Physiological measurements and Brain states

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Measurements - HCI

- Behavioural measurement
  - Eye gaze, reaction time, Expression, (Body language !)

- Objective
  - Performance measure, knowledge test

- Subjective
  - Preference, experience

- Physiological
  - Data measured directly from participants body
Physiological Measurements

- EEG - electroencephalography
  - Brain activity
  - Eye movement

- EMG – electromyography
  - Muscle activity

- ECG or heart rate
  - Autonomic activity

- GSR
  - Autonomic activity

Etc.
- Attention level
- Anxiety and stress
- Cognitive load
- Emotion
- Drowsiness / sleep
EEG measure the electrical activity of neurons in the cortex
EEG waveform is generated by synchronous activity of neurons
EEG rhythms

> 30 Hz : Gamma rhythm
## EEG rhythms

<table>
<thead>
<tr>
<th>Rhythm</th>
<th>Bandwidth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gamma (γ)</td>
<td>[30, 40] Hz</td>
<td>Low in amplitude; can indicate event brain synchronization and be used to confirm some brain disorders.</td>
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<tr>
<td>Beta (β)</td>
<td>[13, 30] Hz</td>
<td>Indicates an alert state, with active thinking and attention.</td>
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<tr>
<td>Alpha (α)</td>
<td>[8, 13] Hz</td>
<td>Indicates a relaxed state, with little or no attention or concentration.</td>
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<tr>
<td>Theta (θ)</td>
<td>[4, 8] Hz</td>
<td>Indicates creative inspiration or deep meditation; can also appear in dreaming sleep (REM stage).</td>
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<tr>
<td>Delta (δ)</td>
<td>[0.5, 4] Hz</td>
<td>Primarily associated with deep sleep or loss of body awareness, but can be present in the waking state.</td>
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</tbody>
</table>

https://csdl-images.computer.org/mags/co/2012/07/figures/mco2012070087t1.gif
EEG rhythms

Broad feature of EEG rhythms

- **Ratio** = \( \frac{\text{High frequency activity (beta and gamma band)}}{\text{Low frequency activity (theta and alpha band)}} \)

- **Ratio increase with increase in cognitive demand**
  - Attention, stress, anxiety, cognitive load, arousal etc.

- **Ratio decrease with decrease in cognitive demand**
  - Decrease in attention level, drowsiness, relax state, sleep

*Useful for continuous monitoring of attention level and alertness of the subject....*
Event-related Changes

- Stimuli – external or internal
- Analysis of change in neural response or activity in response to task or stimuli
- P300 response: target matching
- ERD (event related desynchronization): decrease in power of lower frequency band (theta, alpha and may beta bands) in response to task
- Gamma band activity changes less noticeable in EEG due to lower SNR
Emotion influences both human-human and human-computer interactions

- EEG can help in identification or measurement of emotional state
- Machine learning based approach is common
EOG- electro-occulogram

- EEG channel can be used for eye movement detection
- Indeed, it is based on EMG of eye muscles
- EOG is useful in HC-interface and eye moment behaviour analysis
Autonomic response / involuntary
- Controls functions include sleep/wake cycles, level of arousal/alertness, heart rate, respiratory rate, endocrine function, immune function, digestive function and energy production and utilization

Arousal/Alertness/stress induce sympathetic drive

HR:- Heart rate
- Increase hear rate on sympathetic drive

GSR –galvanic skin resistance
- Measure skin conductance
- Increase skin conduction on sympathetic drive
- EEG Offer real time user states
  - Alertness / attention / cognitive load / fatigue / sleepiness / emotion etc.

- However, EEG based evaluation of human-computer interface is not straightforward in many cases

- But, it is an one of the important interface for HCI system
  - Brain-computer interaction
Thank You