



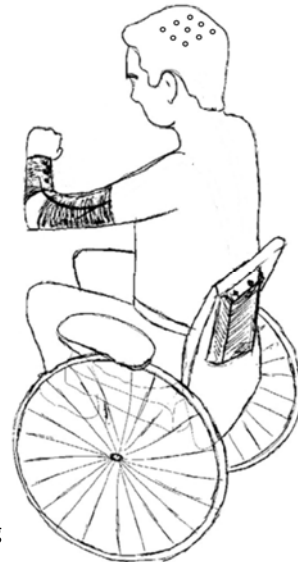
# Brain-Computer Interface – Steuern nur durch Denken?

**Gernot R. Müller-Putz**

Institut für Semantische Datenanalyse, BCI-Labor  
Technische Universität Graz



KEEP ON RUNNING: ICT Call 10 & 11 Informationsveranstaltung



## Stark motorisch beeinträchtigte Menschen



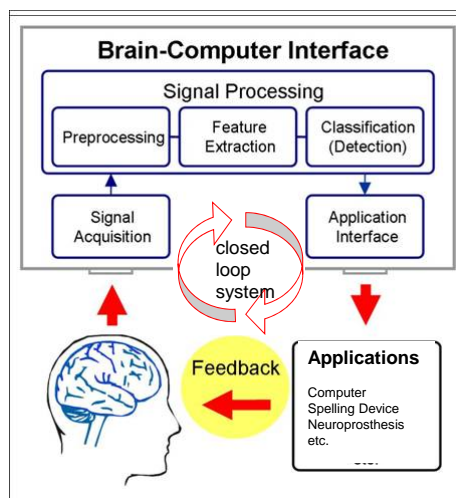
Locked-in Syndrom  
Querschnittlähmung  
Neurodegenerative Krankheiten  
Schlaganfall  
Schädel-Hirn-Verletzungen  
...

# BRAIN-COMPUTER INTERFACE

## Brain-Computer Interface

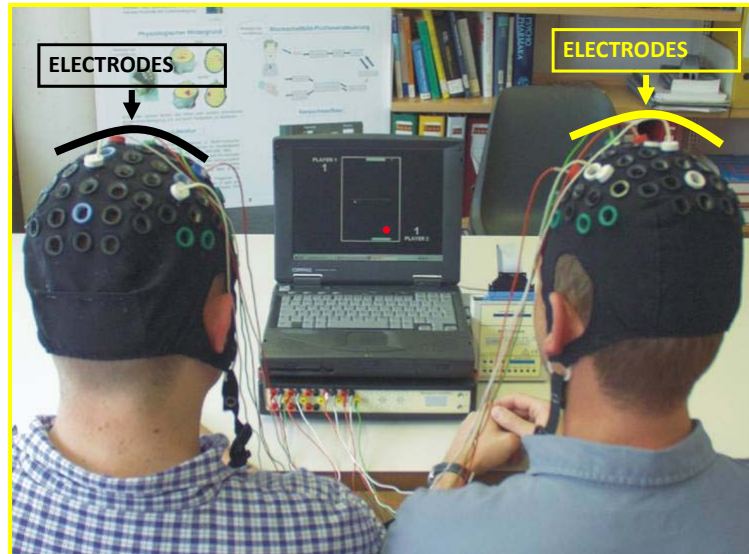
*'A BCI is a device that does not use the normal neuromuscular output pathways of the brain, but accepts commands encoded in neurophysiological signals.'*

*JR Wolpaw, 1991*

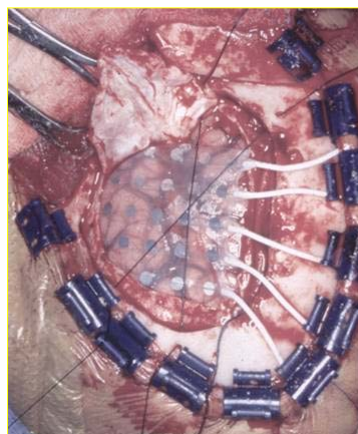


Grainann et al. 2002

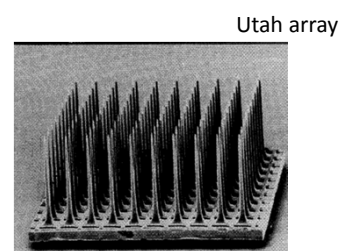
# Scalp EEG



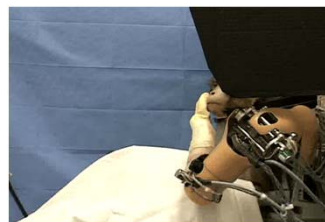
# ECoG / Intracortical rec.





Subdural electrodes for ECoG derivation



Utah array



Schwartz et al.

## Neuronal ensemble control of prosthetic devices by a human with tetraplegia

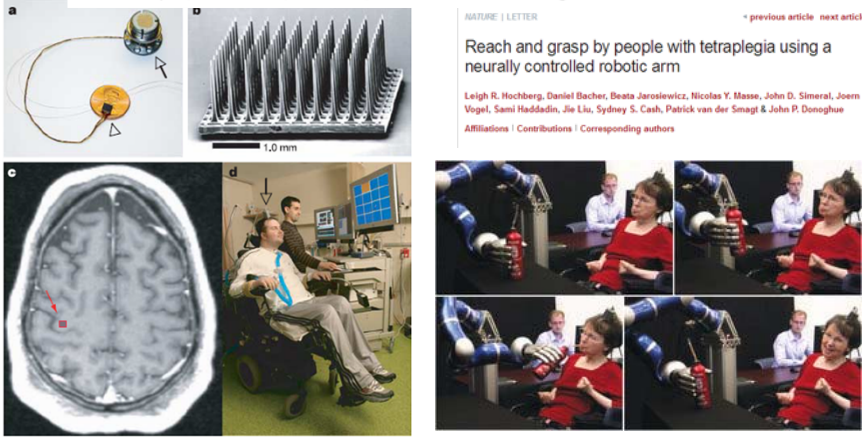
Leigh R. Hochberg<sup>1,2,4</sup>, Mijail D. Serruya<sup>2,3</sup>, Gerhard M. Friehs<sup>5,6</sup>, Jon A. Mukand<sup>7,8</sup>, Maryam Saleh<sup>9</sup>, Abraham H. Caplan<sup>9</sup>, Almut Branner<sup>10</sup>, David Chen<sup>11</sup>, Richard D. Penn<sup>12</sup> & John P. Donoghue<sup>2,9</sup>



NATURE | LETTER - previous article next article -

**Reach and grasp by people with tetraplegia using a neurally controlled robotic arm**

Leigh R. Hochberg, Daniel Bacher, Beata Jarosiewicz, Nicolas Y. Masse, John D. Simeral, Joern Vogel, Sami Haddadin, Jie Liu, Sydney S. Cash, Patrick van der Smagt & John P. Donoghue

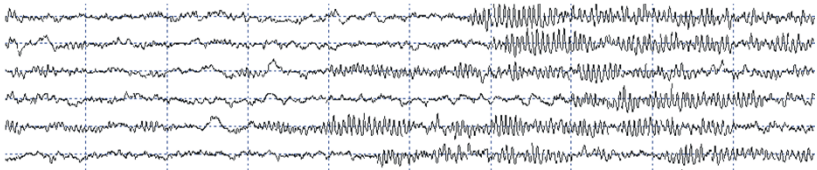
*Affiliations | Contributions | Corresponding authors*



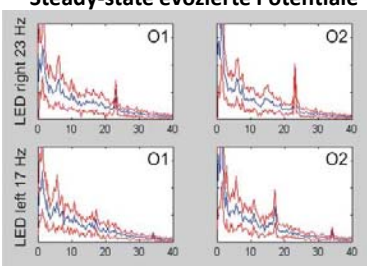



## Gehirnsignale

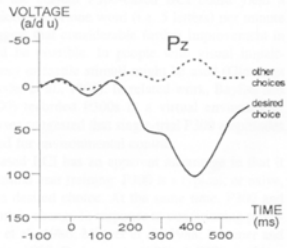
### Spontanes EEG



#### Steady-state evozierte Potentiale



#### P300 evoziertes Potential



**Experimentelle Strategien**

**Operante Konditionierung durch Neurofeedback**  
(e.g. Änderungen von langsamen Potentialen)  
Birbaumer/Tübingen

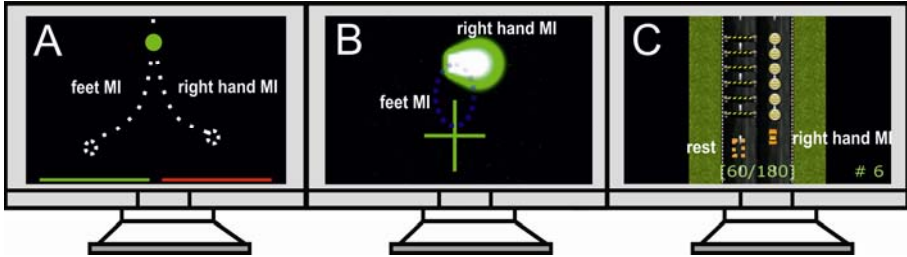
**Mentale Strategie/Art der Gedanken**  
Wolpaw/NY  
Pfurtscheller/Austria

**Fokussierte visuelle/somatosensorische Aufmerksamkeit**  
(z.B. Vergrößerung von VEP P300 Amplituden)  
Donchin/US  
Gao/China  
Müller-Putz/Austria

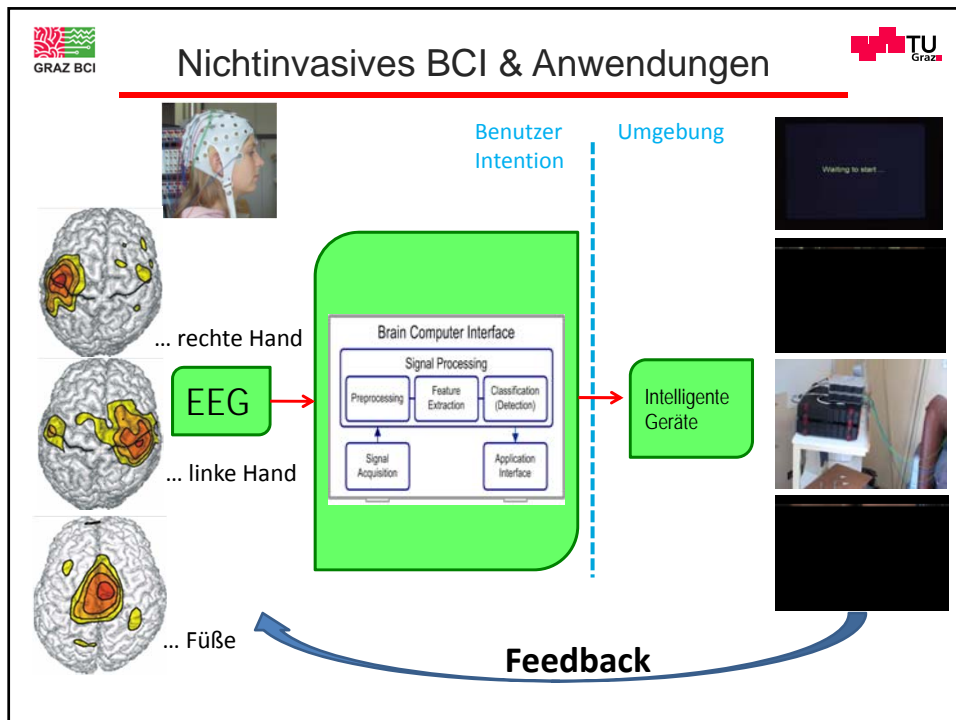
SSVEPs  
SSSEPs

**Feedback**

- **Verschiedene Arten visuellen Feedbacks**
  - Korbspiel (A) (Krausz et al., 2003)
  - Fluider Cursor (B)
  - Autospiel (C)



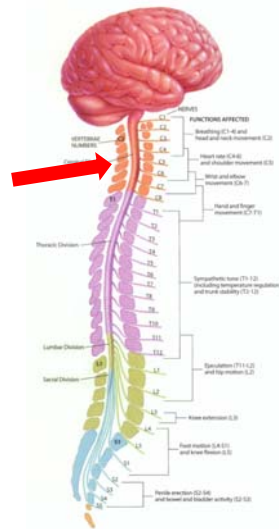
Kaiser et al. 2011



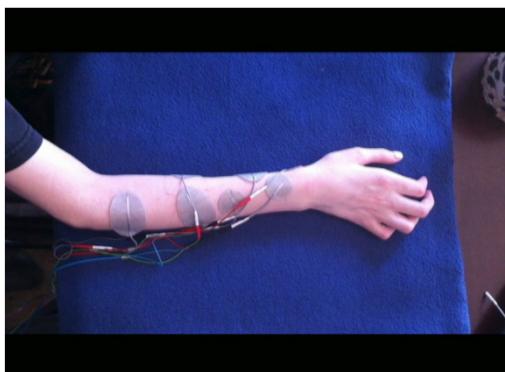
**NEUROPROTHETIK**

**GRAZ BCI** logo is in the top left, and **TU Graz** logo is in the top right.

## Einfache Griffe mittels FES



## Zwei Griffe





FES-Training zwei verschiedener Griffmuster:



- Palmar/Zylinder-Griff
- Lateral/Daumen-Griff

Rupp et al, IEEE EMBS 2012



## BRAIN-COMPUTER INTERFACE ZUR STEUERUNG VON NEUROPROTHESEN


## # 1: BCI steuert Oberflächen-FES

Vorstellung von Fußbewegungen

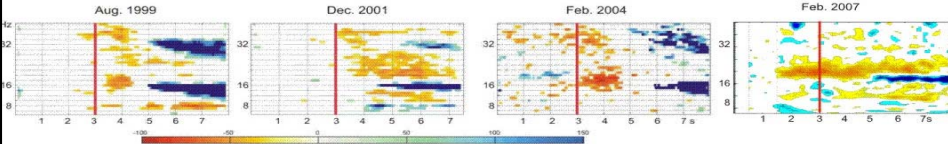
6 Monate BCI-Training  
10 Monate Muskeltraining

stabile 17 Hz Schwingungen  
Seit mehr als 9 Jahren


Trainierte Muskeln,  
tägliche Verwendung von FES




Pfurtscheller et al, NSL 2003  
Müller-Putz PhD 2004

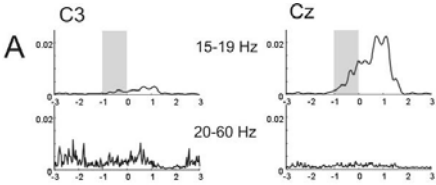







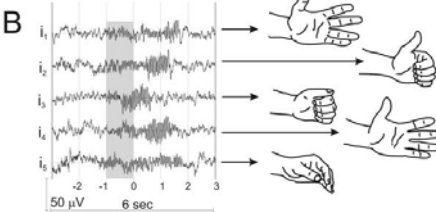
## Schrittweises Schalten durch verschiedene Phasen





**A**







**B**

50  $\mu$ V 6 sec

Pfurtscheller et al. NSL 2003



## #2: BCI steuert implantiertes Freehand-System



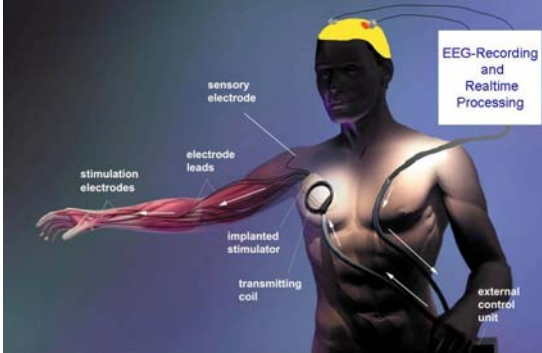
Bewegungsvorstellung  
der linken Hand

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3 Tage BCI-Training  
6 Monate Muskeltraining  
Implantation des  
Freehand-Systems


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detektierbare Gehirnmuster  
(ERD)  
Neuroprothese im  
täglichen Gebrauch

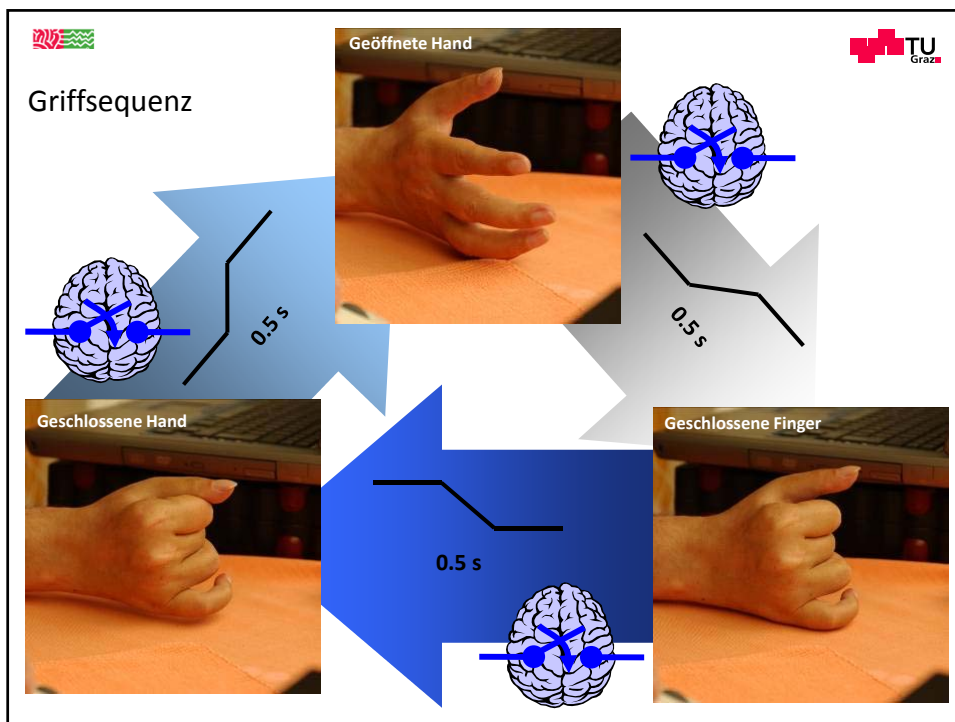


EEG-Recording and Realtime Processing

external control unit



Orthopädie Heidelberg



**Kombination Freehand und BCI**

GRAZ BCI

TU Graz

**Bandleistungsmerkmale**

Logarithmic band power in  $\mu V$

Time in s

C4-18-22 Hz

C4-12-14 Hz

Cz-18-22 Hz

Cz-12-14 Hz

**LDA**

LDA output

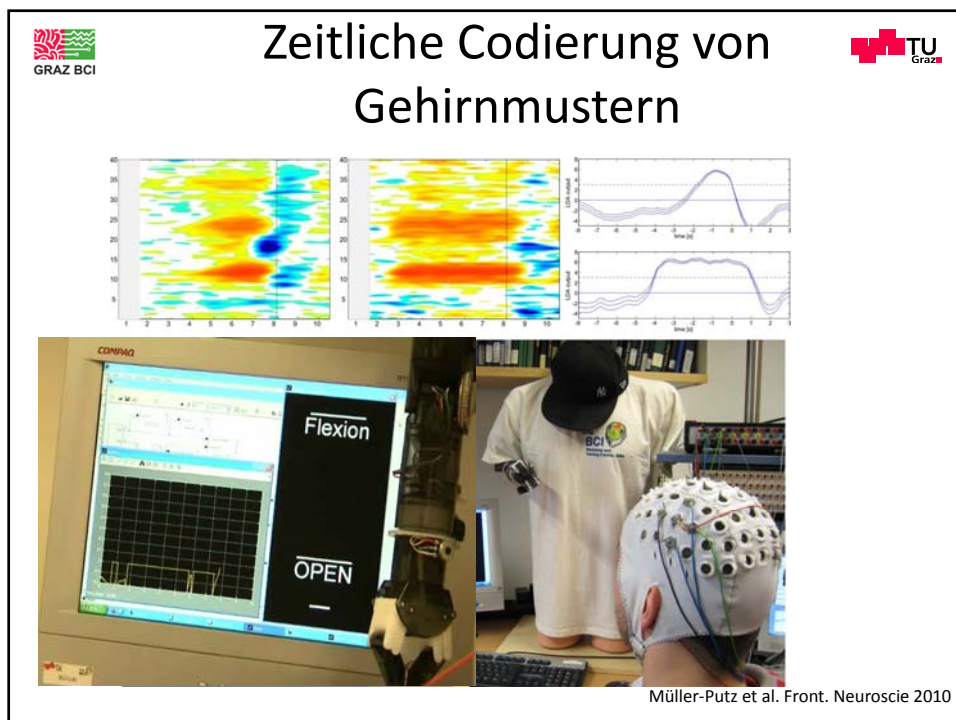
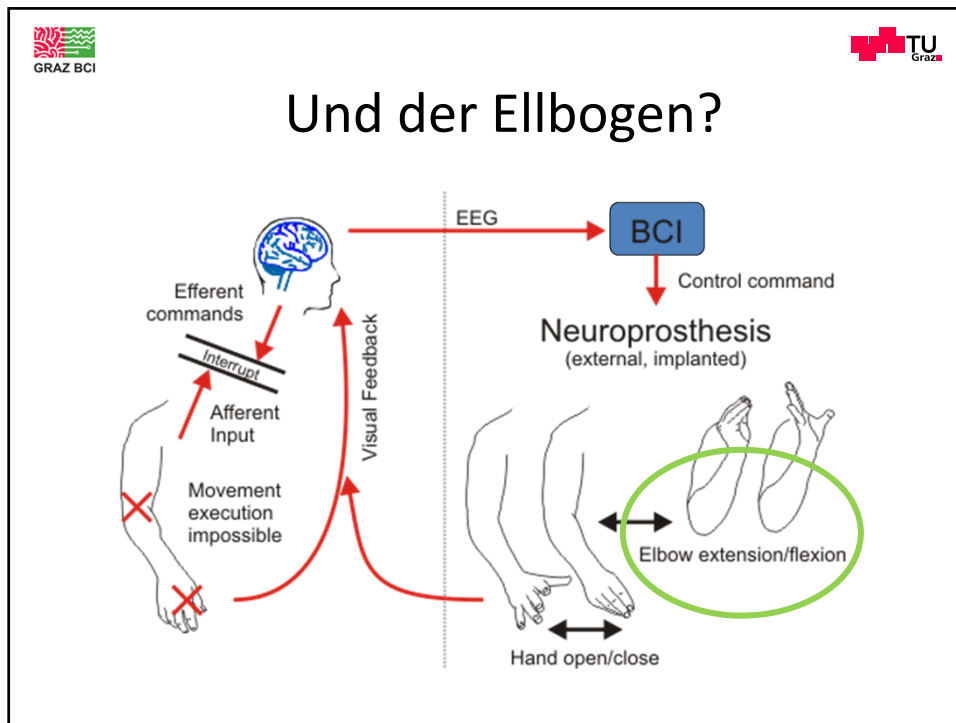
THRESHOLD = 0.7



Time in s

Müller-Putz et al. NSL 2005



Müller-Putz et al. BMT 2006

The slide shows a user wearing a BCI system. It includes two graphs: 'Bandleistungsmerkmale' (band power) and 'LDA' (Linear Discriminant Analysis) output. The band power graph shows power changes in four frequency bands (C4-18-22 Hz, C4-12-14 Hz, Cz-18-22 Hz, Cz-12-14 Hz) over time. The LDA graph shows a peak in output corresponding to a hand movement, with a threshold of 0.7. A diagram at the bottom shows a sequence of hand movements: open hand, closed hand, and closed fingers.









## Diskussion & Ausblick

- Kombination BCI & FES ist möglich
- Griffwiederherstellung mit Hilfe von Neuroprothesen gut möglich
- Greifen kann mit BCI gesteuert werden
- Hand/Ellenbogen-Steuerung vielversprechend
- Direkte Arm-Kontrolle wird zurzeit erforscht & entwickelt
- BCI werden für den Alltagseinsatz tauglich gemacht
- Zukunft: BCI & assistierenden Systemen gleichzeitig in Verwendung



## Danksagungen

**G.R. Müller-Putz**

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**J. Wagner**

**M. Seeber**

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**G. Schober**

		
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