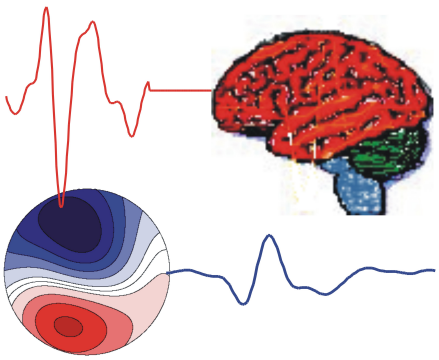
KOGNITIVE NEUROPHYSIOLOGIE DES MENSCHEN

HUMAN COGNITIVE NEUROPHYSIOLOGY



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Editorial

This is the first issue of the journal for 2016. I contains another paper on the achievements of Professor Dr. Dietrich Lehmann (1929–2014). In addition, we include the abstracts of the *24th German EEG/EP Mapping Meeting* that took place in October 2015.
Two book reviews on recent publications are also included.

Wolfgang Skrandies

Kognitive Neurophysiologie des Menschen wurde im Jahr 2008 gegründet. Hier sollen wissenschaftliche Artikel zu Themen der kognitiven Neurophysiologie des Menschen erscheinen Sowohl Beiträge über Methoden als auch Ergebnisse der Grundlagen- und klinischen Forschung werden akzeptiert. Jedes Manuskript wird von 3 unabhängigen Gutachtern beurteilt und so rasch wie möglich publiziert werden.
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Human Cognitive Neurophysiology was founded in 2008. This journal will publish contributions on methodological advances as well as results from basic and applied research on cognitive neurophysiology. Both, German and English manuscripts will be accepted. Each manuscript will be reviewed by three independent referees.
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The *Literature* should only include papers that have been published or accepted for publication. The reference list should be in alphabetical order by author. In the text, references should be cited by author(s) and year (e.g. Johnson, Hsiao, & Twombly, 1995; Pascual-Marqui, Michel, & Lehmann, 1994; Zani & Proverbio, 2002).

Examples of reference format:

Johnson, K., Hsiao, S., & Twombly, L. (1995). Neural mechanisms of tactile form recognition. In M. Gazzaniga (Ed.), *The Cognitive Neurosciences* (p. 253-267). Cambridge, Mass.: MIT Press.

Pascual-Marqui, R., Michel, C., & Lehmann, D. (1994). Low resolution electromagnetic tomography: a new method for localizing electrical activity in the brain. *International Journal of Psychophysiology*, *18*, 49-65.

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Contents

EEG Dynamics, Microstates, and Mind: Philosophical Reflections on the Contributions of Dietrich Lehmann

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Almost forty years ago now (1976–1977), I spent a year working with Dietrich Lehmann in the Department of Neurology of the University Hospital in Zurich. I was there as a visiting scholar from the Department of Psychiatry and the Brain Research Institute at UCLA, and sponsored by a U. S. National Institute of Mental Health, Research Scientist Development Award. Part of my "career development" during this particular year of my award was to learn from Dietrich what I could about spatial analysis of EEG signals. First, it must be said what a wonderful host Dietrich was to me as a visiting scientist and to my family. We had a wonderful year that remains marked in our memories as an exciting and adventurous time. From this respect, my year with Dietrich certainly could not have been better, and my family will always be grateful to Dietrich and Martha for their graciousness as our hosts.

A Tale of Two Papers

Dietrich's impact on my work at the time was substantial. I had been working on EEG event related potential (ERP) correlates of human language perception. His impact is best illustrated by two papers: one published just prior to my year with Dietrich (W. S. Brown, Marsh, & Smith, 1976); see also W. S. Brown, Marsh, and Smith (1973, 1979), and another representing work done with Dietrich and published several years later (W. S. Brown, Lehmann, & Marsh, 1980); see also W. Brown and Lehmann (1979). In the first paper we demonstrated contextual meaning differences in ERPs to verbal stimuli such that the same phonetic stimulus (a spoken word) was found to elicit different ERP waveforms when the stimulus was perceived as either a noun or as a verb. ERPs were recorded from 4 electrodes: over the anterior and posterior language areas of the left hemisphere, and over homologous points over the right hemisphere. ERPs to noun and verb meaning were clearly more different in waveform morphology when recorded from the left anterior area than over the left posterior or either right hemisphere sites. The analyses used for this research were entirely temporal (that is, ERP waveforms) with spatial considerations entirely secondary, at very low resolution (four recording electrodes), and theoretically understood out of a model of cortical localizationism. The second paper explored that same issue – i. e. ERP correlates of the perception of an ambiguous verbal stimulus as either a noun or a verb – but this time, influenced by Dietrich, ERP data were analyzed with respect to spatial topography. As we described it in the introduction to the paper, "We treated the ERP data from a given moment in time as a spatial field with peaks and valleys at different scalp locations (the topography) rather than as a set of independent, time-domain responses recorded at

different electrode locations." (p. 342) There were 3 experiments, all versions of this same paradigm where ambiguous verbal stimuli were contextually disambiguated as either a noun or a verb (experiments 1 and 2) or where a degraded stimulus was imagined to be a phrase ending either in a noun or a verb (experiment 3). In order to detect something about topography (however coarsely), a transverse 3×4 electrode array was used. Topography was first analyzed in this study with respect to the relative positions of the field maxima and minima for nouns versus verbs. In all 3 experiments, maxima for nouns versus verbs were separate in an anterior-posterior direction at the 175 ms point, and minima clearly separate in an opposite anterior-posterior direction at 330 ms. Subsequently, all waveforms in each experiment were subjected to a principal components analysis, in each case extracting early, middle, and late ERP components. Topographic analysis of factor scores from these components again indicated that nouns and verbs differed in their anterior-posterior topography, with nouns resulting in greater anterior positivity and greater posterior negativity.

EEG Analysis and Neurocognitive Models

These two papers, both involving similar questions about ERP correlates of syntax in language processing, illustrate a major shift in views of the way ERPs should be understood and analyzed – a shift in the field that Dietrich Lehmann was instrumental in promoting. But they also differ in the underlying model of brain functioning that is presumed in each analysis method. Separate analyses of ERPs waveforms from each electrode, as represented by the first paper, is clearly a reflection of an implicit localizationist understanding of how the brain functions – that is, a model based on the presumption of functionally and anatomically discreet brain areas that work by receiving information, doing the particular processing task unique to that area, and then passing the results on to the next processing module. In this view, relatively high-level cognitive processes can be localized in specific cortical areas that could hypothetically function on their own to accomplish a particular cognitive task given an input and output stream. Thus, in the case of the first paper, Broca's area (approximately under the left anterior electrode) would be presumed, based on the experimental outcome, to be the site for this form of language processing – distinguishing nouns and verbs. That is, the different scalp electrodes were presumed to measure mostly electrical activity from a focal source somewhere in the general vicinity of the electrode, and higher-level cognitive processes were expected to be localized in specific cortical locations somewhere near a particular recording electrode. The alternative view that underlies topographic analysis of ERPs used in the second paper presumes that cognitive processes occur within widely distributed dynamical networks. In this view, the ultimate mental event (such as perception of a verbal stimulus as a noun or a verb) is a function of the pattern of activity occurring over time in widespread cortical and subcortical areas. These functional networks fluctuate over small increments of time, creating the ongoing temporal dynamics of mental activity. Therefore, the best representation of the electrophysiological consequences of mental activity is a temporally fluctuating spatial topography. Thus, as found in the results of the second paper, processing of nouns and verbs is reflected in anterior-posterior shifts in the topography of scalp electrical field peaks and valleys. Dietrich

Lehmann's contribution to the field of electroencephalography is most clearly represented in his demonstration of EEG microstates that can be detected in EEG topographies. These states are represented in stable topographies that last around 70 to 125 ms (e. g. Lehmann, Strik, Henggeler, Koenig, and Koukkou (1998)), and then rapidly shift to a new spatial topography. It is presumed that the temporal fluctuations of moments of cognitive processing are at least grossly represented in these microstates as defined by shifts in the spatial pattern of EEG/ERP fields. Dietrich and his collaborators have demonstrated repeatable relationships between characteristic microstates and specific forms of mental activity.

Neuroscience and Philosophy of Mind

I still do neuroscience research, but in recent years I have been reading, thinking, and writing about brain and mind from a more philosophical perspective. In thinking back on the shift in my thinking about the meaning of brain electrical signals, it has impressed me how parallel have been the developments Dietrich has led in EEG analysis methodology and recent moves in the philosophy of mind. These moves in philosophy include ideas about interactivity, self-organization, functional patterns, and emergent higher cognitive properties – as well as the modeling of these processes as a complex dynamic system. There are philosophical issues associated with localization of higher cognitive processes in specific brain subsystems – the issues of reductionism and determinism (Murphy & Brown, 2007). If it is true that a particular human cognitive function can be said to reside uniquely in a particular cortical area or subcortical nucleus, then it can be argued that the particular cognitive function can be reduced to the activity of cells in that nucleus. Of course, the activity of networks of cells in a cortical area or subcortical area might be further reduced to molecular events in the membranes and synapses of these cells. When higher level properties are assumed to be reducible to more microlevel neural properties, it is logically consistent to also assume that higher-level properties of mind are determined at the molecular level. In light of human intelligence and creativity, this is a hard position to maintain. Can mental phenomena be reduced to nothing but the activity of certain neuron interactions, or further reduced to certain synaptic transactions or epigenetic fluctuations at the micro level – even though we credit the importance of phenomena at this level in instantiating and influencing ongoing cognition? In philosophy of mind, the move that avoids this sort of reductionism (without escaping to non-material causes) is the idea of emergence – that is, the idea that the higher-level properties of mental life emerge from widespread patterns of interactivity between neurons or neural circuits. The best model of the emergence of causal properties of mind from patterns of interactivity is that of a complex dynamic system (Juarrero, 1999; Johnson, 2001). The critical idea is that a complex and highly interactive system self-organizes into interactive patterns in order to meet the disequilibrium created by environmental challenges. Successful reorganization occurs in the form of a new interactive pattern that allows the system to meet the environmental challenge by way of a new form of emergent neural/mental/behavioral pattern. This is basically a description of adaptation and learning in biological systems, where the cognitive outcome is new large-scale neural patterns of interactivity. Higher cognitive functions are emergent properties of the nature of patterns of whole-system interactivity. In fact many in the

philosophy of mind would include ongoing patterns of interaction between brain and body (embodied cognition; see Clark (1997); Lakoff and Johnson (1998)), and between body and environment (extended cognition; see Clark (2011)), as constitutive of mind. This philosophical shift in understanding of mind is much like the move from understanding EEG/ERP data as an index of discreet neural/cognitive events occuring at each recording electrode (or discreet events in underlying cortical locations reflected in at least regional EEG events) to an understanding mental events as best represented in the EEG activity over widely distributed scalp fields. The innovations of Dietrich Lehmann have occurred in parallel with, and I suspect often predictive of, major changes in the philosophy of mind that have a very similar core premise.

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Buchbesprechung: Dein Gehirn weiß mehr, als du denkst

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In diesem populärwissenschaftlich geschriebenen Buch beschreibt Niels Birbaumer die Anwendungen von Lernmechanismen für die Therapie verschiedener Erkrankungungen. Nachdem es inzwischen zu dem anerkannten Grundwissen über neurophysiologische Prozesse gehört, dass nicht nur das Zentrale Nervensystem von Kleinkindern, sondern auch von Erwachsenen sich massiv verändern kann, existiert eine umfangreiche wissenschaftliche Literatur zu dem Thema "Neuronale Plastizität". Das Gehirn des Menschen und folglich auch kognitive Prozesse, Emotionen und Persönlichkeitsmerkmale verändern sich im Laufe des Lebens. Neue synaptische Kontakte bilden sich als Folge von Lernprozessen zwischen den Nervenzellen; unbenutzte Verbindungen verkümmern. Wie aus tierexperimentellen Studien bekannt ist, lassen sich solche Lernvorgänge auch bei Erwachsenen nutzen, um Hirnfunktionen langfristig zu beeinflussen.

Niels Birbaumer arbeitet seit Jahrzehnten auf dem Gebiet des Lernens, wobei meist die praktische klinische Anwendung der Erkenntnisse das Ziel ist. Die Basis der Studien sind u.a. ältere Befunde zu dem Mechanismen des Biofeedback. Mit dieser Methode können Tiere und auch Menschen lernen, weitgehend unbewusst ablaufende physiologische Prozesse willkürlich zu beeinflussen. Dies funktioniert nach entsprechendem Training nicht nur für vegetative Parameter wie Blutdruck, Durchblutung oder Pulsfrequenz, sondern auch für hirnphysiologische Abläufe. Dabei stehen für die Untersuchung der Veränderung der elektrischen Hirnaktivität (EEG/ERPs) oder der Hirndurchblutung (fMRI) inzwischen relativ einfach einsetzbare Methoden zur Verfügung.

Die Arbeitsgruppe von N. Birbaumer konnte wiederholt zeigen, dass auch *vollständig gelähmte ("locked-in")* Patienten lernen können, ihre Gehirnaktivität zu beeinflussen und so zu kommunizieren. Dies ist sowohl für die Angehörigen als auch für die Patienten sehr wichtig. "Locked-in" *Patienten* können sich aufgrund der Lähmung weder durch Sprache noch durch Gesten verständlich machen, aber durch die gelernte Beeinflussung ihrer Hirnaktivität kommunizieren. Dieses Verfahren wurde über lange Zeit fortentwickelt und verbessert, so dass es inzwischen eine Reihe von klinischen Anwendungen gibt. Neben der Kommunikation mit "locked-in" Patienten wird das Neurofeedback bei der Rehabilitation von Ausfällen nach Schlaganfällen eingesetzt oder auch bei der Therapie von psychiatrischen Symptomen. Birbaumer beschreibt in den einzelnen Kapiteln viele verschiedene Patienten, die er offensichtlich mit großem persönlichen Engagement begleitet hat. So werden die eher theoretischen Grundgedanken zu Lerntheorien durch anschaulichen Schilderungen praxisnah illustriert. Die zentrale Darstellung der Möglichkeiten der Biofeedbacks, mit vollstän-

dig gelähmten Patienten zu "sprechen" und dabei zu erfahren, dass diese überraschenderweise sehr wohl Bewusstsein und Lebenswillen haben, ist sicher auch für die Beurteilung der Frage der Sterbehilfe wichtig.

Der Text ist flüssig geschrieben und leicht verständlich. Inwieweit man den Therapievorschlägen folgen mag, muss jeder für sich überlegen (wobei Niels Birbaumer zugibt, dass hier weiterer Forschungsbedarf besteht). Aber die gezielte und kontrollierte Veränderung von Hirnmechanismen bietet bestimmt eine sinnvolle Alternative zu oft wenig erfolgreichen pharmakologischen Therapien (wie beispielsweise der massenhafte Einsatz von Ritalin). Der Leser lernt in diesem Buch viel über die Grundlagen von menschlichen Hirnfunktionen, die anhand von empirischen Befunden erläutert werden. Niels Birbaumer ist auf diese Weise ein lesenswertes Buch geglückt, das illustriert, dass die populärwissenschaftliche Hirnforschung vor allem auf Fakten und nicht nur philosophischen Annahmen basiert.

Literatur

Birbaumer, N. (2014). *Dein Gehirn weiß mehr, als du denkst*. Berlin: Ullstein Buchverlage. (269 Seiten, € 19,99 (Taschenbuchausgabe, 2015, € 9,99))

Book Review: From Psychophysics and Psychophysiology to Phenomenology of Perception

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The book under review is an introduction into scientific work of a Finnish physiologist and philosopher, Yrjö Reenpää (1894–1976). Reenpää's name is likely to be hardly known, or maybe totally unknown, to most readers of *Human Cognitive Neurophysiology;* a fact indicating one of those blind spots that are not so rare in the history of academic science. For Reenpää was not just a professor of physiology with some philosophical hobbies; he was a truly philosophically minded scientist, dealing with fundamental problems of sensory physiology and revealing the philosophical dimension of those problems. That his work is so little known follows from a synergy of several factors: he was studying fundamental (that is to say: difficult) problems, and so his writings are never easy reading; he cultivated mainly scientific contacts with colleagues in Germany and published most of his works in German language; and his urge for logical and epistemological grounding of science did not square well with the straightforward empiricism dominating sciences in the post-WW2 era.

Fortunately, 'little known' is not the same as 'completely forgotten'. Three authors – all of them former students and co-workers of the late Yrjö Reenpää, and experts in their respective areas of medical or psychological sciences, linguistics, and philosophy – combined their efforts to provide a compact and comprehensive overview of Reenpää's works for the English speaking scientific community.

The book is structured in twelve sections. A short Foreword (Section 1) explains the motivation and the aim of the book project. Section 2 then provides a biographic sketch, focusing on key moments of Reenpää's academic career, and development of his scientific and philosophical interests, in which repeated visits to Germany and exchange of ideas with mentors and colleagues at German universities played a constitutive rôle. Reenpää's early experimental research on sensory psychophysics is reviewed in Section 3, subdivided by sensory modalities: sense of taste, kinæsthetic and tactile sensation, vision and audition. Section 4 follows the relation between Reenpää's research in sensory psychophysics and his theoretical views of psychophysiology, and of the mind–body problem in general. Section 5 is dedicated to central questions and problems on Reenpää's way to a 'general sensory physiology', progressing from a focus on sensation to a broader scheme embracing sensation, perception and concept-based understanding. This is the domain where fundamental problems of subjectivity, spatiality and temporality etc. arise that cannot be solved on

the empirical bases, and thus enforce philosophical reflexion and strict conceptualisation. Reenpää's ideas based on different philosophical influences, that of KANT's transcendental philosophy, HUSSERL's phenomenology, and HEIDEGGER's existential analysis, are presented in separate subsections, followed by remarks on Reenpää's relation to Gestalt psychology and theory of language. Section 6 deals with reception of Reenpää's ideas by some physiologists, but also mathematicians and physicists, thus showing that Reenpää's influence is existent but limited. (Most of the names are Finnish, Germany is represented by the physiologist HERBERT HENSEL.) In the Postscript (Section 7) the authors sketch prospects for further research in the study of mind inspired by Reenpää's approach. Sections 8 to 10 comprise references to cited sources, a complete bibliography of Reenpää's writings, and short authors' profiles. This is rounded up by a glossary of special terms (Section 11), and names index (Section 12).

The authors were facing a difficult task, in fact a dual task: on the one hand, to reduce Reenpää's contributions to sensory physiology, psychophysics and philosophy of mind to the essentials, and on the other hand, to trace the inner logic of Reenpää's intellectual development and to show how he arrived, by necessity, to his ideas. I dare say that they succeeded in their enterprise; a few critical remarks that follow do not change anything in this general evaluation. Some typing errors that escaped the proofreader's attention should be corrected; this is the least problem. Section 5 being a 'center of gravity' of the entire work, is still a 'heavy' reading. This applies especially to parts 5.1 ('The science of sensory physiology between observational and natural sciences') and 5.2 ('The Kantian starting points'). Here, in my opinion, a slower pace and more explanatory style would be helpful. Also, a more detailed exposition of Reenpää's axiomatic theory of sensory manifolds – in my view his most elaborated theoretical contribution – would be appreciated.

Summarizing: Everyone interested in the history and/or in the conceptual foundations of sensory physiology, neurophysiology, and psychophysics, will find in this book a good introduction to Reenpää's works and ideas. We may wish that the book will be read not only out of historical interest but will also stimulate further creative works in the fields of theoretical psychology, philosophy of mind, and related disciplines.

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Abstracts of the 24th German EEG/EP Mapping Meeting, Giessen, October 23–25, 2015

Komplexe Kognitionen und das inverse Problem der Neurowissenschaften — individuelle mentale Strategien machen das Gedankenlesen unmöglich Th. Fehr *Universität Bremen*

Üblicherweise ertappt man den Neurowissenschaftler dabei, wie er versucht irgendeiner Struktur des Gehirns seinen Namen aufzudrücken und es damit prominenten Vertretern modularer Hirnfunktionsorganisation wie Broca oder Wernicke gleich zu tun. Allerdings sprechen mehr und mehr Argumente für eine individuell-vernetzte Organisation komplexer kognitiver und emotionaler Prozesse. Während modulare Modelle von eng umgrenzten Hirnregionen ausgehen, in denen selbst komplexe mentale Vorgänge über verschiedene Individuen hinweg ähnlich oder gleich organisiert sind, geht man in Netzwerkmodellen davon aus, dass ein großer, bisher nicht gut quantifizierter und mangels angemessener Methoden quantifizierbarer, Anteil an neuronalen Ressourcen eher individuell einzugartig organisiert ist. Ausgehend von Hirnregionen, welche typischerweise mit primären perzeptuellen oder grundlegenden motorischen Funktionen beschäftigt sind und Regionen, die im weiteren Sinne mit prinzipiellen Funktionen, wie Objektrepräsentation, räumliches Realisieren oder verschiedenen exekutiven Funktionen, die dem Arbeitsgedächtnis oder dem Unterdrücken irrelevanter Informationsverarbeitung zugeordnet werden können, vernetzen sich neuronale Strukturen im individuellen lebenslangen Lernkontext in entsprechend benachbarte höhere heteromodale Kortexbereiche hinein. Aktivierungen in diesen heteromodalen Hirnregionen müssen sich weder notwendig noch hinreichend über verschiedene Individuen hinweg überlappen, was sie für methodische Ansätze, welche auf regionale und/oder oszillatorische Überlappung und darüber hinaus auf strenge für Betafehler anfällige statistische Korrekturen setzen, unsichtbar erscheinen lassen muss. Mit unseren zeitgenössischen methodischen Ansätzen sehen wir insbesondere einen Teil von dem *wie* (mentale Strategie) und weniger etwas von dem *was* (konkrete Inhalte) jemand mental verarbeitet. Letzteres wird wohl angesichts individuell wechselnder mentaler Denkstrategien und der generellen Natur der Organisation komplexer mentaler Prozesse im Gehirn ein Wunschtraum bleiben. Der Vortrag setzt sich kritisch mit gängigem – nach wie vor streng funktions-phrenologisch geprägtem – Denken in den Neurowissenschaften auseinander und fordert den wissenschaftskritischen Zuhörer auf aktiv an der Diskussion teilzunehmen. Fehr, T. (2013). A hybrid model for the neural representation of complex mental processing in the human brain. Cognitive Neurodynamics, 7, 89-103.

EEG/fNIRS approach in emotions and empathic behaviour M. Balconi, M. E. Vanutelli *Department of Psychology, Catholic University of Milan, Italy*

Emotional empathy is crucial to understand how we react to interpersonal situations. In the present study we aim to identify the neural networks underlying the human ability to perceive and empathize with others' emotions during the observation of cooperative or uncooperative interactions. In addition, for the first time a multimethodological approach was adopted. Indeed the indubitable vantage of acquiring both the autonomic (arousal-related) and the central (cortical-related) activities stands in the possibility to better elucidate the reciprocal interplay of the two compartments in empathy behavior. Electroencephalography (EEG, frequency band analysis; source generators analysis, sLORETA), systemic skin conductance response (SCR) and heart rate (HR) were all recorded simultaneously with hemodynamic (fNIRS, functional Near-Infrared Spectroscopy) measurements as potential biological markers of emotional empathy, related to both central and peripheral systems. Subjects were required to empathize with observed interpersonal interaction. As shown by fNIRS and EEG measures, uncooperative situations elicited an increased brain activity within the right prefrontal cortex (dorsolateral prefrontal cortex), whereas cooperative situations showed an increased response within the left prefrontal cortex. Therefore a relevant lateralization effect was induced by the specific valence (mainly for negative conditions) of the emotional interactions. Also the autonomic response (SCR modulation) was modulated by cooperative/uncooperative conditions. Finally EEG activity (mainly low-frequency theta and delta bands) was intrinsically correlated with the cortical hemodynamic responsiveness, and they both predicted the autonomic activity. The integrated central and autonomic measures better elucidated the significance of empathic behavior in interpersonal interactions.

EEG NIRS: light through the developing brain F. Wallois, M. Mahmoudzadeh, G. Dehaene, G. Kongolo, S. Goudjil *Amiens, France*

Cerebral function rely on the both the neuronal and vascular systems which are intimately linked through the neurovascular coupling mechanisms. Both technics HD EEG and HD NIRS allow to monitor the dynamic of these two systems. Fast optical signal with NIRS allows in addition to evaluate with similar temporal resolution as EEG but better spatial resolution changes in neuronal configuration linked to the activated neurons. Because EEG and Fast optical Signal have a very high temporal resolution and because NIRS has a high temporal and spatial resolution, combining both technics offers the opportunity to address the neuronal mechanisms that are solicited and the spatial distribution of the neuronal network involved.

First, we will use the advantage of both, HD EEG/HD NIRS and Fast Optical signal, to describe the strategy of the neuronal networks and the spatial dynamics involved in the premature brain, as early as 28 weeks gestational age, in a task of phoneme discrimination. Such multimodal, noninvasive approach open new avenues in the understanding of the developing brain and is well adapted for clinical purposes.

Visual and auditory processing in cochlear implant users with simultaneous EEG and fNIRS measurement L.-C. Chen (1), P. Sandmann (2,3), J. D. Thorne (1), M. G. Bleichner (1,3), S. Debener (1,3,4) *(1) Neuropsychology Lab, Department of Psychology, European Medical School, (2) Carl-von-Ossietzky University Old-*

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With functional near-infrared spectroscopy (fNIRS), we have recently confirmed previous observations of higher visual-evoked activation in auditory cortex and higher auditory-evoked activation in visual cortex in cochlear implant (CI) users compared to normal hearing (NH) controls. This potentially reflects residual sensory deprivation-induced and sensory restoration-induced functional reorganizations. It is not well understood how cross-modal reorganizations relate to the functionality of intra-modal processing. Particularly, previous studies have found a lower amount of auditory adaptation in CI users compared to NH controls, and the decrease of auditory adaptation was associated to speech recognition abilities. We investigated whether intra-modal sensory processing in CI users is altered. This was done by investigating neural adaptation in visual and auditory sensory systems with concurrent EEG-fNIRS. EEG was used to estimate the amount of activation in response to individual stimuli presented within a train of stimuli. Each block-averaged single-trial response was then convolved with a hemodynamic response function (HRF) to simulate the block-accumulated hemodynamic response as measured by fNIRS. We found a higher amount of visual adaptation and a lower amount of auditory adaptation in CI users compared to NH controls. Interestingly, stronger neural adaptation yielded differences in the peak latency of the accumulated hemodynamic response. Specifically, stronger adaptation resulted in earlier peak latency and vice versa. Our adaptation findings suggest that CI users have higher efficiency in processing visual stimuli.

Functional Near-Infrared Spectroscopy (fNIRS) & Physiological Signals G. Bauernfeind *Technische Universität Graz, Medizinische Hochschule Hannover*

Functional near infrared spectroscopy (fNIRS) is an emerging technique for the in-vivo assessment of functional activity of the cerebral cortex as well as in the field of brain-computer-interface (BCI) research. A common challenge for the utilization of fNIRS in these areas is a stable and reliable investigation of the spatio-temporal hemodynamic patterns. However, the recorded patterns may be influenced and superimposed by signals generated from physiological processes, resulting in an inaccurate estimation of the cortical activity. Up to now only a few studies have investigated these influences, and still less has been attempted to remove/reduce these influences. Different sources of systemic signals, located in the tissue overlaying the brain (superficial scalp interference) as well as in the brain tissue itself can influence the recording. These signals include heart pulsation, breathing cycles, or low frequency oscillations of the blood pressure (BP) and heart rate (HR). These various quasi-periodic physiological rhythms are clearly visible in the frequency spectrum of the recorded hemodynamic signals. In addition to these more or less uncorrelated signals also task-evoked changes can mask the cerebral activation patterns. Therefore, for the investigation of detailed fNIRS-based brain activity patterns, as well as for the use of these patterns in different applications, it is essential to include methods that detect and reduce the effect of the systemic influences in the cortical activity. However, considering the idea that not only the (cen-

tral) fNIRS but also the peripheral physiological measures reflect different aspects of the task, a combination of both measures in a "hybrid" or "multimodal" investigation might lead to better assessment and investigation of the task performance.

Die Bedeutung des medialen präfrontalen Kortex bei der Furchtextinktion M. Herrmann, A. Guhn, B. Brunhuber, Th. Polak *Psychophysiologie und funktionelle Bildgebung, Zentrum für Psychische Gesundheit (ZEP), Würzburg*

In Tierexperimenten konnte gezeigt werden, dass eine elektrische Stimulation des medialen präfrontalen Kortex (mPFC) die Furchtextinktion verbessert (Milad 2002). In einer ersten Untersuchung überprüfen wir mit Hilfe der Nahinfrarotspektroskopie (NIRS) in Kombination mit verschiedenen psychophysiologischen Maßen (wie Hautleitfähigkeitsreaktion und emotionale Startlemodulation), ob diese Region auch beim Menschen beim Extinktionslernen aktiv ist. In einer zweiten Untersuchung konnten wir zeigen, dass eine hochfrequente Stimulation mittels transkranieller Gleichstromstimulation die Aktivität dieser Region während der Extinktion verbessern kann (NIRS) und zu einer deutlicheren Abnahme der Furchtreaktion in den psychophysiologischen Maßen führt. In der dritten, noch nicht abgeschlossenen Studie überprüfen wir die Bedeutung von theta-Oszillationen im EEG für das Extinktions-gedächtnis in Kombination mit verschiedenen psychophysiologischen Maßen, wieder mit der Frage der Modulierbarkeit durch Neurostimulation. Die Arbeiten stellen einen wichtigen Beitrag zur Pathophysiologie von Angststörungen dar, und haben das Ziel, die Behandlung von Patienten zu verbessern. Die Methodenkombination NIRS, Psychophysiologie und EEG erlaubt uns hierbei eine detaillierte Betrachtung der beteiligten Prozesse.

Performance monitoring, response control and post-error adjustments in adults with Attention-Deficit/Hyperactivity Disorder (ADHD): a combined NIRS/EEG study S. Deppermann, J. Hudak, A. J. Fallgatter, A.-C. Ehlis *Psychophysiologie und optische Bildgebung, Klinik für Psychiatrie und Psychotherapie, Tübingen*

Our study aimed at characterizing the neurobiological underpinnings of post-error behavioural alterations in adult patients with attentiondeficit/hyperactivity disorder (ADHD) and at relating these alterations to other known endophenotypes of ADHD, such as disturbed response control and performance monitoring deficits. To this end, a modified Eriksen flanker task was used that was embedded within a Go-NoGo paradigm. Simultaneously, neurophysiological responses were assessed using a combined electroencephalography (EEG) – near infrared spectroscopy (NIRS) setup.

24 healthy controls and 34 ADHD patients conducted a combined Flanker/Go-NoGo task while EEG and NIRS signals were recorded. Data were analyzed in terms of event-related potentials (EEG) as well as frontal lobe activation (NIRS) elicited by the flanker stimuli, correct and incorrect button presses as well as the inter-trial interval; the correctness of the previous trial was additionally considered (post-correct vs. post-error trials).

EEG data show significant differences between patients and controls for the stimulus-elicited P300 as well as for the error-related negativity (ERN). Moreover, differences were observed with respect to the inter-trial interval, with an opposite effect of previous errors on slow potential shifts in pati-

ents vs. controls. Regarding the NIRS data, preliminary results indicate reduced activation in ADHD patients within a prefrontal region of interest (ROI) specifically for go trials following errors.
Our results further support the notion of performance monitoring deficits and attentional alterations in adults with ADHD. Additionally, preliminary evidence is given on the neurobiological basis of deficient post-error adjustments as indicated by recent behavioural findings.

Eine perfekte Kombi?! Die Möglichkeiten und Herausforderungen simultaner fNIRS-EEG Messungen A. M. Kroczek, F. B. Häußinger, A. J. Fallgatter, A.-C. Ehlis *Klinik für Psychiatrie und Psychotherapie, Tübingen*

Simultane fNIRS-EEG Messungen bieten durch ihre interferenzfreie Anwendung eine vielversprechende Möglichkeit zur zeitgleichen Erfassung der Elektrophysiologie und Hämodynamik kognitiver Prozesse im Neokortex. Die angewandten Analyseansätze sind vielfältig. Deren Entwicklung reicht von Korrelationen gemittelter Haemoglobin Konzentrationen und ereigniskorrelierter Potentiale bis hin zur Betrachtung der Daten auf Einzeltrial-Ebene. Eine Übersicht theoretischer Möglichkeiten und deren praktischer Umsetzung und resultierender Herausforderung soll anhand eigener Daten kritisch diskutiert werden.

Effects of arousal on funtional near-infrared spectroscopy (fNIRS) F. Häußinger, A. Kroczek, A.-C. Ehlis *Universitätsklinik für Psychiatrie und Psychotherapie, Tübingen*

Functional near-infrared spectroscopy (fNIRS) is an optical neuroimaging method that detects temporal concentration changes of oxygenated (oxy) and deoxygenated (deoxy) hemoglobin within the cortex, so that neural activation can be educed. However, fNIRS has been shown to be confounded by systemic signals with extra-cerebral origin. One cause of extra-cerebral artifacts is the task-related vaso-constriction of cutaneous vessels that is driven by increased arousal, i.e. an increased activity of the sympathetic nervous system. These arousal induced signal patterns can disturbingly overlay cerebral signals during mentally challenging tasks, such as the n-back task. Therefore, our aim is to develop an "arousal localizer", i.e. a short and simple paradigm that is able to reliably elicit arousal-related fNIRS-signals for each subject. The resulting arousal-patterns could be used to individually identify affected regions and to correct for systemic artifacts. Within a pilot study we tested two different stimuli for their suitability to act as arousal localizer: emotional pictures and short tones of noise (to provoke the startle reflex). We found that the presentation of emotional pictures is suited to provoke a reliable and strong arousal response, whereas as the data from the startle reflex paradigm was critically confounded by motion artifacts. To obtain a measure for sympathetic activity, we extracted the blood pulse wave from the raw fNIRS-data, analyzed the heart rate variability and calculated the low to high frequency ratio (LH/HF). This ratio (a higher value indicates increased sympathetic activity) was significantly higher during the presentation of emotional pictures than during a 3 minute resting state measurement. The result indicates that it may be possible to measure arousal with fNIRS.

Time-variant modeling of brain processes H. Witte *Institut für Medizinische Statistik, Informatik und Dokumentation, Friedrich-Schiller-Uiversität Jena*

In science and engineering mathematical modeling serves as a tool for the understanding of processes and systems and as a testing bed for several hypotheses e.g. concerning the testing (prediction) of functional limits by simulations. A brief overview of current modeling strategies in brain research is given, spatial scales ranging from single neuron to large scale activity of and between brain regions are considered. The models are mainly time-invariant. Three time-variant modeling strategies, which enable a model-based signal analysis, are described and applied to large scale signals. The first is derived from adaptive filter theory and covers linear systems and linear as well as nonlinear process models. The second is based on modeled brain source signals, i.e. the inverse problem must be solved. The third strategy consists of a generalization of Dynamic Causal Modeling (DCM); DCM is frequently used for analysis of directed interactions between brain structures. Examples are derived from neonatal electroencephalography (EEG) monitoring of preterm and fullterm newborns. A further example is based on high-density recordings of event-related potentials (ERPs) and shows the combination of a time-variant ERP-based source model, as a part of a realistic head model, with a multivariate process model to analyze the time evolution of interactions between source pro-cesses before and during the execution of a complex motoric task. In two other examples hemodynamic signals (functional magnetic resonance imaging – fMRI) are utilized for analysis of interactions between brain regions, where nonlinear, multivariate models are used.

Feasibility of EEG-Neurofeedback to modify resting state microstates L. Diaz Hernandez, K. Heri K, A. Baenninger, Th. Koenig *University of Bern, Switzerland*

Spontaneous EEG signal can be parsed into sub-second time epochs with quasi-stable EEG scalp field topographies separated by rapid configuration changes. These epochs are called microstates and reflect different brain functional states that exert different effects on information processing. A specific class of microstates with a fronto-central distribution has been found to be consistently shorter in schizophrenia patients than in healthy controls, the so called microstate D. This shortening has been correlated to the presence of positive psychotic symptoms. Therefore it is reasonable to think that if patients can learn to normalize microstate D, this might help them reduce positive symptoms. We propose a neurofeedback training protocol for self-regulating microstate D.

20 healthy subjects followed a neurofeedback training to up-regulate the presence of microstate D. The protocol included 20 training sessions and each session included 3 conditions: regulation trials interspersed with baseline trials (resting state) and a transfer trial. Brain activity was recorded with thirty-two active EEG electrodes. In-lab software was used to compute on-line the percentage of microstate D and deliver auditory feedback when this percentage exceeded a threshold. Response to neurofeedback was assessed with mixed effects modelling. Patterns of response within and between-subjects, within- and across-sessions were extracted.

All participants increased the percentage of time spent producing microstate D in at least one of the 3 conditions. Between-subjects acrosssessions results showed that there was an increase of 0.42 % of time spent producing microstate D in baseline (showing a tonic change in the EEG), 1.93 % of increase during regulation and 1.83 %

during transfer. Withinsession analysis showed a 1.65 % increase in baseline and 0.53 % increase in regulation.

Microstate-neurofeedback training was feasible in healthy subjects, therefore it would be reasonable to implement the same protocol in schizophrenia patients. The ultimate aim of this training is to empower patients to reduce positive symptoms by means of EEG-neurofeedback.

Neural correlates of planning processes: A functional near-infrared spectroscopy study

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Numerous studies demonstrated the essential role of prefrontal regions in cognitive processes like planning. A hierarchical organization of prefrontal functions is proposed in which dorsolateral regions are involved in heuristic planning, whereas frontopolar regions are involved in algorithmic planning. To clarify the suggestion, neural correlates of both planning processes were explored while solving the Tower-of-London problems (TOL). An effect of problem complexity and planning strategy on behavior and brain activation patterns in dorsolateral and frontopolar regions were hypothesized. Twenty healthy participants performed the TOL by using both the algorithmic strategy where all planning processes for problem solving were performed in mind and the heuristic strategy where planning was processed during the motor execution of the TOL problem. Brain activation above prefrontal cortices of each hemisphere was examined using functional near-infrared spectroscopy (fNIRS, NIRSport System, NIRx, 8 channels, wavelengths: 760 nm, 850 nm, Sampling rate: 15625 Hz) during the solution of TOL problems which differ in complexity: easy problems (2 and 3 moves) and complex problems (5 and 6 moves). Regarding the effect of problem complexity, results demonstrated for the heuristic strategy a significant increased brain oxygenation in frontopolar regions of the left hemisphere and in dorsolateral regions of the right hemisphere while solving complex problems compared to easy problems. By using the algorithmic strategy for problem solving, no significant effects of problem complexity were observed. Regarding the comparison of both planning strategies, behavioral results showed significantly more moves to generate the plan during the motor execution of the TOL compared to planning in mind. Functional NIRS results showed significant brain activations in frontopolar regions of the left hemisphere in both planning processes and additionally in dorsolateral regions of the right hemisphere for heuristic planning during the motor execution of the TOL. The present study suggests that frontopolar regions generate algorithmic planning, whereas both the frontopolar and dorsolateral regions play an important role in heuristic planning for solving Tower-of-London problems.

Influence of acute hypoxia during maximal breath-holding on visual evoked potentials

F. Steinberg, M. Doppelmayr *Institut für Sportwissenschaft, Johannes Gutenberg Universität Mainz*

Little is known about neural activity associated with short periods of acute hypoxia induced by maximum breath-holding in humans. Therefore,

in a first approach electro-cortical activity was registered by EEG while evoking visual potentials in the occipital lobe of the brain. Based on decreasing oxygen saturation with increasing breath-hold duration it was hypothesized that hypoxia alters the early components of visual processing in the brain. Cortical activity of 34 healthy participants (25.14±2.2 years; 31 male) was measured by a 32 channel EEG system (10-20) while presenting checkerboard reversals (2 Hz and 5 Hz reversal frequency) to evoke visual potentials in the occipital lobe (N75, P100 and N135 at Oz electrode). 17 participants performed phases of 90 seconds (Short-BH) and 17 participants 120 second phases (Long-BH). Stimuli were presented counterbalanced during breath holding phases (BH) and during normal breathing (NB). Amplitudes and latencies were calculated for each 30 seconds (= 60 reversals per segment) to account for decreasing oxygen saturation over breath hold time. For transient VEPs (2 Hz), repeated measures of ANOVA with the factors CONDITION (BH; NB) and TIME (Segment 1–4) showed in the Long-BHT group a significant interaction CONDITION × TIME ($p<0.05$) for the P100 amplitude and a significant TIME effect with increasing amplitudes ($p<0.05$) and latencies ($p<0.001$) over time. N135 showed a significant CONDITION × TIME interaction for the latency ($p<0.05$) and significant TIME effects with decreasing amplitudes ($p<0.001$) and increasing latencies ($p<0.01$). Based on the controversial differences between VEPs in BH and NB and the lack of any CONDITION effects we conclude that human visual processing is highly capable to deal with short periods of acute hypoxia in breath holding and that the emerged interactions over time might be more associated with different attentional processes than by hypoxia.

Motor imagery interventions for springboard divers and their changes in μ-activity

J. M. Pithan, O. Stoll *Martin-Luther-Universität Halle-Wittenberg*

Springboard diving comes with a lot of cognitive demands. Therefore, mental practice has a high value in diving. Several theories discuss motor imagery and mental practice from a neuropsychophysiological perspective. The imagination could be seen as a neuronal simulation of the movement (Jeannerod, 2001). Thus, mental practice should obtain as many aspects of the real movement as possible (Holmes & Collins, 2001). But does an imagery training intervention based on neuropsychological approaches lead to bigger chances in neural activation compared to classical imagery interventions (Eberspächer, 2007)? This was explored using a sample consisting of 12 internationally competing, youth springboard divers (age:m=15.7, sd=1.6; experience: m=9.3, sd=2.2). The object of investigation was one single dive (the reverse two-and-a-half somersaults, tuck). Participants were tested on motor imagery from an external and internal visual perspective previous to and after one of two imagery interventions (video supported, relaxed) lasting for approximately 10 weeks. A 32-channel EEG was recorded for 40 trials of each condition (RCT). Event-related desynchronization (ERD) analysis was performed in μ-rhythm (8–13 Hz). The EEG data reveal group × time interaction at the electrode Pz. μ power decreased more in participants from the video supported intervention compared to the intervention in a relaxed state at the post measurement. This effect was shown for preparation and execution of the imagery but only for the external and not for the internal visual perspective. One explanation could be the favored imagery perspective of most athletes being external. The

results indicate a transfer effect from using video tapes on the learning process of motor imagery.

Motor sequence learning can be enhanced by high definition transcranial direct current stimulation (HD-tDCS) N. H. Pixa, F. Steinberg, M. Doppelmayr *Institut für Sportwissenschaft, Johannes Gutenberg Universität Mainz*

Transcranial direct current stimulation (tDCS) is a non-invasive technique to modulate neural activity. It has been reported that conventional anodal tDCS can increase motor performance. However, it is not known whether high definition HD-tDCS effects performance in a simple motor task. In this double-blind pre-post study, we investigated effects of repeated anodal HD-tDCS in motor sequence learning. 31 right-handed participants (11 female, age M=23.42, SD=2.45) were randomly assigned in two groups. The task was to perform the Purdue-Pegboard-Test (PPT), to measure unimanual and bimanual finger and hand dexterity. Both groups performed the PPT, meanwhile the STIM-group received 1mA HD-atDCS via two Pi-Electrodes (3.14 cm^2 Ag/AgCl) by C1 and C2 for 15 minutes. Six Return electrodes were positioned by FC5, T7, CP5, FC6, T8 and CP6 (10-20-EEG-System). For the SHAM-group only sham stimulation was applied. A follow-up test of PPT was performed five to seven days after the posttest. 3 (TIME) $\times$ 2 (GROUP) ANOVAs show significant benefit for the STIM-group in unimanual right hand dexterity for TIME ($F(2,58)=58.79$, $p=.000$, $\eta 2=.670$), TIME $\times$ GROUP ($F(2,58)=6.23$, $p=.004$, $\eta 2=.177$), bimanual dexterity for TIME ($F(2,58)=39.71$, $p=.000$, $\eta 2=.578$), TIME $\times$ GROUP ($F(2,58)=4.2$, $p=.026$, $\eta 2=.126$) and the sum of right + left + both hands for TIME ($F(2,58)=82.42$, $p=.000$, $\eta 2=.740$) and TIME $\times$ GROUP ($F(2,58)=6.58$, $p=.004$, $\eta 2=.185$). No significant effects for GROUP were found. The results support the positive effects of anodal tDCS and suggest that HD-tDCS exerts an effective influence on learning a simple motor sequence. However, further research is needed to investigate and differentiate between cognitive and motor aspects as well as more complex motor tasks, like in sports.

Manipulation of gamma-band oscillations with MEG neurofeedback in early visual cortex N. Merkel, M. Wibral, G. Bland, W. Singer *Goethe-Universität Frankfurt/Main*

The brain can learn to modify ongoing activity through neurofeedback (NFB). Subjects can learn to deliberately influence the hemodynamic response (Caria et al., 2010), the power of oscillatory activity in selected frequency bands (Gruzelier, J. 2014) and neuronal discharge rates (Clancy et al., 2014). However, little is known about the specificity of NFB effects in the spatio-temporal domain and on the dynamic mechanisms mediating them. We attempt to

1. contribute knowledge about the specificity of NFB training,
2. expand existing approaches to gamma band activity and
3. use MEG source data for NFB training.

We trained 9 human subjects with MEG NFB to manipulate gamma band power in early visual cortex. We restricted training effects to a small volume of visual cortex and to a narrow frequency band. With online beamforming techniques we extracted the feedback signal in source space. The pitch of a tone feedback signaled the increase of narrow band gamma oscillations. Subjects had to modulate this pitch in a controlled way.

Manipulation of gamma-band power in early visual cortex is possible for some but not all subjects. In the successful subjects the modulation was closely related to the frequency band and location selected for training. Some of the subjects learned to modulate muscle activity rather than neuronal activity. In the successful subjects, beta oscillations became prominent as performance improved and synchronized across the right midfrontal and left parietal cortex, presumably reflecting enhanced topdown control by the visual attention network (Buschman & Miller, 2007). This activation could be instrumental for establishing occipital gamma band oscillations.

Sound localization in a "cocktail-party" situation: An EEG study using an auditory oddball paradigm M.-Ch. Schlüter, St. Getzmann, J. Lewald *Leibnitz-Institut für Arbeitsforschung, TU Dortmund, Dortmund*

Selectively attending to a sound source of interest in complex auditory scenes composed of multiple competing sources is a remarkable capacity of human perception. The neural basis of this so-called "cocktail-party effect" is insufficiently understood. Here, we addressed this issue using auditory evoked potentials in combination with an oddball design, in which subjects either had to detect rare spatial deviants in a series of standard sounds (attention condition) or passively listened to the standard and deviant sounds (passive condition). Deviants differed in location from standard sounds by 20°. Two conditions of stimulation were employed: standards and deviants either appeared in isolation (single-source condition) or in the presence of two distractor sound sources at different locations (multi-source condition). Three animal vocalizations of different species were used as sound stimuli. Event-related potentials (ERPs) for standards and deviants were recorded, and difference ERPs (deviant minus standard location ERPs) were calculated. Data obtained in the single-source condition were compared with those of the multi-source condition. The ERP analyses focused on MMN, P3a, and P3b components. With multiple sources, the MMN, P3a, and P3b amplitudes were larger in the attention condition than in the passive condition. A difference between the multiand single-source conditions was observed for the P3b component in attention and passive conditions. Cortical source localization (sLORETA) revealed at the time of the P3a bilateral anterior cingulate cortex and at the time of the P3b bilateral posterior cingulate cortex for the contrast of attention vs. passive listening with multiple sources. For the contrast of multiple vs. single sources in the attention condition, there was significant peak activity in right posterior superior temporal gyrus at the time of the MMN and in right precentral gyrus and left precuneus at the time of the P3b.

Cross-Frequency Functional Independent Brain Networks -– Associations with Modalities of Thinking P. Milz, R. D Pascual-Marqui, D. Lehmann, K. Kochi, P. L Faber *The KEY Institute for Brain-Mind Research, Department of Psychiatry, Psychotherapy and Psychosomatics, University Hospital of Psychiatry, Zurich, Switzerland*

Different functional brain states are constituted by different spatially distributed brain networks. Brain networks can be identified via independent component analysis (ICA) applied to brain activity-derived data. ICA has frequently been applied to fMRI data. However, this approach suffers from the method's limited temporal resolution and indirect measurement of neural ac-

tivity via blood metabolism. Applying ICA to source-localized EEG does not suffer from these limitations. Moreover, EEGderived networks have the advantage of allowing a functional distinction between the varying ranges of EEG frequencies involved. EEG activity is sensitive to changes in demands on modality-specific processing. Consequently, we tested the effect of short-term (tasks) and long-term (person parameters) modality-specific processing on brain networks. Brain networks were derived based on functional ICA applied to source-localized EEG data. Clean 64-channel EEG and modality-related person parameters were available from 61 male, right-handed students. EEG recordings were obtained during four conditions: spatial visualization, object visualization, verbalization, and resting. Cross-frequency functional independent networks were obtained by applying ICA to source-localized EEG data in 6 frequency bands (delta to beta-2). Modality-related person parameters were obtained via visual-verbal cognitive style questionnaires and modality-related cognitive tests. Effects of conditions were evaluated by repeated-measures MANOVAs, post-hoc univariate ANOVAs, and paired ttests. Effects of person parameters were evaluated by Pearson correlations and path modelling. Results revealed four task-dependent and three personal-parameterdependent networks. Task-dependent networks were characterized by alpha decreases in modality-specific pathways. Person-parameter dependent networks were characterized by alpha increases in modalityspecific pathways. All networks were additionally characterized by opposing alpha changes in pathways of other modalities. Results imply a different functional significance of task- (short-term) and person-parameter (long-term) dependent alpha changes. Phasic, task-dependent alpha decreases may reflect decreased inhibition on modality-specific pathways. Tonic, person-parameter-dependent alpha increases may reflect increased automated processing (neural efficiency) in frequently applied modalityspecific pathways. Antagonistic alpha changes in other areas may reflect the prevention of intruding effects of modality-irrelevant processing.

Topographische Effekte des Lernens japanischer Schriftzeichen in der Wavelettransformation A. Klein, W. Skrandies *Physiologisches Institut, Justus-Liebig-Universität Gießen, Germany*

Japanische Schriftzeichen unterscheiden sich sowohl in ihrem Aussehen als auch in ihrer Bedeutung sehr stark von den in Mitteleuropa verwendeten Schriftsystemen. Während mitteleuropäische Sprachen Wörter vor allem als Sequenz von Silben abbilden, die allein für sich genommen häufig keine Bedeutung haben, sind in der traditionellen japanischen Kanji-Schrift Symbole mit Wortbedeutungen belegt, so wird zum Beispiel das Wort „Schnee“ durch das Symbol „雪” repräsentiert. In vielen Arbeiten wurde bereits untersucht, welche Kompetenzen beim Lesen dieser verschiedenen Schriftsysteme benötigt werden, und wie sich die zentrale Verarbeitung von Wörtern aus japanischen oder chinesischen und europäischen Schriftsystemen bei Muttersprachlern aus beiden Kulturkreisen unterscheidet. Allerdings gibt es bislang nur wenige Befunde zum Lernen von Wörtern aus dem jeweils anderen Schriftsystem, wenn dieses noch nicht bekannt ist. Wir zeigen Befunde aus einem Lernexperiment, die die topographischen Unterschiede der Frequenzaktivierung mit Hilfe der Wavelettransformation illustrieren. Dazu wurden bei 41 Versuchspersonen VEPs als Reaktion auf 40 Lern- und 40 Kontrollreize (Bedingung „Grup-

pe“) vor und nach dem Lernen (Bedingung „Zeit“) erhoben, gemittelt und einer Wavelettransformation unterzogen. Aus diesen Wavelettransformationen wurden dann im Rahmen der klassischen EEG-Bänder die Frequenzen und Latenzen maximaler Amplitude bestimmt und mit Hilfe einer zweifaktoriellen ANOVA verglichen. Dabei zeigen sich vor allem linkshemisphärisch interessante Interaktionen zwischen Gruppe und Zeit für Frequenzen im θ-Band, während in anderen Frequenzbändern und für die Latenzen kaum signifikante Interaktionen zu finden sind.

Durch semantisches Lernen ausgelöste topographische Komponenten hirnelektrischer Aktivität W. Skrandies, H. Shinoda *Institute of Physiology, Justus-Liebig University Giessen, Germany*

We studied event-related brain activity elicited by reading learned (i.e., meaningful) or unlearned (i.e., meaningless) Japanese symbols. Twenty healthy native German adults participated in a learning experiment. In a training phase of about 20 minutes, subjects acquired the meaning of 20 Kanji characters. As control stimuli 20 different Kanji characters with similar physical features were used. Stimuli were presented on a monitor, and electrical brain activity was obtained before and after learning. The learning performance of the subjects averaged 92.5% correct responses. EEG was measured simultaneously from 30 channels, artifacts were removed offline, and the data obtained before and after learning were compared. We found five spatial principal components that accounted for 83.8 % of the variance. Significant interactions between training time (before/after learning) and stimulus (learning/control) illustrate the relation between successful learning and topographical changes of brain activity elicited by Kanji characters. Significant effects of learning were observed at short latencies in the order of about 100 ms. In addition, we present evidence that differences in the weighted combination of spatial components allow to identify experimental conditions successfully by linear discriminant analysis using topographical ERP data that had occurred at a single time point. Our data show how the scalp distribution of brain electrical activity relates to successful learning of semantic meaning.

The cortical signature of nociception and pain in circuits of the lateral somatosensory system: a translational approach U. Baumgärtner, M. Mahmotoglu, B. Kretzschmar, C. Heid, A. Draguhn, A. Rupp *Mannheim/Heidelberg*

The processing of nociceptive signals in the central nervous system involves a network of brain areas that has been characterised using neurophysiological and imaging methods. However, the term pain matrix for this network might be misleading, since most sensory stimuli of different origin (somatosensory, auditory, visual) can activate major parts of this system, rendering cortical responses like evoked potentials or BOLD responses less specific with respect to the original specific input. Recent findings have opened new ways to identify a general signature of nociception and – even more challenging – of on-going pain. They suggest that gamma band oscillations show a closer relationship to perceived phasic pain compared to standard evoked potentials. In this project, we want to apply advanced methods of data analysis in complementary models of acute, prolonged and chronic pain in rodents and in humans. Our overarching aim is to identify a functional signature of pain perception at the network level.

1. Rodents: Phasic, tonic and chronic pain models in mice; LFP- and unitrecordings in vivo, analysis of specific waveform patterns, cross-frequency and cross-regional coupling.
2. Humans: Simultaneous EEG-MEG recordings of evoked and on-going brain activity during pain in contrast to non-painful stimulation combined with behavioural ratings; analyses of spectro-temporal responses, source localisation and coherence; structural and functional MR imaging for unambiguous localisation of responses and connectivity analysis.

Pilot data yielded differential evoked brain responses in the time-frequency domain following tactile and nociceptive stimuli in both rodents and humans, similar shifts of the alpha rhythm peak frequency during ongoing pain in both species, and changes in frequency coupling within the insula. These findings may help identify more specific markers of nociceptive processing than previously shown. *Supported by DFG: SFB1158 B05*

Gamma-Oscillations as a clinical marker of pain perception. A promising approach? C. Heid, A. Mouraux, S. Schuh-Hofer, R.-D. Treede, U. Baumgärtner *Mannheim and Brussels*

Up to now there have already been a lot of studies using evoked potentials of the EEG elicited both with nociceptive as well as tactile stimuli. From recent studies the idea emerged that gamma-band oscillations (GBOs), a pattern of neural oscillation in humans with a frequency between 25 and 100 Hz, though 40 Hz is typical, play an important role in conscious perception and are possibly a direct correlate of the perception of pain. Hence, these GBOs are induced and not evoked we need the special TimeFrequency-Analysis to detect these oscillations. Influenced by these recent reports, we conducted a study, where we tried to specify the relationship between the application of nociceptive vs. tactile stimuli and GBOs more closely. Twelve healthy volunteers (6 male, 6 female) participated in the experiment. We applied nociceptive laser heat and pneumatic tactile stimuli. 90 stimuli with 3 different intensities (laser+pneumatic) were applied both to the right hand and the right foot in a balanced sequence including one repetition per block, resulting in 180 stimuli per location and stimulus. In addition, we amended another stimulation block with 1800 pneumatic stimuli to exclude the possibility that in case GBOs are elicited by tactile stimuli as well, the number of tactile stimuli might not be high enough to yield a response beyond noise. Our preliminary results indicate that there is a difference in the appearance of GBOs between nociceptive and tactile stimuli and that GBOs could be specific for the perception of pain.

These results may help to get a better objective understanding of the perception of pain.

Cortical reorganisation nociceptive and somatosensory evoked potentials after capsaicin-induced tonic pain M. A. Mahmutoglu (1), A. Rupp (1), U. Baumgärtner (2) *(1) Section of Biomagnetism, Department of Neurology, University of Heidelberg, Heidelberg, Germany (2) Chair of Neurophysiology, Centre for Biomedicine and Medical Technology Mannheim, Medical Faculty Mannheim, Heidelberg University, Mannheim, Germany*

Electrophysiological and neuroimaging studies indicate that nociceptive stimuli elicit activity in a wide network of cortical areas including the primary and secondary somatosensory cortices, operculo-insular cortex, prefrontal cortex as well as the cingulate gyrus. Furthermore,

a number of studies suggest that capsaicin alters laser-induced cortical evoked potentials as well as the saliency of the stimulus. The underlying functional (re-)organization of such pain processing and the central mechanism of capsaicin-induced hyperalgesia and allodynia has not been adequately explained. To characterize the capsaicin-induced (re-)organization, evoked activity of above mentioned areas was recorded by means of 32-channel electroencephalogram (EEG) and 122-channel magnetoencephalogram (MEG) in 12 healthy volunteers stimulated with noxious laser stimuli and tactile control stimuli before and after intraepidermal capsaicin injection. 90 laser stimuli (Tm YAG, 2 µm wavelength) with three different intensities (pain threshold, moderate, max: 540 mJ) were applied to both hands in pseudo-randomized order to generate laser-evoked potentials (LEP) and magnetic fields (LEF). 2000 tactile stimuli (6 bar) were applied equally on both sides in order to generate somatosensory-evoked potentials (SEP) and magnetic fields (SEF). Balanced stimulation blocks were repeated on both sides after intraepidermal capsaicin injection only to the left hand dorsum (0.05%, 0.02 ml). The goal of such an experimental design is to describe specific cortical processing and plasticity by means of spatio-temporal source analysis (BESA 5.2). Subjective pain intensities were registered by a console and a rating scale (0–100). Our preliminary results suggest a differential capsaicin-induced change pattern of LEPs in operculo-insular and cingulate sources. Furthermore, EEG and MEG source models in corresponding brain areas show different waveform morphologies and change patterns.

This study is supported by DFG SFB-1158 B05.

Announcements — Ankündigungen

- **Human Brain Mapping (HBM)**

  22nd Annual Meeting of the Organization for Human Brain Mapping (HBM)

  Dates: June 26 – 30, 2016

  Venue: Palexpo Exhibition and Congress Centre, Geneva, Switzerland

  URL: http://www.humanbrainmapping.org/i4a/pages/index.cfm?pageID=3662

- **IOP World Congress**

  18th World Congress of Psychophysiology (IOP2016)

  Official World Congress of the International Organization of Psychophysiology (IOP)

  Dates: August 31 – September 4, 2016

  Venue: Melia Habana Hotel, Havana, Cuba

  Chair: Pedro A. Valdes-Sosa

  URL: http://iop2016.cneuro.cu/

- **ECNS / ISNIP / ISBET**

  Conference on Translational Neuroscience: Neurophysiological Biomarkers

  Joint Congress of ECNS / ISNIP / ISBET

  Dates: September, 7 – 11, 2016

  Venue: Istanbul, Turkey

  URL: http://www.ecns2016.com/

- **25. Deutsches EEG/EP Mapping Meeting / 25th German EEG/EP Mapping Meeting**

  Conference language is German; English contributions will be accepted.

  Datum: 28. bis 30. Oktober 2016
  Ort: Schloss Rauischholzhausen

Übersichtsvorträge und Symposien:

D. Brandeis (Zürich / Mannheim), Entwicklungen im EEG-basiertem Mapping.
M. Ruchsow (Göppingen), Mentale Repräsentation.
H. Witte & L. Leistritz, (Jena), Multivariate EEG / MEG / fMRI-Analyse und "Big Data". (Symposium).

Information und Anmeldung unter: http://www.med.uni-giessen.de/physio/