta band 0-4Hz**
  - Central region

- **Theta – 4-8Hz**
  - Hippocampus

- **Alpha 8-12Hz**
  - Visual cortex
These rhythms are measured in terms of Power spectrum

Power (amplitude)

- the synchronicity with which a given neuronal assembly (oscillates)

EEG is filtered through different band pass filters and Fast Fourier Transforms to obtain the spectral power in a band
ERD & ERS

decrease in power in a frequency band = Event related desynchronization (ERD)

Increase in power in a frequency band = Event related synchronization (ERS)

Usually expressed as % power change for different frequency bands

Calculated with reference to baseline period of some seconds

Changes in the power spectrum of different frequency bands before during or after an event reflects changes in firing pattern of neurons (group)

Stimulus is ON
localized area

Stimulus is OFF
wide spread activation
How to record ERD and ERS

1. **Raw EEG signals**
   - Bandpass-filtering (8-11 Hz)
   - Squaring
   - Averaging over N trials

2. **ERD**
   - Relative power
   - [%] [-100, 50] [%]
   - [s] [-4, -3, -2, -1, 0, 1, 2, 3]
   - on trigger

3. **ERS**
   - [%] [0, 200, 400]
   - [s] [-4, -3, -2, -1, 0, 1, 2]
   - off trigger
Interpretation of ERD and ERS

ERD:

• Electrophysiological correlate of activated cortical areas involved in process of sensory or cognitive information or pre programming during execution of a task and production of motor behavior.

• Increased ERD in a band or widespread ERD - large neural networks or more cell assemblies:
  - complex tasks
  - more efficient task performance
  - more effort put
  - in case of elderly participants and patients

• Reduced ERD – small neuronal assemblies working in desynchronised manner

• ERD reduced in motor learning tasks over a period of time and it becomes localized
ERS:

When a patch of neurons shows increase in power in a band – no active processing (most often)

ERS in gamma band is associated with active information processing (motor tasks)

Introduces powerful inhibitory effects which could act to block over excitation e.g. blocking a memory or visual search from entering irrelevant parts of neural networks

Sometimes to define a stimulus, category judgment tasks
ERD/ERS in neurological disorders:

Quantification helps in diagnosis of functional deficits in cerebrovascular disorders and Parkinson's Disease in which ERD is abolished or reduced.

Differentiation between surface and deep vascular lesion (voluntary hand movement tasks)

ERS is believed to associated with recovery of function of primary motor area lesion.
"Mr. Osborne, may I be excused? My brain is full."