

Electrical Oscillations and Analog Neurons Computation

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In this poster we will discuss some issues connected to the implementation through electronic circuits of neuronal models and to their properties such as synchronization and excitability; we will also show some of the results obtained in collaboration with the research group at the University of Potsdam through two Short-Term Scientific Missions and in collaboration with the research group at the University of Florence. After this first part devoted to electrical oscillations, we will then show how these electrical oscillations can be used for analog computation based on neurons. We will show that many interacting units of such oscillators are able to perform complex processing tasks.

Empathic Skills and Preattentive Auditory Processes

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Aim: Empathy is the ability to project oneself into the personality of another person in order to be conscious of that person's emotions or feelings. Listening, especially empathic listening is a very important part of empathy. Deaf children frequently have trouble understanding other people's emotions. Mismatch negativity (MMN) is an event-related brain potential elicited by infrequent, physically deviant sounds in a sequence of repetitive auditory stimuli. MMN reflects pre-attentive deviance detection and the operation of an automatic mismatch detection system and auditory sensory memory.

In this study we examined the relation between preattentive auditory processing and empathic skills.

Method: 40 (20F, 20M 20.9 ± 1.8) volunteers without hearing, psychiatric and neurological problems participated the study. Linkert type Empathic Skills Scale was given to the subjects. ERP was recorded in passive auditory oddball paradigm, while the subjects were reading a self chosen book. The stimuli were 50 ms long and 74 SPL. Standard tones (P: 0.8) were 1000 Hz, deviant tones (P: 0.2) were 1250 Hz. The subjects were divided as high and low empathic skills scores. The groups were compared with repeated measures for ANOVA. The amplitude and latency of ERP components and Empathic Skills Scores correlations were analyzed by Pearson's correlation test (2-tailed).

Results: The MMN amplitudes were significantly larger in the high empathy skill (HES) group than the low empathy skill (LES) group ($F(2,31)=45,3$; $p<0.001$). MMN amplitudes and Empathy Skills Scale scores were correlated moderately ($r= -0,38$, $0<0.024$).

Conclusion: Larger MMN amplitudes in HES than LES group and moderate correlation between MMN amplitudes and empathy skills scores suggests that preattentive, bottom up processes might affect empathy skills. Even though empathy is a very complex emotional cognitive and motivational process, people who have better preattentive sound discrimination abilities, reflected by larger MMN amplitudes, can be advantageous to develop empathy skills. Auditory processing is not only an important component of empathy but also it has reinforcing influences in the development of empathy.

THE EFFECTS OF NEUROFEEDBACK TRAINING ON ADULT ADHD

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Aim: Attention-deficit/hyperactivity disorder (ADHD) is a multifactorial disorder with complex etiology and strong genetic underpinnings. Follow-up studies have found that 5%–66% of children with ADHD persist with this disorder in adulthood Current epidemiologic studies estimate the prevalence of adult ADHD to be between 3% and 5%.

Endophenotypes are measurable internal phenotypes unseen by the “naked eye” along the pathway between disease and genotype. They have emerged as an important concept in the study of complex neuropsychiatric diseases. An endophenotype may be neurophysiological, biochemical, endocrinological, neuroanatomical, cognitive, or neuropsychological in nature.

The reduced P3 amplitude has been observed in ADHD and some of its co-morbid disorders like, anti-social personality, alcohol abuse and dependency, bipolar disorder. These converging P3 findings offer support for reduced P3 amplitude as an endophenotype.

The treatment of ADHD mainly consists of using stimulatory drugs. The stimulating drugs have cardiovascular risks especially for adults. Neurofeedback (NF) treatment had also been shown to be effective in ADHD and impulse control. NF treatment has no known cardiovascular or other morbidity and/or mortality increasing effects. SMR and beta –1 training were shown to increase P3 amplitude in normals by increasing inhibitory control and arousal which is also defective in ADD samples. The aim of the study is to study the effect of NF on adult ADHD symptoms, on endophenotype namely P3 amplitude. In this study the preliminary findings of six adult ADHD patients (age 22-32; 2F, 4M) were reported.

Methods: The ADHD subjects (DSM-IV TR) who had either diagnosed as ADHD in childhood or had fulfilled the scores for Wender-Utah Rating Scale for ADHD in Adults (Öncü et al, 2005-Turkish version) were enrolled for the study. They were given Adult ADD/ADHD DSM IV- based Diagnostic, Screening and Rating Scale (Turgay) (Günay et al. 2004- Turkish version) and their ERP were recorded before and after training. The training consisted of either SMR increase/theta decrease or beta increase-SMR increases/theta decrease in combination.

Results: After 40 treatment sessions Adult ADD/ADHD Diagnostic and Rating Inventory scores decreased more than 50% and P300 amplitudes increased between 50-100%.

Conclusion: Our preliminary results indicate that NF training is an effective candidate treatment modality for adult ADHD. P3b amplitude and MMN latency can be a useful electrophysiological tool to follow up the progress of NF training. By modulating an endophenotype (low P3), NF might be useful not only in ADHD but some other co-morbid conditions with low P3 amplitude.

Title: Methylphenidate modulates sensorimotor integration in healthy adults as reflected by neuroelectric oscillations in a Go/NoGo task

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Aims: Methylphenidate (MPH) is a psychostimulant drug acting mainly on the dopaminergic and noradrenergic systems. It is widely used in the treatment of attention-deficit/hyperactivity disorder (ADHD). Behavioral and psychophysiological studies have shown that MPH affects executive functions at the level of both sensory and motor systems. Thus suggested effects of MPH on sensorimotor integration can be assessed by means of event-related neuroelectric oscillations (Yordanova et al, 2004).

Methods: Fourteen healthy subjects (8 male, aged 20-40 years) performed a visual Go/NoGo task (S₁-S₂ paradigm). MPH (20 mg) or placebo were administered using a randomized, double-blind, cross-over design. Event-related electroencephalographic (EEG) activity after S₂ was recorded. Time-frequency decomposition (wavelet analysis) was applied to evaluate power dynamics in delta, theta, slow and fast alpha, and beta frequency bands.

Results: At the performance level, faster reaction times and a trend towards less impulsivity errors under MPH vs. placebo were observed. MPH effects on EEG were specific for Go-trials at parietal locations. MPH enhanced slow alpha total power (8.29-9.68 Hz), fast alpha total power (10.32-14.45 Hz) within the first 300 ms post-stimulus associated with motor production.

Conclusions: It might be proposed that a single dose of 20 mg MPH modulates early visual information processing related with motor response generation in healthy adults.

Key words: Methylphenidate, sensory and motor systems, sensorimotor integration, event-related oscillations, Go/NoGo task, Wavelet analysis, EEG

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Title: Sleep in child psychiatric disorders: Impact on diagnosis, treatment and early prevention

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Aims: To test whether there are specific sleep patterns that shape attention-deficit/hyperactivity disorder (ADHD), tic disorder (TD) and ADHD/TD comorbidity.

Methods: Eighty-one patients rigorously diagnosed with these child psychiatric disorders (DSM-IV and ICD-10) and 24 controls (aged between 7.0 and 16.4 yrs) were enrolled for a two-night polysomnography. They participated in 5 consecutive (partially overlapping depending on each study's major goal) consecutive studies. Patient and control groups were matched for age, gender and intelligence, and psychopathology was scored by means of standardized questionnaires.

Results: Children with ADHD displayed more time in sleep, more rapid eye movement (REM) sleep (REMS) with REMS latency tended to be shorter and more REMS cycles than controls. Children with TD had less sleep efficiency and delayed sleep onset and latency to slow wave sleep. Children with ADHD/TD comorbidity showed more REMS and a shortened latency to REMS. Whereas the sleep alterations in ADHD samples correlated with scores on inattention and hyperactivity, the less sleep efficiency in TD correlated with tics severity. Importantly, ADHD and TD psychopathologies contributed to sleep changes in ADHD/TD in an independent manner.

Conclusions: ADHD and TD are distinguished by disorder-specific sleep patterns.

ADHD and TD may be separate psychiatric entities. ADHD may belong to a spectrum of child psychiatric disorders with REM sleep overdrive. Mechanisms laying psychopathology of these child psychiatric disorders and sleep regulation may have much in common, which appeals for a more precise evaluation of sleep problems in child psychiatry.

Key words: Sleep, ADHD, TD, ADHD/TD comorbidity, Child psychiatry

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Tomographic Neurofeedback in Healthy Adults - Implications for ADHD Treatment

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Objective:

Tomographic neurofeedback (NFB) based on multichannel scalp electroencephalographic (EEG) mapping (*Congedo et al. (2004)*) aims to control and normalize intracerebral activity in specific brain regions. In this pilot study this advanced method was investigated in healthy adults in the context of further improving the NFB technique for treatment of Attention-Deficit-/Hyperactivity-Disorder (ADHD) in terms of specificity and efficacy (Drechsler et al., 2007).

We hypothesized that the subjects learn to self-regulate their EEG in the trained Regions of Interest and frequencies with corresponding effects on the resting EEG, and leading to improvements in neuropsychological tests and in subjective ratings of attention and control.

Methods:

Ten healthy adults (age: 23-33 years, one excluded for artifacts) were trained to increase their beta/theta ratios (15-18/4-7Hz) in two consecutive blocks targeting different prefrontal regions (Anterior cingulate cortex = ACC and right dorsolateral prefrontal cortex = DLPFC). The counter balanced cross-over design included four sessions per region followed by ratings of attention and control. NFB was based on a multichannel scalp EEG inverse solution (sLORETA; standardized low resolution electric tomography) (Pascual-Marqui, 2002). A topographic 19-channel EEG montage allowed calculating the relevant intracerebral activations.

To test for training effects, pre- and post tests included resting EEG and event-related potentials in cognitive tasks (cued CPT-Flanker-Task) in 47 channels, and subtests of the test of attentional performance (TAP 2.1, Zimmermann & Fimm (2007)), allowing quantifying attention and executive control (e.g. alertness, flexibility, inhibition). EEG power in different frequency bands (theta: 4-7Hz, alpha: 7.5-12.5Hz, beta1: 15-18Hz, beta2: 20-30Hz) were analyzed for topographic differences.

Results:

Subjects partly learned to control their prefrontal activity, given subjective feelings of control, but significant objective improvement was limited to the ACC training ($t(8)=-2.39, p<.05$). Objective control gains over ACC and DLPFC activity were uncorrelated ($r=.15$). ACC training improved TAP RT measures of flexibility, DLPFC training measures of sustained attention and inhibition. No effects in resting EEG with eyes closed were found.

Conclusions:

The selective improvements with ACC training in just 4 sessions were uncorrelated with measures of DLPFC control in this neurofeedback pilot study, suggesting that tomographic neurofeedback is indeed effective and regionally selective.

The results provide a first basis that tomographic ACC NFB has specific cognitive effects. Its clinical / therapeutical relevance remains to be evaluated in a study with subjects suffering from ADHD.

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Key words: ACC, DLPFC, ADHD, tomographic NFB, resting EEG, Power, frequency bands, theta, beta, sLORETA

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Resting EEG and Tomographic Neurofeedback – Implications for ADHD Treatment

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Introduction:

Tomographic neurofeedback (NFB) based on electroencephalographic (EEG) mapping is a new technique which should make it possible to train and normalise intracerebral activity in specific brain regions in attention deficit hyperactivity disorder (ADHD). Suitable regions should be chosen according to robust EEG abnormalities in ADHD.

Methods:

EEG from subjects with ADHD and healthy controls was recorded from 47 channels during rest (eyes closed and eyes open) and cognitive tasks (CPT O-X) in children (age 8.5 to 13 years) and adults (Age 32-49 years). EEG power in different frequency bands (theta: 4-7hz, alpha: 7.5-12.5hz, beta1: 15-18hz, beta2: 20-30hz) were analysed for topographic differences. For the tomographic neurofeedback pilot study, 10 healthy adults were trained in 4 sessions to increase their beta/theta ratios in two prefrontal regions (Anterior cingulate cortex = ACC and right dorsolateral prefrontal cortex = DLPFC).

Results:

The current presentation focuses on the resting EEG of children and adults with ADHD compared to age matched controls, and on a tomographic neurofeedback pilot study. Preliminary results (n=25 ADHD compared to n=13 control children and n=17 ADHD compared to n=18 control adults) do not seem to replicate the EEG abnormalities (theta increase and beta decrease) typically reported in literature. Resting EEG results from larger groups and EEG and ERP results from cognitive activation conditions will be presented.

In the tomographic neurofeedback pilot study, subject partly learned to control their prefrontal activity, but significant improvement were largely limited to the ACC training. Control over ACC and DLPFC activity was uncorrelated.

Conclusions:

Our preliminary failure to replicate consistent resting EEG abnormalities in ADHD casts doubt upon neurometric approaches towards EEG-based ADHD classification. It also suggests that normalizing resting EEG abnormalities via neurofeedback may not be an appropriate rationale in ADHD treatment. Instead, normalizing task-related and event-related neurophysiological abnormalities may provide a better rationale for neurofeedback in ADHD. The lack of correlation between ACC and DLPFC control in the neurofeedback pilot study suggest that tomographic neurofeedback may indeed be regionally selective.

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Key words: ADHD, tomographic NFB, resting EEG, Power, Frequency Bands, Theta, Beta

BEHAVIORAL PARAMETERS FOR ADHD AND NORMAL ADULTS DURING FACE RECOGNITION AND IDENTIFICATION OF FACIAL EMOTIONS

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The objective of this study was to compare the data from Amsterdam Neuropsychological Test (ANT) and Emotional Continuous Performance Test (ECPT) between ADHD and normal adults. 57 ADHD (mean age = 37.4; SD = 9.29) and 46 healthy (mean age = 25.6; SD = 7.90) subjects were included in the study. ANT was recorded during 10 tasks, whereby only two tasks were analyzed: Face Recognition (FR) and Identification of Facial Emotions (IFE). The first task consisted of three parts (frontal, profile and upside-down faces) recognizing the unfamiliar faces with varied mapping condition. The second task comprised the recognition of facial expressions: happy, sad, angry and feared faces. ECPT introduced by Meier, Müller & Kropotov, was given as a part of stimuli presentation protocol for evoked potentials and was recorded simultaneously with the 19 channel EEG. The ADHD group made more errors, showed a greater response time and larger variability of reaction time than the control group. Accordingly, this group showed more difficulties of dealing with complexity of face and facial expression recognition. In addition, we can say that the decoding of complex visual information, as the decoding of emotional states, is difficult, since the different feelings also have an influence on the visual decoding and decision-making process.

Keywords: face recognition, identification of facial emotions, ANT, ECPT, ADHD.

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MULTIDIMENSIONAL SCALING FOR VISUALIZATION OF SLEEP STAGES USING HEART RATE DATA

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The goal was to demonstrate the effectiveness of multidimensional scaling (MDS) in establishing the informative HR pattern characteristics for classification of sleep states.

MDS algorithm based on hybrid optimization criterions of *stress* and *sstress* combining evolutionary global search and local descent was used for identification of sleep stages. MDS algorithm allows to discriminate the clear-cut clusters of points (HR data), representing individual sleep stages, in a two-dimensional plane. For visualization we used parameters of RR interval, its variability (δ RR) as well as power spectrum components (VLFC, LFC, and HFC).

Visualization of HR data during sleep distinguished 5 clusters representing individual sleep stages. RR interval, LFC and HFC were the most informative HR parameters in clustered sleep stages according Spearman correlation. The probability of discrimination of sleep stages into the visualized clusters was nearly 80 percent. HR data visualized outside the sleep stage clusters did not show any correlation ($p > .05$) between sleep stages and HR parameters. Some consistency has been seen in the distribution of parameters reflecting HR variability. The lowest values of δ RR and HFC were characteristic to the stage 4 cluster, while the highest ones – to the REM sleep cluster.

Visualization of HR data into sleep stage clusters helps to find out the most informative HR parameters which can be used for further identification of sleep stages using HR data.

Distinct brain inter-structure complexity patterns induced by two types of anesthesia in rat

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Complexity, entropy and other non-linear measures of the electroencephalogram (EEG) have been recently proposed as the measures of anesthesia depth and sedation. Higuchi fractal dimension (FD) has been particularly proved as the sensitive measure of anesthesia depth. We used the surrogate data test for nonlinearity in order to establish the existence of nonlinear dynamics, and to justify the use of FD as a nonlinear measure in the time series analysis. The surrogate data of predefined probability distribution and autocorrelation properties have been generated using the algorithm of Statically Transformed Autoregressive Process (STAP). FD then was applied to quantify complexity of the cerebral cortical, hippocampal and pontine EEG during stable anesthesia (ketamine/xylazine or nembital anesthesia).

Our study by using FDs has shown for the first time that global neuronal inhibition caused by different mechanisms of anesthetic action (suppression of excitation by ketamine or potentiation of inhibition by nembital) induces distinct brain inter-structure complexity gradient in Sprague Dawley rats. Significantly higher brain complexities (mean FDs) at the cortical and right hippocampal level were detected in ketamine/xylazine versus nembital anesthesia. Hippocampal complexity was higher than cortical complexity of the same brain side, and left hippocampal complexity was the highest in both types of anesthesia. While in ketamine/xylazine anesthesia there was a dominance of hippocampal complexity, in nembital anesthetized rats a characteristic complexity gradient was established: the ponto-hippocampo-cortical order occurred within the right brain – the highest complexity in the pons decreasing toward cortex.

Title: Spectral asymmetry of EEG in major depression

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Aims: The aim of this study was distinction of depressive disorder based on EEG analysis. EEG intra-hemispheric asymmetry and coherence have been reported to detect depressive disorder. Unfortunately these results have not been confirmed in all studies. On the other hand, anomalies in beta-waves have been found to be associated with mental depression (Sun et al., Brain Res. Bull, 2008). Therefore, this study was aimed to investigation of spectral asymmetry of the EEG signal for detection of 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. Patients with Hamilton Depression Rating scores more than 14 were selected. Subjects were without antidepressant treatment. Each group consisted of 18 female persons. The resting eyes closed 9-channel EEG was recorded during 30 minutes. Spectral Asymmetry Index (SASI) was calculated as a relative ratio of powers of higher and lower EEG frequency bands.

Results: Our results showed that calculated SASI values were positive for depressive subjects (except two subjects) and negative for healthy subjects (except three subjects). The calculated SASI parameters differed significantly between healthy and depressive subjects ($p < 0.00001$). Time course of calculated SASI was also different for healthy and depressive subjects. The spectral asymmetry was symmetric in brain hemispheres.

Conclusions: Our results showed that EEG spectral asymmetry is promising for distinction of depression.

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Is there intra-subject variability related to stimulus modality effect on evoked responses?

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The purpose of this study was to use stimulus modality to assess individual's brain lateralization differences; by using the visual-alone, auditory-alone and audio-visual stimuli.

Thirty right-handed healthy young volunteers participated in this study (fourteen male, mean age of all subjects= 21,1 years, S.D.=2,3). Electroencephalographic (EEG) activity was recorded from 32 different sites by Neuroscan 4,1. The recording session was consisted of three experimental paradimgs;

1. *Visual Evoked Potentials (VEPs)*: Black-and-white checkerboard pattern stimuli were presented binocularly.
2. *Auditory Evoked Potentials (AEPs)*: Pure tone stimuli were presented binaurally through headphones at 0.5 Hz (1500 Hz, 80 dB SPL, 10 ms r/f) in a passive condition.
3. *Bimodal Evoked Potentials (BEPs)*: Combined VEPs (1) and AEPs (2) stimuli were presented simultaneously.

Using SPSS statistical software (SPSS 11.5), the amplitudes of responses were submitted to Paired Samples T-Test.

For visual evoked potentials (VEPs), a clear P1 wave occurred at occipital and parietal electrodes. For auditory evoked potentials (AEPs), an N1-P2 complex was clearly observed with central-frontal maximum. Although larger in amplitude, waveforms of BEPs at anterior sites were similar to those of AEPs. BEPs, like VEPs, characterized a well pronounced occipito-parietal P1. Interestingly, although VEPs (P1 wave) were observed with strong right hemispheric lateralization, AEPs (N1-P2 complex) were largest bilaterally or in left side in the same participant. Although larger in amplitude, this property was similar to the BEPs responses.

In conclusion, those intra-subject variability results may explain the contradiction and/or dynamic changes about the hemispheric lateralization of human brain.