



## **LECTURES**

### **Spontaneous EEG oscillations along the life span: Normal and pathological aspects**

***Robert J. Barry***

Brain & Behaviour Research Institute and School of Psychology,  
University of Wollongong, Wollongong, Australia

Data will be presented on EEG activity in the traditional delta, theta, alpha and beta bands through childhood, with some extensions into adolescence and adults. Both eyes-closed and eyes-open data will be discussed. These reflections of normal development will provide a framework for the illustration of EEG anomalies in a number of disorders, particularly in AD/HD and its subtypes throughout the lifespan. Comorbidity effects in the EEG of children with AD/HD and comorbid reading disabilities, conduct disorders, and anxiety/depression, will also be illustrated. Some recent explorations of the links between arousal/activation and EEG activity may contribute to our understanding of the functional nature of brain oscillations in this context.

### **Event-related oscillations in perception and perception stability in children**

***C. Basar-Eroglu, J. Ehlers, S. Gross, C. Wranke, D. Strüber***

Institute of Psychology and Cognition Research, University of Bremen,  
Grazerstr. 4, 28359 Bremen, Germany

Ambiguous patterns such as the *stroboscopic alternative motion* (SAM) make up a well-known class of visual phenomena in which an invariant stimulus pattern gives rise to at least two different perceptual alternatives. It is an often reported fact that the processing of ambiguous figures (measured as the individual reversal rate) varies remarkably between observers, especially between different age groups. The reversal rate, however, shows a high intraindividual stability.

Since previous results of our research group demonstrated reversal-rate dependent differences in EEG oscillations, the aim of the present study was to determine the EEG dynamics elicited during multistable perception in 11 young adults, 11 adult monozygotic twin pairs, 14 children (age: 10 years) and 14 elderly participants (age 65 years or above). As a control, multistable perception was compared with a visual oddball paradigm in all experimental groups. The EEG was analysed in the delta-, theta- and alpha-band for frontal, central, parietal, temporal, and occipital electrodes.

The children present a significant weaker frontal synchronisation and strongly reduced delta amplitudes in comparison to the other location. This pattern is reversed in for elderly participants which show a strong fronto-central delta response. The response for the young adults, as has been demonstrated before, is maximal over parietal electrode sites. Furthermore, our results suggest a stronger genetic influence on the oscillatory responses induced by a simple visual oddball task than by an ambiguous pattern. The pattern of results for the endogenous reversal condition might be related to a differential contribution of bottom-up and top-down processes. Age differences might be related to brain maturation and different strategies used to resolve perceptual ambiguity.



**Ultra-slow oscillations and behavioural control in children and adults**  
**F. Xavier Castellanos, Edmund Sonuga-Barke, Adriana Di Martino, Michael P. Milham**  
Phyllis Green and Randolph Cöwen Institute for Pediatric Neuroscience,  
NYU Child Study Center, 215 Lexington Avenue, New York, NY 10016, USA

A central question in neuropsychology is the extent to which performance deficits in putatively executive function tasks reflect global state-regulation deficits which manifest as increased intra-individual variability. Intra-individual variability is easily operationalized as response time variability, which may possess certain rhythmic or oscillatory components in the ultra-low frequency range, e.g., Slow-4 (~0.03 – 0.07 Hz). This range of frequencies coincides with the most energetic frequency band observed in fMRI BOLD datasets which characterizes intrinsic, spontaneous hemodynamic oscillations in brain. We and others have noted that these intrinsic oscillations provide extraordinarily precise functional maps of brain circuitry. As an example, we will present our initial efforts in mapping anterior cingulate cortex and basal ganglia based circuitry. We have also pursued the 'default-mode hypothesis' by conducting fMRI studies in adults with ADHD and healthy comparisons, and by conducting behavioural response time studies in children with ADHD and healthy comparisons. Preliminary results of these ongoing studies will be presented. The conclusion is that attending to time- and frequency-domains of behaviour and brain function will afford cleaner and more interpretable datasets at a minimum. In the best case, attending to temporal and frequency aspects may reveal fundamental mechanisms that undergird pathophysiological mechanisms relevant to many psychopathological conditions as well as to typical development.

**Event-related oscillations and cognitive processes in children**

**Hartmut Heinrich<sup>1</sup>, Vasil Kolev<sup>2</sup>, Aribert Rothenberger<sup>3</sup>, Juliana Yordanova<sup>2</sup>**

<sup>1</sup> Child & Adolescent Psychiatry, University of Erlangen and Heckscher Klinikum, München, Germany

<sup>2</sup> Institute of Neurobiology, Bulgarian Academy of Sciences, Sofia, Bulgaria

<sup>3</sup> Child & Adolescent Psychiatry, University of Göttingen, Germany

Non-invasive recordings of brain electrical fields allow to measure neural activations associated with a variety of brain states and processes with a time resolution in the millisecond range. They can easily be conducted, even in children. Event-related EEG modulations which are phase-locked to perceptual, cognitive, and motor processes are often studied by means of event-related potentials (ERPs) although event-related oscillatory responses in different EEG frequency bands allow a more refined analysis, closer to physiology.

In this presentation, the basics of time-frequency methods, which are typically applied for the analysis of event-related oscillations, will be introduced, focusing on adaptive procedures (e.g., matching pursuit, wavelet networks; Heinrich et al. 2001) and the potential of these methods are illustrated.

Results of a series of studies (e.g., Yordanova et al. 2000, 2002) dealing with event-related oscillations in children performing an auditory selective attention task will be summarized:

- Event-related theta (3–7.5 Hz) activity was enhanced in two latency ranges. The early event-related theta response occurring 0–200 ms after a stimulus may be associated with representations of relevant target features in working memory. The late fronto-central theta response (200–450 ms) could be related to the processing of task-irrelevant information.
- Both the neuronal substrates of gamma (30-70 Hz) networks and the ability to synchronise these networks in relation to task-specific processes are available in children and adolescents from 9 to 16 years of age. Developmental changes in the task reactivity of synchronised gamma oscillations may provide evidence for a transition in cognitive processing strategies emerging at the age of 12-13 years.

Event-related oscillations can be estimated and parametrised by adaptive time-frequency methods. This approach should intensively be used to study neurocognitive development in children.



**Functional significance of neuroelectric oscillations:  
Individual differences, cognitive development, and aging**  
**Wolfgang Klimesch**

Department of Physiological Psychology, University of Salzburg,  
Salzburg, Austria

In contrast to ERP components, a variety of different oscillatory EEG-parameters – particularly in the theta and alpha frequency range - show a clear association with cognitive performance and intelligence. Several studies have shown that the 'speed' of individual alpha frequency (IAF) is related to the accuracy of time judgment and intelligence. Theta and alpha band power also are related to cognitive and memory performance in particular, but in a rather complex way. Good performance is related to two types of oscillatory EEG phenomena, (i) a tonic increase in alpha but a decrease in theta power, and (ii) a large phasic (event-related) decrease in alpha but increase in theta, depending on the type of memory demands.

Based on these and other findings, the question will be addressed, as to how these performance related parameters change over lifetime and whether good performance can be induced by methods such as neurofeedback or repetitive transcranial magnetic (rTMS) stimulation. Findings from our laboratory will be discussed which show that an increase in individual alpha power by neurofeedback is a promising method to increase cognitive performance. Similar findings were obtained by a rTMS study in which cognitive performance was increased by increasing individual alpha activity, induced by rTMS pulses at IAF.

**Clinical significance of neuronal oscillations in children**  
**Nada Pop-Jordanova**

Pediatric Clinic, Faculty of Medicine, University of Skopje

After a short review of developmental characteristics, integrality and complex structure of EEG spectrum, some original clinical experiences with diagnosis and treatment of related rhythm abnormalities in children and adolescents are presented. In particular, the approach and results concerning ADHD, OCD and dehydration disorders are discussed. In addition, the environmental effects on neuronal oscillations due to lead pollution and electromagnetic radiation are considered.



**COST Action B27**  
**ELECTRIC NEURONAL OSCILLATIONS AND COGNITION (ENOC)**



**MC and WG Meetings - October 12-13, 2007 - Göttingen, Germany**

**The role of abnormal neural oscillations in the pathophysiology of  
co-occurring Tourette Syndrome and Attention-Deficit/Hyperactivity Disorder**  
**Aribert Rothenberger**

Child and Adolescent Psychiatry, University of Goettingen, Germany

*Objective:* To examine the role of aberrant neural oscillatory activity in the pathophysiology of co-occurring Tourette Syndrome (TS) and Attention-Deficit/Hyperactivity Disorder (ADHD).

*Method:* Neural oscillations refer to periodic variations in the recording of neural activity. The temporal synchronization of oscillations represents a mechanism of neural communication implicated in normal brain functioning as well as psychopathology. We reviewed physiological, imaging, and neuropsychological evidence that tics and symptoms of ADHD may result from abnormal oscillatory activity in the brain.

*Results:* Structural and functional abnormalities in the cortical-striatal-thalamo-cortical circuits may result in the disruption of oscillatory activity within the basal ganglia of individuals with TS and lead to transient hyperpolarization of selected thalamocortical regions. Extended to TS plus ADHD this or similar mechanisms, in turn, would lead to the dysrhythmia of particular vulnerable cortical regions and give rise to various deficits in motor control (TS + ADHD) as well as impulsivity and attention (ADHD). Compensatory systems within the prefrontal cortex could be activated and trained to modulate the misguided striatal and thalamocortical oscillations.

*Conclusions:* Although it is highly likely that abnormal neural oscillations have a prominent role in co-occurrence of TS + ADHD, its final relevance in this case deserves further differentiated research (i.e. oscillatory networks disentangled from other neuropsychiatric disorders).

**Event-related oscillations along the life span:  
Power and synchronization effects of development and aging**

**Juliana Yordanova \*, Vasil Kolev**

Institute of Neurobiology, Bulgarian Academy of Sciences,  
Acad. G. Bonchev Str., bl. 23, 1113, Sofia, Bulgaria, jyord@bio.bas.bg

The presentation will focus on event-related oscillations (EROs) and their application in research of brain functions during development and aging. Basic concepts for the generation and functional significance of EROs will be presented. Major advantages of oscillation concepts (susceptibility rule, parallel processing, etc.) for studies of brain functions along the life-span will be outlined.

Principal methodological approaches for analysis of event-related oscillations in the time, frequency and time-frequency domain will be described. Specific techniques for separate analysis of power enhancement and temporal and spatial phase synchronization at the level of single sweeps will be presented as relevant tools for extracting ERO functional reactivity during aging.

Basic findings of age-related alterations of delta (1-4 Hz), theta (4-7 Hz), alpha (8-13 Hz) and gamma (25-70 Hz) response systems in the brain will be demonstrated. Age-dependent dissociation between power and synchronization stability of frequency responses will be emphasized. A differential development of EROs from different frequency ranges will be shown in relation to their specific functional involvement in sensory and cognitive brain functioning in the course of aging. The principle of distributed oscillatory EEG systems in the brain will be extended to a higher integrative (behavioural) and a deeper neural level.



## POSTERS

### Heart rate changes time-locked to EEG bursts in preterm infants at 32/36 weeks of conceptional age and maturational aspects.

Günther Bauernfeind<sup>a</sup>, Klaus Pfurtscheller<sup>b</sup>, Gernot R. Müller-Putz<sup>a</sup>, Berndt Urlesberger<sup>b</sup>, Wilhelm Müller<sup>b</sup>, Gert Pfurtscheller<sup>a</sup>

<sup>a</sup> Institute for Knowledge Discovery, BCI-Lab, Graz University of Technology, Austria

<sup>b</sup> Division of Neonatology, Department of Pediatrics, University Hospital of Graz, Austria

*Objective:* Normative data and maturational aspects of cortico-cardiac coupling mechanisms during periods of discontinuous EEG are presented in a group of healthy preterm infants at 32 and 36 weeks conceptional age.

*Methods:* A group of 6 preterm infants with a conceptional age (CA) of  $32,0 \pm 0,7$  weeks (mean  $\pm$  SD) and  $36,3 \pm 0,6$  weeks (mean  $\pm$  SD), respectively was studied. From long-term EEG and ECG registrations, sections with a length of about 10 to 20 minutes with low heart-rate (HR) variability and discontinuous EEG were selected and further analysed. After an automated detection of bursts, the corresponding instantaneous HR trials were averaged.

*Results:* Healthy preterm infants showed a HR increase, time-locked to the occurrence of slow-wave bursts or alternate EEG activity. At 32 weeks of conceptional age the HR displayed an acceleration of  $2,7 \pm 1,2$  bpm (mean  $\pm$  SD) whereas in the EEG the burst-to-burst-interval (BBI) was  $13,7 \pm 1,4$  s (mean  $\pm$  SD). At 36 weeks of conceptional age the HR displayed an a significant higher acceleration of  $4,2 \pm 1,7$  bpm (mean  $\pm$  SD) and in the EEG the burst-to-burst-interval (BBI) was  $11,1 \pm 1,7$ s (mean  $\pm$  SD).

*Conclusion:* In healthy preterm infants EEG bursts were associated with an HR acceleration which changes during ongoing maturation. This behaviour is important for the study of maturational aspects of the brain and might help to differentiate between normal and abnormal brain function in preterm infants.

### The individual alpha-EEG activity indices are indicators of individual differences in nonverbal creativity

Bazanova O.M.<sup>1</sup>, Aftanas L.I.<sup>2</sup>

State-Research Institute of Molecular Biology and Biophysics (1),

State-Research Institute of Physiology (2)

Siberian Branch, Russian Academy of Medical Sciences, Timakova str. 4, 630117, Novosibirsk, Russia (bazanova@soramn.ru)

The main objective of present investigation was to clarify relationships between nonverbal creativity features and several indices of individual electroencephalogram alpha activity (i.e., alpha peak frequency, alpha band width, amount of alpha suppression and peak shift in response to open eyes). EEG was recorded in 96 healthy male right-handed subjects in eyes closed and eyes open rest conditions. Scores of nonverbal creativity (i.e., fluency, originality, and flexibility) were assessed using the Torrance test of nonverbal performance.

The multiple regression analysis showed that fluency in creative performance was associated with individual alpha peak frequency, whereas plasticity – with individual alpha band width. Findings also show that both highest and lowest individual alpha peak frequency indices are associated with enhanced scores of originality. It is suggested that individual alpha activity indices could be presented as individual predictors of fluency, plasticity and originality of nonverbal creativity.



**The individual EEG alpha indices in the differentiation of healthy vs. ADHD children and its role in efficiency of theta/beta neurofeedback training**

**Bazanova O.M.**

State-Research Institute of Molecular Biology and Biophysics,  
Siberian Branch, Russian Academy of Medical Sciences, Timakova str. 2, 630117,  
Novosibirsk, Russia (bazanova@soramn.ru)

*Objective:* Traditionally EEG analysis in the frequency domain assumes fixed frequency ranges, established rather conventionally than on the theoretical ground [Szava et al 1994, Kaiser, 2001]. Meanwhile the numerous studies by various research teams [Klimesh et al (1990, 1998), Jausovec (1996), Bazanova & Aftanas, 2005] showed a distinctive relationship between mental performance and individual alpha-activity indices: individual alpha peak frequency (IAPF), individual alpha band width (IABW), individual amount of alpha suppression (IAAS) in response to open eyes. As it was reported by different laboratories [Kaiser, 2001; Bazanova & Aftanas, 2005] neurofeedback therapy (NFT) of Attention Deficit Disorder with Hyperactivity (ADHD) with standard theta/beta-1 training protocols which uses the conventional EEG bands width appeared to be inefficient in some cases and even aggravated clinical status [Kaiser, 2001; Bazanova & Aftanas, 2005]. Moreover the NFT with protocol which uses individual adjusted EEG range frequencies according to individual alpha band width had a higher efficiency and induced increasing in individual alpha –activity [Hanslmayr et al 2005].

The objective of this investigation consisted in differentiation of the individual alpha-activity indices of healthy vs. ADHD children and in revealing putative associations of individual EEG alpha frequency indices with efficiency of theta/beta inhibiting neurofeedback training in patients with ADHD. We hypothesized that both higher IAPF, greater IABW and deeper IAAS would index healthy children as well as would predict enhanced NFT efficiency.

*Methods:* Individual EEG alpha indices from 8 electrode sites were studied in 21 children with ADHD and 23 matches control of age 8-12 years. The median age of participants was 9.3 years, and the median "percent male" composition was 89.2%. All participants tests of attention, intelligence and behavioral variables. EEG was recorded during baseline (eyes open and eyes closed) and after 15-20 min lasting NFT session conditions. NFT was aimed at simultaneous increasing the relative power of individual determined beta-1 rhythm (from upper boundary of individual alpha band till 15 Hz) and decreasing relative power of individual theta rhythm (from 3 Hz till low alpha band boundary) in site Cz with a bipolar electrode assembly. "Successful training" periods were defined as periods during NFT session, when beta-1-rhythm power increase was accompanied by simultaneous decrease in the theta power. Efficiency of a NFT session was calculated as the ratio between the sum-duration of the successful periods during the session and the whole length of the session.

*Results:* The discriminant function analyses revealed that individual amount of alpha suppression and individual alpha band width were the best predictors that differentiated children with ADHD from normal children in the present sample with a high accuracy rate of 95.3%. Multivariate linear regression analysis with forward elimination had determined that individual alpha peak frequency and the individual frequency of upper alpha boundary were most contributed to the efficiency of NFT.

*Conclusion:* The results of this investigation are in line with studies showing that decreased alpha activation is pathogenic trait in ADHD. The efficiency of theta/beta decreasing neurotherapy depends on the baseline individual alpha indices.



**EFFECTS OF ALPHA ENHANCEMENT AND EMG DECREASING PROTOCOL IN TREATMENT OF PATIENT WITH TICS, HYPERACTIVITY AND LACK OF CONCENTRATION (Case report)**

**Demerdzieva A., Pop-Jordanova N., Markovska S.\*, Bazanova O.\*\***

Pediatric Clinic, Faculty of Medicine, University of Skopje

\* Bioinformatics Division, ICEIM - Macedonian Academy of Sciences and Arts

\*\* Institute for Molecular Biology and Biophysics – Novosibirsk Branch of Russian Academy of Medical Sciences

*AIM:* The purpose of this presentation is to analyze a case with mixed symptoms (tics and ADHD) and to underline the need of individual approach in EEG and EMG biofeedback treatment.

*METHODS:* A case of 8 years old boy with tics (eye-blinking), hyperactivity and lack of concentration is presented. The clinical evaluation comprised family interview, physical examination, psychometric evaluation as well as determination of individual EEG parameters. Biofeedback started with alpha-EEG enhancing and EMG decreasing (alpha- EEG/EMG training protocol) using “Boslab” equipment (Novosibirsk, Russia). EEG electrodes were put on F3-O1 and F4-O2 and EMG electrodes were placed on the frontal muscle. The treatment concluded with SMR training in Cz, for improving the concentration.

*RESULTS:* Individual alpha band width was 6.33-10.08 Hz, with peak in eyes closed at 8.60 Hz and in eyes opened at 8.21 Hz. After 10 sessions significant increasing ( $t = 4.87$ ,  $p = 0.01$ ) in alpha band width is received, amounting at the end of treatment 6.33-14.06 Hz. Before training mean alpha-power was 3.17 and after 7.25  $\mu\text{V}^2$ . Beta band was 12% of all brain waves before, and 17 % at the end. Mean EMG activity decreased from 7.15 to 5.60  $\mu\text{V}$ . The biofeedback results correlate with significant clinical improvement – tics completely disappeared and parents and teacher informed for significant improvement of child’s concentration, as well as school marks and achievements.

*CONCLUSION:* Efficient alpha and EMG protocols require detailed psychometric and neurometric assessment, including individual alpha band discrimination. This provides correct selection of electrodes sites, optimal EEG pattern tuning and stability of clinical improvements.

**Effectiveness of a neurofeedback training of slow cortical potentials in children with ADHD**

M. Döhnert, M. Straub, D. Brandeis, H.-C. Steinhausen, & R. Drechsler  
Department of Child and Adolescent Psychiatry, University of Zurich, Switzerland

*Introduction:* There is growing empirical support for specific effectiveness of neurofeedback treatment of ADHD. The aim of the study was to evaluate the efficacy of a neurofeedback training of the slow cortical potentials in children with ADHD. Associations between the regulation of brain activity and behavioural changes rated by parents and teacher, and changes in EEG and ERP parameters were analyzed in order to evaluate both specific and general effects of SCP training.

*Methods:* Thirty ADHD children aged between 9 and 13 years were assigned to the index group treated by neurofeedback (N=17; training of slow cortical potentials), or to the control group (N=13) participating in a group training program. The following pre and post measurements were performed: Behavioural ratings by parents (CPRS-R, FBB-HKS, BRIEF) and teacher (CTRS-R, BRIEF), quantitative EEG (QEEG, eyes closed resting condition) and ERP recording (during variants of the continuous performance test - CPT-O-X). We focused on alpha and theta EEG, and on a late ERP-component (CNV).

*Results:* Subjects of the neurofeedback group improved more on several behavioural scales compared to group therapy. Analyses of subgroups revealed that about half the participants of the neurofeedback group had learned to regulate their brain activity in a transfer training condition. In this subgroup, successful self-regulation was related to improvements on some behavioural scales. Regarding QEEG, slightly reduced posterior EEG theta, and increased central and parietal alpha power were observed after neurofeedback but not after group therapy. CNV changes which



correlated with self-regulation abilities after neurofeedback were confined to those neurofeedback subjects who developed negativation on transfer trials.

*Conclusion:* Although according to parents' and teacher's ratings children with ADHD benefited more from a neurofeedback training than from group therapy, only part of the positive effects can be related to the specific contribution of EEG training and the improved regulation of brain activity. QEEG changes support the hypothesis that SCP neurofeedback also normalizes some abnormal brain states measured with spectral EEG mapping, while CNV findings reveal that specific SCP effects are limited to a subgroup demonstrating successful transfer.

**The Effect of Transcranial Alternating Current Stimulation on  
Cortical Excitability in Humans**  
**Leila Chaieb and Daniella Terney**

Dept. of Clinical Neurophysiology, University of Goettingen, Germany

Interference with brain rhythms by non-invasive transcranial stimulation using weak transcranial alternating current (tACS) may reveal itself to be a new tool for investigating cortical mechanisms currently unresolved. Here, we aim to extend transcranial direct current stimulation (tDCS) techniques to transcranial alternating current stimulation (tACS). Parameters such as electrode size and position were taken from those used in previous tDCS studies. Motor evoked potentials (MEPs) revealed by transcranial magnetic stimulation (TMS), EEG-power and reaction times measured in a motor implicit learning task, were analysed to detect changes in cortical excitability after 2-7 min of AC stimulation and sinusoidal DC stimulation (tSDCS) using 1, 10, 15, 30, 45 Hz over the primary motor cortex in 48 healthy subjects. A significantly improved implicit motor learning and non-significant decrease of MEP amplitudes of approximately 20% were observed after 10 Hz AC stimulation only. If the anodal or cathodal DC stimulation was superimposed on 5, 10 and 15 Hz AC stimulation, the MEP amplitudes were increased only after anodal 10 and 15 Hz stimulation. No significant changes were observed in any of the analysed frequency bands of EEG after AC or tSDC stimulation.

Transcranial application of weak AC current may appear to be a tool for basic and clinical research in diseases with altered EEG activity. The application of the tACS technique can be discussed in context with the neural binding hypothesis, whereby reciprocal interactions of neurons coupled by cortical projections are synchronised to oscillate in the gamma wavelength range to produce a collective coherent network output which is manifested in the ability to solve higher cognitive tasks (Singer, 2001, Doesburg et al, 2005). The characteristic of this neural network is a temporarily desynchronised EEG state, detectable by EEG analysis. Further studies are required to extend cautiously the safety range and uncover its influence on neuronal circuitries.

**Multistable perception in ten-year old children**

**Jan Ehlers 1\*, Daniel Strüber 1,2, Michael Stadler 1 & Canan Basar-Eroglu 1**

(1) Institute of Psychology & Cognition Research, University of Bremen, Germany

(2) Hanse Institute for Advanced Study, Delmenhorst, Germany

Multistable perception occurs when reversible patterns are presented in the absence of changes in the stimuli properties. The aim of the present study was to examine age-related changes in the brain activity associated with multistable perception. Fourteen 10-year old children observed an ambiguous pattern, known as the stroboscopic alternative motion (SAM) and were instructed to press a button following each reversal. The results showed the occurrence of a positive slow wave at about 100 ms prior to the buttonpress. The amplitude of this positive wave was remarkably enhanced and had a more posterior topography compared to our studies in adult subjects. Furthermore, the positive component induced by the SAM, did not differ from a slow wave elicited by a stimulus-driven control paradigm, whereas the adult brains strongly differentiate between internal and external generated perception. Concerning the event-related alpha oscillations our results demonstrate a pronounced desynchronisation over occipital locations, starting at about 900 ms preceding the buttonpress. This



**COST Action B27**  
**ELECTRIC NEURONAL OSCILLATIONS AND COGNITION (ENOC)**



**MC and WG Meetings - October 12-13, 2007 - Göttingen, Germany**

posterior alpha decrease was accompanied by a theta enhancement localized only over frontal areas. Our former studies in adults showed a larger distribution of alpha-desynchronisation as well as a stronger frontal theta enhancement. These age differences in topography, amplitude and oscillatory behaviour may be related to brain maturation and / or different strategies used to resolve perceptual ambiguity.

**Endophenotypic measures of altered inhibitory brain processes in ADHD**

**A J. Fallgatter, C. Baehne, M. Richter, M.M. Schecklmann, K.-P. Lesch, M. Plichta, A.-C. Ehlis**  
Department of Psychiatry, University of Würzburg, Fuchsleinstraße, Germany

*Objectives:* Deficits in response inhibition are, amongst others, considered as candidate endophenotypes of altered prefrontal brain function in ADHD. Based on their superior time resolution, electrophysiological methods like Event-Related Potentials (ERPs) are adequate for the measurement of such endophenotypes, i.e. abnormalities in brain functions underlying psychiatric diseases like ADHD. Moreover, ERPs seem to be particularly suited to measure effects of functionally relevant genetic variants directly affecting neurotransmission systems and brain function. This principle of imaging genomics with ERPs has been demonstrated as early as 1999 for the serotonin transporter promoter polymorphism affecting prefrontal brain function (Fallgatter et al., International Journal of Neuropsychopharmacology, 1999).

*Design and Methods:* We employed a multi-channel EEG during performance of a Go-NoGo task to assess the electrophysiological basis of the endophenotype response inhibition in healthy subjects as well as in patients with ADHD. The ERP-measure derived from this protocol was termed NoGo-Anteriorisation (NGA) and is characterized by a high interindividual stability, high short- and long-term test-retest reliability and, moreover, is independent from age- and gender.

*Results:* In patients with ADHD the NGA was diminished as compared to age- and sexmatched healthy controls. Furthermore, a three-dimensional source location analysis with Low Resolution Electromagnetic Tomography (LORETA) indicated an electrical dysfunction of the medial prefrontal cortex comprising the anterior cingulate cortex (ACC) in ADHD patients in childhood as well as in adulthood. Recent studies showed a significant influence of variants of dopaminergic as well as serotonergic genes on this measure of prefrontal brain function.

*Conclusions:* These results exemplify the measurement of disease related disturbances in brain function with ERPs. Future studies will show whether such electrophysiological endophenotypes may contribute to the diagnosis of subgroups of ADHD and whether they may serve as endophenotypes to further clarify genetic contributions to the disease.

**Treatment of the ASD by neurofeedback based on visual stimuli generated by the neuronal networks biochemical reactions dynamics**

**Vladimir Gontar, O. Grechko**

Department of Industrial Engineering and Management,  
Ben-Gurion University of the Negev, P.O. Box 653, Beer Sheva 84105, Israel (galita@bgu.ac.il)

It will be demonstrated that electro-chemical dynamics of neuronal networks in human brain can be simulated by mathematical model derived from the chemical reactions discrete chaotic dynamics (CRDCD). The results of the simulation are presented in a form of discrete time series inherently related within the CRDCD to the colored symmetrical images (mandalas) which are therefore could be naturally correspond to the individual's EEG recorded in real time.

C.G. Jung empirically proved that mandala images, created spontaneously by the individuals, have a therapeutic effect on them [1]. Using CRDCD mathematical models we can generate mandala images for subject's EEG signals (Fig.1), providing an individual with the unique mandalas which are reflecting patient's actual mental state [2]. We are using these EEG related individually created mandala images for the visual feedback in a neurofeedback training process.

Based on the C.G. Jung's hypothesis we expect proposed neurofeedback training to be more efficient for subject's diagnosed with Autism Spectrum Disorders (ATD) as well as for the other neurofeedback used cases[3].

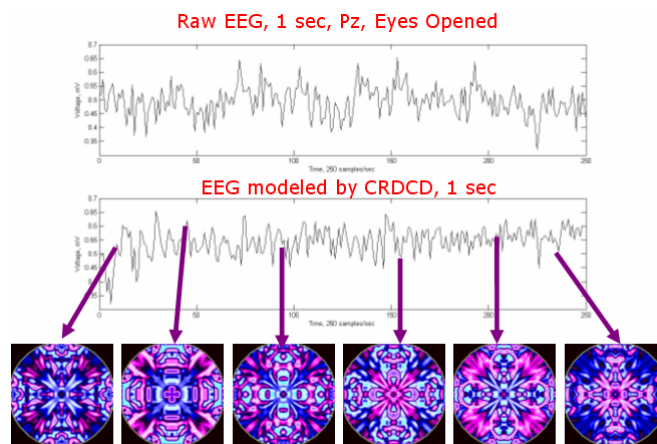


Figure1. Example of EEG-related mandalas generated by BRDCD.



**DRD4 variants and electrophysiological response to Go/Nogo Task in children with Attention Deficit/Hyperactivity Disorder and their healthy sibs**

**M. Henríquez<sup>1</sup>, H. Henríquez<sup>2</sup>, F. Zamorano<sup>1</sup>, P. Rotthammer<sup>1</sup>, Ximena Carrasco<sup>1</sup>, F. Rotthammer<sup>2</sup>, F. Aboitiz<sup>1</sup>**

(1) Department of Psychiatry, Pontificia Universidad Católica de Chile, Chile

(2) Department of Anthropology, University of Tarapaca, Chile

Association between ADHD and variants of the dopamine receptor D4 gene (*DRD4*) has been reported repeatedly. However, the electrophysiological and behavioural correlates of these variants remain understudied.

This study investigated association between the electrophysiological and behavioural response elicited by a Go/Nogo Task and variants of VNTR in exon III of *DRD4* in ADHD children and their healthy sibs.

*Methods:* We studied 20 sib pairs between 8 and 13 years old, each composed by an ADHD patient and his/her unaffected sib.

VNTR variants at exon III of the *DRD4* gene were identified according to standard protocols. EEG recordings were obtained from subjects while they performed a visual Go/Nogo Task with a Nogo probability of 10%. Behavioural and electrophysiological measures (amplitude and latency of ERPs components), were analyzed regarding ADHD status and *DRD4* genotype. In the latter case, subjects were classified as homozygous for the *DRD4* 4-repeat allele (4R-*DRD4*) or any other genotype variant. This classification was based on previous reports of association between ADHD and 7, 2 and 6 repeat variants of the *DRD4*. Statistical analysis was performed by parametrical methods.

*Results:* In respect with behavioural parameters, subjects homozygous for 4R-*DRD4* commit significantly less Omission errors and display lower variability in the reaction time (RTSD) compared with other genotypes subjects (omission errors: 8% v/s 23%  $p < 0,002$ ; RTSD 111ms v/s 138ms  $p < 0,05$ ). In addition, 4R homozygosity was significantly associated with lower P2 and P3 amplitudes. These results are independent of the age and ADHD status.

*Discussion:* Our findings suggest that Omission errors and RTSD during a Go/Nogo Task may be correlates for *DRD4* variants at a behavioural level, while P2 and P3 amplitude are associated with *DRD4* variants at the electrophysiological level. These results are independent of ADHD status. Since there was a trend for association of these measures and ADHD status, they are attractive as potential endophenotypes for ADHD.



**Effects of target probability on response-related brain oscillations**

**Yordan Hodzhev<sup>\*</sup>, Juliana Yordanova, Plamenka Nanova, Vasil Kolev**

Institute of Neurobiology, Bulgarian Academy of Sciences

Acad. G. Bonchev Str., bl. 23, 1113, Sofia, Bulgaria, jordan\_qvo@abv.bg

*Background:* In a probabilistic environment, prediction is critical for behavioral organization and adaptation. The executive system of the brain subserves (1) anticipatory and preparatory processes in the perceptual (input) and motor (output) domains, and (2) performance monitoring. The effects of stimulus probability on stimulus evaluation have been well characterized.

*Aim:* The objective of the present study was to assess the effects of target stimulus probability on processes of (1) motor generation, and (2) performance monitoring.

*Method:* Auditory event-related potentials (AERPs) were recorded in Go-NoGo tasks, in which targets were presented with different probability ( $p=0.15, 0.50, \text{ and } 0.85$ ) and required a button press with the two hands simultaneously. After applying current source density to increase spatial resolution, the following parameters were analyzed: (1) P300 component in stimulus-locked AERPs, (2) motor-related potentials (MRPs) contralateral to the response side, and (3) correct response negativity (CRN) at FCz in response-locked AERPs. Additionally, continuous wavelet transform was applied to extract covert time-frequency components from both the CRN and MRP.

*Results:* Time domain analyses showed that target-P300 amplitude increased gradually with target probability decrease. In contrast, MRP amplitude differentiated low from both equal and high target probabilities, whereas CRN amplitude did not depend on target probability. Time-frequency analysis showed that phase-locked power of delta (1.5-2.5 Hz) MRP component was largest for low-probable targets. Phase-locked delta component of CRN peaked earlier for high than low and equal target probabilities. The maximal expression of the total power of theta (4-6 Hz) CRN component occurred faster in low and equal than high probability conditions.

*Conclusions:* The functional modulation of the contralateral motor cortices depends on target probability such that low probability is associated with insufficient pre-activation of cortical motor areas. Executive processes controlling stimulus cognitive evaluation may dissociate from the executive processes controlling response generation. The strength of motor representations modulated by response probability does not appear to interact with the monitoring of correct responses.

**Heart rate variability and EEG during sleep  
using spectrum-weighted frequencies - a case study**  
**E. Kaniusas<sup>a</sup>, G. Varoneckas<sup>b</sup>, A. Alonderis<sup>b</sup>, A. Podlipskyte<sup>b</sup>**

<sup>a</sup> Institute of Fundamentals and Theory of Electrical Engineering,

Bioelectricity & Magnetism Lab, Vienna University of Technology, Vienna, Austria

<sup>b</sup> Institute of Psychophysiology and Rehabilitation, Kaunas University of Medicine, Palanga, Lithuania

The present study concerns the relevance of the spectrum-weighted frequencies of both heart rate variability (HRV) and electroencephalogram (EEG). The frequencies represent the balance point of power within a certain spectral range. The predictive value of the frequencies and their mutual interrelations are demonstrated with respect to different sleep stages based on data from a single case. In particular, revealed stage-dependant relationships between frequencies from HRV and EEG suggest a close interrelation between autonomic cardiovascular control and activity of central nervous system. The results show that the easy-to-assess frequencies may yield a simple indicator of the sleep quality within the scope of comfortable patient monitoring.



**Gender-specific development of auditory information processing in children:  
Time-frequency analysis**

**Plamenka Nanova, Vasil Kolev, Laura Lyamova, Juliana Yordanova \***

Institute of Neurobiology, Bulgarian Academy of Sciences,  
Acad. G. Bonchev Str., bl. 23, 1113, Sofia, Bulgaria, \*jyord@bio.bas.bg

*Background:* Cognitive development in children is reflected by changes in the frequency content of event-related EEG activity. Behavioural studies have demonstrated that subject's gender affects cognitive maturation.

*Aim:* The aim of the present study was to assess the effects of gender and age on sensory and cognitive information processing as reflected by time-frequency components of event-related brain potentials (ERPs). The major questions were: (1) Do ERPs differ between girls and boys, and (2) Do gender differences in ERPs depend on the development with age and/or task processing demands?

*Method:* Thirty six healthy children, divided into two age groups (7-8 and 9-10 years-old) were studied. Boys and girls were pairwise matched for age. Task processing demands were varied by using conditions with and without activation of memory and sensorimotor processes. Auditory ERPs were recorded in a passive listening condition, a simple reaction task and a serial learning reaction task, in which targets and nontargets followed a hidden regular pattern that had to be discovered. Frequency ERP components were analyzed at the level of single sweeps in the theta (4-7 Hz), slow alpha (8-10 Hz), and fast alpha (11-14 Hz) frequency ranges. The measurable parameters were maximal single-sweep amplitude and phase-locking (between-sweep synchronization). To reflect biological development of neural systems, spontaneous EEG activity was also analyzed.

*Results:* Major results showed that: (1) There was a developmental increase in theta and slow alpha phase-locking, (2) Theta and slow alpha phase-locking was overall stronger in girls than boys, (3) A developmental increase in slow alpha phase-locking occurred only in the group of girls, whereas no such increase with age was observed in the group of boys, and (4) Task variables (memory and sensorimotor activation) had significant effects on theta, slow, and fast alpha amplitude and phase-locking, but only fast alpha amplitudes were specifically sensitive to motor-related processes in older girls.

*Conclusion:* These results suggest that: (1) The functional reactivity of theta and slow alpha networks in auditory information processing substantially changes with development in children, (2) The functional maturation of theta and slow alpha networks is faster in girls than boys, and (3) Fast alpha oscillations may reflect gender differences in the maturation of sensorimotor processes.



**Mapping familial aspects of brain functions in children and adults  
with and without ADHD**

L. Valko, M. Döhnert, G. Schneider, R. Drechsler, U. Müller, H.C. Steinhausen, D. Brandeis  
Department of Child and Adolescent Psychiatria, University of Zurich, Switzerland

ADHD is characterized by deficits in attention, inhibition and time-processing, and is highly heritable. We examined children suffering from ADHD, their nonaffected siblings, plus healthy control children, as well as parents of the ADHD children with and without ADHD and control parents using event-related EEG mapping. Markers of inhibition (Nogo-P300) and preparation/time-processing (CNV) were examined for ADHD-effects. We hypothesized that for some markers, the non-ADHD groups would resemble the ADHD-group rather than the healthy control-children and parents. Such markers might represent vulnerability-factors or endophenotypes, rather than the phenotype defined by the ADHD-status. Regarding inhibition, children/adults with ADHD had smaller Nogo-P300 than the nonaffected sibs/parents. Control-children and control-parents showed the highest Nogo-P300-amplitudes. Children showed a right-posterior and adults a frontocentral Nogo-P300, reflecting typical generation effects. Regarding time-processing, the CNV had a stable topography across generations. ADHD-children showed significantly weaker posterior-central negativity than control-children. The nonaffected siblings were intermediate but closer to the control children. Parents (regardless of their ADHD-status) of ADHD-children showed a weaker (less negative) CNV than control-parents. These results suggest that the Nogo-P300 but not the CNV represents a potential endophenotype.

Supported by the SNF (MFAA-study, 32-109591/1)

**EEG analysis in depression**

**A. Suhhova\*, M. Bachmann\*, K. Adamsoo\*\*, U. Vohma\*\*, J.. Lass\*, R.Tomson\*, V.Tuulik\*,  
and H. Hinrikus\***

\* Department of Biomedical Engineering, Technomedicum of Tallinn University of Technology

\*\* Clinic of Psychiatry, North Estonia Regional Hospital

The *aim* of this study was to find a parameter based on EEG for distinction of changes specific in depression.

*Methods:* The experiments were carried out on two groups of volunteers: a group of patients with major depressive disorder and a group of healthy comparison subjects. Each group consisted of 18 female subjects. Subjects with major depressive disorder were selected from hospital inpatient unit. Subjects with non-psychotic major depressive disorder as defined by ICD-10 criteria and determined by 17-item Hamilton Depression Rating Scale (HAM-D) score more than 14 were eligible. The average HAMD score for the group was 21 (SD 3.3). Subjects were without antidepressant treatment, only regular (same dosage for more than 3 weeks) benzodiazepine use was allowed. Concomitant treatments for current general medical conditions were permitted on the basis of clinical judgment (patients receiving medication with known CNS side effects were not eligible).

The resting EEG was recorded during 30 minutes using 19 electrodes, which were placed on the subject's head according to the international 10-20-electrode position classification system. The channels for analysis were chosen to cover the entire head: frontal - FP1, FP2; parietal P5, P4, temporal - T3, T4; occipital O1, O2 and the reference electrode Cz. The EEG recordings were stored on a computer with a 400 Hz sampling frequency. The dynamics of the EEG power of the theta (4-8 Hz), alpha (8-13 Hz), beta1 (13-20 Hz) and beta2 (20-40 Hz) frequency bands were analyzed.

Three different parameters were selected as measures for estimation of the mode of depression and used for further analysis:

1) Asymmetry scores were calculated for all channel pairs: FP1-FP2, P3-P4, T3-T4, O1- as follows:

$$A = \frac{L - R}{L + R} \cdot 100, \quad (1)$$

where L and R indicate EEG power in the left or right hemisphere channel, respectively. Analysis was performed separately inside each EEG frequency band.

2) Coherence values were computed using the next formula:

$$Coh_{xy}(w) = \frac{|P_{xy}(w)|^2}{P_{xx}(w) \cdot P_{yy}(w)}, \quad (2)$$



where  $P_{xy}$  is the cross-spectrum of two signals and  $P_{xx}$ ,  $P_{yy}$  the power spectrum of each signal. The coherence values were calculated for FP1-T3 – FP2-T4, T3-P3 – T4-P4 and P3-O1 – P4-O2 channel pairs. Analysis was performed separately inside each EEG frequency band.

3) The ratio of the EEG power inside beta and theta frequency bands was calculated as follows:

$$H = \frac{W_{bn} - W_{tn}}{W_{bn} + W_{tn}}, \quad (3)$$

where  $W_{bn}$  and  $W_{tn}$  are the powers inside beta and theta rhythms frequency bands respectively for a subject respectively. Analysis was performed separately for each EEG channels. For statistical comparisons, analysis of variance (ANOVA) was performed.

*Results:* Calculated by (1) asymmetry index showed increase in the left frontal alpha power for depressive patients compared to healthy subjects. However, this trend was not statistically significant for the group.

Coherence values calculated by (2) for channels FP1-T3 – FP2-T4 were about 20% higher in depressive group compared to healthy group in the EEG alpha frequency band. However, this trend was not statistically significant for the group.

The calculated by (3) beta-theta ratio values were positive for patients with depressive disorder (except 2 patients) and negative for healthy subjects (except 3 subjects). Statistical differences between the depressive and healthy groups significant,  $p < 0.0001$ . Statistical comparisons of symmetric channels didn't reveal significant differences between brain hemispheres ( $p > 0.05$ ). Calculated coefficient of correlation between Hamilton score and  $H$ -parameter values in P-channels was 0,67.

*Conclusion:* Our results suggest that the selected measure as a combination of the EEG beta and theta rhythms power can differentiate between patient with depressive disorder and healthy subjects. In our study we didn't reveal significant changes in asymmetry between brain hemispheres for depressive patients.

#### Q-EEG subtyping of Macedonian children with Attention Deficit Hyperactivity Disorder

<sup>1</sup>Zorcec Tatjana, <sup>1</sup>Pop-Jordanova Nada, <sup>2</sup>Mueller Andreas

<sup>1</sup>Pediatric Clinic, Faculty of Medicine, University of Skopje, Macedonia

<sup>2</sup>Praxis für Kind, Organisation und Entwicklung, Chur, Switzerland

Attention Deficit Hyperactivity Disorder (ADHD), characterized with inattention, impulsivity and hyperactivity, is one of the most frequent developmental disorders in childhood. If not treated properly, it can persist in the adulthood. Onset is usually in the preschool and early school years. The worldwide prevalence diverse from 3 to 10%. The prevalence in Macedonian school children is estimated to be about 2%.

The diagnosis is usually made clinically, by using classifications of disorders like ICD-10 or DSM-IV. In the recent decade, a quantitative analysis of the EEG data (qEEG), has proven to be additional valid source for making a precise ADHD diagnosis. Recently, five qEEG subtypes in ADHD children were introduced (A. Mueller and Y. Kropotov, 2006).

This study presents 20 Macedonian children with ADHD, mean age  $10.5 \pm 2.35$  years, both genders. For each child qEEG data (in eyes open and eyes closed conditions) were recorded, together with the continuous performance tests (CPT). Analysis showed that 30% of the children belong to the first subtype (increased theta amplitude in the frontocentral cortex), 25 % to the fourth subtype (overactivated beta in frontal, central or parietal cortex) and 45 % to the fifth subtype (slow alpha excess). The qEEG results were compared with brain-rate calculation. The analysis was used for planning the individual neurofeedback protocols.