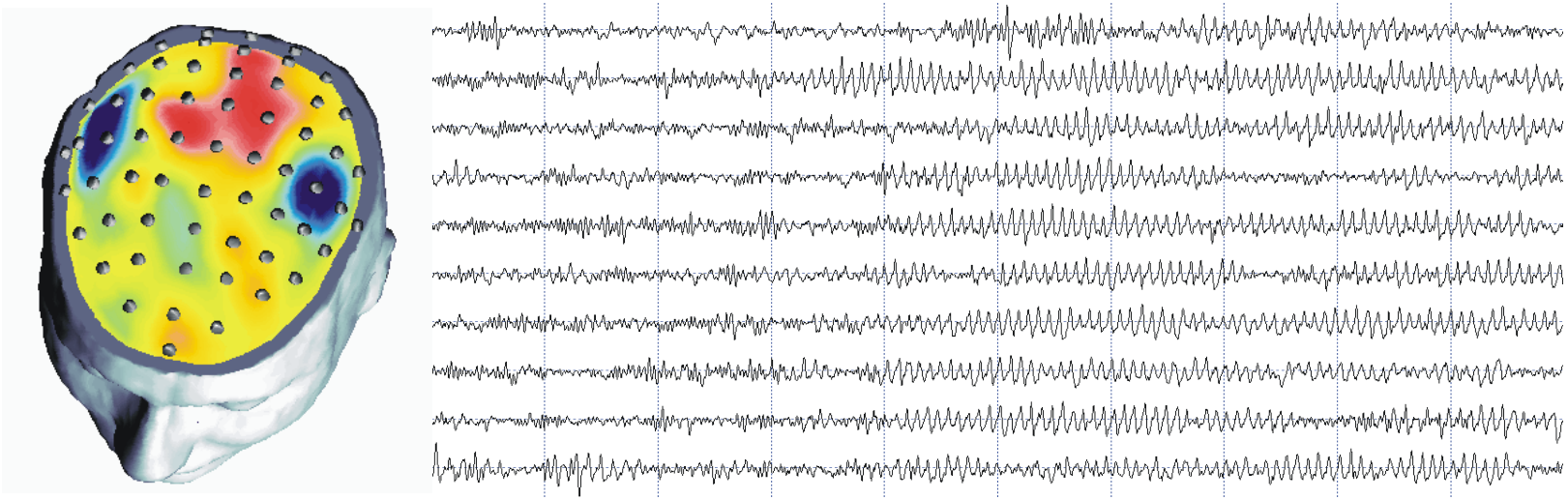

Gedankengesteuerte Kontrolle von virtuellen Welten

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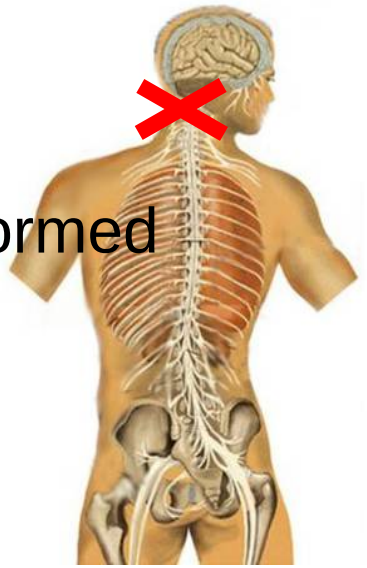
Motivation:

"Gedankengesteuerte Kontrolle von virtuellen Welten"

"Thought based control …"

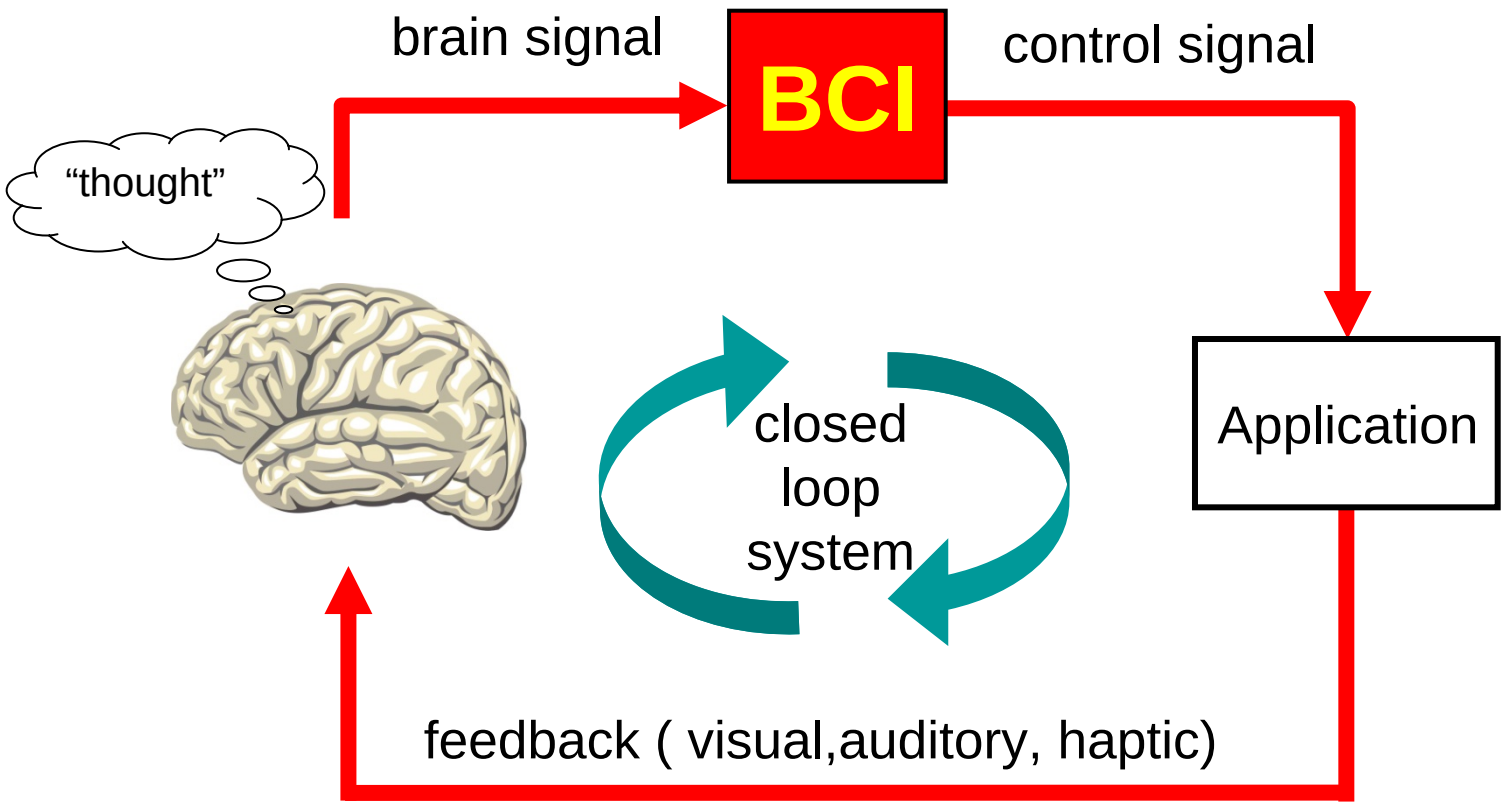
- Realization of a non-muscular control channel
- This means specific thoughts have to be transformed into control signals
- Bypass of existing outputs
- Alternative communication channel



"… of virtual worlds"

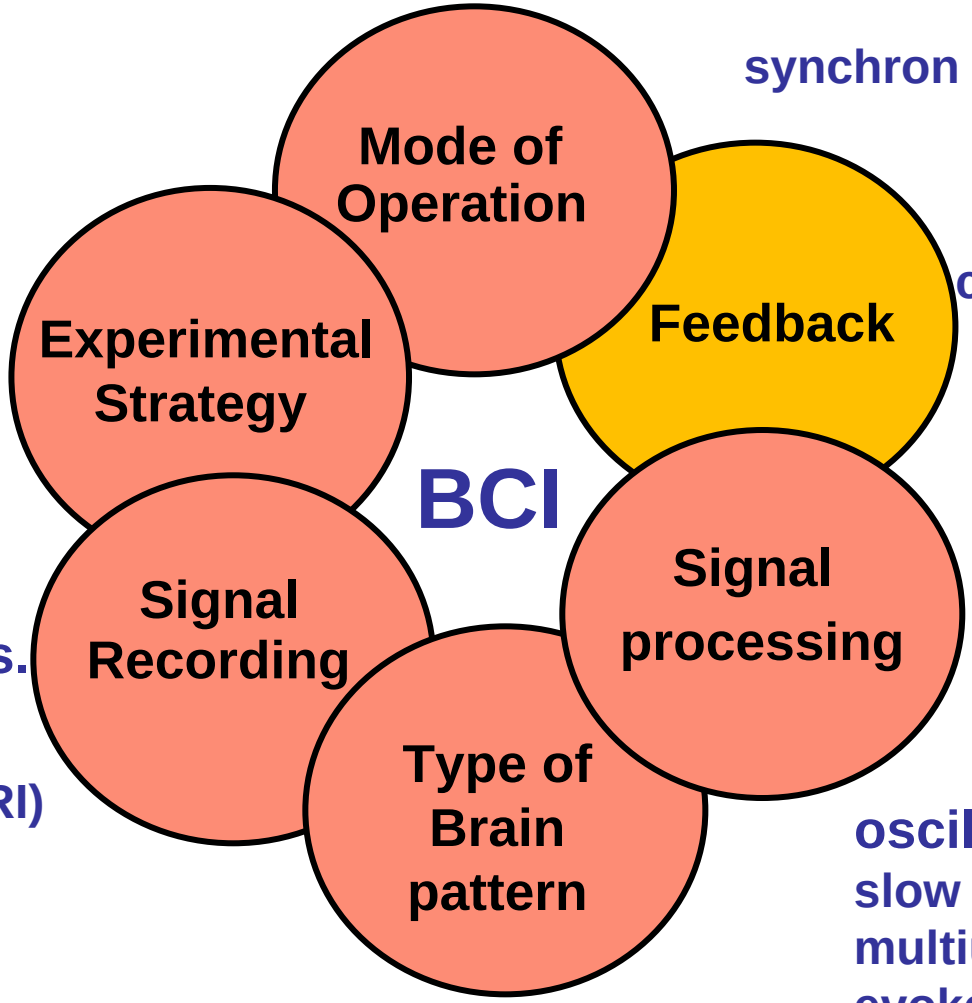
- Stimulating complex environments
- Simulation of real-life scenarios
- Testing of prototypes

Brain-Computer Interface (BCI)



A BCI is a non-muscular information channel for sending messages and commands direct from the brain to the external world (on-line transformation of thoughts into control signals)

BCI – Komponenten



synchron vs. asynchron

Operant conditioning

Gaze control

Visual attention

Motor imagery

continuous vs. diskret
realistic vs. abstract
Virtual reality

non-invasiv vs. Invasiv

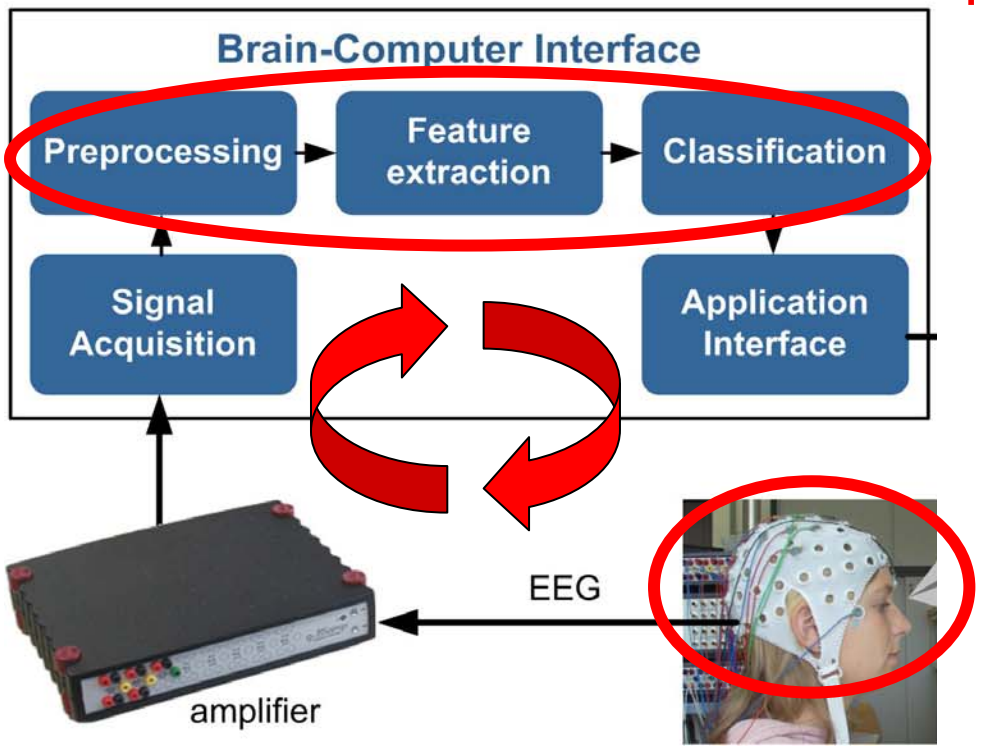
(EEG, MEG, fMRI)

oscillations (ERD, ERS)
slow cortical potentials
multiunit activity
evoked potentials

Scalp Electroencephalogram (EEG)

Functional principle of the Graz-BCI

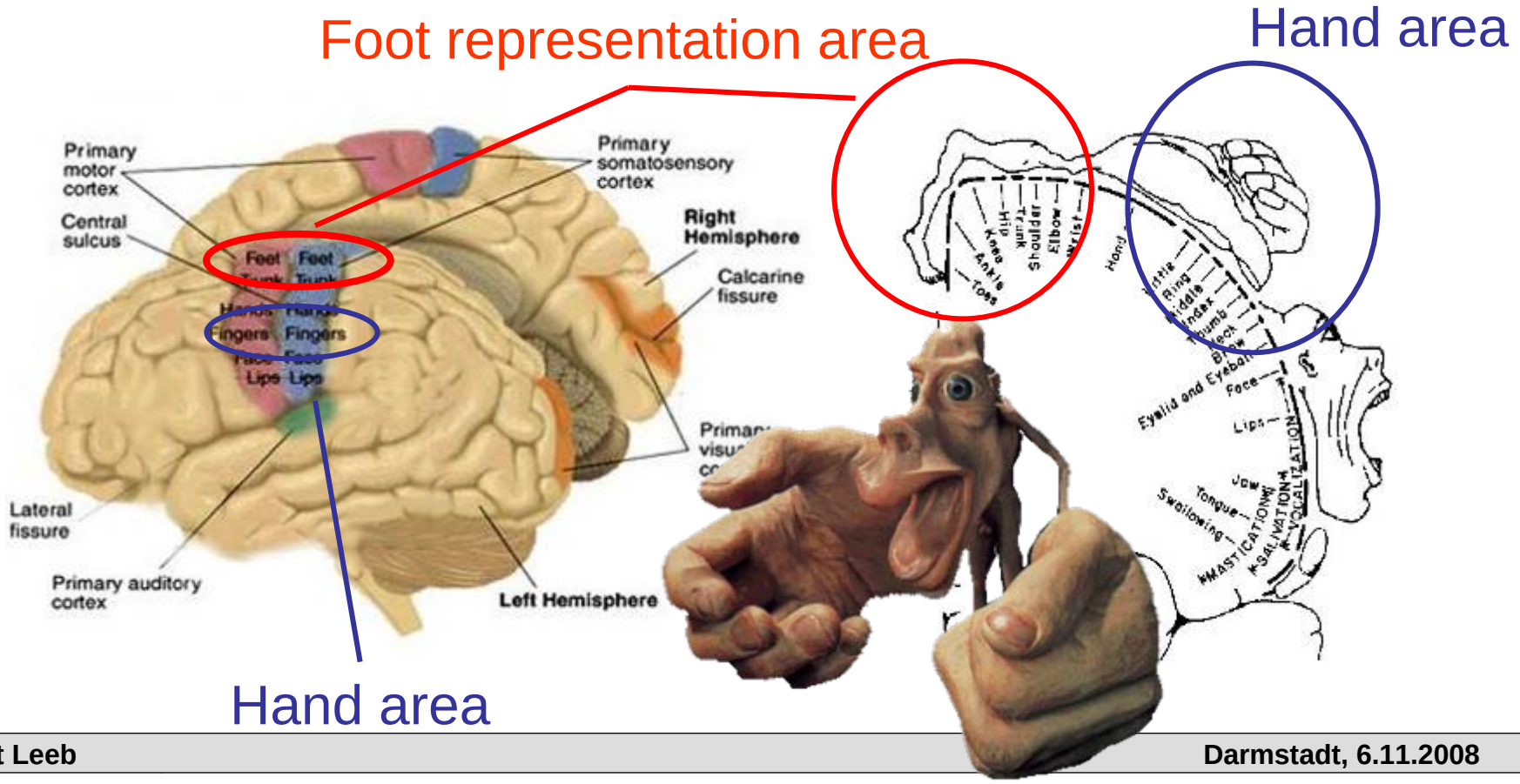
Computer



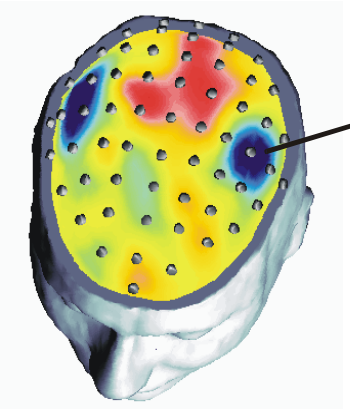
Brain

Mental strategy

Certain brain patterns are correlated to specific mental tasks. These brain patterns have particular characteristics, such as timing, amplitude, frequency, and topography.



Motor imagery results in changes of brain oscillations in the 10Hz and 20Hz band



subject k3

electrode position C3

cue

**** motor imagery ****

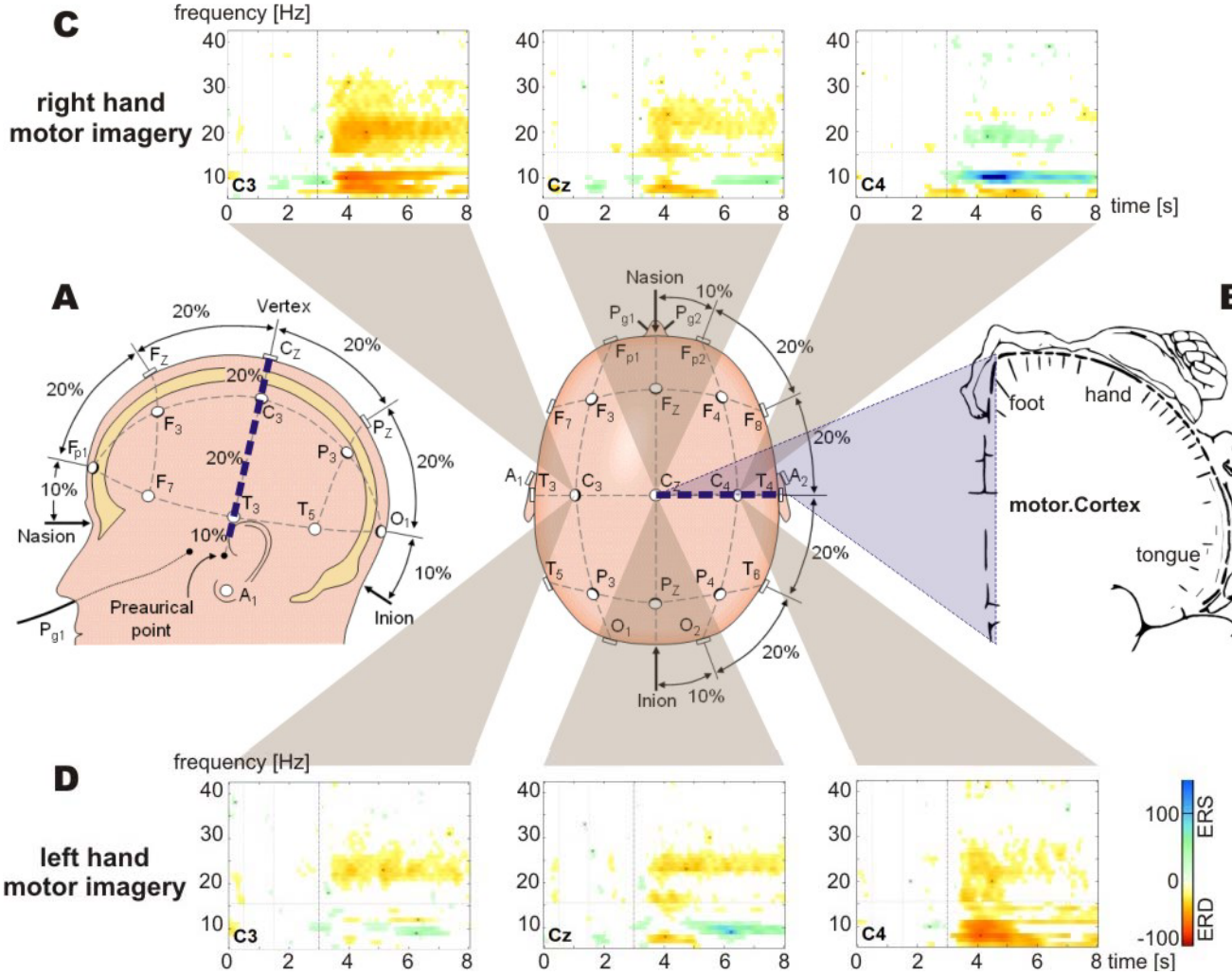
11 - 13 Hz ERS (blue)

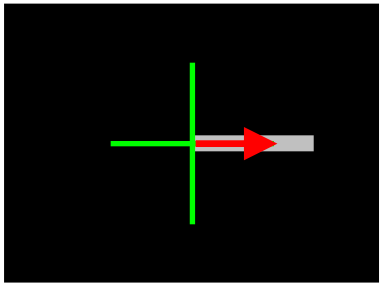
10 µV

1 s

local average reference

Motor imagery and Event-related desynchronisation (ERD/ERS)





Steps to realize BCI control

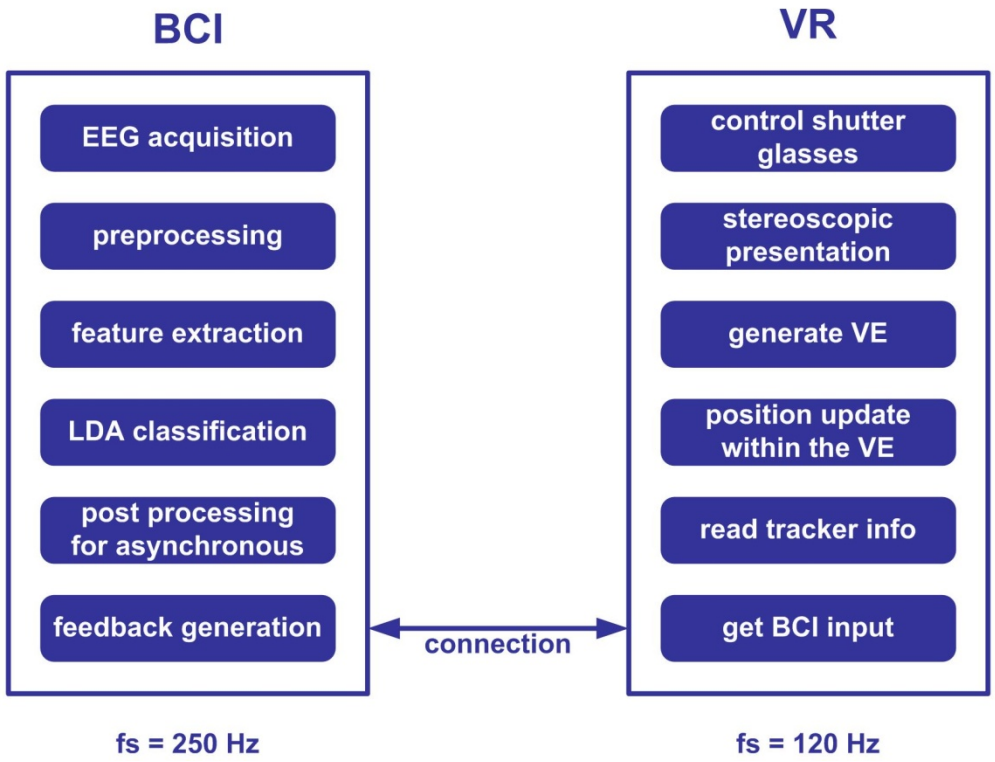
1. Multi-channel EEG recordings using various mental strategies and offline processing

2. Optimize and search for:
   - Best mental strategy
   - Best electrode position
   - High discriminable EEG feature

3. Online training with feedback

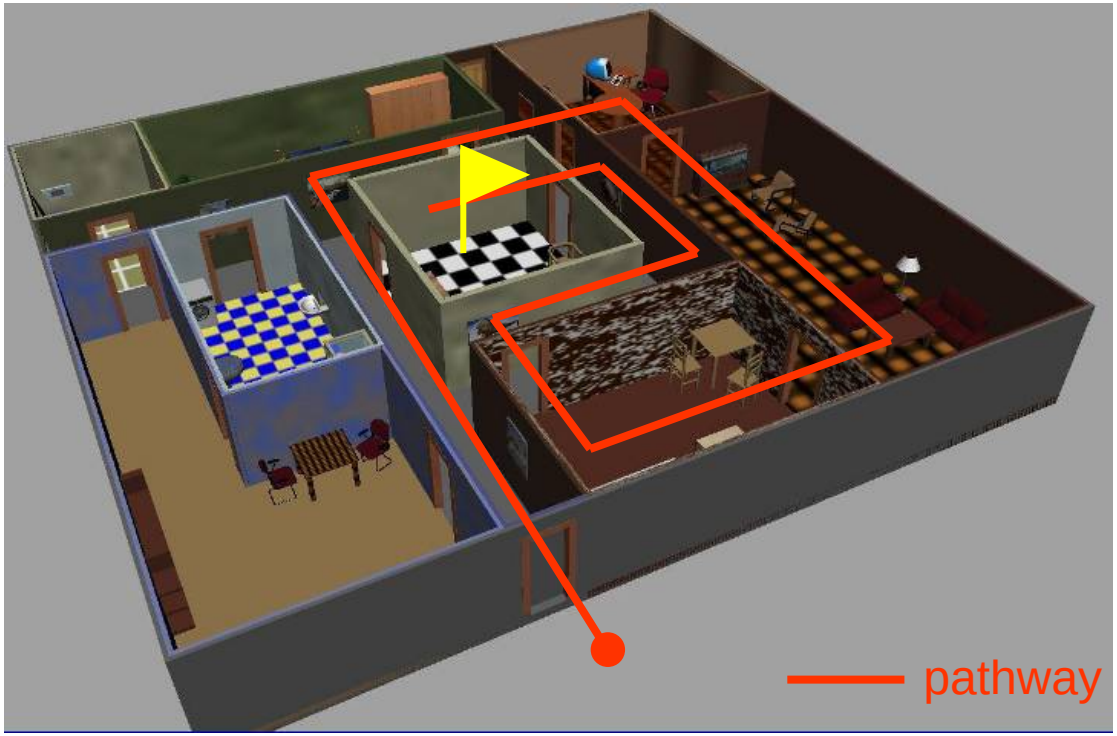
4. **VR-Application**

Coupling of BCI and VR



Study: Exploration of a virtual flat

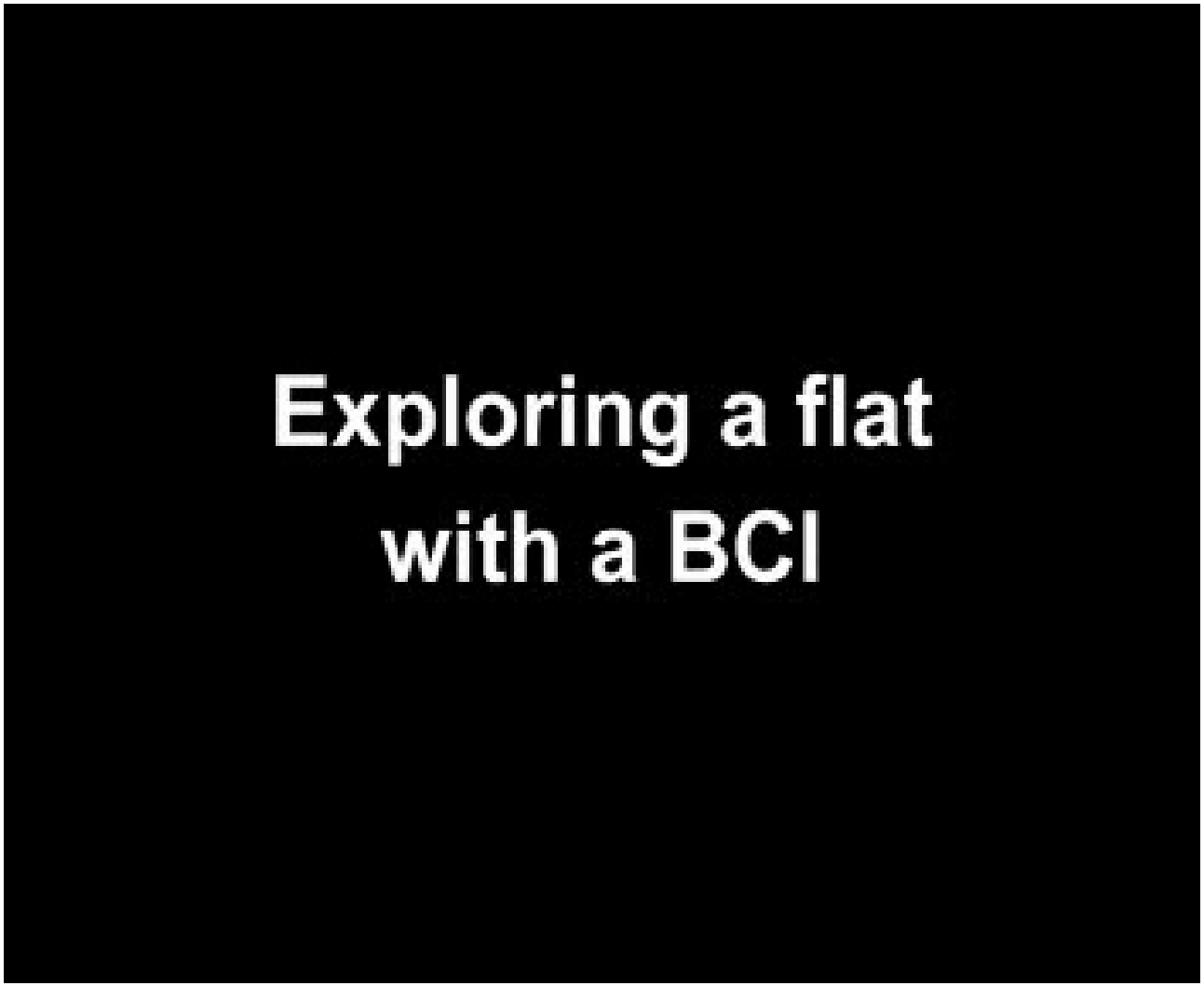
- Goal oriented task → higher challenge for the subjects
- Overcoming limitations of synchronized BCI
  → “neutral” cue with variable trial lengths



Principle

walking direction controlled by left hand vs. right hand motor imagery

Movie



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R.Leeb, et.al: "Brain-Computer Communication: Motivation, aim and impact of exploring a virtual apartment“, IEEE TRNE, 2007.

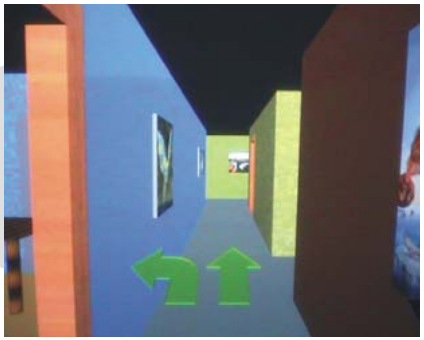
VR-enhanced BCI performance

Feedback

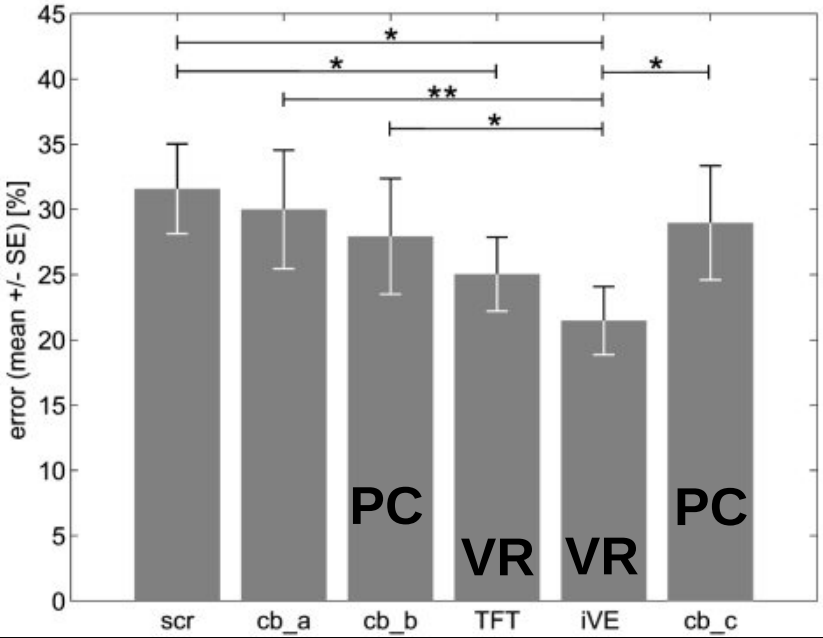
PC

Feedback

VR



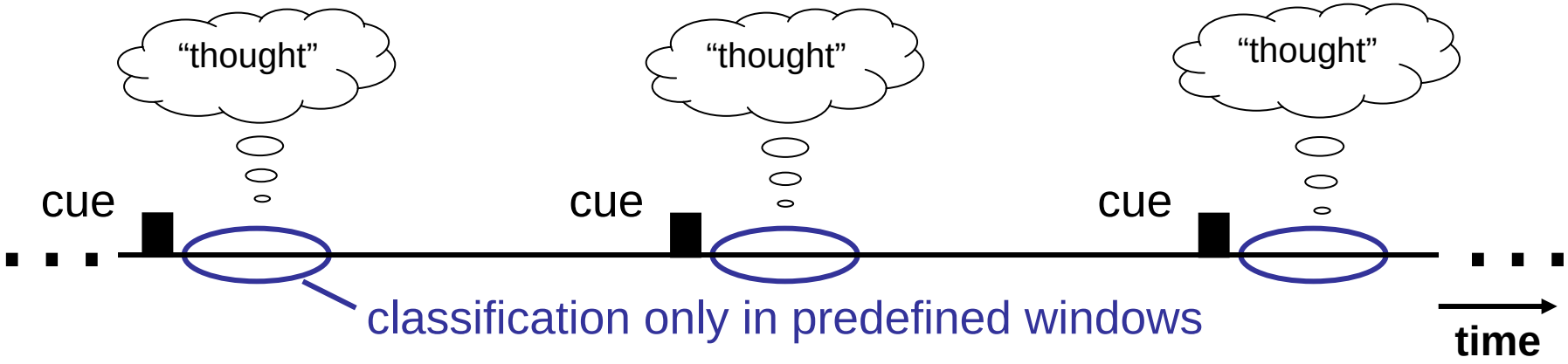
Enhanced BCI performance in a right/left motor imagery task with VR compared to PC feedback



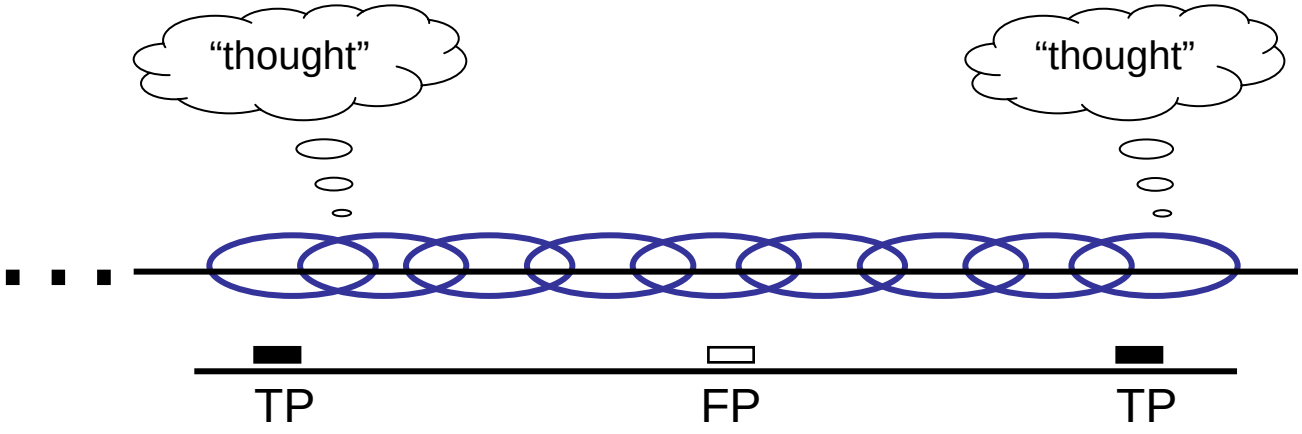
Leeb et.al., IEEE TRNE, 2007

Mode of operation

Synchronous BCI (cue-based, COMPUTER-driven)



Asynchronous BCI (uncued, USER-driven)



Problems:
minimization of FP
Differentiation between mental activity and rest

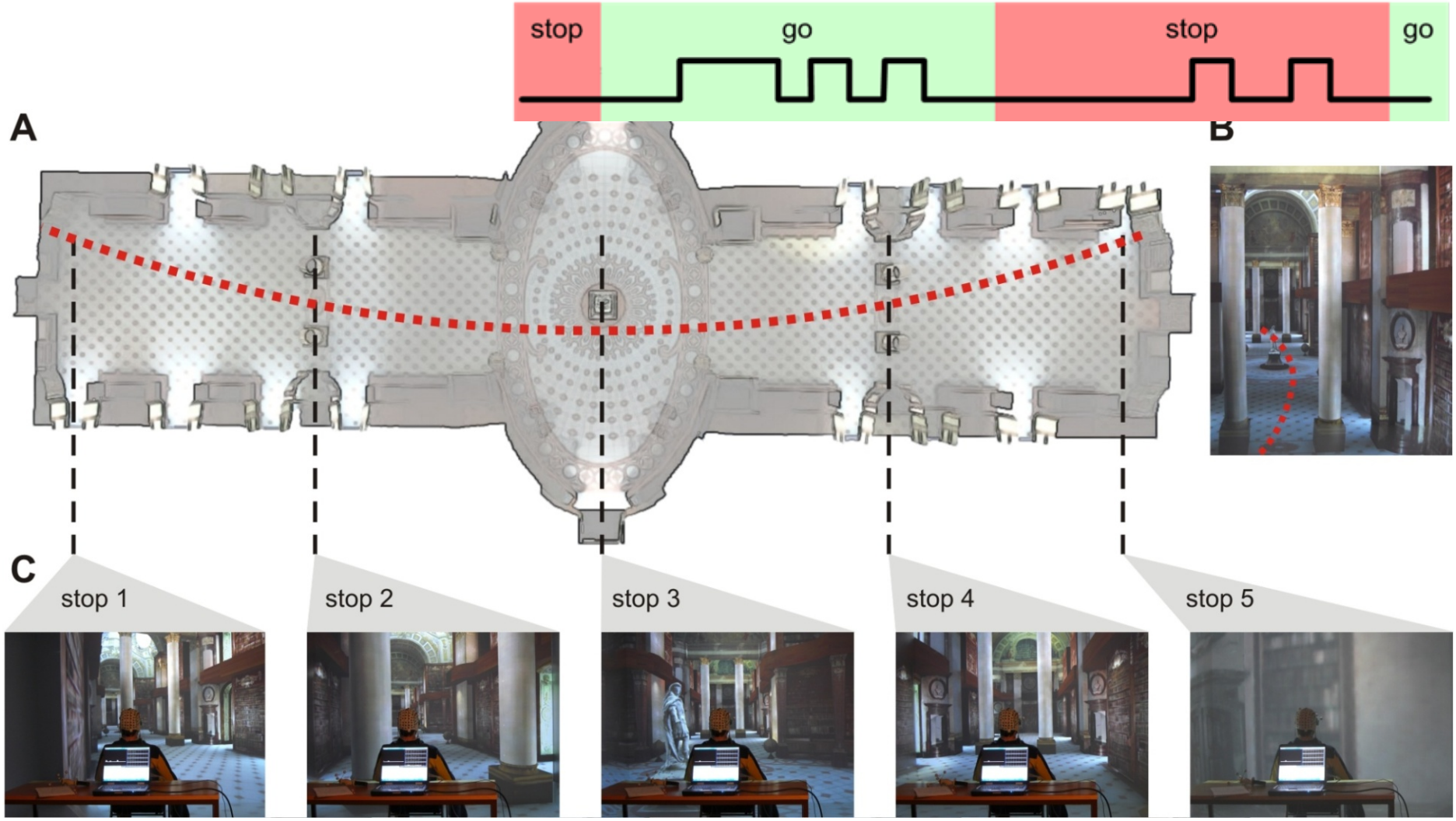
TP – True Positive
FP – False Positive

Study: Movement control with an asynchronous BCI

- Walking should only appear when they are thinking on it.
- Stop at predefined points to evaluate the performance.

In cooperation with the Institute for Computer Graphics and Knowledge Visualisation, Graz University of Technology

Study: Movement control with an asynchronous BCI



R. Leeb, et al.: Self-paced exploration of the Austrian National Library through thought, International Journal of Bioelectromagnetism, vol.9 (4), 2007.

Movie

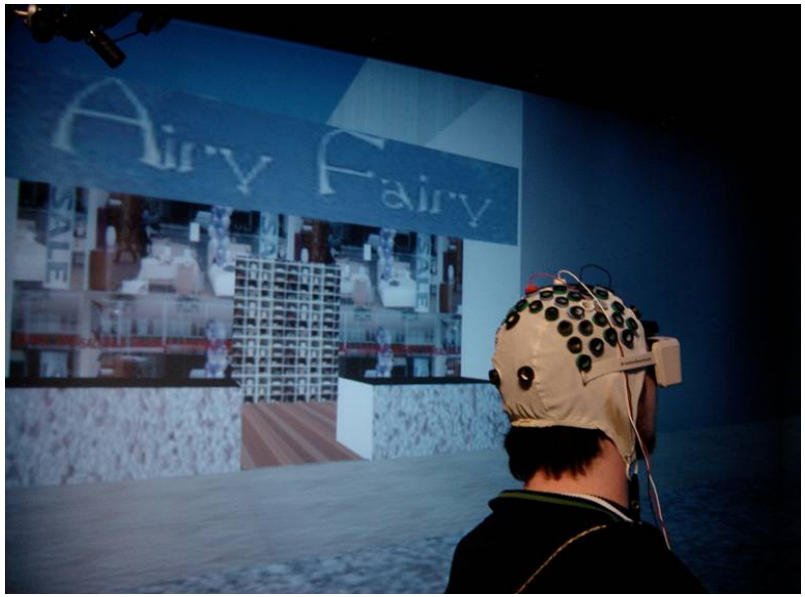
In cooperation with the Institute for Computer Graphics and Knowledge Visualisation, Graz University of Technology

Time [1:14]

R. Leeb, et al.: Self-paced exploration of the Austrian National Library through thought, International Journal of Bioelectromagnetism, vol.9 (4), 2007.

Study: Simulation of a wheelchair movement in VE: A case study with a tetraplegic

EEG-based control of a wheel chair in a real street is equivalent to EEG-based control of a virtual street with a fixed wheel chair



Asynchronous task definition

In cooperation with the
Virtual Environments and Computer Graphics, Department of Computer Science
University College London

R.Leeb, et.al: “Self-paced (asynchronous) BCI control of a wheelchair in Virtual Environments: A case study with a tetraplegic," Computational Intelligence and Neuroscience, 2007.

Movie

Time [1:09]

R.Leeb, et.al: ""Self-paced (asynchronous) BCI control of a wheelchair in Virtual Environments: A case study with a tetraplegic," Computational Intelligence and Neuroscience, 2007.

Advantages of VR for BCI

- prototyping of the utility of systems that are not yet build (e.g. robotic hand, special interfaces)
- rehearsal of scenarios that are in the real world to dangerous (e.g. wheelchair GO/STOP control)

  → closest possible scenario for control a real wheelchair in a real street

- BCI for games (additional input devices)

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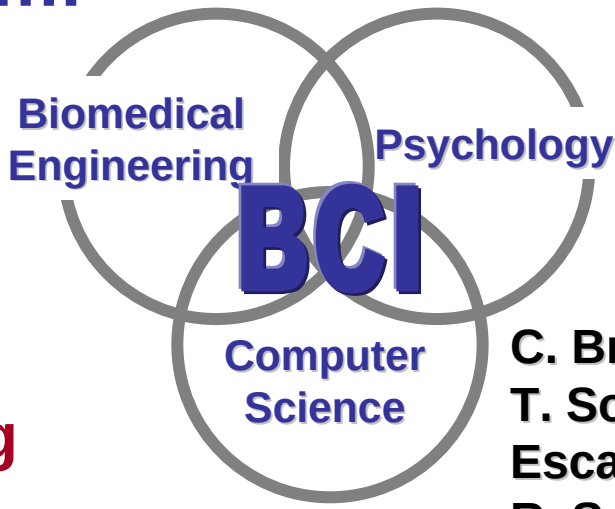

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