BCI Paradigms

211032 – Seminarium HMI

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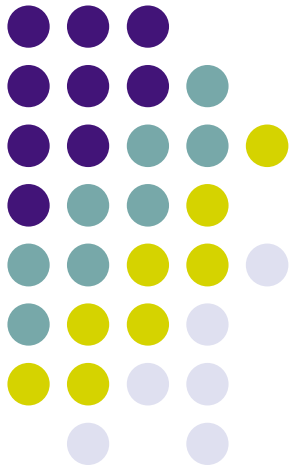

Universiteit Twente
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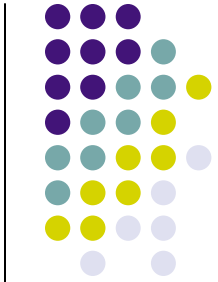
Human Media Interaction

Outline

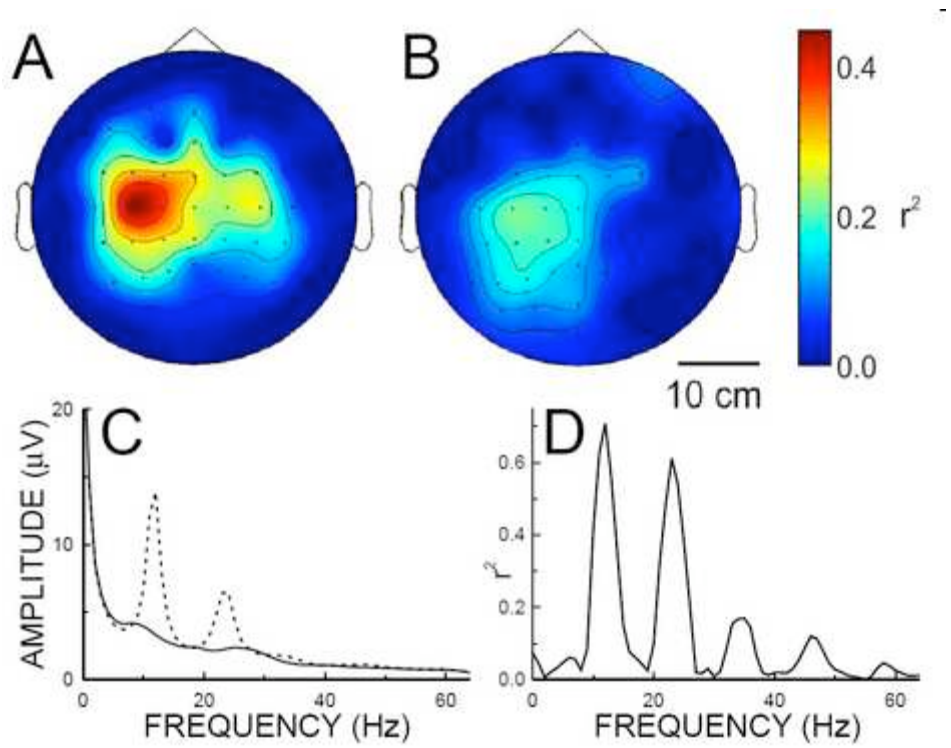


- EEG based BCI paradigms
  - ERD/ERS
  - P300
  - SCP
  - SSEP
- Categorization of BCI paradigms

Event related de/synchronization (ERD/ERS)

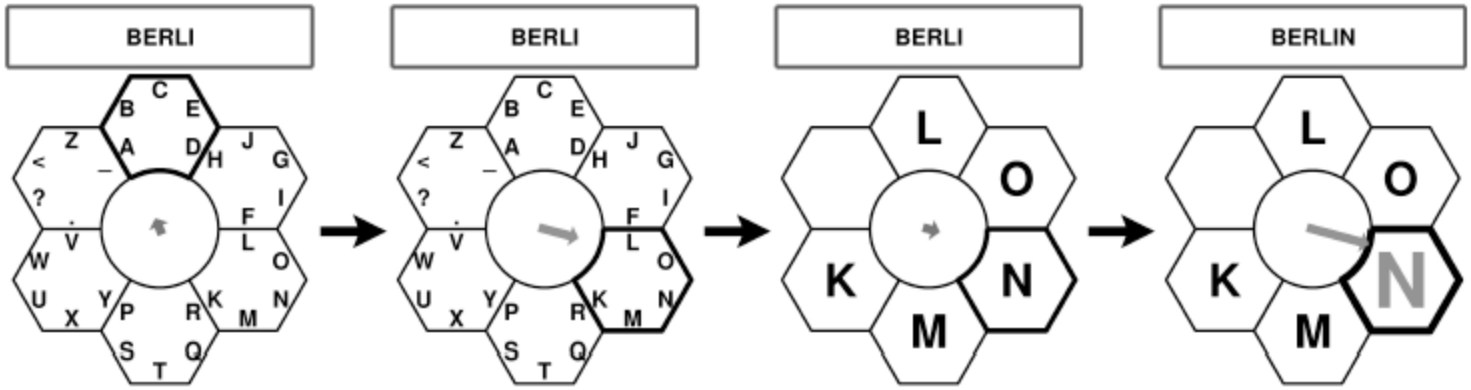
- Sensorimotor rhythms (SMR) (in humans called the μ-rhythm)
  - rhythmic activity usually within 8-12 Hz, often mixed with a β component (around 20 Hz)
  - observed over primary sensory or motor cortical areas
  - occurs (i.e. synchronized) unless processing sensory information or producing motor output
  - blocked (i.e. desynchronized) by movements, movement imagery or movement preparation

ERD/ERS


A
B
0.4
0.2
r²
0.0
10 cm
C
AMPLITUDE (μV)
20
10
0
0
20
40
60
FREQUENCY (Hz)
D
r²
0.6
0.4
0.2
0.0
0
20
40
60
FREQUENCY (Hz)

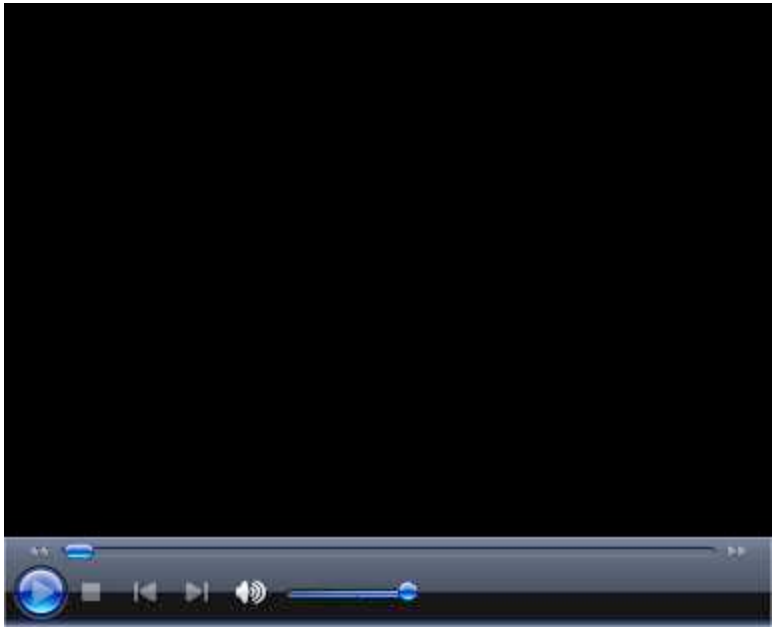
ERD/ERS in BCI

- Hex-o-Spell (Blankertz et al.)
  - Turn the arrow clockwise by imagined right-hand movement
  - Stop and extend the arrow by imagined right-foot movement



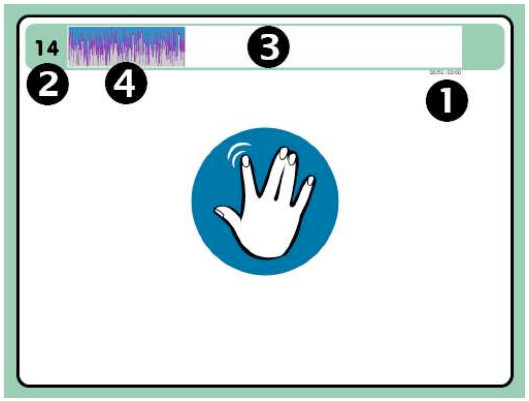
ERD/ERS in BCI

- Hex-o-Spell (http://www.dcs.gla.ac.uk/~rod/Videos.html)

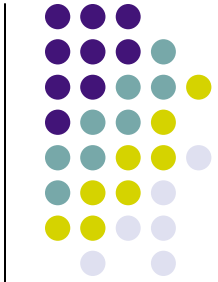


ERD/ERS in BCI

- BrainBasher (Oude Bos & Reuderink)
  - Left vs. right hand imagination cued by hand symbols
  - Try to make as many correct imageries as possible within given time

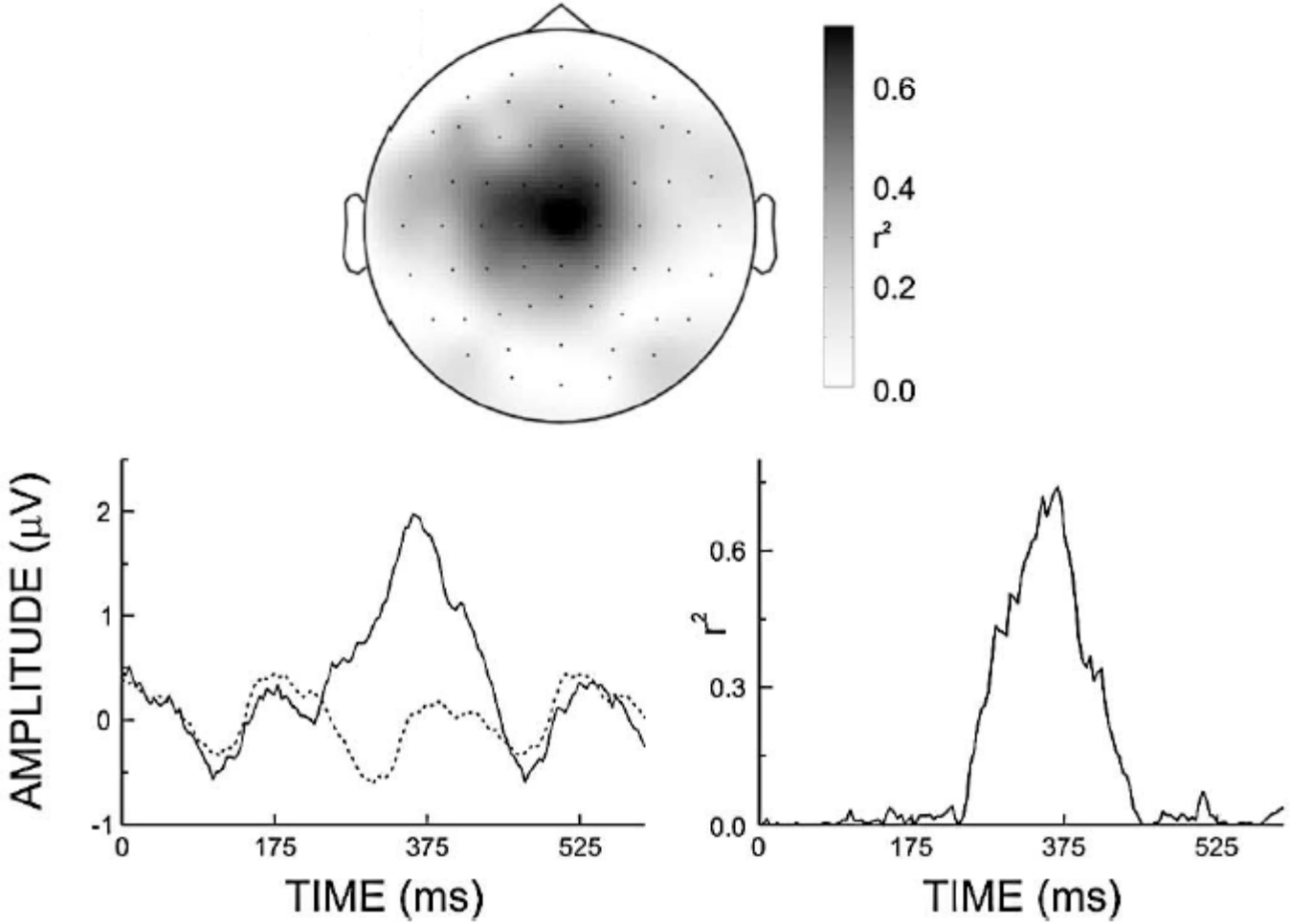


P300

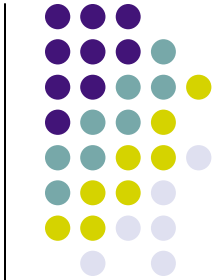


- Condition to occur:
  - A rare *target* stimulus presented w/ low probability
  - During a series of frequent *standard* stimuli
  - Subject has *primary task* to perform on target
- A positive peak occurs over central and parietal cortex ~300 ms after the target stimulus is presented

P300


0.6
0.4
r²
0.2
0.0
AMPLITUDE (μV)
2
1
0
-1
0
175
375
525
TIME (ms)
r²
0.6
0.3
0.0
0
175
375
525
TIME (ms)

P300 in BCI

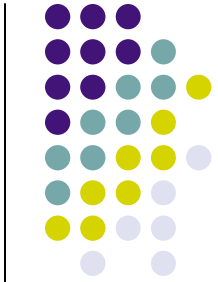


- P300 Speller (Donchin et al.)
  - Visual P300
  - 6x6 matrix of symbols
  - Subject concentrates on a symbol (i.e. cell)
  - Each row and column flashes twice
    - i.e. 2 target flashes vs. 10 non-target flashes
    - random order
    - for very short time (e.g. 100 ms)

P300 in BCI

- P300 Speller
  (Video @ http://www.youtube.com/watch?v=4QxPR25DMAg)

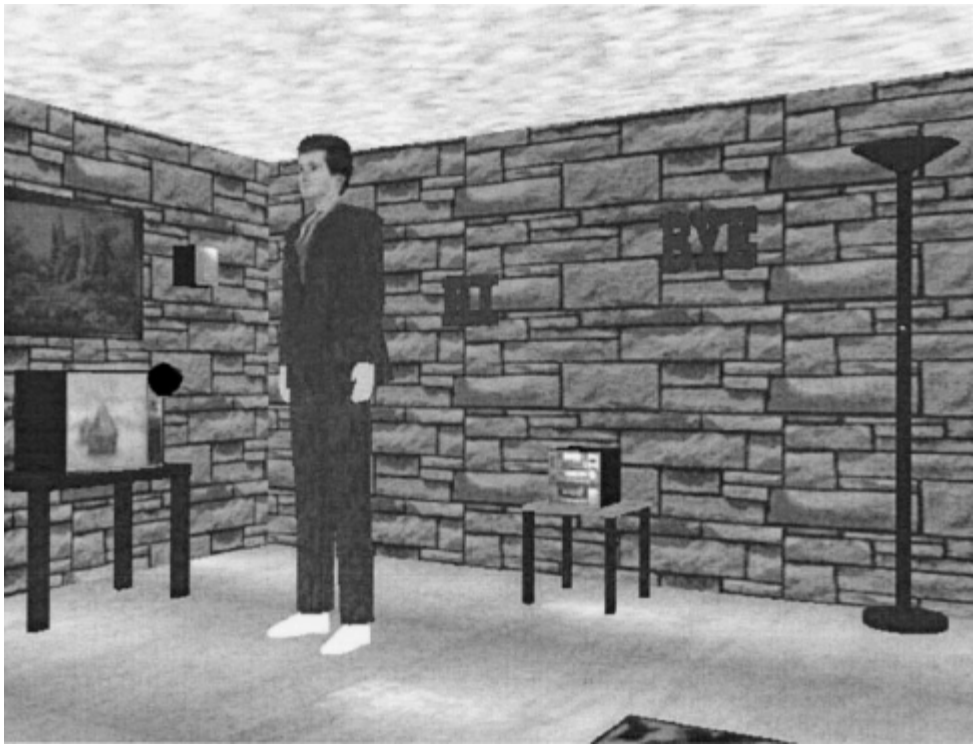
P300 in BCI



- Virtual apartment (Bayliss et al.)
  - Virtual room with controllable objects
  - Task: count # flashes on an object
  - A sphere flashes on each object
    - in random order
    - once per second
    - lasting for 250 ms
  - Total of 250 flashes

P300 in BCI

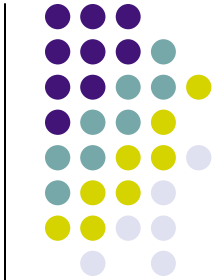
- Virtual apartment (Bayliss et al.)



Slow Cortical Potentials (SCP)

- Slow voltage changes generated in cortex
- Occur over 0.5 – 10 s
- Positive SCP: functions involving cortical activation (e.g. movement)
- Negative SCP: Reduced cortical activation

SCP in BCI



- SCP Speller (Birbaumer et al.)
  - Alphabet split into two halves
  - Each half represented for some time
  - If +SCP is observed, that half is further divided
  - Else the other half is shown
    - If +SCP is observed, that half is further divided
    - Else “Go Back”

SCP in BCI

- SCP Speller

LIEBER-HERR-BIRBAUMER-

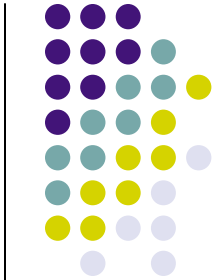
HOFFENTLICH-KOMMEN-SIE-MICH-BESUCHEN,-WENN-DIESER-
BRIEF-SIE-ERREICHT-HAT-.ICH-DANKE-IHNEN-UND-IHREM-
TEAM-UND-BESONDERS-FRAU-KÜBLER-SEHR-HERZLICH,-DENN-
SIE-ALLE-HABEN-MICH-ZUM-ABC-SCHÜTZEN-GEMACHT,-DER-
OFT-DIE-RICHTIGEN-BUCHSTABEN-TRIFFT.FRAU-KÜBLER-IST-EINE-
MOTIVATIONSKÜNSTLERIN.OHNE-SIE-WÄRE-DIESER-BRIEF-NICHT-
ZUSTANDE-GEKOMMEN.-ER-MUSS-GEFEIERT-WERDEN.-DAZU-
MÖCHTE-ICH-SIE-UND-IHR-TEAM-HERZLICH-EINLADEN-.
EINE-GELEGENHEIT-FINDET-SICH-HOFFENTLICH-BALD.

MIT-BESTEN-GRÜSSEN-
IHR-HANS-PETER-SALZMANN

Steady State Evoked Potentials (SSEP)

- Stimulus presented repetitively at high rate
  - So that relevant neuronal structures are prevented to return to their resting states
- The amplitude of the SSEP is increased at the frequency of the modulation of stimulus
- Dominant location depends on type of SSEP
  - VEP (visual)
    AEP (auditory)
    SEP (somatosensory)

SSEP in BCI



- Mind Balance (Lalor et al.)
  - Character walking on a rope, stumbles on one side randomly every 1.5 – 5 s
  - Checkerboards on each side of the character, each flickering at different frequency
  - Subject looks at the checkerboard at the opposite of the side which the character is losing balance
  - Two consecutive errors results the character falling of the rope and the end of the game

SSEP in BCI

- Mind Balance
  (Also see http://www.youtube.com/watch?v=_LtVLsxoN-M)

Categorization of BCI paradigms

- Evoked (Endogenous / Asynchronous)
  - Subject must pay attention for a certain time to external cues (e.g. flashes, sounds, etc.)
  - Cue-based
- Spontaneous (Exogenous / Synchronous)
  - No continuous attention to specific stimulus is necessary
  - User-driven

Categorization of BCI paradigms

- Spontaneous vs. Evoked
  - ERD Spontaneous
  - P300 Evoked
  - SSEP Evoked
  - SCP Spontaneous

Categorization of BCI paradigms

- Dependent
  - Some activity from peripheral nerves and muscles are needed to produce changes in brain
  - E.g. gaze direction
- Independent
  - No such activity is needed
  - EEG signal depends on user's intent

Categorization of BCI paradigms

- Dependent vs. Independent (Open to debate!)
  - ERD Independent
  - P300 Independent
  - SSEP Dependent
  - SCP Independent

References

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