

ENOC Working Group 3: Experimental Studies

Final ENOC Meeting,
Zürich, Switzerland, May 16, 2009

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Objectives

Brief reminder of WG3 objectives:

- (1) to study **complex cognitive functions** (e.g., memory, attention, perception and executive functions) by analysis of temporal and spatial characteristics of frequency-specific oscillations
- (2) to reveal the **functional meaning of frequency-specific oscillatory systems** by introducing their frequency-temporal-spatial (FTS) patterns as relevant correlates of neurophysiological or psychological processes.

Objectives

Brief reminder of WG3 objectives:

(3) to develop and apply **advanced methods of EEG analysis** :

- Time-frequency analysis (*e.g., Wavelet Transform, WT*)
- Latent variable methods (*e.g., Independent Component Analysis, ICA; Phase Locking/Synchronisation, PLV; etc.*)
- Methods especially oriented to single-sweep analysis of event-related oscillatory activity (*ERO, ERD/S*)
- Functional connectivity (*e.g., Coherence, Dynamic causal modelling, etc.*)
- Neuroimaging techniques in combination with ERP/ERO measures to improve the spatial resolution of event-related EEG activity.

Electrical Neuronal Oscillations

The EEG is a highly complex signal generated

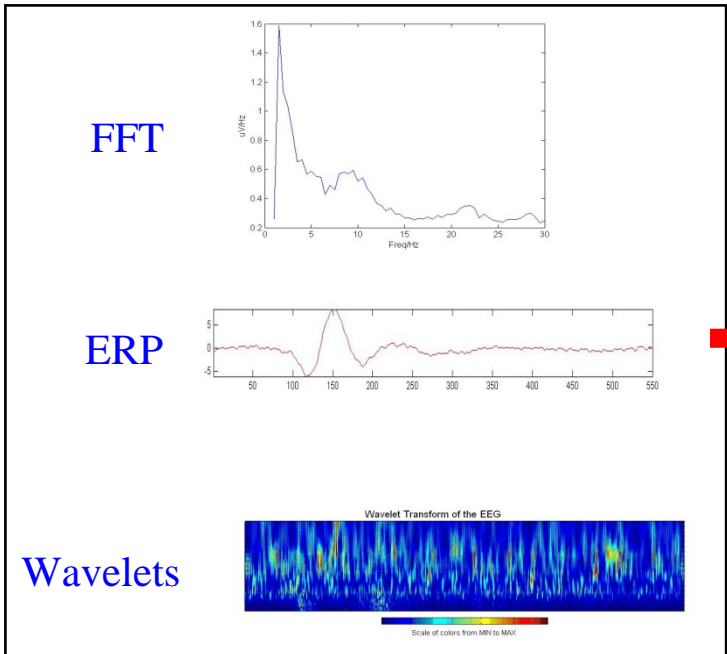
- by multiple brain structures (SPACE)
- that operate at multiple frequency ranges (FREQ),
- change with time (TIME), and
- interact with each other (SPACE x FREQ x TIME)

The conventional methods of EEG/ERP analysis cannot disentangle these overlapping oscillatory components,

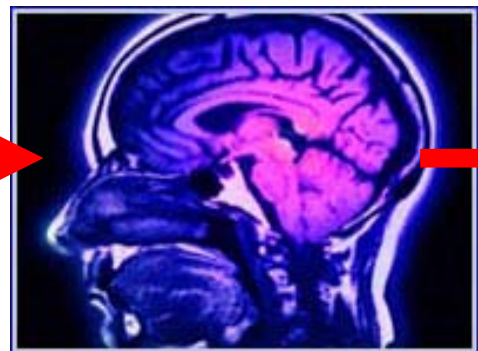
- ▶ access only the so-called "surface structure" of the EEG.

The deep structure of the EEG

Surface Structure of the EEG



Deep Structure of the EEG



Mental structure



Electrical Neuronal Oscillations

There are 3 possible approaches for accessing the "deep structure" of the EEG:

- Anatomical approach (source localization methods, validation with other neuroimaging techniques) ,
- cellular network approach (electrophysiology, physics) ,
- systems approach (complex systems analysis)

Significant highlights (1/5)

Research Topics: Attention, executive function, motor function in healthy subjects and patients (ADHD and other disorders)

Albrecht B, Brandeis D, Uebel H, Heinrich H, Müller UC, Hasselhorn M, Steinhausen HC, Rothenberger A, Banaschewski T (2008), Action Monitoring in boys with ADHD, their Nonaffected Siblings and Normal Controls: Evidence for Conflict Monitoring as an Endophenotype for ADHD, **Biological Psychiatry** 64:615-625

Banaschewski, T., Yordanova, J., Kolev, V., Heinrich, H., Albrecht, B., Rothenberger, A. Stimulus context and motor preparation in attention-deficit/hyperactivity disorder. **Biological Psychology**, 2008, 77(1), 53-62.

Beste, C., Saft, C., Yordanova, J., Andrich, J., Gold, R., Falkenstein, M., Kolev, V. Functional compensation or pathology in cortico-subcortical interactions in preclinical Huntington's disease? **Neuropsychologia**, 2007, 45(13), 2922-2930.

Significant highlights (2/5)

Research topics: Ageing, electrical brain oscillations along the life-span

Falkenstein, M., Yordanova, J., Kolev, V., "Effects of aging on slowing of motor-response generation", **International Journal of Psychophysiology**, 2006, 59, 22-29.

Kolev, V., Falkenstein, M., Yordanova, J. "Motor-response generation as a source of aging-related behavioural slowing in choice-reaction tasks". **Neurobiology of Aging**, 2006, 27(11), 1719-1730.

Kolev, V., Falkenstein, M., Yordanova, J., "Aging and error processing: Time-frequency analysis of error-related potentials", **Journal of Psychophysiology**, 2005, 19, 289-297.

Significant highlights (3/5)

Research topics: Sleep/circadian rhythms, memory consolidation

Kirov, R., Kinkelbur, J., Banaschewski, T., Rothenberger, A. Sleep Patterns in Children with Attention-Deficit/Hyperactivity Disorder, Tic Disorder and Comorbidity. **J Child Psychol Psychiatry**, 2007, 48, 561-570.

Yordanova, J., Kolev, V., Verleger, R., Bataghva, Z., Born, J., Wagner, U. Different roles of early and late night sleep in making implicit knowledge explicit. **Learning & Memory**, 2008, 15, 508-515.

Significant highlights (4/5)

Research topics: Brain-Computer Interactions and Neurofeedback

Pfurtscheller G, Brunner C, Schlögl A, Lopes da Silva FH. "Mu rhythm (de)synchronization and EEG single-trial classification of different motor imagery tasks". **Neuroimage**.2006 May 15; 31(1): 153-9.

Mueller-Putz G., Scherer R., Pfurtscheller G., Rupp R. "EEG-based neuroprosthesis control: A step towards clinical practice". **Neuroscience letters** 382 (2005), pp. 169-174.

Neuper C, Scherer R, Reiner M, Pfurtscheller G (2005) : "Imagery of motor actions: differential effects of kinaesthetic versus visual-motor mode of imagery on single-trial EEG". **Cognitive Brain Research**; 25 (3), 668-677

Gruzelier, J.H. (2008) A theory of alpha/theta neurofeedback, creative performance enhancement, long distance functional connectivity and psychological integration. **Cognitive Processing**, in press.

Significant highlights (5/5)

Research topics: Advanced Methods

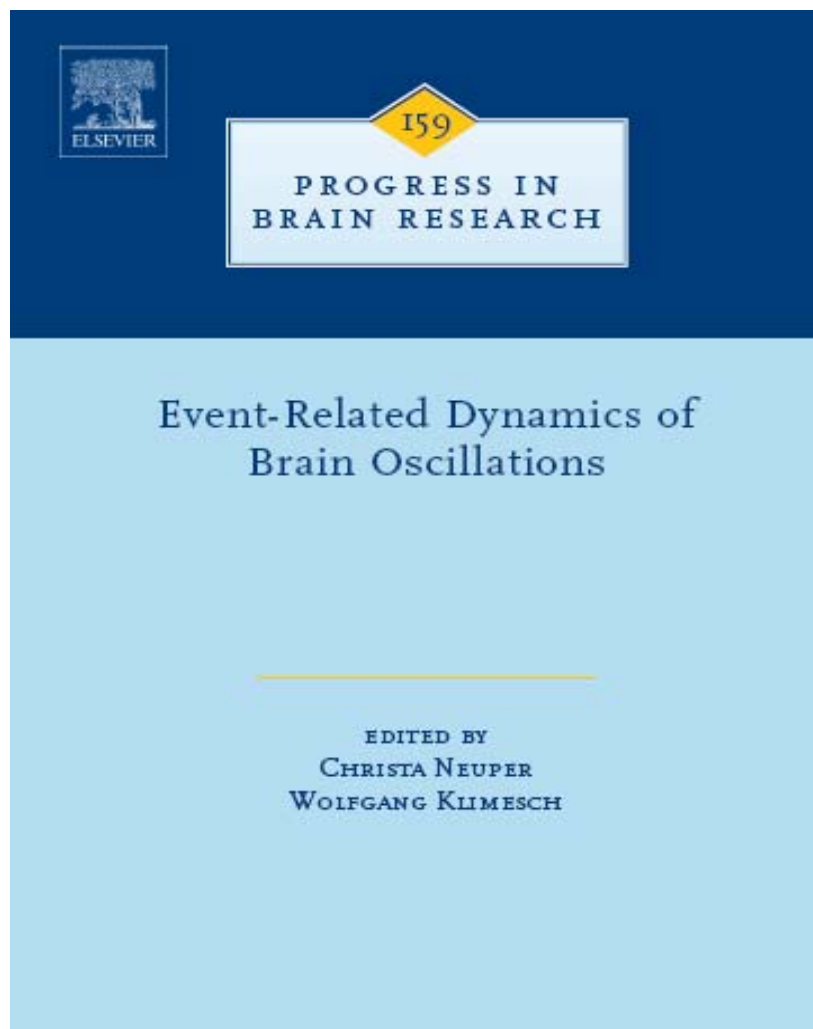
Brunner, C., Scherer, R., Graimann, B., Supp, G., Pfurtscheller, G. "Online control of a brain-computer interface using phase synchronization". **IEEE Trans Biomed Eng**

Ginter J., Blinowska K.J., Kaminski M., Durka PJ, Pfurtscheller G, Neuper C. (2005)
"Propagation of EEG activity in beta and gamma band during movement imagery in human". **Methods of Information in Medicine**; 44, 106-113.

Congedo M., Lotte, F, Lécuyer, A. (2006) Classification of Movement Intention by Spatially Filtered Electromagnetic Inverse Solutions. **Physics in Medicine and Biology**, 51, 1971-1989.

BioSig Toolbox (<http://biosig.sf.net>) A. Schlögl, TU Graz, AT

Book on ERD/ERS research...



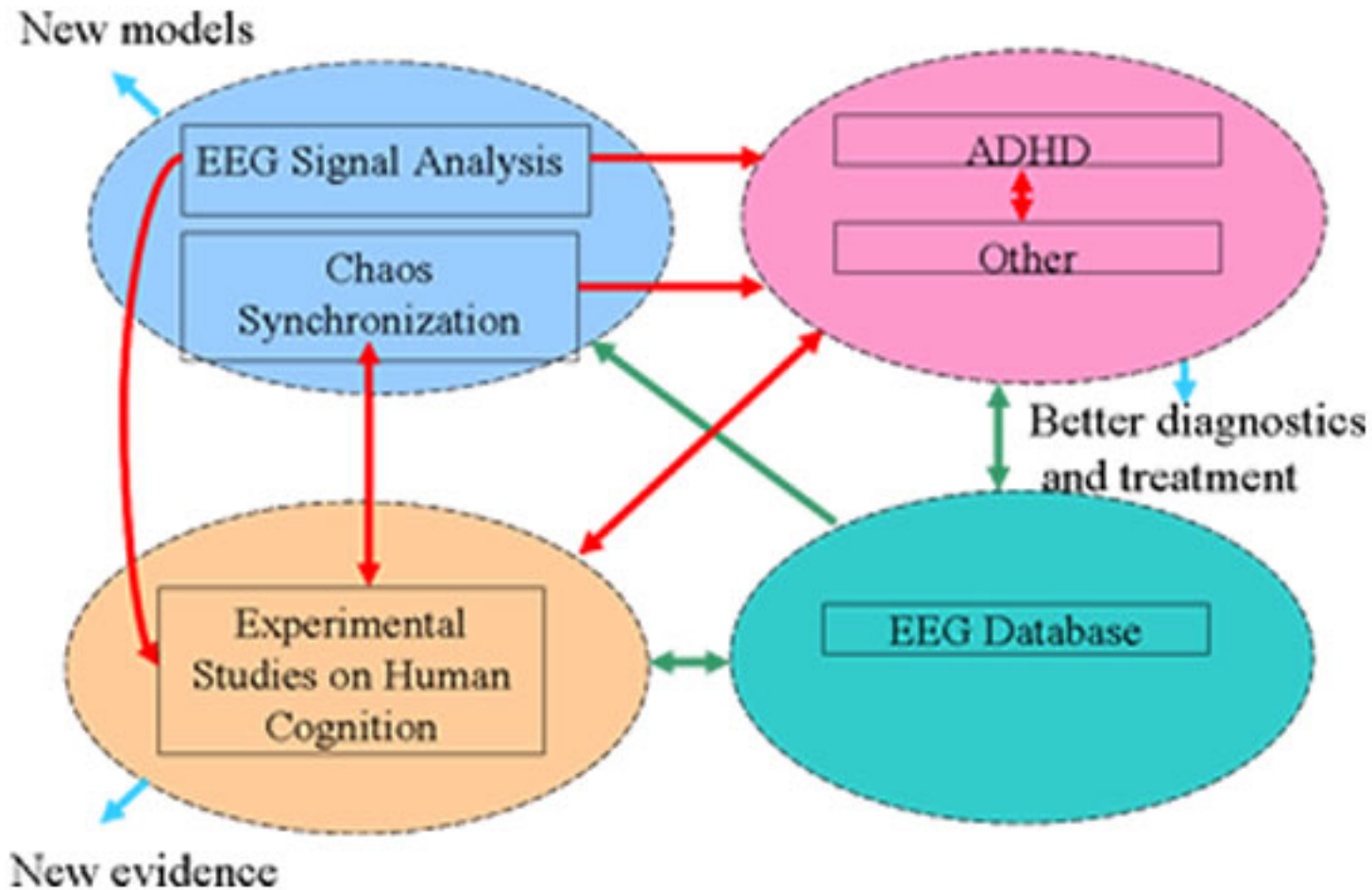
Event-Related Dynamics of Brain Oscillations

Progress in Brain Research, Volume 159, 2006

Contents:

- Neurophysiological Fundamentals and Theories.
- Analysis of Dynamics of Brain Oscillations: Methodological Advances.
- ERD/ERS and Cognition.
- ERD/ERS and Sensorimotor Processing.
- Invasive Approaches and Clinical Applications.
- Brain-computer Interfaces and Neurofeedback

Working groups - Cooperation



Related Projects

- "Brain mechanisms of behavioural slowing with aging“, granted by: Heinrich Hertz Foundation, Düsseldorf, Germany
Awardees: Falkenstein (DE), Yordanova/Kolev (BG)
- “Advanced Neurofeedback with Direct Training of Specific Brain Regions in ADHD Adults and Children “, granted by: SBF Switzerland
Awardees: Jaencke/Brandeis (CH)
- “Electric neuronal oscillations and cognitive processes”, granted by: Polish Ministry of Higher Education and Science
Awardees: Prof. Wlodzimierz Klonowski (PL)

Global dimension

- **Related joint projects (EU FP)**

- EU FP6 “**Presencia**: Presence research encompassing sensory enhancement, neuroscience, cerebral-computer interfaces and applications.”
Partners (involved in COST B27): Pfurtscheller/Neuper (AT), Gruzellier (UK), Jäncke (CH)
- EU FP6 “Upgrading the research capacities for safety and health effects of human exposure to electromagnetic fields”
Partners (involved in COST B27): Grcev/Pop-Jordanova (MK)
- EU FP6 “**Eye-to-IT**: "Development of Human-Computer Monitoring and Feedback Systems for the Purpose of Studying Cognition and Translation“
Partners (involved in COST B27): Pfurtscheller/Neuper (AT),
- EU FP7 “**TOBI**: Tools for Brain-Computer Interaction”
Partners (involved in COST B27): Neuper/Müller-Putz (AT)

Challenges (1/2)

- **Successes and shortcomings**

- Improvements of knowledge related to memory, attention, executive functions and multi-stable perception.
- Progress in the research on motor function, sleep/circadian rhythms and brain-computer interactions (including neurofeedback).
- The use of advanced analytic techniques for the study of cortical oscillations is a notable strength of this group.
- Experimental research with clinical interests (ADHD, elderly, etc.)

Challenges (2/2)

- **Successes and shortcomings**

- The diversity of research topics and applied methods among WG3 members made it difficult to establish completely new collaborations.
- But there is no doubt that existing links between partners have been strengthened considerably by this COST action.
- Overall, the research cooperation within WG 3 was is reasonably good, at least between some of the involved research groups. This can be seen in joined publications, book projects, and participation in other collaborative project proposals.

Significant highlights (1/6)

- Improvement of knowledge related to memory, attention, executive functions, sleep/circadian rhythms and brain-computer interactions (including neurofeedback); clinical interests incl. ageing, ADHD, etc.
- Teams from AT(2), BG(1), HR(2), DE(1), DK(1), FR(1), IT(1), MK(1), NO(1), PL(2), RS(2), TR(1), UK(1).