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Seminar psyM1-1

Data Science in Theory

Prosthetic Control by an EEG-based Brain-Computer Interface (BCI)

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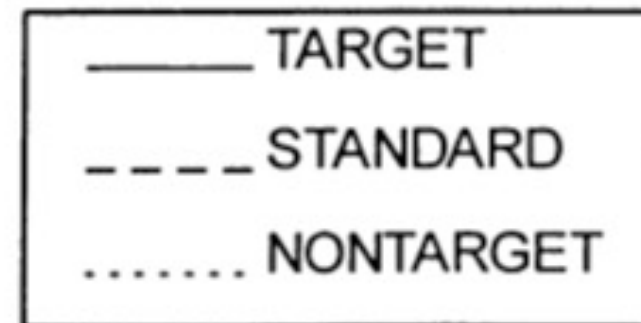
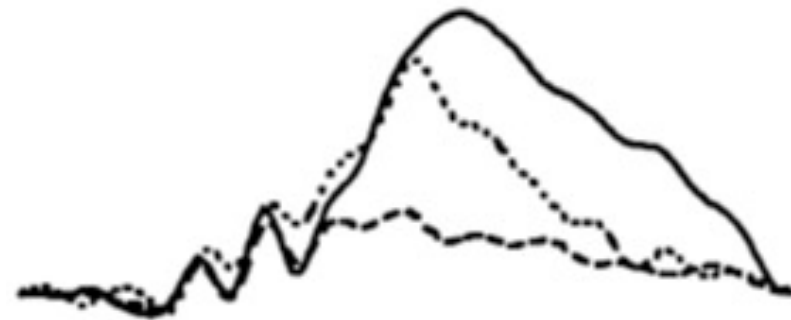
The **real-time analyses of oscillatory EEG** components during right and left hand movement imagination allows the control of an electric device.

- EEG-based BCI provides a control channel without motor input
- **Imagination of a movement causes Event-Related Desynchronization**
- Current controversies on the topic

Diese Woche: P300 speller

Brain-computer interfaces are sophisticated signal processing systems, which directly operate on **neuronal signals** to identify specific human **intentions**.

- What is the P300 and what does it represent?
- What are the basic principles of classifiers?
- Are the P300 spellers useful yet?



Trial-Anzahl und ERPs

Ziel:

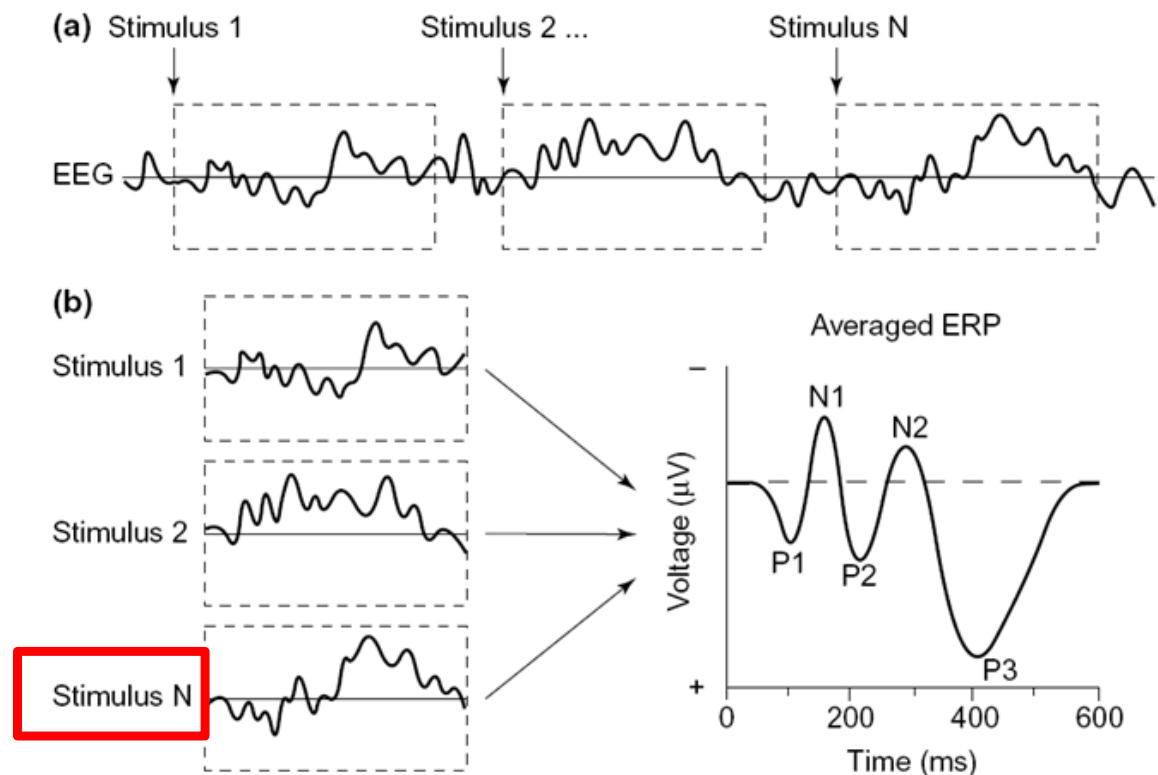
- Trennung zwischen „Signal“ und „Rauschen“

Problem 1:

- Was ist das relevante Signal?
 - Mittelwert als Erwartungswert
 - Abweichung als Rauschen

Problem 2:

- Wann haben wir das „echte“ Signal?
 - Gesetz der großen Zahl

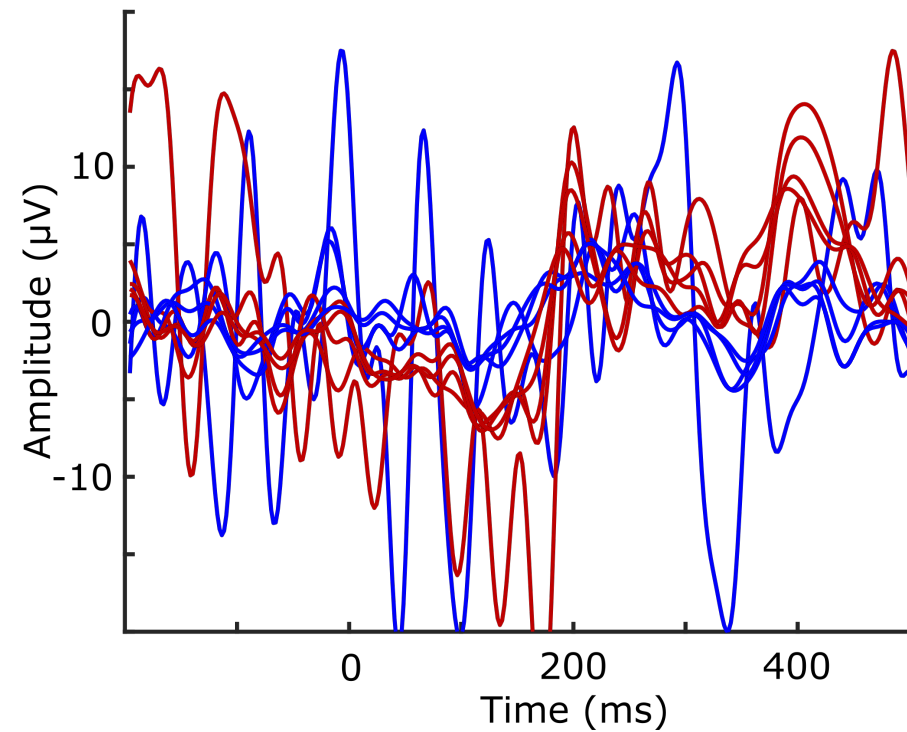


Trial-Anzahl und ERP

Konvergenz auf "wahren" Mittelwert mit großer Anzahl von Trials.

"In my own lab, the rule of thumb is that we need 30-60 trials per condition when looking at a large component like the P3 wave [...]"

Steve Luck



Neuronale Oszillationen

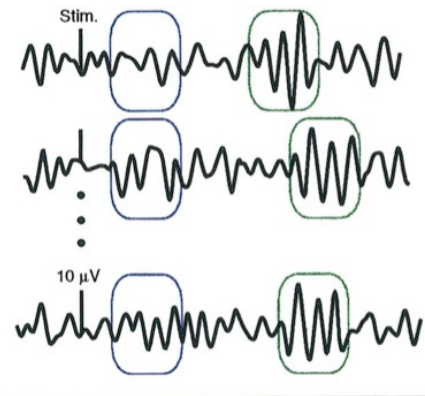
Mittelwert über viele Trials:

- Gegenseitige Werte heben sich auf
- Nur die Anteile, die immer zum gleichen Zeitpunkt (Phase) die gleiche Richtung (Amplitude) haben bleiben als „Signal“

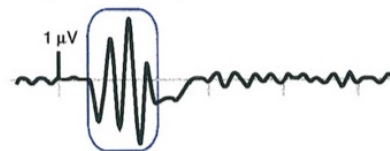
Problem:

- Was ist mit Signalveränderungen zu unterschiedlichen Zeitpunkten?
 - Lösung: Zuerst Amplitude berechnen, dann Mitteln

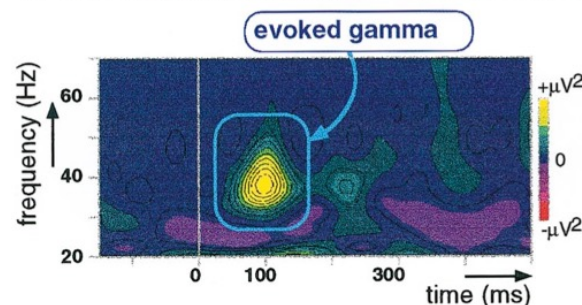
A Single-trials



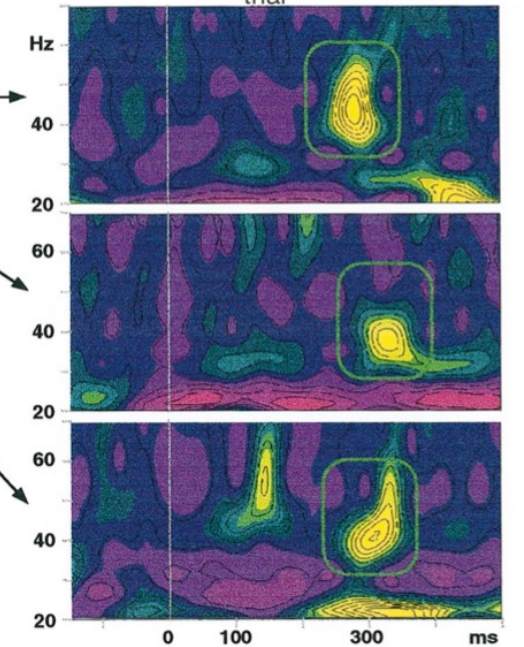
B Time average : evoked potential



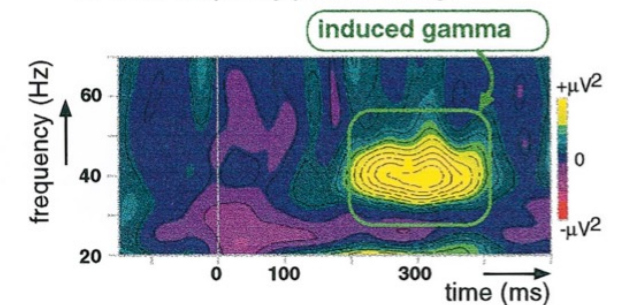
C Time-frequency power of the evoked potential



D Time-frequency power of each single trial



E Time-frequency power average



Single-Trial Analysen

Ziel:

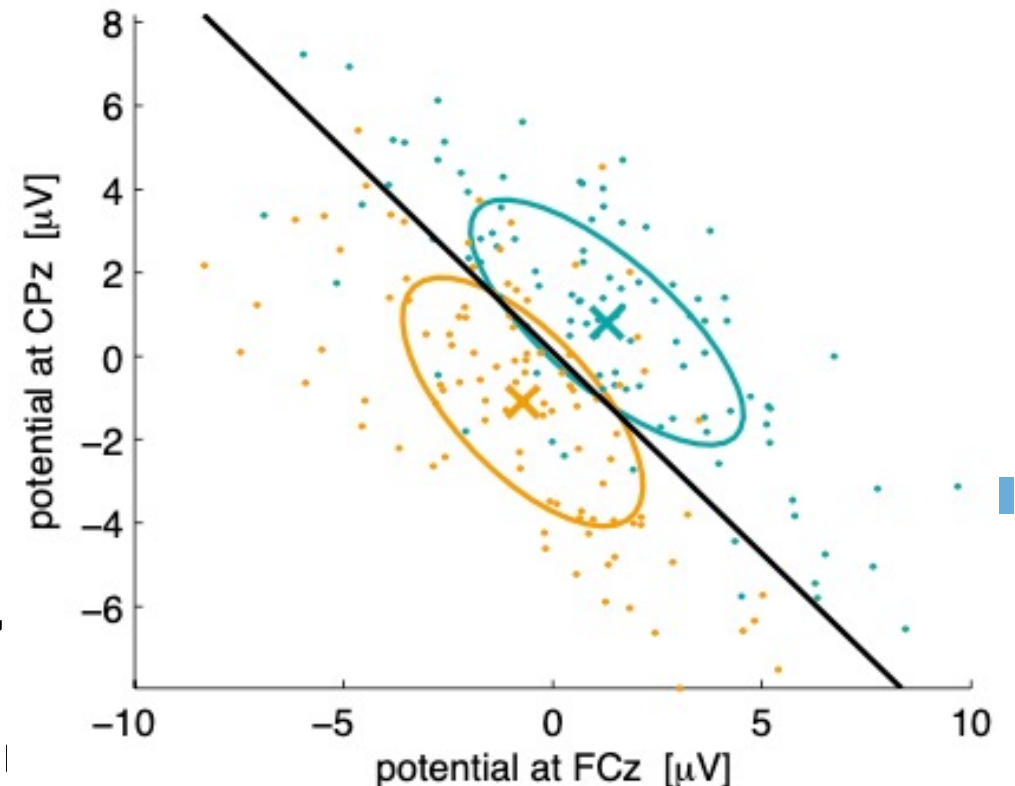
- Trennung zwischen „Signal“ und „Rauschen“

Problem:

- Was ist das relevante Signal?
 - Kein Mittelwert verfügbar

Lösung:


- Vorwissen nutzen
 - Zerlegung des Signals in unabhängige Komponenten (z.B., PCA, ICA)
 - Spezifische Signal-Anteile nutzen (z.B., Alpha ERD)
 - Unabhängigen Datensatz für „Training“ nutzen




Klassifikation des ERPs: P300 speller

Psychology/Psychiatry

Visual P300 Mind-Speller Brain-Computer Interfaces: A Walk Through the Recent Developments With Special Focus on Classification Algorithms

Jobin T. Philip¹ and S. Thomas George¹ 

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Nächste Woche: Weight Vectors? Was ist das?

On the interpretation of weight vectors of linear models in multivariate neuroimaging[☆]

Stefan Haufe^{a,b,*}, Frank Meinecke^{c,a}, Kai Gorgen^{d,e,f}, Sven Dhne^a, John-Dylan Haynes^{d,e,b},
Benjamin Blankertz^{f,b}, Felix Biemann^{g,a,*}

Often it is desired to interpret the outcome of these methods with respect to the **cognitive processes under study**. Here we discuss **which methods allow for such interpretations** [...].

- What are “forward” and “backward” models?
 - What are **key concepts**?
- How can we **interpret** the parameters (results) of these models?
- What is the **problem** with the interpretation?

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<http://doi.org/10.1016/j.neuroimage.2013.10.067>