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Progress report of the European Graduate School „Neurosensory Science and Systems“

1. Implementation of the aim and the concept of the Graduate School

General Aim and Overview

The general aim of the European Graduate school is to investigate the processing of sensory information from the eye, ear, or tactile system into its „internal representation“ with a multidisciplinary approach. Both the structure and function of certain subsystems are considered (e. g., neural networks in the retina) as well as the interaction of these subsystems in well-defined psychophysical tasks (e. g., acoustical localisation or movement detection). Special emphasis is placed on transferring the principles of information processing from one sense system to the other (e. g., with regard to mechanisms of object recognition) and on the interaction between sensory systems.

Within this context, it is the primary aim of the Graduate school to give young, highly qualified Ph.D. students (about 40 so far) the opportunity to work and study towards their doctorate degree in a special program. Hence, graduates and researchers from a broad range contribute to the school, including perception (psychophysics, psychology), neurosensory processing (neurophysiology, neuroimaging), modelling (theoretical biophysics, mathematical psychology) and its applications to technical systems (computer science, applied physics).

After its formal start in June 1st, 2000, 9 Ph.D. student stipends and 2 Postdoc stipends granted by the DFG were filled in Oldenburg, while 2 part-time researcher positions granted by the NWO and the Rijksuniversiteit were filled in Groningen. In addition, an even larger number of Ph.D. students financed through other sources (research grants and faculty positions in Oldenburg, BCN – financed positions in Groningen) were admitted as “associate members” of the European Graduate school Neurosensory science and systems.

Even though the general aim and outline of the graduate school was implemented as described in the original grant applications, several modifications had to be introduced for the following reasons:

- The hints given by the reviewers of the first application period made it necessary to drop the working area “*Principles of distributed neural coding*” and to reduce the working area “*Applications*” (including most of the clinical applications in audiology) considerably.
- Several of the original staff members from the first application round could either not participate (Prof. Dr. Pal Rujan went into industry, Prof. Dr. Bert Mulder died), were appointed at a different university (Prof. Dr. Adele Diederich started at the International University in Bremen) or chose to perform other research goals than depicted in the application (Prof. Dr. Hero Wit, Prof. Dr. Peter Volling, Prof. Dr. Gert Holstege, Dr. Hans v. Hateren).
- Fortunately, several new staff members could be recruited both by the universities Groningen and Oldenburg that support the general aim and program of the European Graduate school. These new members include Prof. Dr. Mark Greenlee (Neuropsychology, functional imaging of the visual system), Prof. Dr. Nikolay Petkov (Visual pattern recognition), Prof. Dr. Georg Klump (auditory neurophysiology) and Prof. Dr. Ulrike Feudel (theory of complex systems).

- Even though the program of the first grant application was designed to have an approximately even partnership and equal contribution across the universities Oldenburg and Groningen, the granted support for the Groningen part of the European graduate school turned out to be much smaller than the granted support for the Oldenburg part. This clearly limited the possibilities of the colleagues from Groningen to actively participate in and contribute to the common research and education program of the graduate school in the same way as the colleagues from Oldenburg. Nevertheless, a continuous exchange between Oldenburg and Groningen has been established by a series of seminars that alternate monthly between both sites and which is subsequently hosted by all groups contributing to the graduate school. Also, close research links have been established between groups working on corresponding areas, especially in the field of functional imaging (Greenlee (OL) – Leenders (Gro)), Receptor physiology (Weiler (Ol) – Stavenga (Gro)), auditory modelling and applications (Kollmeier (Ol) – Duifhuis (Gro)) and psychophysics/cognitive processes (Colonus (Ol) – Bekkering (Gro)).

Given these qualifications of the original application, the research in the European graduate school during the first granting period has been performed in the following areas:

1. *Adaptation*: Characterization and modelling of adaptation mechanisms in the visual and auditory systems

- Retina physiology (Prof. Dr. Reto Weiler, Neurobiologie, Oldenburg; Ph.D. students Mark Pottek, Werner Hoppenstedt, Frank Schütte, Timm Schubert, Mailin Segger-Junius, Martin Greschner)
- Receptor biophysics (Prof. Dr. Doekele Stavenga, Neurobiophysics, Groningen; Ph.D. students Theo Dinklo, Johannes Oberwinkler, Marten Postma)
- Auditory psychophysics (Prof. Dr. Dr. Birger Kollmeier, Dr. Thomas Brand, Dr. Volker Hohmann, Medizinische Physik, Oldenburg; Ph.D. students Manfred Mauermann, Giso Grimm)

The research performed by the involved groups spans from molecular aspects to psychophysics with a strong emphasis on synaptic interactions at the network level. Students have enormously profited from this broad view and have realized the challenge of aligning the different data in order to unravel unifying principles.

2. *Intermodal interaction and information integration*: Experiments and models

- Psychophysics and models of audiovisual interaction (Prof. Dr. Hans Colonius & Prof. Dr. Adele Diederich, Kognitionsforschung, Oldenburg; Ph.D. students Annika Akerfelt, Frouke Hermens, Holle Kirchner, Claudia Steinbrink, Post-Doc Dr. Petra Arndt)
- Experimental and work psychology (Dr. Harold Bekkering, Groningen, Ph.D. student N.N.)
- Psychophysics of the vibrotactile system (Prof. Dr. Volker Mellert, Akustik, Oldenburg; Ph.D. students Handy Oey, Ingo Baumann, Michael Bellmann)
- Auditory models (Dr. Torsten Dau, Prof. Dr. Dr. Birger Kollmeier, Medizinische Physik, Oldenburg; Ph.D. students Ulrike Dicke, Stefan Ewert)

The psychophysical/cognitive psychology part of the graduate school has focused on an experimental characterization of the neurosensory process as a basis for quantitative models that aim at bridging the gap between physiology and psychology.

3. *Functional and diagnostic imaging*: fMRI and EEG-measurement techniques,

- FMRI of the visual system (Prof. Dr. Mark Greenlee, Kognitionsforschung, Oldenburg; Ph.D. students Jose Ignacio Vallines Garcia, Guido Plata, Post-Doc Dr. Roland M. Rutschmann ; Prof. Dr. Nico Leenders, Neuroimaging, Groningen ; Post-Doc Frans Cornelissen)
- FMRI of the auditory system (Prof. Dr. H. Duifhuis, Biomedical engineering, Groningen; Ph.D. students Remco Renken, Sonja Tomaskovic)
- FMRI Image processing (Prof. Dr. N. Petkov, Computer Science, Groningen; Ph.D. student Lucian Muresan)
- EEG analysis of the auditory system (Prof. Dr. Dr. Birger Kollmeier, Dr. Torsten Dau, Medizinische Physik, Oldenburg; Ph.D. students Dirk Junius, Sandra Fobel)

The joint research focused on solving specific technical problems related to behavioral measurement with the MR scanner (i.e., eye movement recordings, visual/auditory stimulus presentation, manual responses via optical response box) as well as on the improvement in post-processing methods (extraction of BOLD signal, motion correction, normalization, grey matter segmentation). The imaging methods are supplemented by EEG-methods that provide a higher temporal resolution.

4. *Applications*: Technical realization of neural processing principles in audition (e.g., front end for automatic speech recognition), touch (e.g., vibration annoyance in cars, aircrafts and medical devices) and vision (e.g., image processing and recognition)
- Auditory model-based speech processing (Dr. Volker Hohmann, Prof. Dr. Dr. Birger Kollmeier, Medizinische Physik, Prof. Dr. Wolfgang Nebel, Entwicklung integrierter Schaltungen, Oldenburg; Ph.D. students Mark Marzinzik, Michael Kleinschmidt, Jörn Anemüller, Laila Kabous)
 - Noise annoyance prediction (Prof. Dr. Volker Mellert, Akustik, Oldenburg ; Ph.D. students Sandra Buss, Matthias Vormann)

The research work performed by the three groups in this area (two from physics, one from computer science) is based on their cooperation originating from the Graduiertenkolleg Psychoakustik which was successfully ended in 2001. All groups use the same models and tools to work on different applications of psychoacoustic knowledge.

In addition to the research progress (which will further be detailed below), the following circumstances had an important impact on the development of the European Graduate school so far:

- Money for new imaging equipment has been granted to the graduate school for behavioural and cognitive neuroscience (BCN) in Groningen that was prolonged for another 5 years in 1999. A 3T MRI scanner will be ordered in april 2002 and installed until winter 2002. In addition, 3 EEG labs will be built and installed by august 2002. An MEG scanner is planned to be installed in 2003. BCN proceeds to focus on PhD projects that fit in the EGK themes. It tries to encourage the BCN groups involved to attract funding for further PhD- and postdoc projects
- Starting January 2001, the Universität Oldenburg and the Hörzentrum Oldenburg have established the “Kompetenzzentrum HörTech” (National Center of excellence for hearing technology), i.e. a consortium of universities and private companies that was among the winners of a competition by the German Ministry of education and research (BMBF) and is co-financed by the Land Niedersachsen. As a consequence, the “house of hearing” is being built in Oldenburg close to the university (completion date: July 2002). Hence, more research facilities and long-term job opportunities will

be available for the graduates of the European graduate school in the area of applied hearing research.

- In early 2001, B. Kollmeier received two offers for a research professorship in Aalborg/DK and Copenhagen/DK. The negotiations with the Minister für Wissenschaft and Kultur in Lower Saxony led him to decline both offers. As a result, B. Kollmeier's group will be embedded within a new institute bridging between applied physics and computer science. Also, another professor position on "Speech processing and communication" for the faculty of physics has been granted by the Universität Oldenburg and the Land Niedersachsen in February, 2002. This position will strengthen the "applications" section of the European Graduate school.
- In September 2001, the Sonderforschungsbereich (SFB 517) Neurokognition (Bremen/Oldenburg) has successfully applied for its third funding period from 2002-2004. Since the European Graduate school has a close cooperation with the SFB and shares some of its resources, this development clearly supports the perspectives of the Ph.D. students from the EuroGK.
- In October 2001, the functional imaging consortium "Center for Advanced Imaging (CAI)" consisting of the universities Magdeburg, Bremen and Oldenburg was decided to be among the five national imaging centers to receive further support from the BMBF. This clearly increases the potential of performing studies within the imaging section of the EuroGK.
- In October 2001, B. Kollmeier was awarded the „Alcatel-SEL-Preis für Kommunikationsforschung“ by the Alcatel-SEL foundation. The main lecture during the prize awarding ceremony was delivered by Dr. Jutta Limbach, the president of the German supreme court. The price was awarded for bridging the gap between fundamental science and applications in speech processing, i.e. one of the areas covered by the EuroGK's topic "Applications".
- In November 2001, the Universität Oldenburg established three new Junior professorships with a relation to the topics of the EuroGK, i.e., one position in functional imaging, one in neurophysics, and one in neurobiology. These positions are expected to be filled by mid-2002.
- In December 2001, an agreement was made between the Universität Oldenburg and the Klinikum Oldenburg to purchase and jointly operate a 1.5 Tesla functional Magnetic Resonance Imaging Scanner. It will be put into work in July 2002.

Short reports from each Professor or Working group

1. Adaptation

Retina physiology (Prof. Dr. Reto Weiler, Neurobiologie, Oldenburg; Ph.D. students Mark Pottek, Werner Hoppenstedt, Frank Schütte, Timm Schubert, Mailin Segger-Junius, Martin Greschner)

Our projects linked to the graduate school centred around mechanisms of neuronal adaptation in the retina. In this context, the analysis of the neuromodulatory role of retinoic acid and the molecular identity and physiological role of electrical synapses in the rod pathway formed the core of our research activities. In both areas we have been quite successful and were able to publish key results in high impact journals which gathered international recognition and put us in a leading position. One of our papers for example was rated as „highlight“ by Nature Reviews. Key findings were among others: The rod pathway in the mammalian retina involves an electrical synapse based on connexons assembled by connexin36 proteins. This electrical synapse funnels the rod signal into the cone pathway and is responsible for the neuronal transition between cone- and rod-vision and therefore for light and dark adaptation. We were

also able to solve an ever pending question about the nature of the feedback mechanisms between cones and horizontal cells responsible for contrast and color adaptation by revealing the responsible molecular components. Based on these data we developed a model of an ephaptic feedback mechanism and verified it with corresponding experiments.

Researchers from the USA, Australia and China have visited our laboratory and have contributed to our work and in particular also to the education of our graduate students. They have not only brought an additional technical knowledge but also an international flair which is important for a remote and rather isolated university. The need to talk in English for all students is an additional value of these collaborations. We have also had a strong and fruitful collaboration with the group of Kamermans from the Netherlands which resulted in a Science paper and which will be continued. Collaborations with colleagues from the graduate school were - due to the different experimental subjects - limited to exchange of ideas and theoretical support. The graduate students and post-docs of our group highly estimated the regular seminars of the graduate school which offered them a chance to present data and ideas and created a social and academic forum so badly needed.

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Receptor biophysics (Prof. Dr. Doekele Stavenga, Dr. S. van Netten, Neurobiophysics, Groningen; Ph.D. students Theo Dinklo, Johannes Oberwinkler, Marten Postma)

Primary visual processes and spectral processing of insect photoreceptors

Many insects are highly visual animals that heavily rely upon their light sensitive cells to gather optical information from their surroundings. From the optical signals, the light sensitive cells produce an electrical signal. The molecular components involved in generating this light response are gradually unraveled, and it is becoming apparent which of the different

molecules interact, and how they do this. However, the knowledge gathered in this research, by molecular biology, optical and electrophysiological measurements, is rarely integrated to form a quantitative theory. It is our view that quantitative descriptions are essential for gaining insight in the mechanisms of biological cells; i.e., the functional possibilities and the physical limitations of a cell, especially of a neuron, can only be clearly seen by constructing quantitative models.

Three distinct but related areas of photoreceptor research are quite amenable to quantitative modelling. The first area is that of the visual pigments, specifically the wavelength dependence of their absorption characteristics and the cycling of the visual pigment molecules between the different states. The second area is that of the changes in membrane permeability caused by visual pigment conversions, and how they translate into changes of membrane currents, potentials, and ion concentrations. For the data we use our own experimental results as well as the rapidly accumulating literature on fly photoreceptors, specifically *Drosophila*. The third area is that of the compound eye, composed of thousands of ommatidia, each having a set of eight or nine photoreceptor cells. The ommatidia together sample the visual environment. The spatial and spectral characteristics of the ommatidia determine the optical information available to the brain.

For modelling the photochemical processes of visual pigment and spectral filtering by the corneal multilayers or by the visual waveguide properties, we have developed a widely used visual pigment template. We thus have been able to understand the complex spectral organization of the retina of flies and butterflies.

We have produced an electro-diffusion model of the electrical and ionic events in a microvillus, i.e., the fundamental subunit of a *Drosophila* photoreceptor cell where the elementary response, to a single photon, is generated. We thus have found that extremely large changes in the calcium ion concentration can be produced by opening only a few light-dependent channels. The computational analysis has been corroborated with experimental results.

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Auditory psychophysics (Prof. Dr. Dr. Birger Kollmeier, Dr. V. Hohmann, Dr. T. Brand, Medizinische Physik, Oldenburg; Ph.D. students Manfred Mauermann, Giso Grimm)

The primary research topic for the report period within this subgroup is the processing of intensity information (and other relevant physical parameters of a sound) and its relation to the psychophysically measured loudness both for normal and hearing-impaired listeners. Since this neurosensory mapping of intensity is characterized by a compressive nonlinearity to cover the large dynamic range of potential input signals, it can be referred to as “adaptation” in analogy to the visual system.

Following up on developing the “Oldenburger Hörfeldskalierung” (i.e., a categorical loudness scaling procedure with 11 response categories similar to the “Würzburger Hörfeldskalierung” (Heller, 1985)), a series of methodological studies was performed to select the appropriate experimental parameters and target functions (Dissertation T. Brand (1999), Brand & Hohmann (2000, 2001, 2002), Brand & Kollmeier (2001)) and to compare the results with the “classical” loudness scaling techniques, such as absolute magnitude estimation, loudness comparison or matching (Blum et al., 2000, 2001). The empirical transformation found between categorical loudness and loudness in some was used to refine loudness models for normal and hearing-impaired listeners by modifying the loudness model developed by Zwicker (Blum et al., 2001, Appell et al., 2002, Dissertation J. Appell, 2002). Subsequently, the loudness perception research focused on temporal properties of loudness perception, i.e., the duration dependence (Dissertation J. Verhey, 1999, Verhey & Kollmeier, 2002) and the loudness of fluctuating sounds (Grimm & Hohmann, 2002). Moreover, the dispersive and nonlinear, active and compressive properties of the inner ear were examined and analyzed with auditory brainstem audiometry (Dau et al., 2000) and otoacoustic emissions (Mauermann et al., 1999) in order to better understand the role of the cochlea for loudness perception. In addition, a first successful attempt was undertaken to combine properties of loudness models (usually for stationary conditions varying in level and spectrum) with those of psychoacoustic processing models (usually for temporally varying stimuli at a fixed level) in the Dissertation by R. P. Derleth (1999) (Derleth et al., 2001). In summary, the quantitative understanding of the neurosensory process of loudness perception has significantly been advanced within the past three years by means of psychoacoustical measurement, physiological experiments with humans, and modelling approaches.

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2. Intermodal interaction and information integration

Psychophysics and models of audiovisual interaction (Prof. Dr. Hans Colonius & Prof. Dr. Adele Diederich, Kognitionsforschung, Oldenburg; Ph.D. students Annika Akerfelt, Frouke Hermens, Holle Kirchner, Claudia Steinbrink, Post-Doc Dr. Petra Arndt)

(a) *Multisensory interaction in saccadic eye movement*: Reflexive saccades toward visual targets are affected by auditory or tactile stimuli presented in close spatial and temporal proximity even if subjects are instructed to ignore them. For auditory stimuli presented horizontally aligned to the visual target, saccadic response time tends to increase with the perceived distance between visual and auditory stimulus. The two-stage model describing these effects (Colonius & Arndt, 2001) was further tested and extended (1) by varying the spatial and temporal proximity between the visual target and a task-irrelevant tactile (vibratory) stimulus applied to the palm (Diederich & Colonius, 2002), (2) by varying the auditory intensity (Arndt & Colonius, 2001), (3) by introducing interstimulus contingencies (Kirchner & Colonius, 2001), and (4) by varying both horizontal and vertical position of the auditory stimulus. For the latter case, it is known that the horizontal position of an auditory target is localized earlier than the vertical. We showed that the time course of multisensory interaction reflects this change in subjective position of the auditory stimulus over time (Heuermann & Colonius, 2001).

(b) *Eye movement control*: In a stop signal paradigm subjects were instructed to make a saccade to a visual target appearing suddenly in the periphery. Whenever an auditory stop signal is presented after a variable delay the subject has to inhibit the saccade. Countermanding was more difficult when both stimuli appeared at the same side. Our data present evidence against a popular (race) model for saccadic reaction time and suggest a multisensory interaction effect in a saccade countermanding task (Özyurt, Colonius, Arndt, 2001). We developed and tested an alternative model for the stopping of eye movements based on a stochastic diffusion process (Colonius & Diederich, 2002).

Multisensory neuron model: We developed maximum likelihood (ML) model operating at the level of a single superior colliculus neuron (Colonius & Diederich, 2002a). The neuron's behavior is solely based on the a-priori probability of a target and the likelihood function for the different sensory inputs. It accounts for the *inverse effectiveness* observed in neurophysiological recording data. Moreover, the model allows to derive a measure of the neuron's ability to discriminate between targets and non-targets. It makes specific predictions how uni- and bimodal discriminability measures (signal-to-noise ratio) are related.

Cooperation

Part of the experiments with visual-auditory stimuli were conducted at the Oldenburg Physics Department. There is an ongoing exchange of ideas and mutual consultation between Colonius and Prof. Ritske de Jong (Groningen Exp. Psychology).

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List of publications 1999 - 2002 (Prof. Dr. Adele Diederich)

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Experimental and work psychology (Dr. Harold Bekkering, Groningen, Sebastiaan F.W. Neggers, Ph.D. student N.N.)

Eye-hand coordination

When humans interact with their environment, they often make a combination of fast, ballistic, saccadic eye movements and goal-directed hand movements. Saccadic eye movements are usually initiated about 50-100 milliseconds before a goal-directed hand movement. However, this does not provide evidence that the two systems are linked by a common control mechanism. It could well be that the visual input is processed in parallel by both systems and that the eyes are faster in the motor processing because lower inertial forces act on the low-mass eyeballs. Alternatively, it could be that the oculomotor and manual motor systems do cooperate to optimize performance.

A series of experiments showed that the participants could not initiate saccades to a second target until the hand had reached the first target. That is, the saccade to the second target was severely delayed - relative to the onset of the second target - in the dynamic condition where a second target was illuminated before the hand movement terminated. Furthermore, there was no evidence that the saccade could be planned during the terminal phase of the hand movement, since no savings in reaction time for the second saccade were found once the hand had landed at the first target.

Visual search

We investigated the influence of action intentions on visual selection processes in a visual search paradigm. Subjects either had to look-and-point, or to look-and-grasp a predefined target object with a certain orientation and color among distractors. Fewer saccades to objects with the wrong orientation were made in the grasp condition compared to the pointing condition, while the number of saccades to an object with the wrong color remained the same. Importantly, saccadic latencies were similar under the different task conditions, ruling out a speed-accuracy trade-off explanation. Since object orientation is relevant for a grasping movement whereas color discrimination is not, the present findings support the view that the planning of motor action depending on the required object-features modulates the visual processing of relevant object features.

What can be the underlying mechanism of this action-related enhancement in visual search? Several authors have proposed that visual attention might be seen as a selection for action mechanism. That is, the intention to perform an action will result in a top-down modulation of visual processes that favor object features (e.g., orientation) that are directly related to the ongoing specification of parameters for action control (e.g., grasping characteristics). In this view, the perception of specific object features and the planning of an action to interact with an object are to some extent tapping the same mechanism.

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Psychophysics of vibration (Prof. Dr. Volker Mellert, Akustik, Oldenburg; Ph.D. students Handy Oey, Ingo Baumann, Michael Bellmann)

Vibration impact on men is common, e.g. in transportation means, at technical work places etc.. But little is known on thresholds, frequency dependence, JNDs of defined vibration input to the human body. Most investigations aim at vibration levels which cause medically relevant effects like motion sickness.

Whole-body vibration input was investigated at low levels. The frequency dependence of the threshold for x-y-z-vibrations between 10 Hz and 200 Hz was found to deviate significantly from literature acceleration values. The weighting functions (like the A-weighting for noise), which are given in technical guidelines, should be re-investigated. Since the objectives of the present investigations deal with the comfort of seats (e.g. for car industry), it was measured, which level difference for respective vibration inputs are noticeable. Only very little research on this aspect was reported in literature. Technical problems arise for applying defined vector directions for the vibration impact, in particular for whole-body vibrations. A "vibration pad" was successfully developed, which is capable to mimic measured x-y-z time-series in such a natural manner, that a "virtual vibration reality" can be reproduced.

A thesis on this subject is nearly completed by an associated graduate. A new graduate started right now with a systematic investigation of vibration input to human with the objective to derive an effective human response model, taking frequency dependence, temporal integration and masking into account.

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Auditory models (Dr. Torsten Dau, Prof. Dr. Dr. Birger Kollmeier, Medizinische Physik, Oldenburg; Ph.D. students Ulrike Dicke, Stefan Ewert)

The primary research topic for this subgroup was to extend our knowledge about the “effective” signal processing in the auditory system with a special emphasis on amplitude modulation processing and the modulation filterbank concept. This was done both by psychophysical experiments and by numerical predictions based on the “Oldenburg perception model” that describes the neurosensory transformation from the acoustical stimulus into its “internal representation”. This representation is supposed to be used by our cognitive system (modeled by an “optimal detector”) to detect the appropriate stimulus. In the dissertation by J. Verhey (1999) (Dau & Verhey, 1999, Verhey et al., 1999) and R.P. Derleth (1999) (Derleth & Dau, 2000) the modelling concept was validated by being able to predict certain experiments on Comodulation masking release and by explaining quantitatively the asymmetry in masking between narrowband- and broadband signals. A further refinement of the filter shape required in the modulation filterbank was described by Ewert and Dau (2000), and a series of experiment to establish further the underlying concepts was performed by Kohlrausch et al. (2000) and Oxenham&Dau (2001).

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properties of the normal and impaired auditory system. Using the same modelling concept Zerbs et al. (2000a,b) developed a model for binaural auditory signal processing. A further refinement of the modulation-filter shape required in the modulation filterbank was described by Ewert and Dau (2000), and a series of experiments to establish further the underlying concepts of modulation processing was performed by Kohlrausch et al. (2000). The role of perceptual organization on modulation detection interference was investigated by Oxenham and Dau (2001a). Effects of concurrent and sequential streaming in MDI were studied and underlying processing strategies of these across-channel phenomenon were described. In Oxenham and Dau (2001b,c) the effects of auditory frequency selectivity and phase response on masking were studied by using tone complex maskers. The results provided a new framework for mapping out the phase response of the auditory filters and provide constraints on future models of peripheral filtering in the human auditory system.

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3. Functional and diagnostic imaging

fMRI and EEG-measurement techniques

fMRI of the visual system (Prof. Dr. Mark Greenlee, Kognitionsforschung, Oldenburg; Ph.D. students Jose Ignacio Vallines Garcia, Guido Plata, Post-Doc Dr. Roland M. Rutschmann ; Prof. Dr. Nico Leenders, Neuroimaging, Groningen ; Dr. Frans Cornelissen)

The major research lines of our project concern cortical control of saccadic eye movements and cortical processing of basic visual properties (e.g. motion perception, spatio-temporal frequency discrimination) and visual attention using functional magnetic resonance imaging (fMRI). Furthermore we apply fMRI methods to interesting patient groups.

A unique development in the Oldenburg and Groningen groups is our ability to monitor eye movement behavior in the magnet. We can correlate on-going oculomotor behavior such as blinks, saccadic eye movements, fixation and saccadic errors with the resulting fMRI time series. Three studies were devoted to the investigation of cortical correlates of oculomotor control in different paradigms. In all experiments we obtained simultaneous acquisition of eye movement and fMRI data. In a block design study of Kimmig et al. (2001) two experimental series served to study the effects of varying the frequency of occurrence and the effects of varying saccadic amplitude respectively. In a third experimental series task difficulty was varied, subjects either performing pro- or anti-saccades. Using event-related fMRI with its inherent temporal sensitivity Cornelissen et al. (2001) performed an experiment to locate cortical activity correlated with pro- and anti-saccade performance. Finally we studied control

of saccadic eye movements in visually guided (step- and gap-paradigm) compared to memory guided saccades (Özyurt et al., in prep.).

In three experiments we examined neural mechanisms underlying motion perception and spatio-temporal frequency discrimination respectively. Rutschmann et al. (2000) explored BOLD (blood oxygenation level dependent) effects in motion-sensitive areas of human visual cortex correlated with perception of different forms of optic flow (expansion, spiral motion, random). Cortical mechanisms underlying discrimination of successively presented spatial-frequency stimuli were examined in a study by Greenlee et al. (2000). Singh et al. (2000) investigated hemodynamic changes in V1-V5 correlated with spatiotemporal frequency and unidirectional motion stimuli. Boundaries of visual cortical areas in this study were identified using retinotopic mapping and cortical flattening techniques.

Retinotopic mapping procedures were also utilized in a study by Smith et al. (2001) where we developed a method to estimate the change in receptive field size with increasing retinal eccentricity using fMRI.

Examination of cortical control of attention in the human visual cortex when an observer attends to a particular location in the visual image was the objective of a study by Smith et al. (2000).

In a clinical study with patients suffering from band heterotopia (“double cortex”) activation patterns associated with a motor task and with visual stimulation were studied (Spreer et al., 2001). In a further clinical study with symptomatic patients suffering from late whiplash syndrome we examined functional activation in motion sensitive areas (V5/V5a) showing a significant reduction in fMRI responses as well as in the patients psychophysical motion performance.

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fMRI of the auditory system (Prof. Dr. H. Duifhuis, Biomedical engineering, Groningen; Ph.D. student Remco Renken, Sonja Tomaskovic)

The auditory imaging work in Groningen started with a postdoctoral project by Charlene Tan (1996-1998). In fact, it was the start of the experimental fMRI research at the Academic Hospital Groningen within the BCN. Auditory research in an fMRI environment has some special problems. That is, it is generally stated that the noise inherently produced by fMRI cameras is not problematic because it would affect the response image and the reference image equally, so that it would disappear when considering the functional response, which is the response difference. We have reasons to dispute this general assumption, and are addressing the issue in a parallel project, but so far we do not have a general solution.

One way to control, or limit, the masking and adaptation effects of the extremely loud EPI pulses (over 100 dB) is to consider these pulse sequences as maskers, and use known temporal masking paradigms to control and limit the effects. This has been tested and implemented by Tan (e.g., Tan et al., 1997). Renken has pursued the idea further and has implemented it in a sparse sampling paradigm, integrated with the optimum use of longer interscan intervals (Tr). This emphasizes single BOLD responses to stimuli, rather than the adapted responses to repeated stimuli.

Another problem turned out to be the poor quality of motion correction features in image processing software. Obviously, this is extremely important in combination with sparse sampling, because that method requires extended time, thereby increasing the possibility of motion artifacts. This problem is addressed in cooperation with the computer science group, in a cooperation project with Muresan. Tentative results have been presented at the recent SPIE meeting (Feb 2002).

Using this technique, Renken investigated the responses to complex tones and single tones of similar pitch. It was observed that the complex tones evoke a stronger as well as a more widely distributed activation in the brain, within the auditory cortex as well as elsewhere. It was also found that stimulation can not only increase, but also decrease, the response activity. The complex tones can evoke a strong pitch perception at the missing fundamental frequency. Reducing the amount of harmonics and / or increasing the lowest harmonic number can alter this pitch perception. In order to understand brain activation upon stimulation with sounds, it is important to know how these sounds are perceived by subjects. If perception changes, the underlying brain state must have changed also. To control and monitor perception, psychophysical measurements are recorded before and during the functional imaging.

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EEG analysis of the auditory system (Prof. Dr. Dr. Birger Kollmeier, Dr. Torsten Dau, Medizinische Physik, Oldenburg; Ph.D. students Dirk Junius, Sandra Fobel)

The primary research goal of this subgroup during the last 3 years was to characterize the first auditory processing steps in the brainstem by auditory brainstem audiometry. To do so, appropriate acoustic stimuli (chirp stimuli compensating the basilar membrane dispersion, Dau et al., 2000, Wegner & Dau, 2002 and binaural click stimuli, Riedel & Kollmeier, 2001) were used and appropriate averaging techniques to optimize the signal-to-noise ratio in the recordings were developed (iterated weighted averaging: Granzow et al., 2001, Riedel et al., 2001). Based on the findings, a model for the generation of ABR for different stimuli was successfully built up (Dau, 2002), and the role of interaural time- and level differences for the early processing of localization information could be clarified (Damaschke et al., 2000, 2002, Riedel & Kollmeier, 2001).

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4. Applications

Technical realization of neural processing principles in audition (e.g., front end for automatic speech recognition), touch (e.g., vibration annoyance in cars, aircrafts and medical devices) and vision (e.g., image processing and recognition)

Auditory model-based speech processing (Dr. Volker Hohmann, Prof. Dr. Dr. Birger Kollmeier, Medizinische Physik, Prof. Dr. Wolfgang Nebel, Entwicklung integrierter Schaltungen, Oldenburg; Ph.D. students Mark Marzinzik, Michael Kleinschmidt, Jörn Anemüller, Laila Kabous)

The main research focus in this subgroup is the application of knowledge about the hearing system into technical systems that deal primarily with speech processing, i.e., automatic speech recognition, noise suppression, and digital hearing aids. During the last three years, it could be demonstrated that the "Oldenburger Perceptionsmodel" (see report on auditory models) can successfully be used as a front end for an automatic speech recognizer to enhance speech recognition under noisy conditions (Dissertation Tchorz, 2000, Tchorz & Kollmeier, 1999, Kleinschmidt et al., 2001). The model can also be used to objectively predict the subjective quality of nonlinearly distorted speech (such as mobile phone communication) (Dissertation Hansen, 1998, Hansen & Kollmeier 1999, 2000a and b). Furthermore, auditory

processing principles such as the modulation filterbank concept have been shown to be advantageous in (monaural) noise reduction techniques, i.e., by directly estimating the respective speech-to-noise from the amplitude modulations spectrogram (Tchorz & Kollmeier, 2002, Tchorz & Kollmeier(submitted)) and subsequently using this estimate to reduce noise. Similarly, principles of binaural processing (i.e., comparison between left and right ear) have been shown to be advantageous in (binaural) noise reduction techniques for “difficult” acoustical situations when two signal channels are available (such as, e.g. bilateral hearing aids or stereo recordings) (Dissertation Wittkop, 2001, Wittkop & Hohmann, Wittkop et al. (submitted), Nix&Hohmann (submitted)). For the evaluation of noise reduction techniques (as well as many other applications in audiology and speech research), a German sentence test (“Oldenburger Satztest”, i.e. syntactical correct, but semantically nonsense sentences) was developed and evaluated (Wagener et al., 1999) which was turned into a real product and distributed by the Hörzentrum Oldenburg (institute “at” the Universität Oldenburg). The development and test of appropriate noise reduction schemes for hearing aids was also one of the main topics of the group’s hearing aid research (Dissertation Marzinzik, 2000, Marzinzik et al, 1999, Marzinzik & Kollmeier, 2002), which also covers dynamic compression, hearing aid fitting (Gabriel et al., 1999, Gabriel & Kollmeier, 1999, Marzinzik et al., 1999, Gabriel et al., 2000, Gabriel, 2001) and classification of the respective acoustical situation to control the appropriate algorithm (Kollmeier, 1999, Wittkop & Hohmann (submitted)). The importance of basic auditory-model based signal processing led to a cooperation with the Computer Science faculty (Prof. Nebel, doctoral student Leila Kabous) with the aim to implement these structures in hardware in a power-saving way (Hohmann, 2002). Taken together, the combination of fundamental research and demonstrations of its usability in speech processing has contributed to the reputation of the medical physics group to be among the leading groups in hearing aid research worldwide, which is largely built on a series of (applied) doctoral theses and the subsequent employment of the Ph.D. candidates in the international hearing aid industry.

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Identification of distinct features of technical noise (Prof. Dr. Volker Mellert, Akustik, Oldenburg ; Ph.D. students Sandra Buss, Matthias Vormann)

Quality control and assessment of technical products and machinery is often performed acoustically, i.e. certain distinct features of the noise produced by the device investigated is analysed by the ear in order to detect characteristic features. Typical examples are tonal components in noise, indicating regular defects in rolling parts of the machine. Methods for detecting tonal or "regular" features within a noise were improved. The basis is a running spectral analysis of the technical acoustic signal, taking the known integration properties of the ear with respect to time and frequency resolution into account (based on an analysis technique of Mummert). The spectrograms are analysed for linked changes of spectral maxima with time (so-called contours). This method was enhanced to take harmonic changes of the base frequencies into account, as they appear e.g. in a roll-out of a decelerated wheel. Certain features of tire noise were successfully identified by this method and transformed to a measurement procedure (comparable to the ear's ability). More basic investigation aim at the psychoacoustic parameter "tonality", which is subjected to a guideline of a technical measurement procedure, albeit a thorough definition including an investigation of limits of applicability is still open. Several basic properties of perceived "tonality" of noise-like signals with tonal components were investigated and a law of non-linear summation of tonal components to "tonality" derived.

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Short report from each collegiate (including temporarily funded and associated doctoral students) : see appendix

1. Adaptation:

Dr. Mark Pottek (1) Retinoic acid as a retinal neuromodulator (2) A novel role for gap junction proteins in the retina (3) Light-evoked activity of single neurons in the intact mouse retina
Werner Hoppenstedt Identification and distribution of connexins in the turtle retina
Frank Schütte Identification and Characterization of Retinoic Acid-binding Proteins
Timm Schubert Coupling of alpha ganglion cells in the mouse retina
Mailin Segger-Junius Characterization of the dendritic transport of shank1 mRNA
Martin Greschner Influence of Identified Amacrine Cells on the Activity of Retinal Ganglion Cells during Simulated Eye Movements
Theo Dinklo Primary visual processes and spectral processing of insect photoreceptors
Johannes Oberwinkler Primary visual processes and spectral processing of insect photoreceptors
Manfred Mauermann Properties of finestructure in otacoustic emissions and loudness perception
Giso Grimm Loudness of fluctuating sounds

2. Intermodal interaction and information integration:

Annika Akerfelt Investigating Voluntary Inhibition and Visuo-Tactile Interaction in Stop-Signal Experiments
Frouke Hermens Considerations on intermodal interaction
Holle Kirchner Visual-auditory interstimulus contingency effects in saccade programming
Claudia Steinbrink Relations between phonological and inflectional errors in spontaneous speech of German-speaking children with hearing impairment and with unimpaired hearing
Dr. Petra Arndt Intersensory integration in eye and arm movements
Oliver Lindemann A common network for Action Recognition and Action Execution
Handy Oey Development of a model of vibration perception
Ingo Baumann Perception of sound and vibration relating to comfort aspects
Michael Bellmann Experiments on the perception of whole-body vibration
Ulrike Dicke A biologically motivated neural circuit describing periodicity coding in the auditory system
Stefan Ewert Modeling the processing of envelope fluctuations in the auditory system

3. Imaging and „smart“ neurosensory analysis:

Jose Ignacio Vallines Garcia Oculomotor behaviour and brain activation
Guido Plata
Dr. Roland M. Rutschmann Human visual areas responding to disparity in Julesz patterns
Frans Cornelissen Event-related fMRI responses in the human frontal eye fields in a randomized pro- and antisaccade task
Remco Renken fMRI and PET analysis of auditory frequency and pitch repres
Lucian Muresan Pattern Detection and Estimation in Functional Neuroimaging
Sonja Tomaskovic fMRI and PET analysis of auditory signals, in particular speech
Dirk Junius Binaural auditory evoked potentials with virtual acoustics
Sandra Fobel Relation between sensorineural hearing impairment and steady-state amplitude modulation following responses

4. Applications:

Mark Marzinzik Noise reduction schemes for digital hearing aids and their use for the hearing impaired
Michael Kleinschmidt Classification of speech signals using perceptive features and its application to robust speech recognition
Jörn Anemüller Across-Frequency Processing in Convolutional Blind Source Separation
Laila Kabous Object oriented development of embedded systems
Sandra Buss Temporal and spectral analysis of acoustic signals by calculating contours
Matthias Vormann Development and Validation of a Psychoacoustic Measuring Procedure and Prediction-Model for the Assessment of Tonality (Tonhaltigkeit) of Noises
Jens Harting Numerical methods in neurosensory science
Christine Hartmann Experiments for auditory-processing based automatic speech recognition

2. List of all collegiates

List of all funded collegiates (1.6.2000 – 31.5.2003) (Oldenburg)

Name of Ph.D. student	Age when entering EuroGK	Diplom Date	Diplom Location	Stipend received from the EuroGK	Ph.D. finished	Thesis supervisor
Annika Akerfelt	22	30.06.00	York, GB	01.09.00 – 31.08.02		Colonius
Ingo Baumann	27	12.07.01	Oldenburg	01.10.01 – 31.12.01		Mellert
Ulrike Dicke	28	22.12.97	Bremen	01.06.00 – 31.05.02		Kollmeier
Sandra Fobel	28	28.06.00	Oldenburg	01.07.00 – 30.06.02		Kollmeier
Martin Greschner	26	14.12.00	Oldenburg	15.12.00 – 31.03.01		Weiler
Giso Grimm	27	31.03.01	Oldenburg	01.04.01 – 31.05.01		Kollmeier
Jens Harting	27	12.03.99	Oldenburg	01.07.01 – 31.12.01		Kollmeier
Christine Hartmann	27	06.11.00	Oldenburg	01.11.00 – 31.12.00		Kollmeier
Frouke Hermens	25	31.07.00	Nijmegen, (NL)	01.09.00 – 31.08.01		Colonius
Werner Hoppenstedt	35	10.07.96	Oldenburg	01.07.00 – 28.02.01		Weiler
Dirk Junius	26	22.05.00	Oldenburg	01.06.00 – 31.05.02		Kollmeier
Laila Kabous	27	29.09.97	Oldenburg	01.06.00 – 31.05.02		Nebel
Mark Marzinzik	30	11.06.96	Oldenburg	01.07.00 – 31.12.00	19.12.00	Kollmeier
Handy Oey	27	09.10.01	Oldenburg	16.10.01 – 15.01.02		Mellert
Guido Plata	30	07.11.00	Oldenburg	01.12.00 – 31.01.01		Greenlee
Mark Pottek	33	16.12.94	Oldenburg	01.06.00 – 31.07.00	17.07.00	Weiler
Frank Schütte	28	30.03.01	Oldenburg	01.04.01 – 31.03.03		Weiler
Jose Ignacio Vallines Garcia	27	1999	Madrid, Spanien	01.10.01 – 31.05.03		Greenlee
Post-Doktorand/in	Age at entry	Diplom Date	Diplom Location	Stipend from EuroGK	Promotion	Supervisor
Mark Marzinzik	30	11.06.96	Oldenburg	01.01.01 – 11.03.01	19.12.00	Kollmeier
Mark Pottek	33	16.12.94	Oldenburg	01.08.00 – 31.07.02	17.07.00	Weiler

List of Collegiates from BCN participating in the EuroGK

Name of Ph.D. student	Age when entering EuroGK	Diplom	Diplom Location	Stipend received from BCN	Ph.D. finished	Thesis supervisor
Lucian Muresan	29 jr.	Physics, 1994	Bucharest	15-01-99 – 15-01-03		Petkov
Remco Renken	25 jr.	Scheikunde, 1998	Groningen	01-09-98 – 01-09-02		D. Duifhuis
Sonja Tomaskovic	25 jr.	Physics, 2001	Zagreb	01-10-01 – 01-10-05		D. Duifhuis
Frans W. Cornelissen 1989 – vast	30 jr.	Biologie, 1989	Utrecht		1994	Houtman, Groningen
Theo Dinklo	23 jr.	Biologie, 1997	Nijmegen	01-07-98 – 30-06-02		D. Stavenga
Johannes Oberwinkler	26 jr.	Biologie, 1996		01-04-98 – 01-01-00	31-03-00	D. Stavenga
Oliver Lindemann	30 jr.	Psychologie, 2001	Trier	01-11-01 – 01-11-05		Th. Mulder
Thomas Gladwin	25 jr.	Psychologie, 2001	Groningen	01-01-02 – 01-01-06		R. de Jong
Martijn Keitz	28 jr.	Biologie, 2000	Groningen	01-06-01 – 01-06-05		K.L. Leenders
Werner Vogels	25 jr.	Psychologie, 1998	Tilburg	01-11-98 – 01-11-02		R. de Jong
Jurjen van de Helden	27 jr.	Psychologie, 1999	Groningen	01-06-00 – 31-05-04		R. de Jong
Maarten Boksem	23 jr.	Psychologie, 2000	Groningen	01-04-01 – 01-04-05		T.F. Meijman
Branislava Curcic	24 jr.	Physics, 1998	Belgrado	18-09-00 – 18-09-04		D. Stavenga
Jaap Bos	25 jr.		Technische cognitiewet Groningen	01-04-00 – 01-04-04		T.F. Meijman
Aave Hannus	27 jr.	Psychologie, 1999	Estonia	01-01-02 – 01-01-06		H. Bekkering

Associated collegiates (Oldenburg)

Name	Date of admittance	Diplom Date	Diplom Location	Ph.D. completed	Thesis supervisor
Jörn Anemüller	19.02.01	01.11.96	London	30.7.01	Kollmeier
Dr. Petra Arndt	14.05.01	02/1990	Bochum	14.12.93	Colonius
Michael Bellmann	19.02.01	22.06.99	Oldenburg		Mellert
Matthias Brucke	20.02.01	10.08.95	Ravensburg-Weingarten		Nebel
Sandra Buss	20.02.01	19.07.99	Oldenburg		Mellert
Stefan Ewert	20.02.01	17.05.99	Oldenburg		Kollmeier
Martin Greschner	18.04.01	14.12.00	Oldenburg		Weiler
Holle Kirchner	20.02.01	05/1998	Münster	20.12.01	Colonius
Michael Kleinschmidt	19.02.01	03/1999	Oldenburg		Kollmeier
Manfred Mauermann	19.02.01	18.08.97	Oldenburg		Kollmeier
Dr. Roland M. Rutschmann	27.03.01	16.08.95	Marburg	24.06.98	Greenlee
Timm Schubert	19.02.01	24.08.99	Oldenburg		Weiler
Arne Schulz	19.02.01	28.04.00	Oldenburg		Nebel
Mailin Segger-Junius	19.02.01	03.05.00	Oldenburg		Weiler
Claudia Steinbrink	19.02.01	09.11.98	Oldenburg		Szagun
Matthias Vormann	10.05.01	09.11.95	Oldenburg		Mellert

3. Selection of the collegiates**a) Universität Oldenburg**

The stipends granted within the German part of the European Graduate School were advertised in “Die Zeit” in April 2002. The most promising candidates were invited to give a presentation about their respective past work, research perspectives and possible topics of interest within the European Graduate School in front of the professors supporting the graduate school. Based on the application, the oral presentation, and the informal interview of the candidate, a decision was made about the acceptance or rejection of the respective candidate. At least two professors were required to actively support the application (usually the prospective thesis supervisor and the prospective second supervisor, preferably from a different discipline) and each professor had a veto right. The same procedure was basically adopted to admit the associate graduate students.

Unfortunately, the begin of the European Graduate School coincided with a very heavy demand for qualified university graduates in the technical disciplines on the job market which offers much higher salaries than the stipends paid by the DFG. Hence, only a very limited number of applications was received and much effort had to be invested by the supporting professors to persuade appropriate qualified graduate students (both from within and outside of the university) to apply for a stipend. Luckily, nearly all stipends could be granted continuously to very talented graduate students. However, one of the postdoctoral positions could not be filled with adequate candidates for quite a period.

**Number of applicants for stipends
Successful candidates**

	Post-Doktoranden	Doktoranden	Assoziierte
intern			
male	2	11	11
female	0	3	5
extern			
male	0	1	0
female	0	3	0

Candidates that were declined a stipend

	Post-Doktoranden	Doktoranden	Assoziierte
intern			
male	0	1	0
female	0	1	0
extern			
male	2	1	0
female	0	1	0

b) Rijksuniversiteit Groningen

If there are vacancies for PhD positions in BCN research groups, they are always posted on internet lists and often also in Dutch newspapers. Suitable candidates are invited to give a presentation. In order to be accepted as PhD student in Groningen, they have to be able to show excellent study results and writing skills, they have to be highly motivated, creative and dedicated to science.

4. Implementation of the study program

List and short description of the courses and activities of the graduate school

Summer term 2000

Seminar of SFB 517 »Neurocognition«, 2 h per week, Oldenburg

Organizers: Weiler, Kollmeier, Mellert, Greenlee, Colonius

Presented were reports by the different research fields of the SFB as well as talks given by external speakers.

Colloquium on medical physics and acoustics

1.5 h per week, Oldenburg

Organizers: Mellert, Kollmeier, Hohmann, Dau, Weber

Mostly external speakers present on-going research to faculty members and graduate students.

BCN PhD Retreat, Groningen

6-7 April 2000, Organizer: Zwarts

About 50 PhD students come together for two days and half of them give a short presentation (about 10 minutes) of their current research. There is time for questioning and discussion. Goal of this intensive activity is exchange of scientific ideas, plans, methods between the PhD students from various BCN research groups.

BCN Summer School Modeling in Cognitive Neurosciences, Groningen

3-7 July 2000, Organizer: Zwarts, Duifhuis

A number of national and international experts gave lectures in the morning and masterclasses in the afternoon for an international audience of PhD students (BCN and related graduate schools).

Start-up symposium

Sept 08/09, 2000, Kloosterburen/NL

Organizers: Kollmeier, Duifhuis

This symposium dealt with an introduction of the different research disciplines cooperating in the graduate school. In addition to a general overview, each research field was illustrated by the former scientific work of the collegiates.

Integrated Laboratory course »Psychophysics and Neurosensory Sciences«

Sept 18–29, 2000, Oldenburg

Organizers: Kollmeier, Dau, Rutschmann

This course offered an introduction into the physical basics of neural science and medical physics. Two main focal points were implemented: (i) Seminars and exercises providing an overview of the hearing system (anatomy, physiology, diagnostics), an insight in psychophysical techniques and methods for neurophysiological measurements on human subjects (EEG, MEG, recording of evoked potentials, functional MRI), as well as basic experiences in modeling of neurosensory events. (ii) project-oriented work concerning more specialized topics (e.g. pitch and loudness perception, acoustical evoked potentials, audio-visual interaction)

Special symposium on "computational neuro-imaging of the visual system"

as part of the European conference on Visual perception 2000.

Aug. 31, 2000, Groningen

Organised collaboratively by Greenlee and Cornelissen

8 international speakers and about 250 attendants.

Winter term 2000/2001

Seminar of SFB 517 »Neurocognition«

2 h per week, Oldenburg

Organizers: Weiler, Kollmeier, Mellert, Greenlee, Colonius

Presented were reports by the different research fields of the SFB as well as talks given by external speakers.

Combined seminar of the graduate schools »Psychoacoustics« and »Neurosensory Science and Systems«

2 h per week, Oldenburg

Organizers: Kollmeier, Mellert

This seminar dealt with the research reports of the collegiates from the graduate school »Psychoacoustics«. In addition, the collegiates from the graduate school »Neurosensory Science and Systems« introduced their current projects.

Neurobiological seminar

2 h per week, Oldenburg

Organizers: Weiler, Richter-Landsberg

Organized by the neurobiological working groups in Oldenburg, this seminar provided a platform for junior neuroscientists to present their own projects. This was combined with research reports given by external speakers.

Colloquium on cognitive science

4 h per month, Oldenburg

*Organizers: Diederich, Colonus, Greenlee**Mostly external speakers present on-going research to faculty members and graduate students.***Colloquium on medical physics and acoustics**

1.5 h per week, Oldenburg

*Organizers: Mellert, Kollmeier, Hohmann, Dau, Weber**Mostly external speakers present on-going research to faculty members and graduate students.***Monthly seminar of the complete graduate school**

Groningen/NL and Oldenburg

*The aim of this seminar was to provide a basic insight into the different research disciplines involved in the graduate school. Each particular meeting was hosted by a different research group and consisted of basic lectures combined with practical demonstrations.**Topics were:***Oct 16: Acoustics and Medical Physics Research Groups, Dept. of Physics, Oldenburg***Organizers: Kollmeier, Mellert*

Program: B. Kollmeier *Overview about hearing research in Oldenburg*
 T. Brand *Audiological Tests made in Oldenburg*
 M. Mauermann *Otoacoustic emissions and other objective hearing test methods*
 Site visit to the laboratories

Nov 09: Medical Imaging. Groningen Neuro-Imaging Project (GNIP), Groningen*Organizers: Leenders, Duifhuis, Cornelissen*

Program: P. Maguire *»Overview GNIP and methods«*
 B. de Jong *»Executive motor system: PET«*
 F. van der Graaf *»Executive motor learning: fMRI«*
 M. Greenlee *»Visual and oculomotor systems: fMRI«*
 B. Wijers *»Working memory: PET«*
 N. Maurits *»Developments in 128-channel (status): EEG«*
 R. Kortekaas *»Neurotransmitter activation: PET«*

*Tour of the PET Center and (f)MRI Center***Dec 11: Neurobiology. Neurobiology Research Group, Dept. of Biology, Oldenburg***Organizers: Weiler, Pottek*

Program: R. Weiler *»Neuronal adaptation«*
 M. Pottek *»Neuromodulators in the retina«*
 M. Greschner *»Stimulus detection by microsaccades«*
 Site visit to the laboratories with emphasis of the electrophysiological techniques
 (patch clamp to multielectrode recording)

Jan 08: Biomedical Technology/Neurobiophysics. Biomedical Engineering and Neurobiophysics Working Groups, Groningen*Organizers: Duifhuis, Stavenga, van Netten*

Program: H. Duifhuis *»The Biomedical Engineering program«*
 S. van Netten *»Mechanically gated ion channels in mammalian hair cells: molecular puppets on a string«*
 D. Stavenga *»The Neurobiophysics program«*
 Site visit to the neurobiophysics laboratories

Febr 05: Computer Science. VLSI Design Group, Dept. of Computer Science, Oldenburg*Organizers: Nebel, Kabous*

<i>Program:</i>	<i>W. Nebel</i>	<i>»From Specification to architecture of embedded systems«</i>
	<i>M. Brucke</i>	<i>»Silicon cochlea: a digital hardware for implementation of a perception model«</i>
	<i>G. Schumacher</i>	<i>»Object oriented modeling of embedded systems«</i>
	<i>A. Schulz</i>	<i>»ORINOCO(r): A tool-suite for power analysis and optimization on behavioral and architectural level«</i>
	<i>F. Oppenheimer</i>	<i>»ComiX«</i>

Winter school »Audiology and medical acoustics«, Jan 15–19, 2001, Pichl/Austria

Organizers: Kollmeier, Welzl-Müller (Innsbruck/A)

Program:

Jan 15 Medical acoustics

<i>Kollmeier</i>	<i>»Einführung in die Akustik«</i>
<i>Hudde</i>	<i>»Elektroakustik«</i>
<i>Vorländer</i>	<i>»Raum- und Bauakustik, Lärm-Messung«</i>
<i>Eysholdt</i>	<i>»Stimme und Sprache«</i>

Jan 16: Physiological and psychological acoustics

<i>Hudde</i>	<i>»Funktionsweise, Modelle und Diagnostik von Außen- und Mittelohr«</i>
<i>Janssen</i>	<i>» Funktionsweise, Modelle und Diagnostik im Innenohr«</i>
<i>Fastl</i>	<i>»Psychoakustik des normalen und geschädigten Gehörs«</i>
<i>Kollmeier</i>	<i>»Sprachwahrnehmung bei Normal- und Schwerhörigen«</i>

Jan 17: Audiological acoustics

<i>Stephan</i>	<i>»Audiometrische Standardverfahren«</i>
<i>Hoth</i>	<i>»otoakustische Emissionen und auditorisch evozierte Potentiale«</i>
<i>Stephan</i>	<i>»Moderne, computerunterstützte audiometrische Verfahren«</i>
<i>Welzl-Müller</i>	<i>»Qualitätssicherung in der Audiologie«</i>

Jan 18: Technical hearing aids

<i>Wesselkamp/Holube</i>	<i>»Hör- und Hörunterstützungs-Geräte der Gegenwart«</i>
<i>Boretzki/Kühnel</i>	<i>»Anpassungsverfahren für Hörgeräte«</i>
<i>Dillier</i>	<i>»Cochlea-Implantate und implantierbare Hörgeräte«</i>
<i>Hohmann</i>	<i>»Signalverarbeitung für Hörgeräte der Zukunft«</i>

Jan 19: Audiological and acoustical systems in practice

Exercises concerning applications of hearing technology, audiological measuring techniques, signal analysis, hearing aids, and cochlear implants in cooperation with leading companies in the field of hearing technology

Summer term 2001

Seminar of the graduate school »Neurosensory Science and Systems«

2 h per week, Oldenburg

Organizers: Kollmeier

In this seminar the collegiates reported on the progress of their research projects.

Colloquium on cognitive science

4 h per month, Oldenburg

Organizers: Diederich, Colonius, Greenlee

Mostly external speakers present on-going research to faculty members and graduate students.

Colloquium on medical physics and acoustics

1.5 h per week, Oldenburg

Organizers: Mellert, Kollmeier, Hohmann, Dau, Weber

Mostly external speakers present on-going research to faculty members and graduate students.

BCN PhD Retreat

5-5 April 2001, Groningen

Organizer: Zwarts

About 50 PhD students come together for two days and half of them give a short presentation (about 10 minutes) of their current research. There is time for questioning and discussion. Goal of this intensive activity is exchange of scientific ideas, plans, methods between the PhD students from various BCN research groups.

BCN Summer School Performance, fatigue, recovery and their periodic control

9-13 July 2001, Groningen

Organizer: Zwarts

A number of national and international experts gave lectures in the morning and masterclasses in the afternoon for an international audience of PhD students (BCN and related graduate schools).

Monthly seminar of the complete graduate school

Groningen/NL and Oldenburg

The aim of this seminar was to provide a basic insight into the different research disciplines involved in the graduate school. Each particular meeting was hosted by a different research group and consisted of basic lectures combined with practical demonstrations.

Topics were:

Apr 23: Psychology. Institute for Cognition Research, Dept. of Psychology, Oldenburg

Organizers: Diederich, Colonius, Greenlee

Program: A. Diederich

»Intersensory interaction models and data«

H. Colonius

»Stop signal paradigm with saccadic eye movements«

M. Greenlee

»Cortical control of voluntary saccades: fMRI studies«

Site visit to the laboratories

May 28: Psychology. Dept of Psychology, Groningen

Organizers: Bekkering, van Rijsbergen

Program: R. de Jong

»Cognitive control«

B. Wijers

»Brain imaging«

H. Bekkering

»Eye-hand coordination«

Site visit and demonstrations in the Dept. of Experimental and Work Psychology and in the Dept. of Developmental Psychology and Experimental and Clinical Psychology

Jun 25: Audiology. Evangelisches Krankenhaus Oldenburg and Hörzentrum Oldenburg

Organizers: Schönfeld, Kollmeier

Program: R. Schönfeld

»Audiology and applied hearing research in Oldenburg«

C. Ahrens

»Study Program "Hearing technology and audiology" at the University of Applied Sciences Oldenburg, Ostfriesland & Wilhelmshaven«

B. Gabriel

»Methods for assessing the benefit of hearing aids at the Hörzentrum Oldenburg«

S. Fobel

»EEG measurements as an audiological tool«

C. Steinbrink

»Phonological and grammatical errors in spontaneous speech of normal-hearing and hearing-impaired children«

Site visit at the Dept. of Audiology and ENT of the Evangelisches Krankenhaus and at the Hörzentrum Oldenburg

International Conference on »The perceptual consequences of cochlear nonlinearity«

Aug 08–11, 2001, Hanse Institute for Advanced Studies, Delmenhorst

Organizers: Long, Oxenham

Program: G. Long

A. Oxenham

»Introduction«

»Behavioral measures and perceptual consequences of cochlear nonlinearities«

N. Cooper

»Direct measurements of mechanical nonlinearity in the apical and basal turns of the cochlea«

M. Ruggero

»«

E. Olsen

»Measuring the spatial variation of distortion products within the cochlea: A study of the shape of basilar membrane motion«

V. Summers

»Characterizing cochlear nonlinearity for low- versus high-frequency signals: Longitudinal changes in cochlear response and perceptual consequences«

S. Buus

»The loudness function and basilar-membrane mechanics«

J. Allen / D. Sen

»A possible role of cochlear micromechanics in explaining two tone suppression and the upward spread of masking«

C. Shera

»Intensity-invariance of fine time structure in basilar-membrane click responses: Implications for cochlear mechanics«

R. Withnell

»What mechanism is responsible for “the active process” in the mammalian cochlea?«

J. Santos Sacchi

»Outer hair cell motor nonlinearity«

A. Lukashkin /

»Phase desynchronization in the cochlear feedback as a possible source of compression«

S. Neely

»Compression ratio of the peripheral nonlinearity«

M. Wojtczak

»Effects of compression on the shapes of masking period patterns in normal and impaired hearing, and recent work on suppression and its relation to cochlear gain«

M. Hansen

»Which type of hearing aid compression is optimal for recruitment compensation? «

J. Lyzenga

»Loss of outer hair cell function may result in a loss of frequency selectivity as well as a loss of compression«

C. Talmadge

»Cochlear fine structure - otoacoustic and psychoacoustic measurements«

M. G. Heinz

»Quantifying the effects of the cochlear amplifier on temporal and average-rate information in the auditory nerve«

L. Carney

»Implications of cochlear nonlinearity for the phase-opponency model of masked detection«

S. Holmes

»Responses to speech sounds of a bank of nonlinear auditory filters«

T. Lin

»«

C. Plack

»The temporal window model«

S. Bacon

»Effects of temporary hearing loss on psychoacoustic measures of cochlear nonlinearity«

- B. Strickland* »Psychoacoustic evidence for changes in nonlinearity with sound stimulation«
- A. Kohlrausch* »Consequences of cochlear nonlinearities on binaural hearing«

Summer school »Psychophysics, physiology, and models of the central auditory system«

Aug 12–16, 2001, Bad Zwischenahn

Organizers: Kollmeier

Program: Binaural Processing

- D. Hamershoij* »Binaural technique«
- A. Palmer* »Physiological basis of the BMLD«
- A. Kohlrausch* »A unified view on spectral integration in binaural hearing«
- Y. Suzuki* »Auditory search asymmetry under a spatial listening condition«

Spectrotemporal Processing and Masking

- L. Carney* »Physiologically-based models for masking«
- C. Plack* »Linearity and nonlinearity in masking«
- N. Viemeister* »Intensity discrimination, loudness, and internal noise«
- R. Meddis* »Signal processing in the cochlear nucleus«

Auditory object perception

- L. van Hemmen* »Zwicker tone and noise reduction: A neurophysical model based on double negatives«
- G. Klump* »A comparative view on CMR«
- B. Moore* »Factors influencing sequential stream segregation«
- H. Schulze* »Representation of stimulus periodicity and its learning induced plasticity in the auditory cortex«
- S. Shamma* »The representation of Timbre and Pitch in the Auditory Cortex«
- B. Carlyon* »The Continuity Illusion: Vowel identification, Frequency Modulation, and Hearing Backwards in Time«

Speech perception and processing

- T. Houtgast* »Psychoacoustics and speech reception by the hearing impaired«
- A. Leijon* »Estimation of auditory information transmission capacity using a hidden Markov model of speech stimuli«
- H. Hermansky* »Speech recognition from Frequency-localized temporal patterns«

Winter term 2001/2002

Seminar of the graduate school »Neurosensory Science and Systems«

2 h per week, Oldenburg

Organizers: Mellert

A main focus of this seminar was to review the fundamentals of neurosensory science with respect to neurobiology, physics, and cognitive psychology. This was combined with lectures given by external speakers from different research disciplines.

Neurobiological seminar

2 h per week, Oldenburg

Organizers: Weiler, Richter-Landsberg, Klump

Organized by the neurobiological working groups in Oldenburg, this seminar provided a platform for junior neuroscientists to present their own projects. This was combined with research reports given by external speakers.

Colloquium on cognitive science

4 h per month, Oldenburg

Organizers: Diederich, Colonius, Greenlee

Mostly external speakers present on-going research to faculty members and graduate students.

Colloquium on medical physics and acoustics

1.5 h per week, Oldenburg

Organizers: Mellert, Hohmann, Dau, Weber

Mostly external speakers present on-going research to faculty members and graduate students.

Laboratory course »Psychophysics and Neurosensory Sciences«

Sept 24 – Oct 05, 2001, Oldenburg

Organizers: Dau, Hohmann

This course offered an introduction into the physical basics of neural science and medical physics.

Intensive Seminar “response time analysis”,

21.-25.01.2002 European Intensive Seminar on “Psychological Models of Response Time and Choice” in Stade organized by H. Colonius . Lectures by Colonius (U. Oldenburg), A.A.J. Marley (McGill U., Montreal), & E. Maris (U. Nijmegen)

Practical Labcourse “Electrical coupling in the Retina”,

10.3.-16.3.2002

Organizer: Reto Weiler,

The course combines molecular, neuroanatomical and electrophysiological techniques in order to analyse retinal signal processing at the cellular and molecular level. It will focus on the physiological and molecular characterization of electrical coupling.

- **Involvement/Participation of the collegiates**

All collegiates participated in the weekly common seminar of the European Graduate school on a regular basis. They actively shaped this common seminar by giving their own presentations and asking certain professors (inside and outside of the graduate school) to give lectures on topics that attracted their interest. In addition, the collegiates participated in several of the meetings/poster presentations organized by the graduate school and associated organizations (e.g., Hanse-Wissenschaftskolleg, SFB). Also, they participated in the regular and special meetings organized by their respective working groups, such as the journal club organized by the neurobiology students or the winterschool in medical acoustics and audiology organized by B. Kollmeier.

- **Involvement/Participation of the professors**

The professors tried to fit as much of their regular teaching load into the curriculum of the graduate school as possible. All lectures and regular teaching activities that fit into the general scope of the graduate school and the Sonderforschungsbereich were listed under a separate heading in the „Vorlesungsverzeichnis“. In addition, most of the professors involved organized special talks (with invited guest talkers), seminars or complete scientific meetings. This mixture of different topics, durations, and intensity of the material covered proved to be very helpful for the collegiates who profited a lot from the enrichment.

- Formal requirements for the Ph.D.: At the Universität Oldenburg, the different PhD-study programs in natural science (biology, chemistry, physics etc.) currently have the same general frame of thesis guidelines. But they differ to quite an extent in certain details like the special subjects required in a particular program (e.g. quantum mechanics required in physics). Presently the natural science departments are transformed into one faculty of natural science including mathematics, biology, chemistry and physics. The faculty will have only one common thesis guideline. A committee of experts is installed to develop the common guideline. The new thesis guideline will be in use end of this year.

5. Spending of coordination costs

The granted funds for coordination costs in Oldenburg were used to pay an administrative assistant (Mrs. Susanne Garre, BAT Vc) for 20h/week (01.06.2000 to 13.11.2001) and 19,25 h/week (01.01.2002 bis 31.05.2003). Since the granted funds were not sufficient for a continuous employment, additional funds (granted by the Lower Saxonian research ministry) had to be used for the remaining time (14.11.2001 to 31.12.2001). In addition, the Universität Oldenburg provided funds to pay one part-time academic assistant (wiss. Hilfskraft) to support the graduate school with respect to web services, preparation of scientific meetings, and literature services.

Coordination costs from Groningen: NWO funding for the EGK has been used for organising summerschools and other meetings, for traveling and for purchasing some neuroimaging related software. University funding for the EGK has been used for three years post doc position within the EGK.

6. Internal quality control of the school

The quality of the running Ph.D. projects is controlled by the regular reports and talks of the graduate students about their running work both within the group seminar (organized within each group of the respective main thesis supervisor) and within the common seminar of the EuroGK. In addition, lab tours and lab presentations/discussions are organized where details of the apparatus and research setup of the graduates are reviewed by the group of students and supervisors.

These presentations definitely help the graduates to communicate with other disciplines and to present their respective work in a way which is not only understandable for the experts. It also puts a constant demand on the graduates to document their work and to present it, which is definitely more work than required in “regular”, discipline-oriented Ph.D. thesis projects. In combination with the increased requirements to participate in courses and special events of the EuroGK, the students obviously have a higher workload than “regular” Ph.D. students. This does not necessarily shorten the period required to finish the Ph.D., even though there is a large interindividual difference among students. However, both the students and the supervisors of the graduates feel that the enrichment due to increased interdisciplinary and international contact is worth the additional effort.

In addition to the internal quality control, BCN performs a formal progress/function evaluation with the personnel involved once a year with support from the faculty/faculties. BCN also has an internal evaluation committee (see BCN web site), as have most of the faculties in Groningen. These help to prepare for the national evaluations.

7. Visiting scientist program

Name	Date	Home town	Invited by	Theme of research or talk
Holger Prante	06.06.00	Berlin	Mellert	Modelling judgements of environmental sound with of neural network
Andreas Meier	13.06.00	Braunschweig	Mellert	Sound insulation within buildings: Are measures subjectively sufficient?
Dr. Erdmute Sommerfeld	26.10.00	Leipzig	Colonius	Synchronization of brain areas as a function of cognitive training
Prof. Dr. Carlo Marzi	29.06.00	Verona, Italien	Colonius	Redundant target effect
Prof. Dr. W.K. Stell	16.07.-27.07.00	Kanada	Weiler	Glutamate receptors in the retina
Prof. Dr. Abraham Akopian	02.08.-02.09.00	New York, USA	Weiler	Calcium-dependent currents in ganglion cells
Jasmin Ostertag	07.11.00	Stuttgart	Mellert	Flow noise evaluation - subjective and acoustic measures
Dr. Bernhard Treutwein	08.-10.11.00	München	Colonius	Psychometrische Funktionsmodelle: Anpassung und Fehler
Prof. Dr. Thomas Houtgast	12.11.-13.11.00	Amsterdam	Kollmeier	A physical approach to speech perception
Dr. Stefan Kindler	22.11.-23.11.2000	Hamburg	Richter-Landsberg	Cytoplasmatischer RNA-Transport
Prof. Dr. Uwe Mortensen	23.11.00	Münster	Colonius	Hebb's rule and its implications for detection and identification of visual patterns
Miyuki Morioka	28.11.00	Southampton	Mellert	Perception thresholds and jnd's of hand-arm vibration
Prof. Dr. Katharina Braun	11.01.-12.01.2001	Magdeburg	Weiler	Einfluß frühkindlicher emotionaler Erfahrung auf die funktionelle Reifung des limbischen Systems
Dr. Helmut Brandstätter	18.01.-19.01.2001	Frankfurt	Weiler	Der synaptische Mikrokosmos Retina: Transmitter, Rezeptoren und Signalverarbeitung
Werner Hemmert	22.01.-23.01.01	Zürich, Schweiz	Kollmeier	Sound processing of the inner ear
Prof. Dr. Howard Hughes	28.01.01-30.01.01	Hanover, USA	Colonius	Sensory adaptations: From the exotic to the sublime
Prof. Dr. Jürgen Bolz	01.02.-02.02.2001	Jena	Weiler	Mechanismen und Moleküle zur Konstruktion kortikaler Schaltkreise
Prof. Dr. Bleckmann	08.02.-09.02.2001	Bonn	Weiler	Hydrodynamiksensorik bei Fischen und aquatischen Säugern
Prof. Dr. David Irwin	19.04.-20.04.2001	Illinois, USA	Colonius	Oculomotor and Attentional Capture
Jüri Allik	03.05.01	Estland	Colonius	The Binding Problem: Feature integration in eye movement programming and visual search
Dr. David I. Vaney	07.05.-18.05.01	Brisbane, Australien	Weiler	Identification and characterization of connexins in the mammalian retina
Dr. Takashi Okada	04.06.-13.06.01	Tokio, Japan	Weiler	Overexpression of AMPA-receptors in hippocampal neurons
Prof. Dr. Stephen C. Massey	11.06.-26.10.01	Houston, USA	Weiler	Amacrine cells in the twilight
Dr. Pim van Dijk	15.05.01	Maastricht	Kollmeier	Otoacoustic emissions and cochlear implants
Malte Kob	12.06.01	Aachen	Mellert	Measurements of radiation impedances within ... (im Hals, bei den Stimmbändern !) for the singing voice.
Prof. Dr. Leo van Hemmen	15.06.01	München	Kollmeier	How the desert scorpion localizes its prey
Oliver Dick	18.06.-22.06.01	Frankfurt	Weiler	Basoon synaptic protein
Natasha Maurits	19.06.01	Groningen	Kollmeier	Biomedical engineering of a multichannel EEG system
Nobert Luks	26.06.01	Köln	Mellert	Investigation of stress of cabin crew during long-duration east-west flight situation
Ingolf Bork	03.07.01	Braunschweig	Mellert	Results of round-robin test for simulation procedures in room acoustics
Markus Knauff	12.07.01	Freiburg	Greenlee	Raum zum Denken: Kognitive und kortikale Korrelate des Schlußfolgerns
Prof. Suzuki	11.08.01	Sendai/JP	Kollmeier	Isoloudness level contours and loudness perception in normal and hearing-impaired listeners
Prof. Dr. Laurel Carney	12.08.01	Boston/USA	Kollmeier	Auditory modelling
Dr. Douglas McMahon	13.08.-26.08.01	Lexington, USA	Weiler	Analyse der funktionellen Eigenschaften von Cx26-Hemikanälen in HC
Dr. Henrik Mouritsen	30.08.-02.09.01	Kingston, Kanada	Weiler	Perception of polarized light in the vertebrate
Dr. Kimmig	September	Freiburg	Greenlee	fMRI during saccadic eye movements
Prof. Dr. Leo van Hemmen	20.09.-01.10.01	München	Kollmeier	Präattentive Mechanismen der neuronalen Objektsegmentierung im visuellen System
Prof. Ethebar Dzhaferov	16.10.-26.10.01	Illinois, USA	Colonius	How can interdependent random variables be selectively influenced by different factors?
Prof. Dr. Barry Stein	25. - 27.10.2001	Wake Forest, USA	Colonius	Neural mechanisms for synthesizing inputs
Dr. Elisabeth Foeller	01.11.-04.11.2001	München	Klump	Neurobiologie und Psychoakustik: Die Wüstenmaus als Modell für das Hören im Störschall
John-Dylan Haynes	01.11.01	Magdeburg	Rutschmann	Neural correlates of lateral masking and perceived contrast.
Prof. Dr. H.-U. Schnitzler	13.11.-14.11.01	Tübingen	Weiler	Sehen, was wir hören
Dr. Annette Denzinger	13.11.-14.11.01	Tübingen	Weiler	Sehen, was wir hören
Prof. Dr. Ludger Rensing	15.11.01	Bremen	Richter-Landsberg	Altern, Streß und Streßproteine
Peter Kessels	23.11.01	Eindhoven	Mellert	Numerical design for noise reduction in high-resolution magnetic resonance scanners
Dorothea Schierding	29.11.01	Göttingen	Weiler	Molekulare Mechanismen der Fusion von Endosomen
E. Wetzel	04.12.01	Frankfurt	Mellert	Noise policy developments in Europe
Dr. Nikolaus Troje	06.12.01	Bochum	Klump	Decomposing biological motion: Identity, gender and emotion in human gait
Jörg Huber	13.12.01	London	Hellmann	Zum Einfluss veränderter visueller Rückmeldung auf die Steuerung von Handbewegungen.
Prof. Dr. Serge Kelm	13.12.01	Bremen	Richter-Landsberg	Sialinsäure und zelluläre Wechselwirkungen
Prof. Ivan Bodis-Wollner	13. - 16.12.2001	New York, USA	Greenlee	Activation of primary visual cortex during eye movements
Prof. Leo van Hemmen	07.12.01	München	Dicke	Theoretical biophysics of neurosensory science
Lars Kurandt	13.12.01	Darmstadt	Kollmeier	Auditory signal quality evaluation
Karin Dedek	10.01.02	Hamburg	Weiler	Molekularbiologie von Ionenkanal-Krankheiten

Dr. Jan Kremers	17.01.02 Tübingen	Weiler	Lateral interactions: Physiology and psychophysics
Matthias Nitschke	24.01.02 Lübeck	Greenlee	Cerebro-cerebelläre Netzwerke bei der Steuerung von Senso- und Okulomotorik - beobachtet mit der funktionellen MRT
Dr. Mathias Seliger	24.01.02 Tübingen	Weiler	Physiologie und Molekularbiologie erblicher Netzhauterkrankungen
Harold Bekkering	31.01.02 Groningen	Colonius	Target selection and the coordination of eye and hand movements
Prof. Dr. Solon Thanos	31.01.02 Münster	Weiler	Molekulare Mechanismen der Wachstumskegelmotilität bei Entwicklung und Regeneration von Nervenfasern
Raimund Kleiser	07.02.02 Düsseldorf	Rutschmann	fMRT Untersuchungen zu Ebenen der visuellen Täuschung
Dr. Andreas Wenzel	07.02.02 Zürich, Schweiz	Weiler	Loosing sight by seeing: Lichtschaden als Modell für Netzhautdegeneration
Klaus Hilgetag	18.01.02 Bremen	Colonius	Computational model of parietal neglect

Summerschool and Symposium at Bad Zwischenahn from August 12-16, 2001 "Psychophysics, physiology and models of the central auditory system"

Prof. Carlyon	Robert P.	Cambridge (GB)	Kollmeier	Illusion and Vowel Identification Auditory Phase Opponency: A Temporal Model for Masked Detection at Low Frequencies
Prof. Carney	Laurel H.	Boston (USA)	Kollmeier	Dynamic loudness model (DLM) for normal and hearing-impaired listeners
Prof. Fastl	Hugo	München	Kollmeier	Methods for Binaural Recording and Reproduction
Dr. Hammershøi	Dorte	Aalborg (DK)	Kollmeier	Zwicker tone and noise reduction: A neurophysical model based on double negatives
Prof. van Hemmen	Leo	München	Kollmeier	Models of internal representation in audition
Dr. Heinz	Mike	Boston (USA)	Kollmeier	Speech recognition from Frequency-localized temporal patterns
Prof. Hermansky	Hynek	Portland (USA)	Kollmeier	Psychoacoustics and speech reception by the hearing impaired
Prof. Houtgast	Tammo	Amsterdam (NL)	Kollmeier	A comparative view on CMR
Prof. Klump	Georg	München	Kollmeier	A unified view on spectral integration in binaural hearing
Prof. Kohlrausch	Armin	Eindhoven (NL)	Kollmeier	Estimation of sensory information transmission using a Hidden Markov Model of speech stimuli
Prof. Leijon	Arne	Stockholm (S)	Kollmeier	A model of signal processing in the auditory system
Prof. Meddis	Ray	Essex (GB)	Kollmeier	Factors Influencing Sequential Stream Segregation
Prof. Moore	Brian C. J.	Cambridge (GB)	Kollmeier	The Physiological Basis of the Binaural Level Difference
Dr. Palmer	Alan R.	Nottingham (GB)	Kollmeier	Linear and nonlinear processes in temporal masking of stimulus
Dr. Plack	Christopher	Essex (GB)	Kollmeier	Representation of stimulus periodicity and its learning plasticity in the auditory cortex
Dr. Schulze	Holger	Magdeburg	Kollmeier	The representation of Timbre and Pitch in the Auditory Cortex
Prof. Shamma	Shihab	Washington (USA)	Kollmeier	Large Auditory search asymmetry under a spatial listening condition
Prof. Suzuki	Yoiti	Sendai (Jpn)	Kollmeier	Intensity discrimination, loudness and internal noise
Prof. Viemeister	Neil F.	Minneapolis (USA)	Kollmeier	

8. Intermediate achievement report about the school

The broad range of research subjects, disciplines and methods encountered in the graduate school (from cell physiology to psychophysical modelling to functional imaging and up to the design of low-power VLSI chips) presented a substantial challenge for all its members. Even though this approach led to considerable logistical problems, e.g. in communicating in the “same language”, the framework of the graduate school definitely helped in establishing communication between graduates and research staff across different disciplines and both universities that would not have happened by itself. In addition to this general positive self-assessment of the running European Graduate School project, the following aspects should be mentioned:

- The field of interest widened for each participant. This is perhaps one of the most important aspects of such an interdisciplinary endeavour, even though it is more demanding to understand concepts and research reports from an unfamiliar area than those from ones’ own area.
- The regular meeting once a week across supervisors and Ph.D. students from different groups forms a interdisciplinary focus at the Universität Oldenburg (with a strong link to the Rijksuniversiteit Groningen) which led to the foundation of the Center for Neurosensorics (CNS), i.e., a research center across different faculties, serving as a model for research centers in other areas of the Universität Oldenburg. The regular meetings also created a stronger bond between groups. Of special importance is that not only the respective heads of the research groups communicated with each other, but that the students and academic staff of each research group frequently interacted. This definitely helped to improve research methods that require expertise from the respective other research group. For example, most groups have profited from the physicists’ and computer scientists’ programming skills or from the psychologists’ knowledge of experimental design and statistics. This cooperation therefore helps to advance the whole field.
- A special highlight of the EuroGK are the Summerschools that have been organized in the context of the EuroGK, but also jointly with BCN in Groningen and the Hanse-Wissenschaftskolleg (HWK) in Delmenhorst (30 km east of Oldenburg). These sites offer excellent chances for the young Ph.D. students to meet the international renown scientists whom they knew only from their publications and to discuss with them in an open and friendly atmosphere. This opportunity is especially made up to give the graduates the chance to approach international senior scientists and spend time with them, not only in formal discussions, but also in informal after-dinner-activities. The students have reported that these contacts have been extremely valuable for their later career, not only because it lowers their threshold to approach these scientists later on in any international meeting and to get immersed into the scientific community, but also because they have perceived reciprocal interest on the part of the senior scientists in their own research work. Such interactions have contributed to a heightened motivation for our graduates.
- The regular meetings approx. once a month between Groningen and Oldenburg (alternating between sites) formed an excellent platform for enhancing the working relation between corresponding groups and between the universities at both cities. However, the logistics of establishing of a stronger and broader research exchange between the Groningen and Oldenburg groups turned out to be more difficult than originally thought. Despite the fact that the exchange “platform” was generally well accepted (as evidenced by a high attendance of the monthly cross-border meetings), no extended laboratory exchange of personnel took place, i.e. no Ph.D. student from

Oldenburg stayed in Groningen for a period of more than a week and vice versa. This is partly due to the short distance (120 km or 90 minutes drive by car) between both universities and partly due to the language problems, which makes it easier to commute rather than to rent a place to stay in the respective city. Another interference in building up a stronger working relation between both university sites is that the trimester structure in Groningen is asynchronous to the semester structure in Oldenburg. Hence, the timing of common meetings not infrequently turned out to be difficult.

- The EuroGK started at a point in time where the job market was very favourable for university graduates in the neurosensory disciplines.. Hence it turned out to be extremely difficult to attract good Ph.D. students and Post-Docs to the graduate school. Therefore, not many qualified candidates actually applied for the stipends granted by the DFG and no “real”, competitive selection among candidates took place. One of the postdoctoral fellowships was even vacant for a period of more than a year. Even so, the applicants are convinced that the stipends have been granted to very qualified candidates. Also, the flexibility to grant stipends for a short periods proved to be valuable to the EuroGK, since this enabled some (formerly associated) graduates to finish their respective Ph.D. thesis with a stipend or to publish parts of their respective master thesis work even though their main thesis work was not supported by the EuroGK.
- The requirement that Ph.D. students in DFG-funded European graduate schools should stay a prolonged period (at least 1/2 year) abroad or at the partner university could not be fulfilled in all cases. Instead, only a few Ph.D. students went abroad (Boston, Helsinki, Cambridge) for less than one-half year and none went to Groningen. This is primarily due to the limited amount of time to be spent on the dissertation project and the little overlap in research themes with other university sites. Both factors make it difficult for the students to spend a substantial amount of time abroad.
- The average duration of dissertation projects within the graduate school has not yet proven to be shorter than in conventional Ph.D. programmes. However, until now only a small number of Ph.D. students successfully finished their thesis within the graduate school, so that no generalization can be made. Since most Ph.D. students from the graduate school perform their thesis work within (experimental) working groups together with various Ph.D. students that are not members of the EuroGK, it is not expected that their respective thesis duration within the EuroGK will significantly be shorter than those by their colleagues in the respective disciplines.

Based on the experience from the current granting period, the following developments are expected for the subsequent funding period (c.f. grant proposal for the extension period):

- The communication between disciplines will be improved by the following measures:
 1. the new colleague Prof. Dr. Ulrike Feudel (Theorie komplexer Systeme, Universität Oldenburg) is expected to bridge the gap between biological experiments and numerical models (based on physical principles).
 2. the new colleague Prof. Dr. Georg Klump (Zoophysiology, Universität Oldenburg) is expected to bridge the gap between psychophysics and neurobiology, especially in the field of audition.
 3. Another challenge for the participating groups is the build-up and experimental support of the new fMRI scanner in Oldenburg to be installed in mid 2002. Since experiments will be run that originate from auditory and visual neurobiology, psychophysics and neuropsychology, the gap between these disciplines will be narrowed by commonly using the same fMRI scanner.

4. The job market has over the last 3 years become less attractive for graduate students from the participating disciplines. This development stresses the need for further qualification in a field like neurosensory science and systems for young graduate students in order to be better qualified for the job market. Hence, it is expected that more qualified students will apply within the subsequent granting period and a more rigid admission procedure will have to be adopted if the application for a prolongation of the EuroGK will be granted.
- The relation between Groningen and Oldenburg and the communication between the corresponding groups from both sites will be improved by the following measures:
 1. The Rijksuniversiteit Groningen planned to purchase and install an MEG device for the Groningen Centre for Functional Brain Research, within BCN, which will be put into operation by mid-2003. Oldenburg (B. Kollmeier) has been granted an option to buy additional equipment or an extension of such an MEG unit for the year 2004. This will allow groups both from Groningen and Oldenburg to collaborate on MEG recordings for different sensory input configurations.
 2. The train connections will be improved between Groningen and Oldenburg (Nordwest-Bahn, eventually the Transrapid) enabling students and researchers to commute more easily between both sites independent from using private cars.
 3. The Groningen part of the EuroGK will try to get more Ph.D.-student and PostDoc-positions financed to work within the EuroGK. An increase of the funds available for the Dutch side will reduce the imbalance in funding between both sites. This will definitely help the Dutch groups to play a more active part in the common research and education programme.

Taken together, the applicants and collegiates of the European Graduate school neurosensory science and systems are convinced that the current granting period has been very successful. They want to express their thanks to the DFG, NWO and both universities that all contributed to making the EuroGK possible. Being able to build upon the positive experience from the current granting period, the applicants expect a further improvement both with respect to the structure and the contents of the EuroGK for the subsequent granting period.

European Graduate School: Neurosensory Science and Systems

Appendix

Report of the Graduates

Funding period 1.6. 2000-31.5.2003
(reporting date: February 2002)

1. Adaptation:

- Dr. Mark Pottek** (1) Retinoic acid as a retinal neuromodulator (2) A novel role for gap junction proteins in the retina (3) Light-evoked activity of single neurons in the intact mouse retina
- Werner Hoppenstedt** Identification and distribution of connexins in the turtle retina
- Frank Schütte** Identification and Characterization of Retinoic Acid-binding Proteins
- Timm Schubert** Coupling of alpha ganglion cells in the mouse retina
- Mailin Segger-Junius** Characterization of the dendritic transport of shank1 mRNA
- Martin Greschner** Influence of Identified Amacrine Cells on the Activity of Retinal Ganglion Cells during Simulated Eye Movements
- Theo Dinklo** Primary visual processes and spectral processing of insect photoreceptors
- Johannes Oberwinkler** Primary visual processes and spectral processing of insect photoreceptors
- Manfred Mauermann** Properties of finestructure in otoacoustic emissions and loudness perception
- Giso Grimm** Loudness of fluctuating sounds

2. Intermodal interaction and information integration:

- Annika Akerfelt** Investigating Voluntary Inhibition and Visuo-Tactile Interaction in Stop-Signal Experiments
- Frouke Hermens** Considerations on intermodal interaction
- Holle Kirchner** Visual-auditory interstimulus contingency effects in saccade programming
- Claudia Steinbrink** Relations between phonological and inflectional errors in spontaneous speech of German-speaking children with hearing impairment and with unimpaired hearing
- Dr. Petra Arndt** Intersensory integration in eye and arm movements
- Oliver Lindemann** A common network for Action Recognition and Action Execution
- Handy Oey** Development of a model of vibration perception
- Ingo Baumann** Perception of sound and vibration relating to comfort aspects
- Michael Bellmann** Experiments on the perception of whole-body vibration
- Ulrike Dicke** A biologically motivated neural circuit describing periodicity coding in the auditory system
- Stefan Ewert** Modeling the processing of envelope fluctuations in the auditory system

3. Imaging and „smart“ neurosensory analysis:

- Jose Ignacio Vallines Garcia** Oculomotor behaviour and brain activation
- Guido Plata**
- Dr. Roland M. Rutschmann** Human visual areas responding to disparity in Julesz patterns
- Frans Cornelissen** Event-related fMRI responses in the human frontal eye fields in a randomized pro- and antisaccade task
- Remco Renken** fMRI and PET analysis of auditory frequency and pitch repres
- Lucian Muresan** Pattern Detection and Estimation in Functional Neuroimaging
- Sonja Tomaskovic** fMRI and PET analysis of auditory signals, in particular speech
- Dirk Junius** Binaural auditory evoked potentials with virtual acoustics
- Sandra Fobel** Relation between sensorineural hearing impairment and steady-state amplitude modulation following responses

4. Applications:

- Mark Marzinzik** Noise reduction schemes for digital hearing aids and their use for the hearing impaired
- Michael Kleinschmidt** Classification of speech signals using perceptive features and its application to robust speech recognition
- Jörn Anemüller** Across-Frequency Processing in Convolutional Blind Source Separation
- Laila Kabous** Object oriented development of embedded systems
- Sandra Buss** Temporal and spectral analysis of acoustic signals by calculating contours
- Matthias Vormann** Development and Validation of a Psychoacoustic Measuring Procedure and Prediction-Model for the Assessment of Tonalness (Tonhaltigkeit) of Noises
- Jens Harting** Numerical methods in neurosensory science
- Christine Hartmann** Experiments for auditory-processing based automatic speech recognition

1. Adaptation

Dr. Mark Pottke, Neurobiologie, University of Oldenburg

(1) Retinoic acid as a retinal neuromodulator

The visual system exerts a suitable sensitivity over an extended range of light intensities which is achieved by a fine tuning of the neuronal pathways. Thereby, adaptation of the retinal circuits is attained by chemical messengers whose endogenous presence depends on the respective ambient light conditions. Yet, the properties of the known messengers are not sufficient to explain the full range of processes observed during retinal adaptation to changing light levels. This nourishes the search for additional modulators. Due to its well-known bioactivity (Dräger & McCaffery, 1997; Hyatt & Dowling, 1997) and its synthesis in the course of the phototransduction cascade (McCaffery et al., 1996), retinoic acid is a promising candidate for mediating light adaptational processes. It was therefore examined whether retinoic acid could influence those physiological properties of retinal cells that are modulated by the ambient light levels.

The experiments were performed in the fish retina which is best studied with respect to the adaptational processes. Intracellular recordings of light-induced responses were obtained from horizontal cells, and the effect of exogenously applied retinoic acid on the response properties was studied in the dark-adapted retina. Retinoic acid modulated the receptive field size, the overall responsiveness, and the spectral response characteristics of horizontal cells in a way identical to the situation when a previously dark-adapted retina was subjected to light adaptation. The effects were elicited within a few minutes introducing a new property of retinoic acid which is hitherto only known for its long-lasting effects in developmental processes.

These findings invoke retinoic acid as a novel modulator mediating light adaptation in the retina.

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(2) A novel role for gap junction proteins in the retina

Gap junctions are specialized intercellular contact sites representing the morphological correlate of electrical synapses. They consist of channels being composed of two hexameric membrane-spanning halves (hemichannels) each provided by one of the adjacent cells at a time. Recent findings in the fish retina propose the existence of such hemichannels, but not of a functional gap junction, at the terminal dendrites of horizontal cells, which are part of the cone synaptic complex (Janssen-Bienhold *et al.*, 2001). These hemichannels are composed of the protein connexin26 and are suggested to mediate the inhibitory feedback from horizontal cells to cone photoreceptors (Kamerlings *et al.*, 2001), which is a crucial step at the first level of synaptic integration in the neuronal cascade of vision, but yet not fully understood. Since the feedback action was first described in the turtle retina where it is a prominent feature, a multi-method approach based on molecular, anatomical, and electrophysiological techniques

was performed to look for evidences of an involvement of hemichannels in the turtle feedback action.

Connexin26 mRNA as well as protein were detected in the turtle retina. The connexin protein revealed a prominent localization in horizontal cell dendritic membranes near the photoreceptor synapse, a location evidentially being devoid of gap junctions and well-suited for interfering with the feedback action. To investigate the physiological implications of these findings, light-evoked responses from horizontal cells were intracellularly recorded in the intact retina, while hemichannels were chemically blocked. In these experiments, horizontal cells displayed changes of the resting membrane potential and light response characteristics that were in accordance with a suppression of the feedback.

Feedback in the fish retina is suggested to work via a nonsynaptic, so-called ephaptic, mechanism involving connexin26 hemichannels (Kamermans *et al.*, 2001). The actual findings from the turtle retina support this mechanism which therefore might be a common feature at the first visual synapse in vertebrates.

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- Kamermans, M., Fahrenfort, I., Schultz, K., Janssen-Bienhold, U., Sjoerdsma, T. & Weiler, R. (2001) Hemichannel-mediated inhibition in the outer retina. *Science (Wash. D.C.)*, **292**, 1178-1180.

(3) Light-evoked activity of single neurons in the intact mouse retina

In the past decades, intracellular recordings from retinal neurons have eminently contributed to the understanding of the retinal physiology of cold-blooded animals. Besides that, successful attempts have been performed to extend this method to the mammalian species. But unfortunately, this is mostly lacking for the mouse, which on the other hand is a favored experimental animal due to its easy accessibility to the transgenic techniques. Therefore, the current work is aimed at closing this gap.

The superfused eyecup preparation successfully used with cold-blooded animals was adapted to the mouse. In this kind of preparation, the retina retains contact with the pigment epithelium prolonging their viability and enabling changes of the adaptational condition with respect to the ambient illumination. At present, a few minutes lasting intracellular recordings of light-evoked activity could be performed from ganglion cells and horizontal cells. The future activity is directed towards a methodical improvement and an analysis of the neuronal behavior with respect to neuromodulators and the light adaptational condition.

Duration of dissertation: Jan 1997 – July 2000

Publications:

- Pottek, M. & Weiler, R. (2000) Light-adaptive effects of retinoic acid on receptive field properties of retinal horizontal cells. *Eur. J. Neurosci.*, **12**, 437-445.
- Weiler, R., Pottek, M., He, S. & Vaney, D.I. (2000) Modulation of coupling between retinal horizontal cells by retinoic acid and endogenous dopamine. *Brain Res. Rev.*, **32**, 121-129.
- Weiler, R., Pottek, M., Schultz, K. & Janssen-Bienhold, U. (2001) Retinoic acid, a neuromodulator in the retina. *Prog. Brain Res.*, **131**, 309–318.
- Pottek, M., Hoppenstedt, W., Janssen-Bienhold, U., Schultz, K. & Weiler, R. (2002) Contribution of connexin26 to electrical feedback inhibition in the turtle retina (submitted).

Conferences:

Apr 29–May 04, 2001: Meeting of the Association for Research in Vision and Ophthalmology (ARVO); Fort Lauderdale, USA

June 07–10, 2001: 28th Göttingen Neurobiology Conference / 4th Meeting of the German Neuroscience Society; Göttingen, Germany

Conference posters:

Pottek, M., Schultz, K., Janssen-Bienhold, U. & Weiler, R. (2001) Physiological and anatomical evidence for an involvement of connexin26 in the negative feedback loop between horizontal cells and cones in the turtle retina. *Invest. Ophthalmol. Vis. Sci.*, **42**, S671.

Pottek, M., Schultz, K., Janssen-Bienhold, U. & Weiler, R. (2001) Involvement of connexin26 hemichannels in the feedback pathway of the outer retina in fish and turtle. In: *The Neurosciences at the Turn of the Century. Proceedings of the 4th Meeting of the German Neuroscience Society 2001, Volume I* (Elsner, N & Kreutzberg, G.W., eds.) p. 80, Georg Thieme Verlag, Stuttgart, New York.

Awards:

Gerhard-Wachsmann-Preis 2001 awarded by the Universitätsgesellschaft Oldenburg

Attended courses:

Seminar of the SFB »Neurocognition« during summer term 2000 and winter term 2000/2001
Sept 08–09, 2000: Start-up symposium in Kloosterburen/NL; own talk given

Seminar of the graduate school »Neurosensory Science and Systems« during winter term 2000/2001, summer term 2000, and winter term 2001/2002; own talks given in Dec 2000 and Nov 2001

Monthly meeting in Groningen/NL and Oldenburg during winter term 2000/2001 and summer term 2001; own talk given in Dec 2000

Neurobiological seminar during winter terms 2000/2001 and 2001/2002

Workshops and other activities:

July 17–18, 2001: »Das Wissen der Forschung – verständlich für Laien« organized by the Deutsche Forschungsgemeinschaft; Kiel, Germany

Nov 29, 2001: Junior Scientists Workshop, Oldenburg; own talk given concerning the representation of the graduate school

Mar 10–16, 2002: Tutorial in the EMBO practical course »Electrical coupling in the retina«, Oldenburg

Dipl. Biol. Werner Hoppenstedt, Neurobiologie, Universität Oldenburg

Identification and distribution of connexins in the turtle retina

Connexins represent a family of integral membrane protein subunits forming gap junction channels between adjacent cells. The connexin proteins are separated into three groups and at present more than 20 connexin genes have been cloned. In the retina gap junctions represent an important mode of intercellular communication, allowing electrical and/or metabolic coupling between cells. Electrophysiological and dye or tracer coupling studies in all kind of vertebrate retinas have shown that all classes of retinal neurons are coupled, and thereby form independent neuronal networks within the plane of the retina. The expression of some of the connexins has been mainly demonstrated in the mammalian retina, including members of each subgroup. In comparison, information about the identity of connexins in the retina of lower vertebrates is sparse. The aim of one part of my dissertation project was to analyse the expression of connexin genes in the turtle retina. The turtle retina has been a favourite of electrophysiologists because of the ease and stability of intracellular recordings from the different neuronal elements. The identity of the connexin proteins that form homologous or heterologous gap junctions between the different retinal neurons and glial cells in the turtle retina was still unknown.

In order to analyse the expression of connexin genes reverse transcriptase-polymerase chain reaction was used to demonstrate the presence of connexin26, 32 and 45 mRNA in the turtle retina. By means of immunoblotting with Cx26-, Cx32- and Cx45-specific antibodies it was possible to show that the detected connexin transcripts were translated into protein.

Immunofluorescence microscopy with the same antibodies exhibited the cellular localization of Cx26, Cx32 and Cx45 with a distinct and partially overlapping expression pattern. Cx26 is expressed in both plexiform layers with the most intense labelling in the outer plexiform layer and to a weaker extent in two distinct sublayers of the inner plexiform layer. Additionally, punctate immunoreactivity was present in the ganglion cell layer and cell bodies of neurons in the inner nuclear layer were faintly labelled. Cx32 immunoreactivity was restricted to the outer plexiform layer and the distal part of the inner nuclear layer, most likely due to Cx32 expression in horizontal cells. Cx45 immunoreactivity was located in the inner segments of photoreceptors and in the inner nuclear layer. The labelling pattern in the inner nuclear layer appeared as a punctate staining between cell bodies, suggesting that retinal cells exhibit gap junctions between somata.

In summary, the results illustrated that Cx26, Cx32 and Cx45 show a distinct and partially overlapping pattern in the turtle retina, with Cx26 showing a prominent expression in the outer and inner retina, while Cx32 expression is restricted to the outer plexiform layer and Cx45 was localized most prominent in the inner nuclear layer.

Publications

Janssen-Bienhold U, Schultz K, Hoppenstedt W & Weiler R (2001): Molecular diversity of gap junctions between horizontal cells. *Prog Brain Res* 131: 93-107.

Hoppenstedt W, Janssen-Bienhold U, Schultz K, Ammermüller J & Weiler R (2001): Connexin26, 32 and 45 expression in the turtle retina. In: *Proceedings of the 4th Meeting of the German Neuroscience Society 2001* (Elsner & Kreutzberg, eds): 77. Thieme, Stuttgart.

Schütte F, Janssen-Bienhold U, Hoppenstedt W, Schultz K, Dermietzel R & Weiler R (2001): Dopamine-induced modulation of connexin43 and its localization in horizontal cells of the fish retina. In: *Proceedings of the 4th Meeting of the German Neuroscience Society 2001* (Elsner & Kreutzberg, eds): 78. Thieme, Stuttgart

Conferences

June 7-10, 2001: 4th Meeting of the German Neuroscience Society
28th Göttingen Neurobiology Conference, Göttingen, D

Dipl.-Biol. Frank Schütte, Neurobiologie, Universität Oldenburg

Identification and Characterization of Retinoic Acid-binding Proteins

The aim of my dissertation project is the identification and characterization of retinoic acid-binding proteins. Recent studies have shown, that retinoic acid (RA) induces physiological effects in dark-adapted carp retinal horizontal cells which are also induced by light (Weiler *et al.*, 1998; Pottek & Weiler, 2000; Zhang & McMahon, 2000). This suggests that RA acts as a light-mediating modulator. The mechanisms by which RA mediates its effects are still unknown. Zhang & McMahon (2000) have shown that only external application of RA to retinal horizontal cells affects coupling between horizontal cells, indicating an external binding site on horizontal cells.

In order to estimate the binding characteristics of retinoic acid to retinal proteins, a binding assay with radiolabeled retinoic acid and different retinal fractions was established. In this assay the separation of bound and unbound ligand is performed with activated charcoal (Norit A[®]) which is normally used only for binding assays with cytosolic fractions. Furthermore a photoaffinity labeling assay (modified from Bernstein *et al.*, 1995), using UV to crosslink radiolabeled retinoic acid to the RA-binding proteins, was established in order to prepare retinoic acid-binding proteins for further analysis via SDS gel electrophoresis.

The photoaffinity labeling assay revealed the existence of several retinoic acid-binding-proteins in the molecular weight range between 15 and 50 kD in cytosolic and membrane fractions of the carp retina. Of special interest is a membrane protein with a molecular weight of approximately 48 kD, which is similar to the molecular weight of the retinoic acid receptor alpha (RAR α , ~55 kD) and might indicate the existence of an RAR α -like protein in retinal membranes. This assumption is supported by immunobiochemical and immunohistochemical findings. These show RAR α -immunoreactivity in retinal membrane and horizontal cell fractions (~ 48 kD protein) and cryosections of the retina as well as dissociated horizontal cells.

Following the initial stage in which the binding assay was established, this assays shall now be used to estimate the binding characteristics of the protein-ligand-interaction. The photoaffinity labeling assay allows a further characterization of the RA-binding proteins by means of 2D-gel electrophoresis and immunobiochemical techniques (for example immunoprecipitation).

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- Zhang, D.Q. & McMahon, D.G. (2000). Direct gating by retinoic acid of retinal electrical synapses. *Proc. Natl. Acad. Sci.* 97: 14754-14759.

Thesis period: 1.4.2001 – 31.3.2004 (projected)

Own publication: Schütte, F.; Janssen-Bienhold, U.; Hoppenstedt, W.; Schultz, K.; Dermietzel, R. and Weiler, R. (2001). Dopamine-induced modulation of connexin43 and its localization in the fish retina. In: *The Neurosciences at the Turn of the Century. Proceedings of the 4th Meeting of the German*

Neuroscience Society 2001, Volume I (Elsner, N & Kreutzberg, G.W., eds.) p. 78, Georg Thieme Verlag, Stuttgart, New York.

- List of attended courses:** Neurobiological seminar, 2000/2001, Oldenburg
Seminar of the graduate school »Neurosensory Science and Systems«, 2001, Oldenburg; own talk given May 2001 “
Seminar, 2001, Groningen/NL and Oldenburg
Seminar of the graduate school »Neurosensory Science and Systems«, 2001/2002, Oldenburg
Neurobiological seminar, 2001/2002, Oldenburg
- List of attended conferences:** June 07-10, 2001: Göttinger Neurobiologen-Tagung 2001, Göttingen, D

Dipl. Biol. Timm Schubert, Neurobiologie, Universität Oldenburg

Coupling of alpha ganglion cells in the mouse retina

Retinal ganglion cell projection to more complex structures of the brain provide the basis for an internal representation of the visual world. Due to the convergent organization of the retina, all information of the visual environment is encoded in the ganglion cell activity. The aim of this project is to study the cellular and molecular basis for correlated activity of ganglion cell ensembles. Coupling of cells via fast electrical synapses is essential for the exact timing of correlated activity. Gap junction-mediated coupling is a common retinal feature, and direct intercellular communication plays an important role in retinal information processing. In the mouse retina, coupling of horizontal and AII amacrine cells and its functional implication have been extensively studied (He et al., 2000, Weiler et al., 2000, Feigenspan et al., 2001). However, it is not clear to what extent coupling is present among mouse ganglion cells. In the dissertation project presented here, the tracer coupling pattern in neurons are investigated that have morphologically been identified as alpha ganglion cells. Alpha ganglion cells were described in previous reports in several other mammalian species (Peichl and Wässle, 1991).

A second approach is the use of a Connexin36-knock-out mouse strain. Connexin36 is a membrane protein that forms gap junctions which function as electrical synapses. In our experiments alpha ganglion cells of retinae obtained from these mice do not show any coupling pattern indicating that Connexin36 plays an important role for the synaptic connections of alpha ganglion cells.

Ganglion cells of isolated retinae were filled with the tracer Neurobiotin. The spread of Neurobiotin was visualized by incubation of the retina with streptavidin-indocarbocyanine (Cy3), and the coupling pattern was examined using a confocal microscope.

Tracer studies in mouse retinal whole-mount preparations revealed a population of ganglion cells that could be identified as alpha ganglion cells by their large somata, their stratification depth in the inner plexiform layer and the branching pattern of the dendritic processes. Injected alpha ganglion cells showed tracer coupling with other alpha ganglion cells and at least one population of wide field amacrine cells. A lack of coupling in the Connexin36-deficient mice has already been observed in these studies although it is still unknown where Connexin36 is located in the synaptic organisation of the alpha ganglion cells. The cellular localisation of the connexin and physiological consequences of these described findings will be examined in future experiments that have already started.

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- Weiler R., He S., Vaney D.I.: Retinoic acid modulates gap junctional permeability between horizontal cells of the mammalian. *Eur. J. Neurosci.* 1999 Sep;11(9):3346-50.

Thesis period:

1.10.1999 – 31.12.2002 (projected)

Own publication:

T. Schubert, A. Akopian, R Weiler: Glutamate receptor activation increases intracellular calcium levels of salamander third order neurons. In: *The Neurosciences at the Turn of the Century. Proceedings of the 4th Meeting of the German*

Neuroscience Society 2001, Volume I (Elsner, N & Kreutzberg, G.W., eds.) p. 78, Georg Thieme Verlag, Stuttgart, New York.

A. Akopian, T. Schubert, R. Weiler: Glutamate-induced calcium accumulation in salamander retinal neurons. In: Investigative Ophthalmology and Visual Science, Abstract Issue March 15, 2001 Volume 42, No. 4

List of attended courses: Neurobiological seminar, 2000/2001, Oldenburg
Seminar of the graduate school »Neurosensory Science and Systems«, 2001,
Seminar, 2001, Groningen/NL and Oldenburg Seminar of the graduate school »Neurosensory Science and Systems«, 2001/2002, Oldenburg
Neurobiological seminar, 2001/2002, Oldenburg

List of attended conferences: April 29- May 4, 2001 ARVO-Annual meeting, Florida, USA
June 07-10, 2001: Göttinger Neurobiologen-Tagung 2001, Göttingen, D

Dipl. Biol. Mailin Segger-Junius, Neurobiologie, Universität Oldenburg

Characterization of the dendritic transport of shank1 mRNA

Activity-dependent long-lasting modifications of synaptic structure and function seem to be a key event for learning and memory formation on the molecular level. These modifications require a *de novo* synthesis of synaptic proteins. Local protein synthesis in dendrites under control of the synapse itself may thus contribute to modify activated synapses. This concept implicates that mRNAs are present locally in dendrites, and that proteins synthesized from these mRNAs can mediate the use-dependent modulation of the synapses.

Recently, a novel family of multidomain proteins termed shank has been identified. The three members of the shank family, shank1 – 3, possess multiple protein-protein interaction domains including ankyrin repeats, an SH3 domain, a PDZ domain, several prolin-rich regions and a C-terminal sterile α -motif. The mRNAs of the shank proteins can be alternatively spliced. It has been shown that shank proteins are major scaffolding proteins in the postsynaptic density of excitatory synapses in the mammalian CNS. In contrast to most mRNAs, the mRNAs of all three shanks are dendritically localized in different regions of the rat brain. Shank1 mRNA are found in the molecular layers of the hippocampus and in the dendritic fields of Purkinje cells. The widespread presence of shank1 mRNA in dendrites suggests that dendritic synthesis of shank proteins plays a major role in synaptic development and plasticity.

The purpose of this dissertation project is to analyze the different splice-variants of shank1 with regard to their subcellular distribution and to identify the signal sequence in the shank1 mRNA (*cis*-acting dendritic targeting element) which is responsible for the dendritic transport.

The first results with radioactive *in situ* hybridizations show a prominent dendritic localization for all splice-variants of the shank1 mRNA, with differences only in their expression strength. Because the dendritic targeting of shank1 transcripts is independent of the complex alternative splicing in the 5' part of the coding region of the shank1 gene, it is very likely that the dendritic targeting element of the shank1 mRNA is localized in the 3' region.

This is confirmed in a cellular expression system of primary hippocampal neurons. For this, several fragments of the shank1 cDNA were cloned into a eukaryotic expression vector and transfected in hippocampal neurons, resulting in the expression of an EGFP- (enhanced green fluorescent protein) shank1 chimeric RNA. The intracellular distribution of the chimeric transcripts was analyzed by non-radioactive *in situ* hybridization with a probe directed against the EGFP-part. Only after transfection with transcripts possessing the 3' end of the shank1 sequence (with part of the coding region and the 3' UTR) chimeric RNA can be detected in the dendrites of the neurons. Transcripts with the 5' part of shank1 or from the empty vector are restricted to the cell bodies and not transported into dendrites. These results indicate that the dendritic targeting of the shank1 mRNA is mediated by a sequence element in the 3' region of the mRNA. Future work will require a limitation of the shank1 sequence in chimeric transcripts to allow for a precise localization of the dendritic targeting element in the mRNA of shank1.

Thesis period:

1.7.2000 – 30.6.2003 (projected)

**Own publications
and lectures:**

Segger-Junius, M., Bockmann, J., Gundelfinger, E. D., Kreutz, M., Richter, D., Kreienkamp, H.-J. and Böckers, T. M. (2002): "Differential expression and dendritic localization of transcripts of all three members of the ProSAP/SSTRIP/shank family of synaptic proteins: a dendritic targeting element in the 3' region of shank1 mRNA", *Journal of Neuroscience*, submitted

Segger-Junius, M., Böckers, T. M., Richter, D. and Kreienkamp, H.-J. (2002): "Characterization of the dendritic transport of shank1 mRNA", poster presented at the Symposium "Structure of the Nucleus and Trafficking of RNPs in the cell", MPI for Biophysical Chemistry, Göttingen (Germany).

List of attended courses:

EuroGK seminar Oldenburg; own talk given December 2001 "Characterization of the dendritic transport of shank mRNAs"

List of attended conferences:

January 2001: monthly meetings Groningen/Oldenburg

Jan 31-Feb 2, 2002: Symposium "Structure of the Nucleus and Trafficking of RNPs in the cell", MPI for Biophysical Chemistry, Göttingen (Germany)

LA Gym. Martin Greschner, Neurobiologie, Universität Oldenburg

Influence of Identified Amacrine Cells on the Activity of Retinal Ganglion Cells during Simulated Eye Movements

The activity of retinal ganglion cell populations represents the only source of information about the visual world available to the brain. Therefore, the temporal change in features of visual objects must be encoded within the limited response interval of ganglion cells. It is strongly suggested that most of the mechanisms involved are influenced or exclusively driven by amacrine cells. Amacrine cells are thought to influence the receptive fields of ganglion cells (Taylor, 1999), their direction selectivity (Ammermüller et al., 1995), their synchronization (Brivanlou et al., 1998; Vaney, 1994) and their modulation in adaptation and gain control. They are morphologically, physiologically and neurochemically the most diverse group of retinal interneurons, adding up to 30 to 40 different types, depending on the species. Within the retina, amacrine cells account for 30-40 % of all non-photoreceptor cells.

This project is set up to study the influence of identified amacrine cells on the activity of simultaneously measured ganglion cells. In particular, the influence on the synchronization of ganglion cells during simulated eye movements will be measured and analyzed. Through the combination of multi-electrode and intracellular measurements, followed by dye-filling of the cell, specific functions of identified amacrine cells shall be revealed.

During the initial period, the evaluation of turtle eye movements has been completed and the measurement setup has been completely rebuilt. The retina is vertically fixed in a special holder to guaranty steady ringer flux, stable temperature and a visual stimulation with simultaneous multi-electrode and intracellular measurements. For this, special measurement protocols have been established.

So far, several pilot experiments have been performed.

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- Brivanlou ICH, Warland DK, & Meister M (1998) Mechanisms of concerted firing among retinal cells. *Neuron* 20: 527-539
- Taylor WR (1999) TTX attenuates surround inhibition in rabbit retinal ganglion cells. *Vis Neurosci* 16: 285-290.
- Vaney DI (1994) Patterns of neuronal coupling in the retina. *Prog Ret Eye Res* 13: 301-355

Thesis period: 12.2000 – 12.2003 (projected)

(15.12.2000 - 31.3.2001 stipend from Euro-GK, since 1.4.2001 associate member)

Publications:

- Wilke SD, Thiel A, Eurich CW, Greschner M, Bongard M, Ammermüller J & Schwegler H (2001), Population coding of motion information in the early visual system. *JCompPhysiol*
- Greschner M, Bongard M, Rujan P & Ammermüller J (2002), Retinal ganglion cell synchronization by fixational eye movements improves stimulus feature estimation. *Nature Neurosci* (resubmitted)
- Ammermüller J, Greschner M, Voges N, Bongard M (2000), Stimulus feature extraction from the ensemble activity of retinal ganglion cells: Experiments using periodic stimuli with and without external information, and stimuli simulating microscopic eye movements. in Mertsching B (ed) *Dynamische Perception. Proceedings in artificial intelligence.* Infix Sankt Augustin.
- Wilke SD, Thiel A, Eurich CW, Greschner M, Bongard M, Ammermüller J, Schwegler H (2001), Extracting Motion Information Using a Biologically Realistic Model Retina.

Proceedings of the 9th European Symposium on Artificial Neural Networks; 323-328; Verleysen, M; Evere, Belgium

Thiel A, Wilke SD, Eurich CW, Greschner M, Bongard M, Ammermüller J, Schwegler H (2001), Temporally faithful representation of salient stimulus movement patterns in the early visual system. in Visual Attention Mechanisms; Cantoni V, Petrosino A, Marinaro M; Plenum Press; New York

Abstracts:

Thiel A, Wilke SD, Greschner M, Bongard M, Ammermüller J, Eurich CW (2000), Neural responses in retina and optic tectum reflect the temporal structure of salient stimulus movement patterns. 4th Conf Cognitive Neural Systems. Boston

Greschner M & Ammermüller J (2000), Microscopic eye movements synchronize retinal ganglion cell activity. Perception 29 (suppl): 30.

Greschner M, Bongard M, Ammermüller J (2000), Ganglion cell activity in the turtle retina is synchronised by microscopic eye movements. Zoology 103, (suppl III)

Greschner M, Voges N, Ammermüller J (2001), Stimulus feature extraction from the ensemble activity of retinal ganglion cells: Experiments simulating microscopic eye movements. Proceedings of the 28. Göttingen Neurobiology Conference; Georg Thieme Verlag Stuttgart

Thiel A, Wilke SD, Greschner M, Bongard M, Ammermüller J, Eurich CW (2001), The time course of retinal population activity faithfully represents rapid changes in stimulus velocity. Proceedings of the 28. Göttingen Neurobiology Conference; Georg Thieme Verlag Stuttgart

Ammermüller J, Greschner M (2001), Stimulus feature extraction from retinal ganglion cell ensembles synchronized by fixational eye movements. Ophthalmic research, Vol. 33, Supplement 1

Attended courses:

Seminar of the graduate school »Neurosensory Science and Systems«

Seminar Groningen/NL and Oldenburg

Seminar of SFB 517 Neurocognition

Neurobiological seminar

NeuroNord Kurs, „Neural Modeling“, Bremen, 19.3-23.3.2001

Attended conferences:

Jahrestagung, Deutsche Zoologische Gesellschaft, Bonn, 2000

European Conference of Visual Perception, Groningen, 2000

Neurobiologie-Tagung, Göttingen, 2001

Theo Dinklo, Johannes Oberwinkler, Neurobiophysics, Groningen

Primary visual processes and spectral processing of insect photoreceptors

Many insects are highly visual animals that heavily rely upon their light sensitive cells to gather optical information from their surroundings. From the optical signals, the light sensitive cells produce an electrical signal. The molecular components involved in generating this light response are gradually unraveled, and it is becoming apparent which of the different molecules interact, and how they do this. However, the knowledge gathered in this research, by molecular biology, optical and electrophysiological measurements, is rarely integrated to form a quantitative theory. It is our view that quantitative descriptions are essential for gaining insight in the mechanisms of biological cells; i.e., the functional possibilities and the physical limitations of a cell, especially of a neuron, can only be clearly seen by constructing quantitative models.

Three distinct but related areas of photoreceptor research are quite amenable to quantitative modelling. The first area is that of the visual pigments, specifically the wavelength dependence of their absorption characteristics and the cycling of the visual pigment molecules between the different states. The second area is that of the changes in membrane permeability caused by visual pigment conversions, and how they translate into changes of membrane currents, potentials, and ion concentrations. For the data we use own experimental results as well as the rapidly accumulating literature on fly photoreceptors, specifically *Drosophila*. The third area is that of the compound eye, composed of thousands of ommatidia, each having a set of eight or nine photoreceptor cells. The ommatidia together sample the visual environment. The spatial and spectral characteristics of the ommatidia determine the optical information available to the brain.

For modelling the photochemical processes of visual pigment and spectral filtering by the corneal multilayers or by the visual waveguide properties, we have developed a widely used visual pigment template. We thus have been able to understand the complex spectral organization of the retina of flies and butterflies.

We have produced an electro-diffusion model of the electrical and ionic events in a microvillus, i.e. the fundamental subunit of a *Drosophila* photoreceptor cell where the elementary response, to a single photon, is generated. We thus have found that extremely large changes in the calcium ion concentration can be produced by opening only a few light-dependent channels. The computational analysis has been corroborated with experimental results.

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Dipl. Phys. Manfred Mauermann, Medizinische Physik, Universität Oldenburg

Properties of finestructure in otoacoustic emissions and loudness perception

The aim of the dissertation project is to establish a more detailed understanding for the principles of the generation of otoacoustic emissions (OAE) and its relation to the psychoacoustic capabilities of human hearing. One important aspect of this project is to clarify which regions of the cochlea contribute to the OAE measured in the sealed ear canal.

For distortion product otoacoustic emissions (DPOAE) with frequencies below the primary frequencies ($2f_1-f_2$, $3f_1-2f_2$ etc.), it is widely accepted that the generation site is the overlap region of the excitation patterns of the two primaries, which has a maximum close to the characteristic site around f_2 . But it is still a point of discussion whether the generation site is the only source or to what extent other sources might also contribute to the emission. The DPOAE fine structure found in human subjects is closely related to this question of DPOAE sources. Therefore as part of the dissertation project a set of critical experiments on the properties of DPOAE fine structure in normal hearing (see own publication Mauermann et al., 199a) and hearing impaired subjects (see own publication Mauermann et al., 199a) has been performed. In a close collaboration with Peter van Hengel (BCN, Rijksuniversiteit Groningen) the experimental results had been modeled in an active nonlinear time domain model of the cochlea. The good correspondence between experimental and model results gave strong evidence for two interfering components contributing to the DPOAE measured in the sealed ear canal. The improved knowledge about the mechanisms of DPOAE generation - based on this work and the results from other researchers - might be used to develop more sensitive audiometric tools.

The initial DPOAE component generated close to characteristic place of f_2 on the basilar membrane (BM) is a direct result of the nonlinear processing in the cochlea. While the second component is a result of coherent reflection around the distortion product frequency (fdp) site. Heitmann (Heitmann et al, J Acoust Soc Am., 1998; 103: 1527-153) presents a third tone close to fdp to suppress the second DPOAE component. With a suppressor which guarantees a) a complete suppression of the second component while b) not significantly influencing the initial DPOAE component this paradigm allows to measure so called single generator DPOAE (sgDPOAE). SgDPOAE directly reflect the nonlinearity of cochlear mechanics. The compressive characteristic of loudness perception most probably is also based on the nonlinear behavior of BM motion. So the growth behavior of sgDPOAE might be a objective tool to detect recruitment in subjects with a light to moderate hearing loss. Therefore a further aim of the dissertation project is to investigate a relation between these two i.e., sgDPOAE growth functions and recruitment. As a first step we just investigate suppressor growth functions (SGF) to find optimal suppressor levels (to suppress the second DPOAE component) for a whole set of different primaries levels.

In close collaboration with Prof. Glenis Long (now City University New York) we compared the fine structure in isophone contours, threshold in quiet and otoacoustic emissions. The question behind this part of the dissertation project is: How are the properties of loudness perception influenced by cochlear preprocessing? Since OAE provide a noninvasive method to investigate cochlear properties this question is closely related to questions of the similarities of properties of hearing thresholds, loudness perception and OAE. There have been several studies investigating the relation of OAE properties and hearing near threshold (reviewed in Long, G., Hear Res. 1998; 119(1-2):49-60.), but there exists only a small database focussing the relation of OAE and detailed properties of hearing above threshold.

Therefore we have investigated the extent to which spectral fine structure can be observed in estimates of loudness perception. Measurements of isoloudness contours from 1600 to 2000 Hz has been performed at a high frequency resolution (25 Hz) for several levels up to 70 phon. These data will be compared with the threshold in quiet (12.5 Hz frequency resolution),

DPOAE fine structure and the fine structure of SFOAE using different paradigms as suggested by Brass and Kemp (J Acoust Soc Am. 1991;90(5):2415-2427) and Keefe (J Acoust Soc Am. 1998;103(6):3489-3508) as well as a simple level difference method. A good correspondence of the different fine structures even at levels well above threshold provides evidence that properties of the perceptual quantity loudness are reflected in properties of otoacoustic emissions, i.e. at least up to moderate levels loudness perception is strongly influenced by the cochlear preprocessing.

Thesis period: Sept.1997 – May 2002 (projected) - with a leave of 1 year to build up the study program “hearing technology and audiology” at the university of Applied Sciences, Oldenburg

Own publications and lectures:

- Mauermann, M., S. Uppenkamp und B. Kollmeier, (1998), "Messung von Verzerrungsprodukt-Emissionen mit Chirp-Signalen," in Fortschritte der Akustik - DAGA 98, pp. 316-317, Deutsche Gesellschaft für Akustik e.V., Oldenburg.
- Mauermann, M., S. Uppenkamp und B. Kollmeier, (1998), "DPOAE fine structure for different shapes of hearing loss - evidence for the distortion product frequency place as a source of DPOAE fine structure." in Abstracts of the 21th ARO midwinter research meeting, #595 (A).
- Mauermann, M., S. Uppenkamp, et al. (1998). DPOAE Feinstruktur und ihre Implikation für Cochlea Modelle. Medizinische Physik. L. Vogtmann. Dresden, DGMP: 367-368.
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- Mauermann, M., S. Uppenkamp, P.W.J. van Hengel und B. Kollmeier, (1999a) "Evidence for the distortion product frequency place as a source of distortion product otoacoustic emission (DPOAE) fine structure in humans. I. Fine structure and higher order DPOAE as a function of the frequency ratio f_2/f_1 ," J Acoust Soc Am, vol. 106: 3473-3483.
- Mauermann, M., S. Uppenkamp, P.W.J. van Hengel und B. Kollmeier, (1999b), "Evidence for the distortion product frequency place as a source of distortion product otoacoustic emission (DPOAE) fine structure in humans. II. Fine structure for different shapes of cochlear hearing loss," J Acoust Soc Am, vol. 106: 3484-3491.
- Mauermann, M., G. R. Long, et al. (2000a). „Comparison of fine structure in isophone contours, threshold in quiet and otoacoustic emissions.“ Abstracts of the 23th ARO midwinter research meeting, St. Petersburg Beach, Florida, #984 (A).
- Mauermann, M., G. Long, et al. (2000b). „Vergleich der Feinstruktur von Isophonen, Ruhehörschwelle und otoakustischen Emissionen.“ in Fortschritte der Akustik -

DAGA 2000, Oldenburg, Deutsche Gesellschaft für Akustik e.V., pp.

Lecture/Tutorial EuroGK Blockpraktikum „Psychophysik und Neurosensorik“, 2000 and 2001, Oldenburg

List of attended courses:

Sep 2000: EuroGK workshop in Kloosterburen, NL; talk given: “Cochlear fine structure and fine structure in loudness perception”

Aug 2001: Summerschool and Symposium "Psychophysics, physiology and models of the central auditory system", Bad Zwischenahn, Germany;

Regularly (in 2000): EuroGK seminar Oldenburg;

List of attended conferences:

Mar. 1998 AHEAD European Commission Workshop “Advances in Otoacoustic Emissions”, Basel, Switzerland

Feb. 1998 ARO, St. Petersburg Beach, USA.

Mar. 1998 DAGA, Zürich, Switzerland

Feb. 2000 ARO, St. Petersburg Beach, USA

Mar. 2000 DAGA, Oldenburg, Germany

Aug. 2001 Workshop on "Perceptual Consequences of Cochlear Nonlinearities", HWK Delmenhorst, Germany

List of research stays:

Feb. 1998 Visiting Prof. Long and Phd. C. Talmadge at Purdue University (Indiana) for one week. Detailed discussions about cochlea modeling and OAE measurement techniques

Dipl. Phys. Giso Grimm, Medizinische Physik, Universität Oldenburg

Loudness of fluctuating sounds

Giso Grimm worked only for a short period (01.04.01 – 31.05.01) as a graduate within the graduate school in order to write up the results of his Diplom thesis as a publication for an international journal. During this time he decided not to pursue a dissertation project and to leave the graduate school in order to take up an attractive job offer.

Reference:

Grimm, G., V. Hohmann, Verhey, J. (2002). "Loudness of fluctuating sounds." *Acustica united acta acustica* (in press)

2. *Intermodal interaction and information integration*

B.Sc. Annika Åkerfelt, Institut für Kognitionsforschung, Universität Oldenburg

Investigating Voluntary Inhibition and Visuo-Tactile Interaction in Stop-Signal Experiments

The aim of the dissertation project is to investigate the interaction between visual and tactile information in the planning, selection and execution of actions. These processes will be studied on both behavioural and neural level, and mathematical models of the cognitive operations involved will be formulated and evaluated on the basis of the data obtained. An essential part of voluntary control of action is the ability to inhibit programmed responses to stimuli if required. The stop signal, or countermanding, paradigm is a reaction time task used to investigate this capacity, how it differs across conditions and populations, and what it may reveal about related issues such as attention, self-monitoring of action, or the effects of participant strategies on performance.

In stop signal experiments the participant is in each trial presented with a go signal requiring a fast and relatively uncomplex response. In a minority of trials, a further stimulus (the stop signal) is also presented, signalling that the well-practised response to the go signal should be inhibited. By choosing the delays between go and stop signals appropriately the effect of the stop signal can be mapped as an inhibition function, and the unobservable “reaction time“ to the stop signal (the stop signal processing time) can be estimated from the response time distributions. These results are employed in evaluating and developing models of the cognitive processing involved in inhibition (e.g., Logan, 1994; Colonius, 1990; Hanes & Carpenter, 1999)

As well as using the stop signal paradigm in my experiments for exploring inhibition behaviour, another subject of investigation is intersensory interaction. Thus, the first experiment, for which testing was finished in December 2001, utilised visual go signals requiring saccadic responses and tactile stop signals. Previous research has tended to use unimodal visual signals or investigated interactions between visual and auditory signals, as well as using manual responses (e.g., De Jong et al., 1990; Logan & Irwin, 2000). Hence, a first significant outcome of this experiment is the immediate result of the efficacy of tactile stop signals. The results obtained are being analysed further to test the fit of existing processing models on the data and to explore possible differences between the present results and those in the literature using other conditions. A general difference to previous work using auditory stop signals seems to be the somewhat longer stop signal processing times estimated from the present results (Colonius et al., 2001).

Concurrently, the subsequent experiments of the thesis work are planned. The combination of visual and tactile stimuli in stop signal processing will remain the focus of investigation throughout the dissertation. In addition to the behavioural measurements used in the present experiment, one of the planned experiments will include combining these with EEG. That experiment is being prepared in collaboration with researchers at Helsinki University of Technology (Espoo, Finland).

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- Logan, G.D., & Irwin, D.E. (2000). Don't look! Don't touch! Inhibitory control of eye and hand movements. *Psychonomic Bulletin and Review*, **7**, 107-12.

- Thesis period:*** 1.9.2000 – 31.8.2003 (projected)
- Own publications and lectures:*** January 2002: Invited colloquium lecture, BioCog, Universität Leipzig, Germany, "Using Tactile Stop Signals in Countermanding Experiments"
- List of attended courses:*** January 2001: European Seminar on Mathematical Psychology, Leuven, Belgium (1 week), supported by Erasmus/Socrates
 March 2001: Neural Modelling (course), Bremen, Germany (1 week), supported by Hanse-Wissenschaftskolleg
 September 2001: Helsinki Summer School in Cognitive Neuroscience, Lammi, Finland (1 week), supported by the Academy of Finland, Poster presented: "Using a Tactile Stop Signal to Countermand a Saccadic Movement (1)"
- List of attended conferences:*** December 2001: The 13th BOMG Annual Meeting, London, Great Britain (1 day), supported by the Wellcome Trust, Poster presented: "Using a Tactile Stop Signal to Countermand a Saccadic Movement (2)"
- Research stay*** Helsinki University of Technology, Espoo, Finland, (projected: September - December 2002)

Frouke Hermens, Institut für Kognitionsforschung, Universität Oldenburg

Considerations on intermodal interaction

For the description of data from a focussed attention bimodel perception task, a model consisting of two stages was developed by Colonius and Arndt (2001). The parameters of the model were estimated using the method of moments, using predicted means and variances. This method was evaluated by sampling data points from the model with known parameter values, and estimating the parameters by using the method and the sampled data points. The method is found, on average, to estimate the correct parameter values, but a large variation of parameter estimates is found. One way to improve data estimation using the method of moments, would be by bootstrapping (Efron & Tibshirani, 1993). In addition, it was tried to implement a maximum likelihood (ML) estimation method for the model. In the ML method the likelihood of observing the entire set of data points given the model (assuming independence in sampling) is computed and this likelihood is maximized. Unfortunately it was found that in most of the parameters the likelihood function was monotonically increasing or decreasing. This makes it impossible to maximize the function, and still obtain finite parameter values outside the borders of the searched domain. Also by setting the problematic parameter values to the values used to sample data from the model no stable estimation of the remaining parameters could be obtained. Another disadvantage of the ML estimation was that the method proved to be very slow. In order to obtain parameter estimates within an hour, one should not enter more than about 300 data points into the estimation procedure. It was suggested to use Gibb's sampling instead. But if exact computation of the likelihood function is already very slow, it is not expected that this method will result in good parameter estimates for large data set within a short amount of time. A part of the computation of the likelihood that might be responsible for the long computation times, is the numerical integration procedure to estimate the cumulative Gauss part of the likelihood function. Because the cumulative Gauss function can be approximated quite well by the logistic function, the estimation method is changed by replacing the cumulative Gauss by the logistic function. This results in faster, and more stable parameter estimates, but these parameter estimates seem to deviate systematically from the real values of the parameter estimates, both when the cumulative Gauss and the logistic function are used to generate the data.

Because the two-stage model, in which facilitation in the second stage takes place if a certain process in the first stage wins the race, does not give excellent fits of the data, a new two-stage model is proposed.

In this new two-stage model facilitation takes place if there is less than a certain amount of finishing time difference of the two processes to race in the first stage. Because exact derivations of the probability density function of the total process duration are difficult to obtain, a simulation study of the new version of the model was carried out first. Histograms, mean, and variance of the total process durations were obtained by simulation, but unfortunately no data was available to me to compare these outcomes with real data.

In the literature there are some doubts about the outcomes of bimodel interaction experiments in general.

In the article by Mordkoff and Yantis (1991) it is shown that all evidence for intermodal interaction found until now can be explained by contingencies in the used design. Mordkoff and Yantis demonstrate that if these contingencies are eliminated, no evidence of interaction is found. A model of divided attention is proposed, but no evidence for the various substages of the model is provided. In two experiments it was tried to find additional evidence for the various substages of the model, and for the contingency explanation. In the first experiment stimulus-response location congruency was varied along with the number of targets, and the onset asynchrony between the stimuli (SOA). Congruency in stimulus-response location is

shown (Simon & Berbaum, 1990) to be affecting the motor stage, which is the final state in the race model. This motor stage is not part of the race, so no interaction between SOA and stimulus-response location is expected. Unfortunately many different patterns of results are found across participants, and across sessions, which make it very likely that strategy effects affected the results.

In the second experiment, the visibility of the stimuli was varied. It was found that the data of this experiment fitted the race model very well. The experimental method of this experiment might later on be used to estimate the duration of the identification stage. In the psychology of reading, for example, (Rayner & Pollatsek, 1989) several other methods of estimation the duration of this stage have been used, but each of them had certain problems associated with it.

To study the influence of divided attention on perception a masking experiment was carried out similar to the experiments by Enns and Di Lollo (2000). In this experiment either two, eight, or sixteen possible targets were shown to the participant for a very brief time, after which the target was highlighted by a four dot pattern around the former stimulus location. The task of the participants was to identify the highlighted target. Performance is found to increase with delay of the four dot pattern for two targets, while a U-shaped function is found for eight or sixteen targets.

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- Simon, J.R., & Berbaum, K. (1990). Effects of conflicting cues on information processing: The 'Stroop effect' vs the 'Simon effect', 159-170.

Funded thesis period: 01.09.00 – 31.08.01

Dr. phil. Holle Kirchner, Institut für Kognitionsforschung, Universität Oldenburg

Visual-auditory interstimulus contingency effects in saccade programming

In this thesis we investigated the effects of visual-auditory interstimulus contingencies (i.e., the presence of an auditory stimulus was a more or less valid cue for the onset and position of a visual target) on the latencies and amplitudes of saccadic eye movements. In the literature on multimodal integration it has been established that the spatial and temporal proximity of a visual and auditory stimulus play an important role for their multimodal processing (Colonius & Arndt, 2001). The aim of the present thesis was to determine whether human subjects learn to use the predictive context of visual-auditory interstimulus contingencies for even better performance (Mordkoff & Yantis, 1991).

In a new experimental procedure, the interstimulus contingencies were defined in the locations of a target and an accompanying stimulus rather than in the mere presence or absence of the stimuli. The subjects were asked to make a saccade to a visual target and to use the location of an auditory accompanying stimulus as a possible, but unreliable cue for the location of the visual target.

We investigated several different types of saccades. The latencies of reflexive visual prosaccades did not show contingency effects. However, in a bimodal go/no-go task the contingency effects did reach significance indicating shorter latencies in the positively and negatively correlated conditions than in the control condition. It was concluded that these effects were specific to the go/no-go task, because in experimental tasks which involved the choice in saccade direction the saccade latencies in the unlikely condition were longer than in the control condition. This result was true for visual antisaccades, auditory prosaccades and visual prosaccades with outline boxes. We therefore conclude that the processing of interstimulus contingencies requires the choice in saccade direction and thus leads to shorter latencies to targets at the likely location and longer latencies to targets at the unlikely location. The choice in saccade direction was implemented in a new, per interval linear approach to threshold (ILAT) model. Simulations of the model gave a good fit to the mean saccadic latencies of auditory prosaccades. The model parameters were in good accord with neurobiological evidence (Hanes, Patterson & Schall, 1998).

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- Mordkoff, J.T. & Yantis, S. (1991). An interactive race model of divided attention. *Journal of Experimental Psychology: Human Perception and Performance*, 17, 520–538.
- Colonius, H. & Arndt, P. (2001). A two-stage model for visual-auditory interaction in saccade latencies. *Perception & Psychophysics*, 63, 126–147.

Thesis period: 1.8. 1998 – 20.12. 2001 (defence) grade of ‘summa cum laude’.

Own publications and lectures: Kirchner, H. & Colonius, H. (in revision). Saccadic responses in a bimodal go/no-go task show interstimulus contingency effects. *Journal of Experimental Psychology: Human Perception and Performance*.

Kirchner, H. & Colonius, H. (2000). Visual-auditory interaction in saccades: Interstimulus contingency effects. In: M. Meis & C. Reckhardt (Hrsg.), *Contributions to psychological acoustics. Results of the 8. Oldenburg symposium on psychological acoustics*. Oldenburg: BIS, p. 449-454.

Kirchner, H. & Colonius, H. (2000). Visual-auditory inter-stimulus contingency effects: Prosaccades vs. anti-saccades. *Perception*, vol. 29, supplement, p. 18a.

McAdams, S., Kudo, K. & Kirchner, H. (1998). Perceptual interaction of excitor and resonator properties in percussive instrument sounds. *Journal of the Acoustical Society of America*, vol. 103, p. 2966.

List of attended courses:

Sep 8-9, 2000: EuroGK workshop in Kloosterburen, NL.
regularly: EuroGK-seminar Oldenburg; talk given in June 2001 “Visual-auditory interstimulus contingency effects in saccade programming”.

List of attended conferences:

5.-8. June 2001: Workshop on EEG and MEG data acquisition and analysis at the MEG Centre of Salpêtrière Hospital, Paris.

Kirchner, H. & Colonius, H. (2000). Zeitbereich visuell-auditorischer Interstimulus-Kontingenzen. In: D. Vorberg, A. Fuchs, T. Futterer, A. Heinecke, U. Heinrich, U. Mattler und S. Töllner (Hrsg.), *Experimentelle Psychologie. Beiträge zur 42. Tagung experimentell arbeitender Psychologen*. Lengerich: Pabst Science Publishers, p. 141.

Troidl, K.E., Kirchner, H. & Colonius, H. (1999). Untersuchung visuell-auditorischer Interstimuluskontingenzen anhand von Blickbewegungen. In: Erich Schröger, Axel Mecklinger und Andreas Widmann (Hrsg.), *Experimentelle Psychologie: Beiträge zur 41. Tagung experimentell arbeitender Psychologen*. Lengerich, Berlin: Pabst Science Publishers, p. 165.

Dipl.-Psych. Claudia Steinbrink, Institut für Kognitionsforschung, Univ. Oldenburg

Relations between phonological and inflectional errors in spontaneous speech of German-speaking children with hearing impairment and with unimpaired hearing

This dissertation project aims at contributing to controversial debates in language acquisition research concerning the role of language input for the acquisition of language and the relation of grammar to other aspects of language (Bates & Goodman, 1999; Crain, 1991; Elman, Bates, Johnson, Karmiloff-Smith, Parisi & Plunkett, 1996; Pinker, 1991). In this project, types and frequencies of phonological and inflectional errors in the language of normally hearing and hearing-impaired children are analysed. As these children have differential possibilities of using language input, the role of language input for the acquisition of language can be investigated. Moreover, relations between the frequencies of phonological and inflectional errors are examined to address the question if grammar relates to other aspects of language. Three groups of children are investigated: children with unimpaired hearing, children with cochlear implants and children using hearing aids. Children are matched in language age (measured by mean length of utterance). The CHILDES program (MacWhinney, 2000) is used for computer-assisted transcription and analysis. Spontaneous speech samples of normally hearing and cochlear-implanted children are taken from Szagun's corpus of German child language (Szagun, 2001; DFG-Nr. Sz 41/5-1/2). Data collection for children with hearing aids is in progress. In the initial phase of this dissertation project, systems for phonological transcription and for the analysis of phonological and inflectional errors were developed and tested. At present, spontaneous speech data of normally hearing and cochlear-implanted participants are analysed. An analysis of phonological and inflectional errors in ten normally hearing children and ten children with cochlear implants revealed significant correlations between frequencies of phonological and inflectional errors for seven out of ten categories tested. These preliminary results support the view that phonological and inflectional development are related in the course of language acquisition. In future work, data collection for the group of children with hearing aids will continue. For all three groups, more data will be analysed. Groups will be compared concerning frequency and types of phonological and inflectional errors produced. Further relations between the frequencies of phonological and inflectional errors will be tested. Up to now, relations were tested for phonological and inflectional errors found in the same speech sample. Future work will also incorporate time-lagged relations between phonological and inflectional errors.

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- Elman, J.L., Bates, E.A., Johnson, M.H., Karmiloff-Smith, A., Parisi, D. & Plunkett, K. (1996). *Rethinking innateness. A connectionist perspective on development*. Cambridge (Mass.)/London: MIT Press.
- MacWhinney, B. (2000). *The CHILDES project: Tools for analyzing talk*. Hillsdale, New Jersey: Erlbaum.
- Pinker, S. (1991). Rules of language. *Science*, 253, 530-535.
- Szagun, G. (2001). Language acquisition in young German-speaking children with cochlear implants: Individual differences and implications for conceptions of a sensitive phase. *Audiology and Neuro-Otology*, 6, 288-297.

Thesis period: December 1st, 1998 - December 1st, 2003 (projected)

Publications: Steinbrink, C. & Szagun, G. (1999). The effect of exaggerated segmentation

on the language acquisition of children with cochlear implants. Poster presented at IXth European Conference on Developmental Psychology, Spetses (Greece), September 1-5, 1999.

Steinbrink, C. & Szagun, G. (1999). Der Einfluß überdeutlichen Sprechens auf den Spracherwerb von Kindern mit Cochlea-Implantat. *Sprache-Stimme-Gehör*, 23, 213-217.

Szagun, G. & Steinbrink, C. (2000). With a little help: Effects and non-effects of maternal language input on language-acquisition in German-speaking children with cochlear implants. Paper presented at XXVII International Congress of Psychology, Stockholm (Sweden), July, 23-28, 2000.

Steinbrink, C. (2001). Phonological errors in the language of German-speaking children and their relations to morphology. Poster presented at the Child Language Seminar, Hertfordshire (England), July 9-11, 2001.

Steinbrink, C. & Szagun, G. (2001). Phonological and morphological errors in the spontaneous speech of children with cochlear implants and with normal hearing. Poster presented at Xth European Conference on Developmental Psychology, Uppsala (Sweden), August 22-26, 2001.

Steinbrink, C. & Szagun, G. (2001). Phonologische und morphologische Fehler in der Spontansprache von normalhörenden Kindern und Kindern mit Cochlea-Implantat. Poster presented at 15. Tagung der Fachgruppe Entwicklungspsychologie in der Deutschen Gesellschaft für Psychologie, Potsdam (Germany), September 2-5, 2001.

Attended courses:

Patricia K. Kuhl: Language and the Brain; Nijmegen Lectures (Netherlands), December 6- 8, 1999

Modeling in Cognitive Neurosciences; Summerschool at BCN Groningen (Netherlands), July 3-7, 2000

Weekly Euro-GK-Seminar in Oldenburg (talks given in July 2000 and June 2001)

Fortnightly research colloquium at the Institut fuer Kognitionsforschung, Oldenburg

Attended conferences:

IXth European Conference on Developmental Psychology, Spetses (Greece), September 1-5, 1999

Conference on Cognitive Neuroscience, Bremen (Germany), October 31-November 3, 1999

Child Language Seminar, Hertfordshire (England), July 9-11, 2001

Xth European Conference on Developmental Psychology, Uppsala (Sweden), August 22-26, 2001

15. Tagung der Fachgruppe Entwicklungspsychologie in der Deutschen Gesellschaft für Psychologie, Potsdam (Germany), September 2-5, 2001

Dr. rer. nat. Petra A. Arndt, Institut für Kognitionsforschung, Universität Oldenburg

Intersensory integration in eye and arm movements

The presentation of accessory auditory stimuli reduces reaction times (RT) of saccadic eye movements and of goal directed arm movements towards a visual target stimulus even if subjects are instructed to ignore the accessory stimuli (e.g., Hughes et al., 1994). For eye movements, magnitude of reduction depends on the spatio-temporal relationship between visual target and auditory non-target (Frens et al. 1995, Arndt & Colonius, 2001). Similar results are found for goal directed hand movements (Arndt & Colonius, 2000). However, the data suggest a stronger dependency on the auditory stimulus for hand movements than for eye movements. The overall reduction of latencies is substantially higher for arm than for eye movements. Moreover, arm movement latencies show a stronger dependence on changes in temporal and in spatial features of the visual-auditory stimulus arrangement than eye movement latencies. To further investigate this issue, both, the intensity of the accessory auditory stimulus and the spatial stimulus arrangement were varied in a subsequent experiment. Again, the dependence on spatial relationship suggested a stronger effect of the auditory stimulus on hand than on eye movements. However, this stronger influence was not reflected in the effect of stimulus intensity. The results support the model proposed by Colonius & Arndt (2001) where the effect of stimulus intensity is mediated completely by changes in peripheral processing time. Moreover they suggest, that differences between saccadic latencies and hand movement latencies may be evoked by different processes in intersensory integration. Several interpretations of the findings are possible. Differences between eye and arm movements may be based on different integration rules. Alternatively they might be a consequence of the generally longer latencies of hand movements allowing for longer processing (integration) times. The latter hypothesis is currently investigated experimentally. The temporal offset between visual target stimulus and auditory distractor is varied in a range covering the possibly different processing times for eye and hand movements.

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List of publications:

- Arndt, P.A. & Colonius, H. (2002). Effects of accessory auditory stimulus intensity on saccades to visual targets. *Experimental Brain Research* (under revision).
- Arndt, P.A., Colonius, H. (2000). Where and how does stimulus intensity affect visual-auditory interaction? In: *Beiträge zur 3. Tübinger Wahrnehmungskonferenz*, Bülhoff, H.H., Fahle, M., Gegenfurtner, K.R., Mallot, H.A. (eds.), Kirchentellinsfurt: Knirsch, p. 160.
- Arndt, P.A., Colonius, H. (2000). Auditory intensity effects on visual-auditory integration in the control of eye and hand movements. 23rd European Conference on Visual Perception, *Perception*, Vol.29, Suppl.2, p.90.

- Arndt, P.A., Colonius, H. (1999). Visually guided arm movements under accessory auditory stimulation. In: *From Molecular Neurobiology to Clinical Neuroscience, Proceedings of the 1st Göttingen Conference of the German Neuroscience Society 1999; 27th Göttingen Neurobiology Conference*, Elsner, N., Eysel, U. (eds.), Stuttgart: Georg Thieme, p. 194.
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- Colonius, H., & Arndt, P. (1999). A comment on „A model of saccade generation based on parallel processing and competitive inhibition“ by J. M. Findlay & R. Walker. *Behavioral and Brain Sciences*, 22, 677-678.
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- Özyurt, J., Colonius, H., Arndt, P.A. (1999). Einfluß auditorischer Stop-Signale auf visuell gesteuerte Augenbewegungen. In: Schröger, E., Mecklinger, A., Widmann, A., Hrsg. (1999) *Experimentelle Psychologie. Beiträge zur 41. Tagung experimentell arbeitender Psychologen*. Pabst Science Publishers, Leipzig. S. 148.

List of attended courses:

Regularly: EuroGK seminar Oldenburg

Regularly: monthly meetings Groningen/Oldenburg

List of attended conferences:

23rd European Conference on Visual Perception, Groningen, 27-31 August 2000

Bursaal Oliver Lindemann, Experimental Psychology, Groningen

A common network for Action Recognition and Action Execution

Two widely studied topics in cognitive neuroscience are I. The perception of biological motion, and II. The execution of goal-directed movements. Typically, these topics have been regarded to reflect two different pathways in the brain. The perception of biological motion is assumed to start in the striate cortex, where areas as V5 are specialized in the perception of movement. Subsequently, visual motion information detected here is supposed to be processed for higher cognitive understanding in the ventral also called “what” pathway including the temporal lobe. Movement execution, on the other hand, is typically supposed to start with an internal plan, presumably organized in the frontal lobe, and then this plan is transformed into an action by means of the pre-motor and motor cortex. Moreover, if stimulus-driven actions are taken into account, that is actions that start with the perception of an external event in the striate cortex, they are supposed to be processed in the dorsal also-called “where” or “how” pathway, involving the parietal lobe.

Recently, however, both neurophysiological and psychophysical studies after the processes involved in **imitation** offer the possibility that both the perception and execution of action might be processed within the same neural network. Some years ago, Rizzolatti and colleagues were able to observe single cell activity in the rostral part of the inferior premotor cortex, area F5, of the monkey during goal-directed hand movements such as grasping, holding and tearing, but also when the monkey only observed these actions performed by the experimenter (di Pellegrino, Fadiga, Fogassi, & Rizzolatti, 1992). In most of these so-called mirror neurons, there needed to be a clear link between the effective observed movement and that executed by the monkey in order to find discharges in the same neuron (Gallese, Fadiga, Fogassi, & Rizzolatti, 1996) that led the authors to propose that these mirror neurons form a system for matching observation and execution of motor action.

Evidence for such a mirror neuron system in man derives from a recent study by Fadiga, Fogassi, Pavesi, & Rizzolatti (1995). The results of their transcranial magnetic stimulation experiment showed that the excitability of the motor system increased when an observer watched grasping movements performed by a model. Furthermore, the pattern of muscle activation evoked by the transcranial magnetic stimulation during action observation was very similar to the pattern of muscle contraction present during the execution of a similar action. The recent findings of the above described mirror neurons would suggest that stimulus-response translations should interact much more directly when one would use an (quasi-) imitative stimulus-response arrangement. Particularly, employing finger and mouth movement stimuli might activate directly the pre-motor areas necessary to initiate the correct responses. This was indeed found in the studies by Brass et al. (2001, 2001). Importantly, a subsequent fMRI study (Iacoboni et al., 1999) indicated that the same areas as previously found in monkey are responsible for the linking between action perception and action execution in man. Particularly, the finding that when executing the same finger movement, Broca’s area was higher activated following an imitative cue than a symbolic cue provided good evidence for the existence of a mirror neuron system in man.

However, the notion that action recognition might take place in the pre-motor cortex raises two major problems: I. If the personal motor cortex simulates the actions perceived, only actions that are in the personal motor repertoire can be recognized, this is clearly not the case as we for instance can recognize a salto mortale without being able to perform it. II. The idea of the (pre-) motor cortex being the critical area might answer some questions about action recognition, but leaves open many questions about action execution. Implicitly, this notion again argues that for execution we can choose one specific motor program out of the existing repertoire, meaning that we should have an enormous storage of all kind of actions in our brain. A notion doubted widely in the literature so far (Rosenbaum, 1991).

The present PhD proposal aims to offer a new account on action recognition and action execution. The main different principle starting point is that action execution relies heavily on the perceptual control of effectors involved. That is, an action planned is not only organized in motor areas but also in perceptual areas as found in the temporal lobe (STS). Recent convincing evidence that such a temporal area can be involved in action control comes from the studies of Perrett and colleagues. Those areas likely control action perception in a feed forward manner that is these neurons check if the sensory consequences anticipated in the action plan are also achieved. If this is true, it can be much better understood that the same network that is involved in action execution can also be used for action recognition.

Aims of the PhD

The major aim of this PhD project is to develop a neurobiological plausible model that can account for major findings of behavioral studies on imitation so far, and that can help us to make predictions for new experimental paradigms in the future. The starting point for the model is to include findings about the cortical areas STS, the parietal cortex and the premotor cortex (Broca) into one common network that enables action recognition and action execution. One of the bigger challenges will be to identify excitational and inhibitory links between these different areas in the processing of recognition and execution of action. *Within one year*, the model should be running. In the second year, a first manuscript about the general principles of the model should be submitted. Also, the model should be critically tested by means of simulations (second article to be written at the end of the second year). In the third and four years, psychophysical (third article) and neuro-imaging experiments (fourth article) should be ran to clarify critical aspects of the model in more detail.

Dipl. – Phys. Handy Oey, Akustik, Universität Oldenburg

Development of a model of vibration perception based on psychophysics and physiology in the somatosensory system

So far a literature study about the current research regarding vibrations and vibration perception has been done. This investigation should specify the major open research topics for the dissertation project. The literature study lead to insight in the current research about whole body vibrations, hand-arm vibration, vibro-tactile speech-reading and communication aid, effect of vibrations on visual and auditory performance, haptics, including vibrotactile display research and vibrations as feedback for teleoperating of dexterous robots.

Present research is mainly focussed on

- technical applicability of a given set of vibration devices for certain virtual-reality implementations
- medical (health) impacts of various vibration inputs to human
- vibration perception and (spatial) representation within the somatosensory system (for given vibration-sensitive neuronal transducers)

A deficit is observed in the development of a comprehensive model of perception of vibration, which can be used in a human-response-model for environmental impact.

Perspective:

A model should start with the physical input of all sensory-vibrational transducers involved over a large range of frequency and amplitude. The model has to mimic the functionality of the different sensors, which respond to different physical properties of the vibration signal. The model will take the rather simple, straight-forward connection of each peripheral transducer with the cortical system into account. Since the internal representations of a complex vibrational input in some sort of "gestalt" is only investigated for selected vibration signals, an extended research of the psycho-physics of vibration has to be started, e.g. JND's in level and frequency are largely unknown, perceptual transition from one vibration-sensory input to the other is not investigated yet, feature detection of distinct properties of the vibration signal is not analysed systematically, if at all.

It is planned to perform a large variety of psycho-physical experiments with defined vibration inputs, to measure the human response with the well-known tools of psycho-acoustics and to monitor related excitations in the brain with the experimental set-ups available in the EuroGK and SFB 517 (i.e. fMRI and EEG).

Thesis period: Started in Nov. 2001, expected three years

Own publications none

and lectures:

List of attended courses: Regularly: EuroGK seminar "Neurosensorik", Oldenburg
Regularly: Aku – Medi seminar "Aktuelle Probleme der Akustik und Medizinischen Physik", Oldenburg

List of attended conferences: Active participation at DAGA 2001 in Hamburg-Harburg with own contribution – during phase of Diplom thesis

Dipl. Phys. Ingo Baumann, Akustik, Universität Oldenburg

Perception of sound and vibration relating to comfort aspects

The aim of the dissertation project is to investigate subjective comfort or discomfort caused by sound and vibration e.g. in aircrafts. It would be very advantageous to have objective parameters which are able to describe and probably forecast the subjective comfort.

The human beings are exposed to different kinds of vibrations in the daily life, e.g. transportation. Most previous studies in literature deal with measurements on non-padding seats in a noisy environment. Therefore some basic experiments are necessary especially measurements of limits like thresholds or equal vibration level contours and just noticeable differences in level on different (cushioned) seats in silent environment. Additional parameters which influence the perception of vibration will be investigated.

In the initial thesis project period, a full account literature research is made to get a better understanding to different aspects of the perception of vibration. Existing national and international standards like the ISO 2631 part 1 and 2 (1989) define some measurement categories. But the data from different studies on the perception of vibration show considerable varieties to the existing standards and to each other probably due to the used measurement methods and set-ups.

Future work will deal with the apparatus and paradigms of the experiments which will be optimized to receive reliable data relating to comfort aspects.

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Thesis period: 1.10.2001 – 31.12.2001 (1.1.2002 changeover to EC-project HEACE: Health Effects in Aircraft Cabin Environment)

Own publications and lectures: Baumann, I., Bellmann, M.A., Mellert, V., Weber, R. (2001). "Untersuchung von Föhlschwellen und JNDs von Vibrationen auf Automobilsitzen", DAGA 2001

List of attended courses: Non Regularly: EuroGK seminar Oldenburg

List of attended conferences: Mar 26-29, 2001: DAGA 2001, Hamburg, D

Dipl. Phys. Michael A. Bellmann, Akustik, Universität Oldenburg

Experiments on the perception of whole-body vibration

The aim of the dissertation project is to investigate the perception of whole-body vibrations.

The human body is exposed to various whole-body vibrations from different sources, e.g. at working place in industry or in daily life traffic. In real situations not only narrowband and sinusoidal vibrations occur but also broadband signals with accidental and stochastic character. Existing standards, e.g. ISO 2631-1/2 (1997, 1989), refer to sinusoidal excitation on the base of the perception of vibrations in buildings. These standards address perception thresholds of whole-body vibrations in all directions or equivalent-comfort contours. Existing data in literature (e.g. Griffin, 1991; Reiher and Meister, 1932) on the perception of sinusoidal whole-body vibration show considerable differences to the ISO standard. Data from different laboratories (e.g. summarised in Griffin, 1991) deviate from each other too, probably due to differences of the psychophysical measurement method. Additionally, incomplete details exist in the literature for JNDs (Just Noticeable Differences) in the frequency or in the magnitude of whole-body vibration.

In this dissertation project not only basic experiments are conducted on the perception of (vertical) whole-body vibrations but also the influence of interior sound and vibration in cars are investigated on the subjective comfort caused inside cars. In the first part following basic experiments on the perception of sinusoidal whole-body vibration are conducted with new and reliable psychoacoustic measurement methods: 1) Perception thresholds in vertical direction (y- and z-axis), 2) just noticeable differences and 3) equal-vibration level contours (comparable with equal-loudness level contours) for vertical whole-body vibrations.

The second part deals with the perception of interior low frequency sound and vibration in cars because these components impair the subjective comfort. Desirable are objective signal parameters which describe and are able to predict subjective assessments of sound and vibration. One testing method in car industry is to judge the quality of booming noise, seat and steering-wheel vibrations by professional testers. In this project seat and steering-wheel vibrations as well as sound are recorded inside of small and middle class cars in idle running conditions simultaneously with the subjective ratings. From the 19 channel-recordings objective signal parameters for the seat and steering-wheel vibrations are calculated which correlate significantly with the subjective ratings and consequently describe the subjective vibration comfort. In the correlation analysis signal parameters from car industry and from existing standards (e.g. ISO 2631-1/2, ISO 5349, VDI 2057-1/2/3) are used.

It turns out that psychophysically motivated vibration signal parameters as proposed in the ISO 2631 1/2 (1997, 1989) give significantly higher correlation coefficients with the subjective assessments than spectrally unweighted vibration parameters. This holds only for the steering-wheel vibrations. For the seat vibrations spectrally unweighted but band limited vibration signal parameters show significant high correlation coefficients with the subjective ratings.

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International Organisation for Standardisation (1989) Evaluation of human exposure to whole-body vibration: Part 1: General requirements. International Standard, ISO 2631-1

International Organisation for Standardisation (1997) Evaluation of human exposure to whole-body vibration: Part 2: Continuous and shock- induced vibration in buildings (1 to 80 Hz). International Standard, ISO 2631-2

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- Verein Deutscher Ingenieure (1987) Einwirkung mechanischer Schwingungen auf den Menschen – Blatt 2: Bewertung”, VDI Richtlinie, VDI 2057
- Verein Deutscher Ingenieure (1986) Einwirkung mechanischer Schwingungen auf den Menschen – Blatt 3: Beurteilung. VDI Richtlinie, VDI 2057
- Verein Deutscher Ingenieure (1987) Einwirkung mechanischer Schwingungen auf den Menschen – Blatt 4.1: Messung und Beurteilung von Arbeitsplätzen in Gebäuden. VDI Richtlinie, VDI 2057

Thesis period:

1.9.1999 – 30.3.2002 (projected)

Own publications and lectures:

- Bellmann, M.A., Mellert, V., Reckhardt, C. & Remmers, H. „Sound and Vibration at Low Frequencies“, J. Acoust. Soc. Am. 105 ,pp. 1297, 1999 and Forum 99 on CD, Berlin, 1999.
- Bellmann, M.A., Mellert, V., Reckhardt, C. & Remmers, H. „ Experimente zur Wahrnehmung von Vibrationen“ , in: Fortschritte der Akustik, DAGA 2000 on CD, 2000.
- Bellmann, M.A., Weber, R., Baumann, I., Hillebrand, P. & Mellert, V. “Methods for improving the objective description of subjective car vibration quality assessments“ , Proc. ISMA 25 (2000), Leuven, 2000.
- Bellmann, M.A., Mellert, V., Remmers, H. & Weber R., „Experiments on the perception of whole-body vibration“ presented at the 35th UK Group Meeting on Human Response to Vibration, Southampton, 2000, pp.355-364
- Bellmann, M.A., Baumann, I., Hillebrand, P., Mellert, V. & Weber, R. „Comfort inside cars: Effects of seat and steering-wheel vibrations“, presented at the 36th UK Group Conference on Human Response to Vibration, Farnborough, 2001
- Bellmann, M.A., Baumann, I., Hillebrand, P., Mellert, V. & Weber, R. „Methoden zur Verbesserung der objektiven Beschreibung subjektiver Qualitätsurteile der Sitz- und Lenkradvibrationen“, in: Fortschritte der Akustik, DAGA 2001*
- List of attended courses:** Sep 20-21, 2001: 1.Workshop des FA Fahrzeugakustik der DEGA “Fahrzeugakustik”, Dept. of Acoustics, University of Oldenburg, D
- List of attended conferences:** Mar 20-23,2000: DAGA 2000, Oldenburg,D
Sep 12-13, 2000, ISMA 25, Leuven, B
Sep 12-14, 2000, 35th UK Group Meeting on Human Response to Vibration, Southampton, GB
Mar 26-29, 2001: DAGA 2001, Hamburg, D
Sep 13-15, 2001, 36th UK Group Meeting on Human Response to Vibration, Farnborough, GB

Dipl. Phys. Ulrike Dicke, Medizinische Physik, Universität Oldenburg

A biologically motivated neural circuit describing periodicity coding in the auditory system

Pitch is a perceptual attribute of an acoustic stimulus that underlies various higher-order processes, e.g. auditory streaming and speaker recognition. Understanding the neural mechanisms that lead to the perception of a pitch is thus a necessary condition for understanding higher-order auditory processing.

It is not clear so far whether pitch predominantly arises from spectral or from temporal processing mechanisms, but temporal processing must play a role if a pitch is perceived from an acoustic signal whose spectral components cannot be resolved by the cochlear filters. Hence the relationship between pitch processing and the processing of amplitude modulations is of particular interest.

The objective of this thesis in progress is to suggest a biologically motivated neural model describing temporal aspects of pitch and amplitude modulation processing mechanisms in the auditory system.

Sinusoidally amplitude-modulated (SAM) tones are useful to explore possible temporal processing mechanisms of the auditory system, even though more complex stimuli (e.g. iterated rippled noise or harmonic tone complexes) represent better real-world stimuli.

Biological experiments have shown that the synchronisation of auditory-nerve (AN) activity is relatively weak in response to SAM stimuli.

At the level of the cochlear nucleus (CN) different cell types, e.g. onset and chopper cells, have been identified to show enhanced temporal synchronisation to SAM stimuli. While the rate modulation transfer function (RMTF) does not vary with different modulation frequencies, the temporal modulation transfer function (TMTF) of a CN chopper cell shows a peak at its so-called best modulation frequency (BMF). The peaked shape of the TMTF leads to the assumption that stimulus periodicity is encoded in the temporal firing pattern of CN chopper and onset cells.

Among various other projections CN cells project into the inferior colliculus (IC) where so-called coincidence detectors have been found. While the TMTF of such a cell does not differ significantly from the TMTF of a CN cell, the RMTF of the IC cell also exhibits a peak at its BMF. The peaked shape of the RMTF at the level of the IC leads to the assumption that at the level of the IC a transformation of the temporal firing pattern into a rate-place code has taken place. Such a transformation of temporal stimulus periodicity into a rate-place code indicates that a neural periodicity map has been formed. Each neuron of this periodicity map can be considered as a filter in the modulation domain and the array of neurons is known collectively as a “modulation filter bank”.

A number of models concerned with pitch perception focus on spectral processing mechanisms (e.g. Goldstein 1973) and most of the models that deal with temporal aspects of pitch processing suggest an autocorrelation mechanism (e.g. Licklider 1951, Meddis and Hewitt 1991a & 1991b). Although autocorrelation mechanisms can reproduce a variety of pitch percepts, psychophysical evidence shows that human pitch perception cannot simply be based on an autocorrelation (Kaernbach and Demany 1998). There are primarily two models that are concerned with pitch processing using biologically motivated neural circuits (Langner and Schreiner 1988, Hewitt et al. 1992 & 1994). Both models describe the transduction of temporal information at the CN level into the rate-place representation at the level at the IC. Even though both model architectures seem to differ significantly at first sight, the BMF of an individual model neuron depends on its intracellular properties, i.e. the ordered representation of different BMFs results exclusively from different membrane time constants along the neuron array.

The objective of this thesis is to suggest a neural circuit in the tradition of the models by Langner and Hewitt, without simply using neurons having different intracellular properties.

Instead we will attempt to form an ordered periodicity representation using constant synaptic delays and variable synaptic couplings.

As a first step in modelling, the peripheral processing in the cochlear was simulated. Two existing models, both based on the Gammatone filter bank, were implemented on a computer: the AN model by Heinz et al. (2001) and the hair cell model by Meddis et al. (1986). In order to test the performance of these models, particularly with regard to temporal aspects of AN firing, the model outputs were compared with AN data from biological experiments using SAM stimuli. This comparison led to the result that both models are capable of reproducing the temporal features of AN firing in response to SAM stimuli.

The next step consisted of finding a suitable neuron model showing sufficient temporal precision. The Spike Response model (Gerstner 1998) proved to be a particularly suitable candidate for this kind of simulation. Based on this neuron model, cochlear onset neurons were simulated, which show the strong temporal synchronisation to the envelope of SAM stimuli that is observed in biological experiments.

Starting from these first steps, a biologically motivated model will be developed. In case of good model performance using SAM stimuli, the model will be tested using other stimuli that show periodic envelope fluctuations. Additionally the model performance will be compared with the existing models by Langner and Hewitt.

Thesis period: June 2000 – May 2003 (projected)

List of attended courses:

BCN Summer School, July 2000, Groningen

Start-up Symposium, September 2000, Kloosterburen, including a presentation of former work

Blockpraktikum Neurosensorik, September 2000

Combined seminar of the graduate schools »Psychoacoustics« and »Neurosensory Science and Systems«, winter term 2000/2001, Oldenburg, including a presentation of current research

Visits of the different research groups in Groningen and Oldenburg, winter term 2000/2001

Summer School in Bad Zwischenahn (discussions and exchange with Prof. Ray Meddis and Prof. Shihab Shamma), August 2001

Seminar of the graduate school »Neurosensory Science and Systems«, summer term 2001, Oldenburg, including a presentation of current research

Visits of the different research groups in Groningen and Oldenburg, summer term 2001

Seminar of the graduate school »Neurosensory Science and Systems«, winter term 2001/2002, Oldenburg, including a presentation of current research

List of research stays:

Dept of Neurobiophysics, University of Groningen (Prof. Duifhuis), February, 2001.

Auditory Processing Group of the Max Planck Institute of Neurobiology in Munich (PD Dr. Benedikt Grothe), Mai, 2001.

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Gerstner, W. (1998). Spiking neurons. In: W. Maass and C.M. Bishop (editors). Pulsed Neural Networks. MIT Press, Cambridge.

Goldstein, J.L. (1973). An optimum processor theory for the central formation of the pitch of complex tones. J. Acoust. Soc. Am. 54, 1496-1516.

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- Meddis, R. and Hewitt, M.J. (1991a). Virtual pitch and phase sensitivity of a computer model of the auditory periphery. I: Phase identification. *J. Acoust. Soc. Am.* 89, 2866-2882.
- Meddis, R. and Hewitt, M.J. (1991b). Virtual pitch and phase sensitivity of a computer model of the auditory periphery. II: Phase sensitivity. *J. Acoust. Soc. Am.* 89, 2883-2894.

Dipl. Phys. Stephan Ewert, Medizinische Physik, Universität Oldenburg

Modeling the processing of envelope fluctuations in the auditory system

The aim of the thesis is to understand the processing of envelope fluctuations in the human auditory system which is one important aspect of the neurosensory process in hearing. Psychoacoustic experiments with normal-hearing and hearing-impaired listeners were conducted. An effective signal processing model is developed, based on the empirical findings.

Characterization of envelope-frequency selectivity

The envelope-frequency selectivity of the auditory system was investigated using modulation masking experiments. Comparable to masking experiments in the auditory periphery (audio-frequency domain), modulation detection thresholds for sinusoidal (probe) amplitude modulation (SAM) in the presence of narrowband-noise (masker) modulations were measured as a function of the spectral separation of the probe and masker modulation. Peaked detection threshold patterns for the probe were found. The highest threshold was observed when the probe modulation was spectrally centered in the masker modulation. Detection performance increased with increasing spectral separation of the probe and masker modulation. Masked threshold patterns were obtained for probe modulation frequencies of 4, 16, 64 and 256 Hz applied to a broadband noise carrier in an earlier study (Ewert and Dau, 2000), and for modulation frequencies of 4, 16, and 64 Hz applied to a pure tone carrier at 1.4, 2.8, and 5.5 kHz in a recent study (Ewert et al, subm. to JASA). A simple model of envelope processing was suggested, relating modulation detection thresholds to the envelope-power spectrum of the stimulus (envelope-power spectrum model; EPSM). In both studies, second-order bandpass filters were fitted to the empirical data and the best fitting Q-value was obtained as an estimate of envelope-frequency selectivity.

It was found that envelope-frequency selectivity is independent of the specific type of carrier (broadband noise or pure tone) and that modulation filters have a constant Q-value of about 1 for modulation frequencies up to 64 Hz. These findings contrast with earlier assumptions for the modulation filter bandwidth as proposed in the framework of a more complex auditory processing model by Dau et al. (1997). A combination of both modeling approaches is currently under investigation.

The role of non-linearities in modulation processing

Non-linearities are known to play an important role in auditory processing. One can arbitrarily divide non-linear mechanisms in the auditory processing pathways into a compressive non-linearity associated with cochlear processing and non-linear mechanisms occurring at higher stages of processing (e.g., neural adaptation). So far, it has been demonstrated that modulation detection can be well described assuming linear processing of envelope fluctuations. Ewert and Dau (2000) showed that the incorporation of a compressive (cochlear) non-linearity to the (linear) EPSM does not affect simulated modulation detection data for broadband noise carriers. This prediction is in line with the empirical finding that modulation detection performance is generally the same in cochlear hearing-impaired listeners as in normal-hearing impaired listeners. Cochlear hearing impairment is associated with a loss or reduction of the compressive non-linearity in the cochlear. It was also found that the detection of second-order envelope fluctuations (fluctuations arising from beats between different components in the envelope spectrum) is not related to the detection of an (envelope) distortion component introduced by a compressive cochlear non-linearity as suggested by Moore et al. (1999). On the other hand, it is shown in Verhey et al. (in preparation for JASA) that model predictions based on the "venelope" (second-order envelope, introduced in Ewert et al, subm. to JASA) can account for the empirical findings. The mathematical concept of the venelope might be associated with post-cochlear expansion.

Psychophysical estimates of the phase response of auditory filters

The envelope structure of harmonic tone complexes depends on the phase relation between the individual components. A specific choice of the phase relations (so called Schroeder phase) results in a maximally flat envelope of the temporal waveform while a zero-phase relation between all components of a harmonic tone complex gives a peaked waveform. When a harmonic tone complex is passed through an auditory filter, the phase distortion introduced by the filter changes the phase relations of its components and thus affects the envelope of the temporal waveform. Since a pure-tone probe stimulus embedded in a tone-complex masker is detectable more easily if the masker waveform is "peaky" (Kohlrausch et al., 1995), Schroeder-tone-complexes and their derivatives can be used as a psychophysical approach to estimate the phase transfer function of auditory filters (Oxenham and Dau, 2001). In collaboration with Dr. Andrew Oxenham (MIT, Cambridge), the phase distortion in auditory filters was estimated separately for the main passband of the filter (on-frequency) and the low-frequency skirt region (off-frequency) using a simultaneous masking paradigm. Additionally, forward-masking experiments were conducted for modified on- and off-frequency Schroeder-tone-complex maskers. The obtained psychophysical estimate of the phase transfer function is in excellent agreement with recent findings reported by Shera (2001) based physiological animal data: Auditory filters exhibit zero-phase distortion in the low-frequency skirt region and a quadratic-phase (linear group delay) distortion in the passband region. Although the low-frequency skirt region is commonly associated with more linear processing than the passband (tip) region of an auditory filter, the results from the forward-masking experiments can be also interpreted in favor of non-linear processing in this region. The results are being presented at the ARO midwinter meeting 2002.

Thesis period: June 1999 – June 2002 (projected)

Own publications and lectures:

- Ewert, S. D., Dau, T., Verhey, J.L., and Kollmeier, B. (2001). „Asymmetry of masking in the envelope-frequency domain," J. Acoust. Soc. Am. 109, 2466.
- Verhey, J. L., Ewert, S. D., and Dau, T (2001). „Modulation masking produced by masker modulation tone complexes," J. Acoust. Soc. Am. 109, 2466.
- Ewert, S. D., and Dau, T. (2000). "Characterizing frequency selectivity for envelope fluctuations," J. Acoust. Soc. Am. 108, 1181-96.
- Ewert, S. D., Verhey, J., Kollmeier, B., and Dau, T. (2000). "Across-channel processing of amplitude modulation," J. Acoust. Soc. Am. 107, 2899.
- Ewert, S., Verhey, J., and Dau, T. (2000). "Across-channel processing of amplitude modulation," Fortschritte der Akustik DAGA 2000, 328--329.
- Verhey, J., Ewert, S., and Dau, T. (2000). "Modulationsverarbeitung im Gehör: Autokorrelation versus Filterbank," Fortschritte der Akustik DAGA 2000, 296--299.
- Ewert, S. D., and Dau, T. (1999). "Psychophysical tuning in auditory AM processing," in Psychoacoustics, Physiology and Models of Hearing, edited by T. Dau, V. Hohmann, and B. Kollmeier (World Scientific, Singapore), 73-76.
- Ewert, S. and Dau, T. (1999). "Frequency selectivity in amplitude-modulation processing," J. Acoust. Soc. Am. 105, 1234.

Publications in preparation:

- Ewert, S. D., Verhey, J. L., and Dau, T. (2002). „Spectro-temporal processing of envelope fluctuations," subm. to J. Acoust. Soc. Am.
- Verhey, J. L., Ewert, S. D., and Dau, T. (2002). „Modulation masking produced by masker modulation tone complexes," in preparation for J. Acoust. Soc. Am.

Attended Lectures:

Lecture/Tutorial EuroGK Blockpraktikum „Psychophysik und Neurosensorik“, 2000 and 2001, Oldenburg

Lecture/Tutorial Blockpraktikum „Digital signal processing“, 2000, Oldenburg

List of attended courses:

8/2001: Summerschool and Symposium "Psychophysics, physiology and models of the central auditory system", Bad Zwischenahn, Germany; Poster Presentation, exchange and discussion with N. F. Viemeister, T. Houtgast, B. C. Moore, S. Shamma, A. Kohlrausch

Regularly: EuroGK seminar Oldenburg; Medical Physics Group seminar

List of attended conferences:

3/1999: joint meeting EAA ASA (137th), Berlin, Germany; Poster Presentation, exchange and discussion with R. Meddis, M. B. Fitzgerald, A. de Cheveigne

3/2000: *DAGA 2000, Oldenburg, Germany; Poster Presentation*

6/2000: 139th Meeting of the Acoustical Society of America, Atlanta, Georgia, USA; Talk, exchange and discussion with N. F. Viemeister, J. H. Grose, S. P. Bacon

6/2001: 141st Meeting of the Acoustical Society of America, Chicago, Illinois, USA, Poster Presentation, exchange and discussion with N. F. Viemeister, J. L. Goldstein, L. Carney, A. Oxenham

1/2002: ARO 2002 MidWinter Meeting, St. Petersburg Beach, Florida, USA

3/2002: *DAGA 2002, Bochum, Germany*

List of research stays:

3/2001-6/2001 Visiting Scientist at the Res. Lab of Electronics at the Massachusetts Institute of Technology, Cambridge, MA, USA.

3. Imaging and “smart” neurosensory analysis

Licenciado on Psychology (Dipl. Psych.) J. Ignacio Vallines, Kognitive Neuropsychologie, Universität Oldenburg

Oculomotor behaviour and brain activation

The aim of this thesis is to contribute to the understanding of the relation between oculomotor behaviour and brain activation and its role in the process of sensory information processing during visual perception, combining psychophysics, oculomotor analysis, and functional magnetic resonance imaging.

Results from this dissertation project should bring some light to the question of how we recompose and interpret the visual world from retinal information. It has been found that visual attentional processes involved in the cognitive processing of visual information extraction from this retinal information are, to certain extent, inhibited at the time of saccadic movements in order to assure the perception of a continuous stable visual world (Bridgeman et al., 1994). There is some evidence that this inhibition process starts even before the actual eye movement commences, at the time of saccadic preparation. (Ross et al., 1997). Whether this "saccadic suppression" is triggered by structural cues, neural inflow, or neural outflow has been long discussed (Helmholz 1866). Taking advantage of newly developed method that allows measuring eye movements with high temporal resolution during actual fMRI sessions (Kimmig et al., 1999) we intend to study the time course of this physiologically pre-motor inhibition and locate the structures taking part in the process in order to be able to develop a plausible model for visual stability across saccades. Experiments to be conducted involve the development of a new technique that synchronizes the MR scanner with the Visual Stimulus Generator and the MR Eyetracker. The first experiments will consist on a modified Gap Paradigm that includes making a decision about the orientation of briefly flashed gabor-function stimuli (the product of a sinusoidal and a Gaussian luminance profile) presented at different stages of the saccade's time-course. By previously elaborating retinotopic flatmaps of the subjects visual cortex (two dimensional point-for-point copies of the topography of the retina), we believe it is possible to detect small localized changes in the blood oxygen level dependent (BOLD) signal induced by the visual stimulus at the time when saccadic inhibition is most active. Previous research in this direction has already achieved partially successful results finding diffuse focal hypooxygenation in the human visual cortex depending on the saccade frequency in an acoustically triggered saccades paradigm (Wenzel et al 2000).

Since my recent incorporation to the EuroGK I have been working on the literature and programming the software that must coordinate the MR scanner, the MR Eye Tracker and the Visual Stimulus Generator to try to "catch" such ephemeral process in an event-related design. I have also been working on writing the software for the first experiment and done important hardware testing. A new mounting device for the infrared-light reflection analysis eyepiece of the MR Eye Tracker has been design and it is being built at the moment. I expect to start collecting data within the next weeks.

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- Bridgeman, B., Van der Heijden A.H.C., Velichkovsky, B.M. (1994) *A theory of visual stability, across saccadic eye movements*. Behavioral and Brain Sciences, 17; 247-292.
- Helmholtz, H. von (1856 - 1866, 1867). *Handbuch der Physiologischen Optik*. Leipzig: Voss.
- Kimmig, H., Greenlee, M.W., Heuthe, F., Mergner, T. (1999). *MR- Eyetracker: A new method for eye, movement recording in functional magnetic resonance imaging (fMRI)*. Experimental Brain Research, 126; 443-449.
- Ross, J., Morrone, M.C., Nurr, D.C. (1997). *Compression of visual space before saccades*. Nature, 386; 598-601.

Wenzel, R., Wobst, P., Heekeren, H. H., Kwong, K. K., Brandt, S.A., Kohl, M., Obrig, H., Dirnag, U., Villringer, A. (2000). Saccadic suppression induces focal hypooxygenation in the occipital cortex. *Journal of Cerebral Blood Flow and Metabolism*, 20(7): 1103-10.

Thesis Period: 01.10.2001-01.10.2004 (expected). Stipend since 01.10.2001

Currently Attended Courses :

Kognitive Neuropsychologie. Carl von Ossietzky Universität Oldenburg.
Objektorientiertes Programmieren mit Delphi. Hochschulrechenzentrum Uni-Oldenburg.
EuroGK seminar Carl von Ossietzky Universität Oldenburg.
Kolloquium Neuropsychologie. Universität Bremen.

Attended Conferences:

European Conference on Visual Perception (ECVP) August 26-30, 2001. Kusadasi, Turkey.

Conference Proceedings:

Vallines, J.I., Thomas, J.T., Greenlee, M.W. (2001) Concurrent judgments of colour and shape. *Perception*, Vol 30 supplement; Abs. 14a.
Weerda, R., Thomas, J.T., Vallines, J.I., Greenlee, M.W. (2001) Neocortical areas underlying shape and colour discriminations as assessed by fMRI . *Perception*, Vol 30 supplement; Abs. 114a.
Thomas, J.T., Vallines, J.I., Weerda, R., Greenlee, M. W. (2001). Interaction of color and shape processing: Psychophysical and imaging evaluations. *Optical Society of America PV*. 19.

Dr. Roland Marcus Rutschmann, Institut für Kognitionsforschung, Universität Oldenburg

Human visual areas responding to disparity in Julesz patterns

Disparity has been shown to be an important cue for depth perception in binocular vision as well as for perceived self motion (Rutschmann et al. 2000, Beer et al. 2002).

In a series of experiments we used gradient-echo, echo-planar imaging (EPI) to identify areas in visual cortex and associated areas in temporal and parietal cortex that show fMRI-BOLD contrast effects to stimuli presented dichoptically with vs. without disparity.

Present results indicate that both ventral and dorsal visual areas respond to the presence of disparity in RDK. An area at the parietal-occipital border responded to the relative disparity level in correlated fashion. These findings suggest that various cortical areas underlie our ability to detect the presence and to discriminate the magnitude of binocular disparity.

References:

Backus, B. T., Fleet, D. J., and Heeger, D. J. (1999). Differential fMRI response to absolute and relative disparity in human V3/V3a. *Invest Ophthal Vis Sci*, 40(suppl), 71.

Beer, J., Blakemore, C., Previc, F. H., and Liotti, M. (2002). Areas of the human brain activated by ambient visual motion, indicating three kinds of self-movement. *Exp Brain Res*, 143, 78-88.

von der Heydt, R., Zhou, H., and Friedman, H. S. (2000). Representation of stereoscopic edges in monkey visual cortex. *Vision Res*, 40, 1955-1967.

Nishida, Y., Hayashi, O., Iwami, T., Kimura, M., Kani, K., Ito, R., Shiino, A., and Suzuki, M. (2001). Stereopsis-processing regions in the human parieto-occipital cortex. *Neuroreport*, 12(10):2259-2263.

Rutschmann, RM, Schrauf, M, Greenlee, MW (2000) Brain activation during dichoptic presentation of optic flow stimuli. *Exp. Brain Res.* 4, 533-537

Own publications and lectures:

Greenlee, MW, Rutschmann, RM (2000) fMRI Responses to Binocular Disparity in Random-Dot Patterns. *Invest. Ophthal. Vis. Sci.* 41(suppl.)

Rutschmann, RM, Schrauf, M, Greenlee, MW (2000) Brain activation during dichoptic presentation of optic flow stimuli. *Exp. Brain Res.* 4, 533-537

Rutschmann, RM, Greenlee, MW (2001) Brain activities correlating with levels of disparity as revealed by fMRI. *Perception* 30(suppl), 78

Özyurt, J, DeSouza, J, West, P, Rutschmann R, Greenlee, MW (2001) Comparison of cortical activity and oculomotor performance in the gap and step paradigms *Perception* 30(suppl), 101

Lecture/Tutorial EuroGK Blockpraktikum "Psychophysik und Neurosensorik", 2000 and 2001, Oldenburg

Organization "Kolloquium des Inst. für Kognitionsforschung" SS 2000, WS 2000, SS 2001, and WS 2001

List of attended courses:

22.-24. March 2001: 3. Tübinger Kursus: Neuro-fMRI

Regularly: EuroGK seminar Oldenburg

Regularly: monthly meetings Groningen/Oldenburg

Regularly: Kolloquium des Instr. für Kognitionsforschung

List of attended conferences:

26.-30. August 2001: European Conference on Visual Perception (ECPV) in Kusadasi, Turkey

Frans W. Cornelissen, BCN, Rijksuniversiteit Groningen

Event-related fMRI responses in the human frontal eye fields in a randomized pro- and antisaccade task

We examined whether the frontal eye fields (FEF) are involved in the suppression of reflexive saccades. Simultaneous recording of horizontal eye movements and functional Magnetic Resonance Imaging (fMRI) enabled us to perform a randomized pro- and antisaccade task and to sort blood oxygenation level dependent (BOLD) timeseries on the basis of task performance.

We find that when saccades to both real (prosaccades) and virtual objects (antisaccades) are presented in a randomized manner, both saccade latency, distributions (see figure 1) and BOLD responses in FEF (see figure 2) are very similar. The mean difference in latency for pro- and antisaccades in our randomized paradigm of 32 ms is comparable to the 28 and 27 ms difference reported by Weber (1995) for a cue lead time of 0 and 300 ms respectively (our cue lead time was 500 ms). The difference is much smaller than that found in a regular block design (e.g. Weber reported a difference of 72 ms, and Kimmig found a difference of 50 ms). Peaks in the frequency distribution of reaction times indicate different processing stages of saccades. The distributions for pro- and antisaccades were comparable. We take this as an indication for similar preprocessing of pro- and antisaccades in our paradigm. The similarity in latency also supports the idea that randomizing pro- and antisaccades renders the prosaccades voluntary, rather than reflexive, as the latter occurring in a non-random block paradigm. In such a paradigm, the differential activity for pro- and anti-saccades has been taken to indicate FEF involvement in suppression. In the randomized paradigm, suppression is required prior to both pro- and antisaccades. The similarity in BOLD response for both saccade types is thus supporting a role of the FEF in the suppression of reflexive saccades. Interestingly, FEF activation started prior to target presentation and saccade generation. While we observed only few erroneous antisaccades, these were accompanied by an increase in BOLD activity relative to correctly performed antisaccades (see figure 2). These findings are consistent with a role of the FEF in the suppression of reflexive saccades. The increase in activity during antisaccade errors can only be indirectly linked to a role of the FEF in the suppression of reflexive saccades. FEF BOLD activity could therefore further represent preparatory-set, short-term memory or salience map related activity.

Remco Renken, Department of Biomedical Engineering, Rijksuniversiteit Groningen

fMRI analysis of auditory frequency and pitch representations

This project tries to observe how the human brain registers auditory stimuli. There are many parameters that determine how a sound is perceived by humans. The two main (subjective) parameters of interest for this study are pitch and timbre. Both play an important role in speech and music. Pitch determines the intonation in speech and it gives information about which note is played by an instrument. The distinction between different instruments, but also between different vowels is determined based on timbre.

It is known that the inner ear is capable of (partly) analysing an auditory stimulus with respect to the frequencies present. Therefore, it is reasonable to expect that a part of the brain will show an area where frequency is coded in a spatial manner. On the other hand, it is also possible that the pitch of a stimulus is coded in a spatial manner. For both hypotheses, there exists evidence in literature. (Romani et al., Pantev et al.) Besides spatially encoding, auditory features can also be coded in a temporal manner.

This research focuses on the question how auditory features, like pitch and timbre, are encoded by the human brain. This is done by using pure and complex tones. The pure tones are sinusoidal with a single frequency. Complex tones consist of multiple harmonic frequencies but the fundamental frequency is not present. The complex tones can evoke a strong pitch perception at the missing fundamental frequency. Reducing the amount of harmonics and / or increasing the lowest harmonic number can alter this pitch perception. In order to understand brain activation upon stimulation with sounds, it is important to know how these sounds are perceived by subjects. If perception changes, the underlying brain state must have changed also. To control and monitor perception, psychophysical measurements are recorded before and during the functional imaging.

Results so far have shown that complex tones evoke a stronger and wider range of activation in the brain, as well in the auditory cortex as elsewhere. Furthermore, it was found that using an extra REST condition facilitates the interpretation of fMRI data. By using REST as a reference, it is shown that brain activity did not only increase from one stimulus to the next, but also a decrease in activity was found.

Future work will further try to investigate brain activity correlated to pitch perception. The stimuli for these measurements will be chosen on the results of the psychophysical experiments.

Pantev et al: Hearing Research 100, 164-170, 1996

Romani et al: Science 216, 1339-1340, 1982

- Thesis period:** 1.9.98 – 31.8.2002 (projected)
- Own publications and lectures:**
- Hyder F, Renken R, Kennan RP, Rothman DL (2000). Quantitative multi-modal functional MRI with blood oxygenation level dependent exponential decays adjusted for flow attenuated inversion recovery (BOLDED AFFAIR). *Magn Reson Imaging*. 2000 Apr;18(3):227-35.
- Hyder F, Renken R, Rothman DL. (1999). In vivo carbon-edited detection with proton echo-planar spectroscopic imaging (ICED PEPSI): [3,4-(13)CH(2)]glutamate/glutamine tomography in rat brain. *Magn Reson Med*. 1999 Dec;42(6):997-1003.
- Yang X, Renken R, Hyder F, Siddeek M, Greer CA, Shepherd GM, Shulman RG. Dynamic mapping at the laminar level of odor-elicited responses in rat olfactory bulb by functional MRI. *Proc Natl Acad Sci U S A*. 1998 Jun 23;95(13):7715-20.
- Lecture/Tutorial
- “Natuurkunde voor Biologen” (2000 & 2001)
 - “MRI in Reality” summer school Biomedical Engineering 2001
 - “Auditieve fMRI” at a course for clinical physicists in training.
- Selective list of attended courses:**
- BCN summer school 1999, 2000 & 2001
 - EuroGK workshop in Kloosterburen, NL; Presentation given:” Auditory Stimuli Reveal Activation in the Occipital Cortex”
 - Regularly: monthly meetings Groningen/Oldenburg “Werkgroep Auditief Systemen (WAS)dag” 2 times a year.
- List of attended conferences:**
- Presentation given in 1999 & 2001
 ISMRM 1999 Philadelphia
 Workshop on speech and Hearing in Utrecht 2000 (presentation given “Auditory Stimuli Reveal Activation in the Occipital Cortex”)
 Auditory fMRI Micro Symposium. (Presentation given” Results and how to obtain them in auditory fMRI”)

Lucian Muresan, Department of Computer Science, Rijksuniversitet Groningen

Pattern Detection and Estimation in Functional Neuroimaging

Many techniques currently exist to produce images of the human brain, such as CT (Computerized Tomography), MRI (Magnetic Resonance Imaging) or PET (Positron Emission Tomography). These imaging techniques are not only useful to obtain images of brain structure, but also of brain function. For example, time series of PET images can be used to study changes in regional neurological activity, e.g. cerebral blood flow. The detection of significant changes in neurological activity is not an easy task, since in general these changes are small and distributed over the whole brain, although not in the same amount. The general approach is to obtain data under both activation and resting conditions, and assess significant change by comparing these data. Also comparisons between different test persons, and between images obtained from different modalities (multimodality imaging: e.g. CT vs. PET), are possible. The goal of this project is to carry out fundamental research in functional neuroimaging, covering both image analysis and statistical estimation. Statistical analysis is applied to partition the neurophysiological phenomena as observed in the images into significant, insignificant and random components. This involves techniques based on a modified Principal Component Analysis (SSM: Scaled Subprofile Model), resulting in 'eigenimages' corresponding to some spatial pattern, or methods which create an image of a statistical parameter: Statistical Parametric Mapping (SPM). Volume visualization for interpretation of the results also will play an important role.

In the past I investigated MRI motion artifacts. Patient motion, whether voluntary or involuntary, is the most frequent cause of serious image-degrading artifact in MR imaging. The MRI motion artifacts are able to influence a functional MRI (fMRI) studies. To cancel the blur introduced by the head motion we need to understand the mechanism which generates the blurring. Usually blurring is related with loss of information. For some types of motion artifacts the resulting blurred image can be seen as an encrypted version of the clear image. The encryption key is the unknown motion. The blurred image contains full information about the image and we need to find the key to decode that information.

My current work is focused on spin-history artefacts generated by the position-history of the scanned object. In fMRI an object is driven to steady state by applying a few dummy scans at the start of each measurement. A change in object position will disrupt the tissue's steady state magnetization. The disruption will propagate to the next few acquired volumes until a steady state is reached again. The variables which are involved in changing the longitudinal magnetization are: the shape and the position of the slice profiles, the times at which RF pulses occurred, the equilibrium magnetization map and the T1 map. Knowledge of these variables enables the prediction of those situations and the locations where the spin-history may compromise the fMRI analysis.

A simulation of spin-history artefacts was implemented as a stand alone program.

The simulation shows that these effects, following a displacement, are similar to the transient period at the beginning of the measurement. Introducing gaps between the acquired slices increases these artefacts.

Sonja Tomaskovic, Dept. of Biomedical Engineering, Rijksuniversiteit Groningen
fMRI and PET analysis of auditory signals (in particular speech) at varying SNR.

The aim of the research is to answer the following question: how do we perceive speech under low signal-to-noise (SNR) conditions? Although there is considerable general knowledge about speech perception as a function of SNR, detailed knowledge is still incomplete. In natural human speech communication, SNR is often close to 0 dB. However, there is considerable variation within the speech signals; for example, vowels are in general louder than consonants. Also, variations of background noise change speech intelligibility. We shall try to determine which parts of the brain are involved in detecting and recognizing speech signals (under low SNR) and, more specifically, the differences between short and long vowels, as well as between vowels and consonants. Psychophysical results obtained in quiet as well as under different SNR conditions, will be compared with fMRI and PET data.

Thesis period: October 2001 – October 2005.

Dipl. Phys. Dirk Junius, Medizinische Physik, Universität Oldenburg

Binaural auditory evoked potentials with virtual acoustics

The aim of the dissertation project is to establish the relationship between the sensory input required for spatial perception (i.e., interaural level and time differences) and its neural representation in humans using auditory evoked potentials (AEP).

Most previous studies use click-stimuli with “artificial“ binaural differences, i.e., fixed interaural time and level differences (Furst et al., 1985; Jones et al., 1990; McPherson et al., 1995; Brantberg et al., 1999; Riedel et al., 2002). Instead of the click, an optimized chirp was used, designed to compensate for basilar membrane dispersion resulting in a significantly larger ABR wave-V amplitude (Dau et al., 2000). The chirp was presented with “natural” binaural differences, i.e., convolved with individual head-related transfer functions (HRTF). Eight virtual directions were chosen for this study (horizontal plane with 45° angular spacing). In addition, the unconvolved “pure” chirp was presented diotically as a reference condition. AEP were recorded from 32 scalp electrodes.

In contrast to stimuli with artificial binaural differences, the “natural” spatial stimuli result in a perceived object outside the subject’s head (externalization). As neural correlate for binaural processing, the binaural difference potential (BD), i.e., the difference between binaural response and summed monaural responses, is commonly analyzed. Therefore, one of the questions addressed in this study is, whether the gain of externalization results in a larger BD. Furthermore, the dependency of AEP on the (virtual) direction of sound is analyzed.

The present results show that the “natural” spatial stimuli result in a two-fold wave-V for lateral sound directions. The BD is largest for central and smaller for lateral directions. This is in accordance with results from click stimuli with “artificial” binaural differences (Riedel et al., 2002). The present results question the hypothesis that the perception of a fused image is correlated to the presence of a BD (Furst et al., 1985).

Future work will deal with dipole source analysis of the data. It will be investigated, if the locations and orientations of the equivalent dipoles are systematically dependent on the direction of sound.

In the initial thesis project period, the apparatus and paradigms of the experiments were optimized and several pilot experiments were performed. For example, a second 32-channel-EEG recording unit had to be adapted and tested to be combined with the existing 32-channel system. Hence, for future recordings within this thesis a 64-channel setup can be used. This will increase spatial resolution for the analysis of dipole sources.

References:

- Brantberg, K., Hansson, H., Fransson, P. A., and Rosenhall, U. (1999). "The binaural interaction component in human ABR is stable within the 0- to 1-ms range of interaural time differences", *Audiol Neurootol* 4, 88-94.
- Dau, T., Wegner, O., Mellert, V., and Kollmeier, B. (2000). "Auditory brainstem responses with optimized chirp signals compensating basilar-membrane dispersion", *J Acoust Soc Am* 107 (3), 1530-1540.
- Furst, M., Levine, R. A., and McGaffigan, P. M. (1985). "Click lateralization is related to the beta component of the dichotic brainstem auditory evoked potentials of human subjects", *J Acoust Soc Am* 78 (5), 1644-1651.
- Jones, S. J., and Poel, J. C. v. d. (1990). "Binaural interaction in the brain-stem auditory evoked potential: evidence for a delay line coincidence detection mechanism", *Electroencephal Clin Neurophys* 77, 214-224.
- McPherson, D. L., and Starr, A. (1995). "Auditory time-intensity cues in the binaural interaction component of the auditory evoked potentials", *Hear Res* 89, 162-171.

Riedel, H., and Kollmeier, B. (2002). "Auditory brain stem responses evoked by lateralized clicks: Is lateralization extracted in the human brain stem?" *Hear Res* 163 (1-2), 12-26.

Thesis period:

1.6.2000 – 30.4.2003 (projected)

***Own publications
and lectures:***

- Junius, D., Wegner, O., and Dau, T. (2000). "Human Auditory Brainstem Potentials Using Optimized Stimuli to Compensate for Basilar-Membrane Dispersion", *Assoc. Res. Otolaryngol. Abs.* 23.
- Junius, D., Wegner, O., and Dau, T. (2000). "Zusammenhang zwischen Frühen Akustisch Evozierten Potenzialen (FAEP) und Frequenzfolgepotenzialen (FFP)", *Fortschritte der Akustik - DAGA 2000*, 336-339.
- Junius, D., Wegner, O., and Dau, T. (2001). "Human auditory brainstem potentials using optimized stimuli to compensate for basilar-membrane dispersion", poster presented at the Summerschool and Symposium "Psychophysics, physiology and models of the central auditory system", Bad Zwischenahn.
- Junius, D., Riedel, H., and Kollmeier, B. (2002). "Binaurale akustisch evozierte Potenziale (AEP) mit virtueller Akustik", presented at the DGA, Zürich.

Lecture/Tutorial EuroGK Blockpraktikum „Psychophysik und Neurosensorik“, 2000 and 2001, Oldenburg

***List of attended
courses:***

Jul 5, 2000: BCN Summer School “Modeling in Cognitive Neurosciences”, Groningen, NL, courses “Computational Psychophysics and Speech Processing I + II”

Sep 8-9, 2000: EuroGK workshop in Kloosterburen, NL; talk given: “Human auditory brainstem potentials: Transition from ‘transient’ to ‘continuous’/periodic stimulus presentation”

Aug 12-16, 2001: Summerschool and Symposium "Psychophysics, physiology and models of the central auditory system", Bad Zwischenahn, Germany; poster presentation (see publications), discussions and exchange with Alan R. Palmer, Nottingham, UK and Prof. Glenis Long

Aug 31-Sep 1, 2001: Workshop “Cortical Physiology of Complex Behaviour and Adaptation”, Dept. of Neurology, University of Tübingen, D

Regularly: EuroGK seminar Oldenburg; own talks given January 2001 and June 2001 “Binaurale Interaktion in Akustisch Evozierten Potenzialen

Regularly: monthly meetings Groningen/Oldenburg

***List of attended
conferences:***

Mar 26-29, 2001: DAGA 2001, Hamburg, D

Feb 27-Mar 2, 2002: DGA 2002, Zürich, CH

Dipl. Phys. Sandra Fobel, Medizinische Physik, Universität Oldenburg

Relation between sensorineural hearing impairment and steady-state amplitude modulation following responses

Among other problems, a sensorineural hearing loss is usually associated with:

- A reduced dynamic range, which is known as ‘recruitment phenomenon’. The hearing-impaired listener cannot hear low-level sounds but perceives high-level sounds as loud as a normal-hearing listener. This distortion effect is caused mainly by the loss of the active amplification (produced by outer hair cells in the cochlea) which enhances low-level sounds but have no effect on high-level sounds.
- The deterioration of binaural processing which causes the ‘cocktail party effect’, where the ability to understand speech in a noisy environment is markedly reduced.

The aim of the current project is both a more profound understanding of the impairment in auditory adaptation and spatial perception and a better objective method to quantify them, i.e. by using evoked potentials in electroencephalography (EEG). The results may enable better hearing aid fitting especially when feedback from the patients is not obtainable. This is particularly important for newborns and infants with hearing problems.

The first part of this thesis in progress is concerned with the recruitment phenomenon.

Loudness perception is usually measured psychoacoustically by methods like loudness scaling or magnitude estimation. Since infants and very young children cannot perform these tasks, an objective method is needed, e.g. auditory brainstem potentials (ABR). They arise up to ten milliseconds after stimulus presentation and are often used for estimating hearing impairment. However there seems to be no direct relation between loudness and the amplitude or phase of the auditory brainstem potentials (e.g. Wegner, O., Dau, T., Verhey, J., and Kollmeier, B. (1998), "Untersuchungen zu Lautheits-Korrelaten in akustisch evozierten Potentialen," in Fortschritte der Akustik - DAGA 98 (Deutsche Gesellschaft für Akustik e.V., Zürich), pp. 308.).

A more promising method for objectively assessing loudness perception seems to be the recording of the ‘amplitude modulation following response’ (AMFR), which is evoked by a continuously presented sinusoidally modulated stimulus. The recorded response follows the modulation frequency of the stimulus but is evoked by neurons tuned to the carrier frequency. This allows an objective and frequency-specific assessment of the hearing threshold (Kuwada, 1986, *Hearing Research*, 21, p. 179-192; Griffiths et al., 1991, *Ear and Hearing*, 12(4), p. 235-241.). The existing literature is for the most part concerned with the general dependence of the AMFR on experimental parameters such as level, carrier frequency and so forth for normal-hearing listeners. Kuwada (1986, *Hearing Research*, 21, p. 179-192) showed that for hearing-impaired listeners an increased level results in an abnormally high amplitude rise in the area where the hearing impairment is greatest. Since the loudness function for hearing-impaired listeners is steeper in frequency regions of hearing loss than in regions with better hearing, a correlation between loudness perception and AMFR might exist. This relationship will be investigated in the current study.

The study consists of three experiments:

- Recording the AMFR to continuously presented amplitude-modulated tones with carrier frequencies between 500 and 8000 Hz, modulated with 40 Hz and 80 Hz.
- Measuring the absolute hearing threshold using a 3 IFC procedure for pure tones and amplitude modulated tones (as described above) to compare the subjective threshold with the objective AMFR threshold.

- Carrying out a loudness scaling procedure with a third-octave noise band (usually used) and amplitude-modulated tones for investigating a relationship between subjectively perceived loudness and the AMFR.

The experiments will be carried out with normal-hearing and hearing-impaired listeners. We expect a rise in AMFR amplitude with rising level, which will be correlated with the rise in loudness with rising level. In the past months, the respective experimental set-ups and measuring paradigms have been set up and pilot experiments have been performed.

Start of dissertation: 01.07.2000

Planned end of dissertation: 30.06.2003

Attended conferences:

- Summerschool "Psychophysics, physiology and models of the central auditory system", 12.08.2001-16.08.2001, Bad Zwischenahn, Germany
- Kloosterburen - Start-up symposium of the EuroGK, 08./09.09.2000, Kloosterburen, Netherlands. (Own talk has been given)

Attended seminars:

- Non-regular:
 - Practical course on neuroscience, 18.-29.09.2000, Oldenburg, Germany - (Own talk has been given)
 - Summerschool BCN, 5.07.2000, Groningen, Netherlands
 - XIII. Winterschule für Medizinische Physik: Audiologie und Medizinische Akustik, 15.01.2001-19.01.2001, Pichl/Steiermark, Austria.
 - DFG Seminar "Das Wissen der Forschung – verständlich für Laien" 17.07.2001-18.07.2001, Kiel, Germany.
 - Einführungskurs "Medienkompetenz für WissenschaftlerInnen", 20.09.2001-22.09.2001, Berlin, Germany
- Regular:
 - Seminar of the EuroGK, Fridays, 10-12, Oldenburg, Germany - (Own talk has been given)
 - 'Monday meetings', once a month, alternating between Oldenburg, Germany and Groningen, Netherlands – (Own talk has been given)

Research stays

CNBH, Cambridge, Great Britain, Dec. 2000

4. Applications

Dr. Mark Marzinik, Medizinische Physik, Universität Oldenburg

Noise reduction schemes for digital hearing aids and their use for the hearing impaired

The aim of my work was to improve both the assessment methods and the available algorithms for noise reduction in hearing aids. In particular, the whole development chain from the construction of algorithms, subjective assessment of algorithmic performance by normal-hearing and hearing-impaired listeners as well as objective assessment methods was considered.

I proposed a speech pause detection algorithm which detects speech pauses by tracking minima in a noisy signal's power envelope, specifically in its low-pass and high-pass power envelopes. It maintains a low false-alarm rate over a wide range of signal-to-noise ratios. This facilitates its application for noise estimation in noise reduction algorithms.

It was shown that the musical noise phenomenon, one widely reported artifact of most single-microphone noise reduction schemes based on spectral subtraction, can to a high degree be overcome by the Ephraim-Malah noise reduction algorithms (Ephraim and Malah, 1984, 1985). If combined with the speech pause detection algorithm, a self-adaptive noise reduction scheme is obtained.

Comprehensive evaluations of the Ephraim-Malah noise reduction algorithms with hearing-impaired subjects show that besides better "sound quality", most obvious benefits are reductions in the mental effort needed to listen to speech in noise. To assess this feature, I proposed a new listening effort test.

Although a significant amount of noise reduction is obtained with the Ephraim-Malah algorithms for various noise conditions, an increase in speech intelligibility measured with a sentence test was not found. On the other hand, differences in terms of listening effort are found for different algorithms which did not show up in word recognition scores. These findings indicate that conventional speech recognition tests and tests of listening effort measure different aspects of the effect of noise reduction schemes in speech perception. Furthermore, I applied the method of paired comparisons in combination with the Bradley-Terry scaling model for subjective quality assessment of the algorithms. The results show that noise reduction is worthwhile in all of the different noises that were investigated. The Ephraim-Malah single-microphone noise reduction algorithms can be recommended for use in rather stationary noises. They fail in strongly fluctuating noises where a binaural directional filter and dereverberation algorithm may be used, particularly at lower SNRs.

In addition, I investigated the predictive power of several "objective" speech quality measures with respect to the subjective noise reduction effect for hearing-impaired listeners.

Particularly two measures (the so-called PMF, and the LAR) well reflect different subjective results.

My doctoral dissertation has been published online under

<http://docserver.bis.uni-oldenburg.de/publikationen/dissertation/2001/marnoi00/marnoi00.html>

Furthermore, it appeared as

Marzinik, M. (2001). *Noise reduction schemes for digital hearing aids and their use for the hearing impaired*. Aachen: Shaker (Berichte aus der Medizinischen Physik). ISBN 3-8265-8513-5.

From July 1st, 2000 to December 31st, 2000 I received a grant from the "Graduiertenkolleg Neurosensorik" to finish my doctoral dissertation which I started in the framework of the European Project "SPACE" (Signal processing for auditory communication in noisy environments).

From January 1st, 2001 to March 11th, 2001 I received a grant from the "Graduiertenkolleg Neurosensorik" as a "post-doc".

My main focus in these two and a half months was on preparing publications from my doctoral dissertation work which was finished in December 2000.

Recently, the full dissertation appeared as a book published by Shaker (Marzinzik, 2001a). A modified version of the second chapter was accepted by *IEEE Transactions on Speech & Audio Processing* (Marzinzik, 2001b). A modified version of the third chapter will appear soon in the *Zeitschrift für Audiologie* (Marzinzik, 2001c). Modified versions of chapters four and five were submitted to *Ear & Hearing* (Marzinzik, 2001d,e). A modified version of chapter six was submitted to the *Journal of the Audio Engineering Society* (Marzinzik, 2001f).

Datum of Promotion: 19. Dezember 2000, Oldenburg

Employment after Promotion: 2,5 Monate Post-Doc im GK

Employment after Graduate School: HELM AG (Hamburg), head of software engineering

References

- Marzinzik, M. (2001a). *Noise reduction schemes for digital hearing aids and their use for the hearing impaired*. Aachen: Shaker (Berichte aus der Medizinischen Physik). ISBN 3-8265-8513-5.
- Marzinzik, M. (2001b). Speech pause detection for noise spectrum estimation by tracking envelope minima. *IEEE Transactions on Speech & Audio Processing*. In press.
- Marzinzik, M. (2001c). A review of the Ephraim-Malah noise reduction algorithms. *Zeitschrift für Audiologie*. Accepted.
- Marzinzik, M. (2001d). Noise reduction schemes for digital hearing aids: I. Listening effort and speech intelligibility. *Ear & Hearing*. Submitted.
- Marzinzik, M. (2001e). Noise reduction schemes for digital hearing aids: II. Subjective quality assessment based on paired comparisons. *Ear & Hearing*. Submitted.
- Marzinzik, M. (2001f). Predicting the subjective quality of noise reduction algorithms for hearing aids. *Journal of the Audio Engineering Society*. Submitted.

Dipl. Phys. Michael Kleinschmidt, Medizinische Physik, Universität Oldenburg

Classification of speech signals using perceptive features and its application to robust speech recognition

The aim of the dissertation project is to include knowledge about the neurosensory processes in hearing into speech recognizers in order to make them more robust against background noise and other acoustical interferences.

A major deficiency in current automated speech recognition (ASR) systems is the lack of robustness in additive and convolutive noise. The performance most often degrades significantly when presenting test material recorded in a different acoustical situation than the training material. The problems are additive background noise, interfering speakers, channel distortions and reverberation. Normal hearing normal listeners still outperform any technical system by far, especially in adverse acoustical conditions.

The idea is therefore, to copy properties of the (human) auditory system derived from psychoacoustical and physiological models and experiments in order to enhance the robustness of automatic classification systems. The model of auditory perception (Dau et al.) has been successfully applied as a front end for ASR systems and combined with other noise reduction techniques [3, 7]. This model describes the peripheral auditory pathway from the inner ear to more central stages of the auditory system. Recently, there has been evidence from a number of different psychoacoustical and physiological experiments (deCharms, Kaernbach, Shamma), that spectro-temporal processing is a key element of the central (cortical) auditory system. A simple sigma-pi cell approach (Gramß) has been revised and combined with the peripheral auditory model, yielding improvements in ASR [5] and signal-to-noise ratio (SNR) estimation [1] tasks. Automated estimation of SNR is crucial for a number of technical systems (hearing aids, ASR, mobile phones), that depend on a varying parameter setting according to the acoustical situation.

The perceptual feature based approach has been extended to more complex spectro-temporal features [2], based on two-dimensional Gabor functions that are very similar to the spectro-temporal response fields observed for individual cortical neurons. An elaborate optimization scheme is used to automatically extract a sub set of all possible features, which is optimized for a given classification task. The optimized sub set may then be analyzed which has the potential to yield some insight and feedback to auditory modeling. First results indicate that (diagonal) spectro-temporal patterns only play a supplementary role to purely spectral (cepstral) and purely temporal features for phoneme recognition, but a more significant role in diphone recognition (i.e., a task where a recognition of the transitions between phonemes is explicitly required) .

Currently, I am in the process of combining these Gabor-type features with other features in a multi-stream approach using a state-of-the art ASR system, in order to investigate their compatibility with other front end and back end approaches and its feasibility for large vocabulary tasks.

Thesis period: July 1999 to May 2002 (expected).

List of publications:

M. Kleinschmidt und V. Hohmann: 'Sub-band SNR estimation using auditory feature processing' (submitted to *Speech Communication*)

M. Kleinschmidt: 'Methods for capturing spectro-temporal modulations in automatic speech recognition' (submitted to *acustica united with acta acustica*)

- M. Kleinschmidt, J. Tchorz and B. Kollmeier: 'Combining Speech Enhancement and Auditory Feature Extraction for Robust Speech Recognition', *Speech Communication* 34 (2001) pp. 75-91, Special Issue on Robust ASR.
- Tchorz, J., Kleinschmidt, M., and Kollmeier, B.: 'Noise suppression based on neurophysiologically motivated SNR estimation for robust speech recognition', *Proceedings of NIPS 2000*, in press.
- M. Kleinschmidt und V. Hohmann: 'Perzeptive Vorverarbeitung und automatische Selektion sekundärer Merkmale zur robusten Spracherkennung', *Fortschritte der Akustik - DAGA 2000*, Oldenburg, pp. 382-383, DEGA, Oldenburg.
- J. Anemüller, M. Kleinschmidt und B. Kollmeier: 'Blinde Quellentrennung als Vorverarbeitung zur robusten Spracherkennung', *Fortschritte der Akustik - DAGA 2000*, Oldenburg, pp. 364-365, DEGA, Oldenburg.
- C. Hartmann, M. Kleinschmidt, J. Tchorz und B. Kollmeier: 'Gehörgerechte Vorverarbeitung für die robuste Spracherkennung auf Basis von Wortuntereinheiten', *Fortschritte der Akustik - DAGA 2000*, Oldenburg, pp. 380-381, DEGA, Oldenburg.

List of attended courses: (all semesters for the since 1999)

- weekly "Seminar of EuroGK and SFB 517:Neurosensory Science & Systems"
- weekly seminar talks "Seminar Medizinische Physik"
- weekly invited talks „Akustik-Kolloquium“
- annual held two-week long practical courses "Blockpraktikum Signalverarbeitung" (as tutor)
- weekly seminar "Neurokognition" (every other semester)

List of attended conferences and research stays:

- Conference: DAGA 2000, Oldenburg
- Conference: NIPS 2000, Denver, CO, USA
- Winterschool : DGMP 2001 Audiology, Pichl, Austria
- Summerschool and Symposium: "Psychophysics, physiology and models of the central auditory system" 2001, Oldenburg,
- Research Stay: October 2001 to March 2002 at the International Computer Science Institute, Berkeley, CA, USA.

Dr. rer. nat. Jörn Anemüller, Medizinische Physik, Universität Oldenburg

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PO Box 85800, San Diego, CA 92186-5800, USA

Across-Frequency Processing in Convolutional Blind Source Separation

The aim of this finished dissertation project was to establish new algorithms for separating acoustical sources using - among others - acoustic processing principles that are derived from sound processing in the human brain.

The need to separate some sound sources from others is ubiquitous in acoustic signal processing. A typical example is the field of signal processing for the hearing impaired, where speech intelligibility needs to be enhanced in situations with multiple simultaneous speakers or with speech embedded in a background of noise. Similar problems are encountered in the field of automatic speech recognition where recognition rates still drastically degrade in the presence of interfering sources.

Blind source separation (BSS) and the related field of independent component analysis represent a relatively novel approach to this problem which has gained some attention over the past years. In contrast to other noise reduction schemes, BSS techniques aim at incorporating as little prior knowledge as possible into the algorithms, hence the term 'blind'. The key assumptions made incorporate basic knowledge about the (second-order or higher-order) statistics of the different sources and about the principles of the mixing process by which the sound source signals are superimposed to form the recorded microphone signals. Three different algorithms for the problem of separating convolutively mixed acoustic signals have been proposed in the dissertation:

In the first approach the structure of the separating filters was limited to a signal delay and attenuation. Under this constraint, optimal separation can be achieved only in the free field, where the sound signals are superimposed with a finite propagation speed and attenuation, however, without echoes and reverberation. Adaptation of the filter coefficients is performed by an ICA algorithm for Fourier transformed speech signals which was derived from the principle of maximum likelihood. By making efficient use of information contained in all frequency channels of the mixed signals, this algorithm achieves a very robust and fast convergence within approx. 0.2s of signal time. Estimation of the separating filter is continuously adapted and computations can be performed in real-time. Therefore, the algorithm is also applicable for the separation of non-stationary signal mixing and represents the first published blind source separation algorithm which has been shown to separate moving speakers and track their position.

The 'AMDecor' algorithm presented subsequently can be regarded as complementary to the first approach since no limiting assumptions were imposed with regard to the separating filters. Therefore, the algorithm can be employed to separate signals in rooms with echoes and reverberation. Rather, assumptions are made about the sources' modulation structure which is assumed to bear similarities with modulations observed in speech signals. The application to standard data sets showed that the separation is improved compared to other state-of-the-art blind source separation methods. Evaluation using signals with strong reverberation proved that the quality of separation is close to the physical optimum also under very difficult conditions. The comparison with non-blind noise reduction schemes by means of an automatic speech recognition task revealed that source separation exhibits the best improvement in recognition rate for strong interfering noise, whereas alternative methods are superior for soft noise.

The third algorithm developed also refrains from imposing constraints on the separating filters. Its spirit is very similar to the AMDecor algorithm, however, this algorithm approaches the problem by using second-order correlations. Since this approach results in a

fully linear problem formulation, it admits an analytic solution, resulting in a system of eigenvalue equations which can be solved by efficient numerical techniques. The algorithm has been evaluated using synthetic data, image data and real room speech recordings.

Thesis period: 1.3.1997 - 30.7.2001

Publications:

- J. Anemüller and B. Kollmeier. Adaptive separation of acoustic sources for anechoic conditions: A constrained frequency domain approach. *Speech Communication*, 2002 (conditionally accepted).
- G. Jongen, J. Anemüller, D. Bollé, A. C. C. Coolen, and C. Pérez-Vicente. Coupled dynamics of fast spins and slow exchange interactions in the xy spin glass. *Journal of Physics A: Mathematical and General*, 34(19):3957-3984, 2001.
- J. Anemüller and B. Kollmeier. Convolutional blind source separation of speech signals based on amplitude modulation decorrelation. *J. Acoust. Soc. Am.*, 108:2630, 2000.
- J. Anemüller and B. Kollmeier. Amplitude modulation decorrelation for convolutional blind source separation. In P. Pajunen and J. Karhunen, editor, *Proceedings of the second international workshop on independent component analysis and blind signal separation*, Seiten 215-220. Helsinki, Finland, 2000.
- J. Anemüller, M. Kleinschmidt, and B. Kollmeier. Blinde Quellentrennung als Vorverarbeitung zur robusten Spracherkennung. In V. Mellert, editor, *Fortschritte der Akustik: DAGA 2000*, Seiten 364-365. Deutsche Gesellschaft für Akustik (DEGA), Oldenburg, Germany, 2000.
- J. Anemüller and T. Gramß. On-line blind separation of moving sound sources. In J. F. Cardoso, C. Jutten, and P. Loubaton, editor, *Proceedings of the first international workshop on independent component analysis and blind signal separation*, Seiten 331-334. Aussois, France, 1999.
- J. Anemüller. Correlated modulation: A criterion for blind source separation. In *Joint meeting of the Acoustical Society of America and the European Acoustics Association*. Berlin, Germany, 1999. 4 pages on CD-ROM proceedings.
- J. Anemüller and T. Gramß. A neural network for sound source separation. In T. Dau, V. Hohmann, and B. Kollmeier, editor, *Psychophysics, Physiology and Models of Hearing*, Seiten 255-258. 1999.
- J. Anemüller and T. Gramß. Blinde akustische Quellentrennung im Frequenzbereich. In A. Sill, editor, *Fortschritte der Akustik: DAGA 98*, Seiten 350-351. Deutsche Gesellschaft für Akustik (DEGA), Zürich, Switzerland, 1998.
- J. Anemüller. *Coupled Synaptic and Neuronal Dynamics for Oscillator Networks*. Master's Thesis, Department of Mathematics, King's College London, 9. September 1996.

List of external talks:

- 13.7.1999 TU-Berlin, group of R. Orgelmeister
- 6.9.2000 MPI für Physik komplexer Systeme, Dresden, group of H. Kantz
- 26.9.2000 GMD-First, Berlin, group of K.-R. Müller
- 7.11.2000 Siemens corporate research, Princeton, USA, group of R. Balan
- 15.11.2000 BBN Technologies, Cambridge, USA, group of J. Makhoul
- 16.11.2000 MIT, Cambridge, USA, group of L. Braida
- 22.11.2000 The Salk Institute and UCSD, San Diego, USA, groups of T. J. Sejnowski and T.-W. Lee

List attended courses and conferences:

- 27.1.-31.1.1997 Winterschule Medizinische Akustik, Pichl, Österreich
- 30.6.-12.7.1997 Cargese Summer School on Neuronal Information Processing, Cargese, Frankreich (Poster)

- 27./28.2.1998 Neuro Northwest Workshop, Oldenburg (Poster)
- 7.-14.3.1998 Interdisziplinäres Kolleg IK98, Günne am Möhnesee
- 23.-27.3.1998 Konferenz DAGA 1998, Zürich, Schweiz (Talk and proceedings paper)
- 31.8.-4.9.1998 Sommerschule Psychophysics, physiology and models of hearing, Bad Zwischenahn (Poster and proceedings paper)
- 10.-12.12.1998 Winterschule Networks with Spiking Neurons and Synaptic Plasticity, Berlin
- 11.-15.1.1999 Konferenz ICA 1999, Aussois, Frankreich (Poster and proceedings paper)
- 14.-19.3.1999 Konferenz ASA/EAA/DAGA 1999, Berlin (Poster and proceedings paper)
- 29.8.-1.9.1999 Sommerschule Psychologische Akustik, Bad Zwischenahn
- 20.-23.3.2000 Konferenz DAGA 2000, Oldenburg (Talk and proceedings paper)
- 19.-22.6.2000 Konferenz ICA 2000, Helsinki, Finnland (Talk and proceedings paper)
- 27.11.-2.12.2000 Konferenz Neural Information Processing Systems, Denver and Breckenridge, USA
- 3.12.-8.12.2000 Konferenz ASA 2000, Newport Beach, USA (Talk and abstract)

Dipl.-Inform. Laila Kabous, Department of Computer Science, VLSI Design Unit, University of Oldenburg

Object oriented development of embedded systems

The aim of the current dissertation project is to develop and optimise a design methodology (OOHARTS - Object Oriented Hard Real Time System) with appropriate tool support which allows – among other applications – to develop embedded systems based on the neurosensory models and applications developed in the European graduate school.

An embedded system is a component within a larger system. Embedded systems (real-time systems) are in general electronic systems, integrated in a certain environment. They consist of a combination of computer hardware and software, designed to perform specific functions. Typical representatives of such systems are controllers, communication systems, medical systems, etc. Embedded systems can contain general-purpose microprocessors and micro-controllers, as well as application specific hardware and software.

The OOHARTS approach was developed to reduce the overall design time of complex and reliable real time systems satisfying all the requirements (e.g. timing) imposed to those systems. This allows the designer to make qualitative predicates about the system properties early in the design process resulting in a system realisation that works correctly at first go. In the framework of this project first of all the existing specification and design methodologies have been evaluated regarding their applicability for designing real time systems based on the properties and requirements that characterise those kinds of systems. The different methodologies have been assessed according to their applicability for specifying real time systems, in a continuous design flow for hardware and software. Existing methodologies lack the possibility to explicitly specify the temporal behaviour, and characteristics like concurrency and synchronisation, which are very important for the description of real time systems. These disadvantages can be overcome by applying the OOHARTS approach. The OOHARTS method is based on an extension of the unified modelling language and it permits the designer to specify functional and non-functional requirements of real time systems on a high level of abstraction. The real time models described with the OOHARTS method can be verified by translating them into a simulation language which allows the analysis of the translated models by means of mathematical scheduling algorithms. The used simulation language and the tool performing the analysis have been also developed within the framework of this project.

The first phase of the graduate school for neurosensory science, systems and applications has served as an introduction to the field of neuronal and sensory processing. This phase was used as orientation phase and for laying the base for the ongoing research. The developed object oriented approach for specifying real time systems has been evaluated regarding its applicability in the area of speech processing by means of existing case studies that were resulting from previous co-operations between the medical physics group and the VLSI-Design group.

During this research project the treated models and algorithms for speech processing are modelled and realised as embedded system. Key point of the realisation is the effective implementation of the digital signal processing steps. The necessary knowledge of digital signal processing has also been imparted in another phase of the Euro-GK. The embedded system for speech processing, that shall improve the man-machine communication, is specified starting from the object oriented OOHARTS approach and based on the mentioned requirements.

After the specification of the system and before its implementation simulations will be runned on that system by means of the simulation tool which has been developed specially for that purpose during this project to verify whether the non-functional requirements are met.

The results gained from the previous step (specification of the whole system and the simulation results) will be used in the realisation of the system with a concrete hardware description language. The hardware implementation of the "effective" auditory processing can be used to test the developed real-time algorithms for "intelligent" hearing aids with hearing-impaired listeners

Thesis period: June 2000 – May 2002, Ph.D. students stipend since 1.06.2000)

Lectures and Own Publications:

- Kabous, L.: Modellierung von eingebetteten Systemen – Der OOHARTS Ansatz. Internes Kolloquium, Fachbereich Informatik. Dezember 2000
- Kabous, L.: Modellierung von objektorientierten eingebetteten Systemen. Euro-GK Seminar WS2000/2001
- Kabous, L.; Nebel, W.: Modeling Hard Real Time using UML: The OOHARTS Approach. UML'99 Unified Modeling Language Conference. Published in UML'99 Beyond the Standard, Lecture Notes in Computer Science (1735), Springer Verlag.
- Kabous, L.; Nebel, W.: OO-Methoden für Harte Echtzeitsysteme. Objekt Orientierte Modellierung von Realzeitsysteme OMER Workshop. Mai 99 Herrsching am Ammersee. Bericht Nr.1999-01.
- Kabous, L.; Nebel, W.: An Object Oriented Design Method for Hard Real Time Systems. Euromicro Conference on Real Time Systems ECRTS99. Work in Progress YCS 315 (1999).
- Kabous, L.: Design and Specification of Hard Real Time Systems. Technical Report.
- Nebel, W.; Schumacher, G.; Oppenheimer, F.; Kabous, L.; Radetzki, M.; Putzke-Römig, W.: Modeling and Specification of Embedded Real Time Systems, 16th IFIP Conference 2000.
- Kabous, L.; Nebel, W.: Development of hard real time systems based on an object oriented approach. Conference on Parallel and Distributed Processing Techniques and Applications. Published in The Conference on Parallel and Distributed Processing Techniques and Applications PDPTA'2001. CSREA Press.

List of attended courses

- SFB-Seminar SS00
- Psychoacoustic Seminar: SS00
- European graduate school workshop in Klusterburen. September 2000
- Practical Courses in the Medical Physics Group AG:SS00
- Graduate School Neurosensory Seminar /SFB-Seminar: WS00/01

Monthly meetings of all EuroGK-members

- Physics/Biophysics/Audiology
- Neurobiology/Neuroanatomy/Medical Imaging
- Psychology
- Computer Science

Dipl. Physicist Sandra Buss, physics/acoustics, University of Oldenburg

Doctoral student since 2000 January 1

Supervisor: Prof. Dr. Volker Mellert

Temporal and spectral analysis of acoustic signals by calculating contours

The aim of this thesis is to develop a practically applicable model of acoustical pattern perception that uses aspects of auditory signal processing to predict the annoyance of technical sounds. As a first approximation, the method of calculating contours, developed by Mummert at the Technical University of Munich, is used in order to detect tonal components in tire noise. In this context the functional modeling of the auditory signal treatment is based on auditory filter characteristics, masking - and temporal resolution properties of the auditory sensory system. Contours are spectrotemporal maxima in level either at a single point in time (frequency contours, representing tonal components) or at a single frequency (time contours, representing transient signal components).

Tire/road noises are chosen as technical sounds. To investigate the relationship between subjective assessments and objective signal parameters a thorough analysis of subjective judgments and tire/road noise patterns are carried out..

Subjective evaluations of tire/road noise

Subjective testers judge the total degree of irritation of tire/road noise while coasting in steps of 10 km/h. Assessments are made on a categorical scale from 1 to 10 in steps of 0.5. Additionally conspicuous noises are characterized by noise terms. These noise terms refer to special potentialities.

Subjective Evaluations of tire/road noise of 833 tire sets are analyzed according to noise terms and their relation to rating and the speed dependency. The judgments were carried out between January 1997 and March 2000. The whole data recording contains 9501 judgments each representing the evaluation of one tire in a 10 km/h step.

The most frequently named noise term is Drumming (28%). Pattern noise, Booming, Rumbling, White noise and Growling/Grinding are mentioned in about 15% of all judgments and Knocking and Sizzle less than 5%.

In about one third of all judgments no noise term is mentioned and in another third only one noise term. The relative frequency decreases with increasing number of noise terms in one judgment. The highest number is five and the mean one term.

With increasing number of noise terms the rating decreases.

The frequency of noise terms is speed dependent. Pattern noise, Booming, White noise, Knocking and Sizzle are mentioned most often in the range 80-100 km/h. Drumming occurs most often at 50-60 km/h and Growling/Grinding at 20-30 km/h.

Objective signal parameters correlated with Pattern noise

It is known that the pattern noise is related to the level of the first pitch harmonics (around the 60th order). Two subjective tests are carried out in order to find signal parameters correlated with Pattern noise.

In a first experiment 84 signals were ordered by four subjects according to the strength of Pattern noise using an AFC procedure. The signals were generated by increasing the level of the first pitch harmonics of four tire/road noise recordings by -10 to 10 dB in steps of 1 dB. Assuming that the strength of Pattern noise increases when the level of the first pitch harmonics of one signal is increased, the four signal series (each containing one recording and their modifications) are ordered to each other according to the strength of Pattern noise. It is proven that the resulting order is very well correlated with the RMS of the absolute level of the first pitch harmonic.

In the second experiment six signals were ordered by eight subjects according to the strength of Pattern noise by paired comparison. The six signals were a tire/road noise recording and modifications of the spectral width of the first pitch harmonic of this signal. The level in a range of one third resp. two third around the mean order of the first pitch harmonic was increased by 2 dB resp. 4 dB. The level of the first pitch harmonic of this four signals was adjusted to the level of the first pitch harmonic of the original recording. The sixth signal was that signal (also used in the first experiment) with a first pitch harmonic increased by 2 dB. When the level of the first pitch harmonic is kept constant the amount of Pattern noise increases with decreasing width of the first pitch harmonic and with increasing tonality. So the contours could be related to pattern noise. A change of the level of the first pitch harmonic doesn't effect the tonality. But it has a stronger effect on the amount of Pattern noise than the tonality. An evaluation of the same signals by subjective testers led to the same ranking than the paired comparison test.

Conclusion

In order to find a relation between the contours and subjective ratings of tire/road noise subjective evaluations of tire/road noise are analyzed. In subjective tests a positive correlation between the level (RMS) of the first pitch harmonic and the amount of pattern noise can be found. When the level of the first pitch harmonic is kept constant, the amount of Pattern noise increases with increasing tonality.

Thesis period: 1.1.2000 – 31.12.2002 (planned)

List of own publications

Sandra Buss, Nicolas Chouard, Brigitte Schulte-Fortkamp: "Semantic Differential tests show intercultural differences and similarities in perception of car-sounds", In: Fortschritte der Akustik - DAGA 2000.

Reinhard Weber, Sandra Buss, Nicolas Chouard: "Multidimensional methods in car-sound quality assessments: Comparison of preference test results and polarity profiles in three European countries", In: Fortschritte der Akustik - DAGA 2000.

Sandra Buss, Brigitte Schulte-Fortkamp, Petra Muckel: "Combining methods to evaluate sound quality", In: Proceedings of inter.noise 2000.

Sandra Buss, Reinhard Weber, Werner Liederer, Volker Mellert: "Charakterisierung von Reifengeräuschen mit Geräuschbegriffen", In: Fortschritte der Akustik - DAGA 2001.

Sandra Buss, Reinhard Weber, Werner Liederer, Volker Mellert: "Subjective and objective characterization of tire noise", In: Proceedings of inter.noise 2001.

List of attended courses

- Summerschool and Symposium "Psychophysics, physiology and models of central auditory system", 2001, Bad Zwischenahn, Germany
- Seminar of the European Graduate School, 1999-2002, University of Oldenburg, Germany

List of attended conferences

- DAGA 2000, Oldenburg, Germany
- Inter-noise 2000, Nice, France
- DAGA 2001, Hamburg, Germany
- Inter-noise 2001, The Hague, Netherlands

List of research stays

Many measurements and questioning concerning the characteristics and subjective evaluation of tyre/road noise is done in a Research Centre of a large manufacturer of tires.

Dipl. Phys. Matthias Vormann, Fachbereich Physik, Akustik, Universität Oldenburg

Development and Validation of a Psychoacoustic Measuring Procedure and Prediction-Model for the Assessment of Tonalness (Tonhaltigkeit[1]) of Noises

The overall objective of this dissertation is to achieve a sophisticated psychoacoustic model for the prediction and calculation of tonalness, which is highly adapted to human hearing and auditory perception.

This modeling of the human hearing and auditory perception suggests a close link between my dissertation-project and the EuroGK “Neurosensory Science, Systems and Application”.

Tonalness, in German called “Tonhaltigkeit” and defined by the German standard DIN 45681 (draft) [1], in English publications often called “tonal noise”, is an important parameter affecting sound quality and is substantial for the assessment of the annoyance of tonal components in environmental noises.

For the measurement of time-varying weak tonal components of complex technical and natural sounds none of the existing standards like DIN45681 [1] or ANSI S1.13-1995 correspond to subjective ratings [3-9].

This is due to the fact that conventional methods neglect the time and frequency resolution as well as masking properties of the human hearing [e.g. 3, 4, ...]. Furthermore a possible frequency dependence of tonal noise components is disregarded.

A further problem is the subjective rating of tonalness. Most subjects are not able to link a sensation or perception to the term “tonalness”, because tonalness is a technical definition and unknown in every-day life (unlike for example “loudness”).

Therefore the underlying perception has to be investigated first. This has to be done on the one hand in a psychological way, investigating the sensation and perception of humans, concerning tonalness. This yields a description and definition of the tonalness on a psychological basis, combining similar terms, for example squeal, screech, creak, squeak and so on. This is important to realize the “range” and “extend” of “psychological tonalness” (which is a measure for the perception and sensation). On the other hand, a technical approach to explore the connection between physical sound-parameters and “subjective tonalness” is required.

From this point of view, the different methods and results obtained in different experimental set-ups [e.g. 3, 6, 8] must be investigated and compared to get a universal description of tonalness and thus to yield unified subjective tonalness rating-procedures.

Up to now psychoacoustic measurements have been carried out to determine the range, perception, sensation and description of tonalness to standardize tonal-assessments. Physical sound-parameters affecting the tonalness have been discovered quantitatively in various psychoacoustical experiments with listeners using different methods.

At the moment a model related to human hearing and perception including the discovered facts is developed.

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- Beckenbauer: „Anwendung der DIN 45681 (Entwurf) in der Praxis“ DAGA 1993, S. 620-623
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- Daniel/Vormann/Ellermeier: „Berechnung der THK von Reifengeräuschen mit einem Modell der Tonhöhenwahrnehmung“, DAGA 1998, 484-485

<i>Associated Member</i>	Since 10.05.2001
<i>EuroGK:</i>	
<i>Member GK “Psychoacoustics”:</i>	01.05.1998 – 31.03.2001
<i>Thesis period:</i>	01.05.1998 – 30.07.2002 (projected)
<i>List of attended courses:</i>	SS 2001 and WS 2001/2002: Regularly: EuroGK seminar Oldenburg
<i>List of given courses:</i>	SS 2001 and WS 2001/2002: Introduction to Psychoacoustics for Psychologists.(Seminar) SS 2001: Practical Training “Human Ear and its function” for advanced Physics students (Advanced Lab Course). WS 2001/2002: Lecture “Mechanics and Thermodynamics” at Fachhochschule Oldenburg, Ostfriesland, Wilhelmshaven, Fachbereich Seefahrt in Elsfleth
<i>List of attended conferences:</i>	DAGA 1998, Zürich; Summerschool and Symposium 1998, Bad Zwischenahn; DAGA/Forum Acusticum/Meeting of the Acoustical Society of America 1999, Berlin; 8th Oldenburg Symposium on Psychological Acoustics, Bad Zwischenahn, 1999; DAGA 2000, Oldenburg; InterNoise 2000, Nice; XIII. Winterschule “Audiologie und medizinische Physik” 2001, Pichl/Steiermark; DAGA 2001, Hamburg;
<i>List of other activities:</i>	Webmaster of the European Acoustics Association (EAA) Homepage. Processing and preparation of the Nuntius Acusticus, the “Acoustic Messenger” of the European Acoustics Association (EAA).
<i>List of Publications:</i>	Daniel, P., Ellermeier, W. and Vormann, M. (1998), “Computational and Subjective Procedures for the Assessment of Sounds with Weak Tonal Components“, in 16th International Congress on Acoustics and 135th Meeting Acoustical Society of America, edited by Kuhl, P.K. and Crum, L.A., Acoustical Society of America, 1509-1510. Vormann, M., Schick, A., Meis, M., Klatt, M. and Mellert, V. (1998), “Tonhaltigkeit aus psychophysikalischer Sicht-

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- Vormann, M., Verhey, J.-L., Mellert, V. and Schick, A. **(2000b)**, “Ein adaptives Verfahren zur Bestimmung der subjektiven Tonhaltigkeit“, in Fortschritte der Akustik – DAGA 2000, 304-305.
- Vormann, M., Verhey, J.L., Mellert, V. and Schick, A., **(2000c)**, “An adaptive Procedure for Determinating the Subjective Tonalness“, Internoise 2000, in press.

Dr. rer. nat. Jens Harting, Medizinische Physik, Universität Oldenburg

Numerical methods in neurosensory science

Jens Harting finished his doctoral project in theoretical physics with the defense of his thesis on the 14th of December. He left the Physics department of the University of Oldenburg in March 2002 in order to accept a postdoc position in London or Copenhagen.

Next to the research being performed for his thesis, he has been involved in the work of the European Graduiertenkolleg by participating in the seminars and supporting the work of the medical physics group and the other stipends from the european graduate school. This support consisted of introducing various members of the group to working with Linux workstations and discussions about the most effective implementation of several server applications.

Further-more, numerous Linux workstations have been reinstalled and integrated into the local network. Jens Harting has further been responsible for the preparation and maintenance of a server based installation source, opening the possibility to install and integrate additional workstations with the least possible effort.

Period of funded stipend: 01.07.01 – 31.12.01

Completion of Ph.D.: 14.12. 2001

Dipl. Phys. Christine Hartmann, Medizinische Physik, Universität Oldenburg

Experiments for auditory-processing based automatic speech recognition

Christine Hartmann finished her Diploma in physics in November, 2000 with a thesis on robust automatic speech recognition. Due to her very good performance in her diploma thesis and her exam, she was awarded a stipend from the EuroGK. She wrote up parts of her thesis for publication published during this period. However, she decided to turn into an other area of specialization (medical radiation physics) and was offered an attractive position for performing her Ph.D. in a hospital, which she accepted effective January 2001.

Hartmann, C. (2001). Spracherkennungssysteme. Z. f. Audiologie/Audiological Acoustics Heft 1/2001.

Period of funded stipend : 01.11.00 – 31.12.00