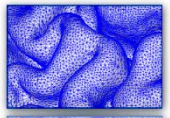
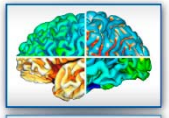
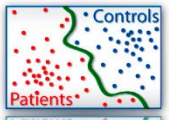
The tissue segmentation result is used to create a mesh of the central surface in the middle of the GM that represents the cortex **[1457 WTh-AM]**. This reconstruction based on distance information that are also used to measure the thickness of the GM, WM and CSF tissues **[1458 WTh-PM]**. Because noise and partial volume effects lead to misclassification the reconstructed surface usually contains topological defects, like a bridge between two gyri, or holes within a gyrus, that have to be corrected **[1342 WTh-PM]**. Now, the cortical surface can be projected to a sphere to compare individuals.



Each individual surface can be used to estimate morphometric measures like curvature, gyrification index **[1459 WTh-AM]**, fractal dimension **[1341 WTh-AM]**, or to map volumetric data like the tissue thickness **[1458 WTh-PM]** or fMRI data. This data can now be used for statistical analysis and classification methods.

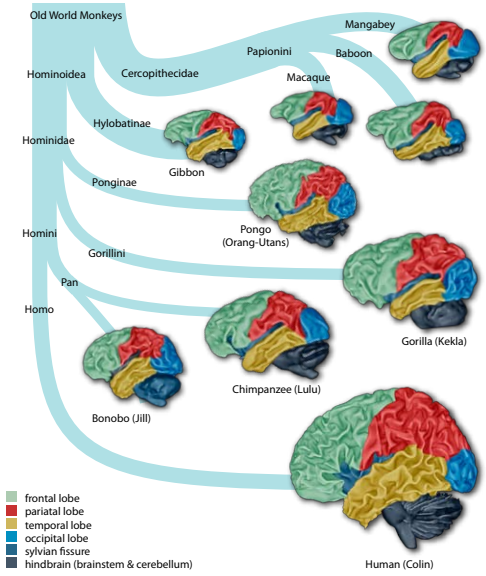


The major concern of classification methods in a psychiatric imaging context is the separation of groups (e.g., patients and controls) based solely on structural properties of the brain. For this purpose, we used support vector machines (SVM) to estimate borderlines for multidimensional brain attributes in direct comparison of two or more groups. In many cases, predicting the group membership of further (previously unclassified) individuals can be accomplished with a high degree of accuracy. One aim of this classification procedure is to support objective diagnoses of certain psychiatric and neurological diseases **[1262 WTh-PM, 339 WTh-AM]**.

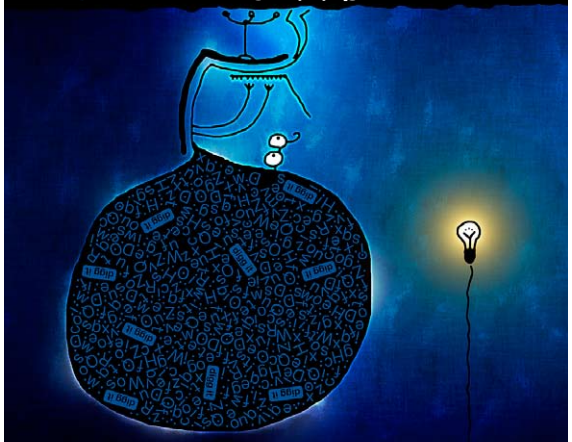


Our work is supported by the German BMBF grants 01EV0709 & 01GW0740.

Inside this flyer you will find an overview about our posters and presentations for HBM2010.



Christian Gaser
Department of Psychiatry
University of Jena



STRUCTURAL BRAIN MAPPING GROUP

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Header illustrations by Vlad Gerasimov
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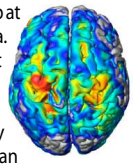
STRUCTURAL BRAIN MAPPING GROUP



Welcome to the Structural Brain Mapping Group at the Department of Psychiatry, University of Jena. Our principal research focuses on the development of methods for structural brain imaging and their application. Specific areas of interest include the investigation of structural brain plasticity and schizophrenia research. Inside you will find an overview about our work and our posters for HBM 2010 with poster number and day for each topic, i.e. **[769 WTh-AM]**. All posters are on our web-page: http://dbm.uni-jena.de/HBM2010/ .

RESEARCH

Brains constantly change in response to internal and external cues. While most of these changes simply reflect normal development and learning, others could lead to brain diseases or detrimental aging processes. Helping people with the latter kind of changes is one of the central motivators of neurology and psychiatry research. However, many aspects of brain structure and function – as well as their interactions, from the molecular to the cognitive and sociological levels – are still not sufficiently understood to provide a clear biological framework on which clinicians can base their diagnoses and therapeutic decisions. As a consequence, many neuropsychiatric disorders continue to lack promising therapies, and quite a few are still hard to diagnose.
Our group focuses on the quantification of macroscopic structures in the brain and on the classification of the changes they undergo, especially in the early phases of neuropsychiatric disorders like schizophrenia and Alzheimer's disease. Any findings can be considered to be a contribution to a coherent theoretical framework for brain changes across time and levels of biological organization.

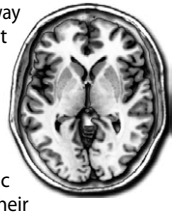
VBM-SOFTWARE

The VBM toolboxes are a collection of extensions to the segmentation algorithm of SPM2, SPM5, and SPM8 (Wellcome Department of Cognitive Neurology) to provide voxel-based morphometry (VBM). The toolboxes are named according to the SPM version. The software was developed by Christian Gaser and is available to the scientific community under the terms of the GNU General Public License.

PEOPLE:

1. Christian Gaser, Ph.D. [Principal Investigator]
2. Daniel Mietchen, Ph.D. [Postdoc]
3. Rachel A. Yotter, Ph.D. [Postdoc]
4. Katja Franke, Dipl. Psych, M.A. [Ph.D. Student]
5. Robert Dahnke, Dipl. Inf [Ph.D. Student]
6. Gabriel Ziegler, Dipl. Psych [Ph.D. Student]

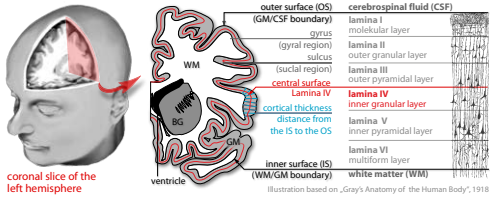
METHODS FOR STRUCTURAL BRAIN IMAGING



Magnetic resonance imaging (MRI) is a way to visualize spatial information about macroscopic ensembles of atomic nuclei within a patient lying in a clinical scanner. Image contrast can be generated in a variety of ways that highlight different properties of these nuclei (e.g., their density, their interaction with electromagnetic fields, their chemical environment, or their diffusion or flow), averaged over small volume elements of the brain, typically with a resolution of 1 mm^3.

Neuropsychiatric diseases like schizophrenia are the result of processes acting on time scales of both an individual's lifetime and our species' history **[769 WTh-AM]**. For this reason, insights into human brain development or brain evolution in general can also help to elucidate related aspects of brain disorders. Specifically, the mammalian brain is characterized by a six-layered cerebral cortex which folds up with increasing brain size. Abnormalities in the thickness and folding of the cerebral cortex have been observed in patients with schizophrenia, autism, William's syndrome, and other medical conditions. We therefore investigate the common principles underlying these processes by quantifying brain shape, both in humans (particularly children) and across species (particularly other primates) on the basis of data obtained with Magnetic Resonance Imaging.

The cerebral cortex is a highly folded sheet of gray matter (GM) that lies inside the cerebrospinal fluid (CSF) and surrounds a core of white matter (WM).



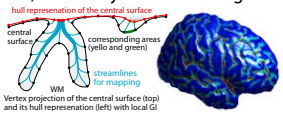
To analyse cortical structures, it is necessary to remove non-brain tissue and to segment the remaining tissue into GM, WM, and CSF **[1369 WTh-AM]**.

There are three common ways to analyse the structure of the brain: deformation-based (DBM), voxel-based (VBM), and surface-based morphometrie (SBM). DBM measures the normalization forces that are necessary to transform the individual to a common group brain. VBM analyses the tissue volume within each voxel after normalization. SBM analyses data of each surface point that represents the cortex. For SBM, it is also necessary to separate the brain into left and right hemispheres and to remove the brainstem and cerebellum.

3D LOCAL GYRIFICATION INDEX BASED ON THE LAPLACE EQUATION

R. Dahnke, R.A. Yotter, C. Gaser

A strong relation between cortical convolution and cognitive development is known to exist between species. To describe brain convolution, Zilles defined the gyrification index as the relation between the inner and outer contour within a slice of a brain. Most previous GI measures have some sort of drawback, for instance, requiring manual interaction, work only in 2D or on a global level. Here, we present a fully automatic, locally defined method that overcomes these limitations.

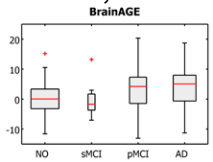


Poster: 1459 WTh-AM
PDF: http://dbm.neuro.uni-jena.de/HBM2010/Dahnke03.pdf

BASELINE BRAINAGE SCORE RELATES TO PROGRESSION FROM MCI TO AD WITHIN 2 YEARS

K. Franke, S. Klöppel[2], N. Koutsouleris[3], C. Davatzikos[4], H. Sauer, C. Gaser

For Alzheimer's disease (AD), it may be possible to identify biomarkers that can predict probable development of AD before the onset of cognitive decline or clinical symptoms. Here, we investigate the capability of our recently presented age estimation framework to contribute to an early diagnosis of AD and an early indication of progressive mild cognitive impairment (pMCI). The framework can recognize pathologic brain atrophy two years before the onset of clinical symptoms, as well as predict the rate of decline over a two-year time span.

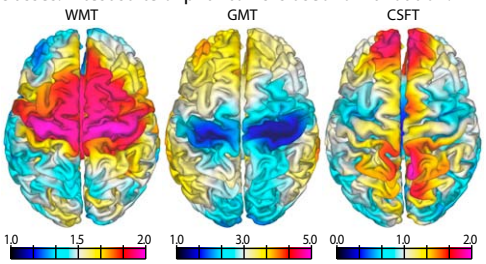


Poster: 339 WTh-AM
PDF: http://dbm.neuro.uni-jena.de/HBM2010/Franke02.pdf

BRAIN TISSUE THICKNESS ESTIMATION USING A PROJECTION SCHEME

R. Dahnke, R.A. Yotter, G. Ziegler, C. Gaser

Cortical thickness estimation can provide clinically relevant information with respect to several neurodegenerative diseases, such as AD and schizophrenia. Previously, most cortical thickness measurements have focused solely on GM thickness. Here, we present a method that allows, besides GM thickness, also the thickness estimation of WM and CSF. All thickness measurements are projected onto the central surface, allowing direct comparison of thicknesses of all tissue classes. A test suite of phantoms is used for validation.

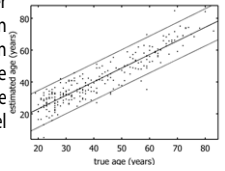


Poster: 1458 WTh-PM
PDF: http://dbm.neuro.uni-jena.de/HBM2010/Dahnke02.pdf

BRAINAGE: A COMPLETELY AUTOMATED AGE ESTIMATION FRAMEWORK USING STRUCTURAL MRI

K. Franke, G. Ziegler, S. Klöppel[2], C. Gaser

Recently, a number of cross-sectional and longitudinal MRI studies of age-related brain changes contributed to a more substantial understanding of the ongoing aging processes in healthy brains. Notably, neurodegenerative diseases such as AD were found to alter brain structure in abnormal modalities. Identifying pathologic brain atrophy before the onset of clinical symptoms could contribute to early diagnosis and facilitate early treatment. In order to recognize faster brain atrophy, a model of healthy brain aging is needed, which can estimate an individual's age from its brain scan. We introduce an automatic and efficient age estimation framework using a kernel method for regression.

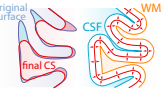


Poster: 1262 WTh-PM
PDF: http://dbm.neuro.uni-jena.de/HBM2010/Franke01.pdf

CENTRAL SURFACE RECONSTRUCTION USING A PROJECTION SCHEME

R.Dahnke, R.A. Yotter, C. Gaser

We present a new method that allows an anatomically correct reconstruction of the central surface using a projection-based thickness (PBT) algorithm. It based on a CSF-GM-WM tissue segmentation and requires no explicit sulcal reconstruction. A test suite of phantoms is used for validation.

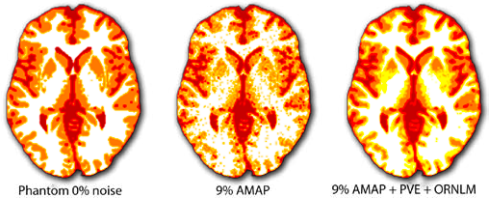


Poster: 1457 WTh-AM
PDF: http://dbm.neuro.uni-jena.de/HBM2010/Dahnke01.pdf

IMPACT OF NON-LOCAL MEANS FILTERING ON BRAIN TISSUE SEGMENTATION

C. Gaser, P. Coupé[1]

A wide number of magnetic resonance imaging (MRI) analysis techniques rely on brain tissue segmentation. Automated and reliable tissue classification is a challenging task as the intensity of the data typically does not allow a clear delimitation of the different tissue types because of partial volume effects, image noise and intensity non-uniformities caused by magnetic field inhomogeneities. To solve this problem, classification algorithms traditionally combine data-term (e.g. gray-level intensity or gradient values) with prior spatial information (e.g. local neighborhood and/or atlas information). To be robust to noise, local interactions between voxels are usually taken into account by using Markov random field (MRF) models. In this work, we propose to study the impact of Non-local (NL) means denoising prior to brain tissue segmentation.

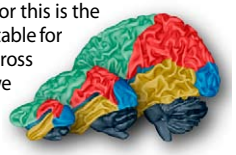


Poster: 1369 WTh-AM
PDF: http://dbm.neuro.uni-jena.de/HBM2010/Gaser.pdf

OPTIMIZING AUTOMATED PREPROCESSING STREAMS FOR BRAIN MORPHOMETRIC COMPARISONS ACROSS MULTIPLE PRIMATE SPECIES

D. Mietchen, R. Dahnke, C. Gaser

MR techniques have delivered images of brains from a wide array of species, ranging from invertebrates to birds to elephants and whales. However, their potential to serve as a basis for comparative brain morphometric investigations has rarely been tapped so far, which also hampers a deeper understanding of the mechanisms behind structural alterations in neurodevelopmental disorders. One of the reasons for this is the lack of computational tools suitable for morphometrci comparisons across multiple species. In this work, we aim to characterize this gap, taking primates as an example.

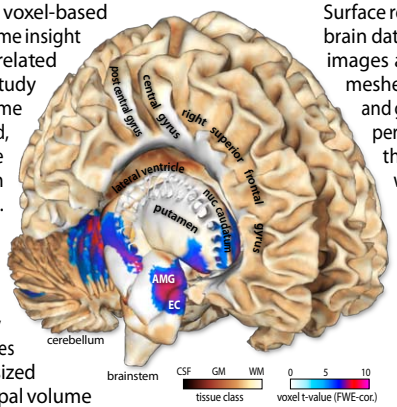


Poster: 769 WTh-AM
PDF: http://dbm.neuro.uni-jena.de/HBM2010/Mietchen.pdf

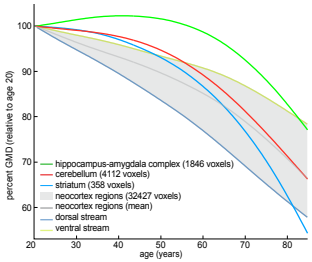
PRESERVATION EFFECTS AND HIPPOCAMPAL STRUCTURAL INCREASES DURING HEALTHY ADULTHOOD

G. Ziegler, R. Dahnke, R.A. Yotter, C. Gaser

Aging is a developmental process characterized by inherent dynamics that can be studied via trajectories showing growth/decline, extreme values and different rates of change. Recent neuroimaging studies using manual volume tracing and voxel-based morphometry (VBM) gave some insight into the complexity of age-related structural brain changes. To study age-related grey matter volume (GMV) effects during adulthood, we investigated a large sample of 547 healthy subjects with an age distribution of 19-86 years. We explored aging trajectories in sensory-motor brain regions to further elucidate functional hypotheses of observed large regional heterogeneity in grey matter aging. Some recent studies on structural aging hypothesized a preservation of hippocampal volume during early adulthood.



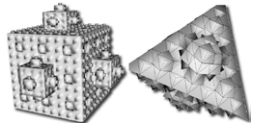
Poster: 1463 WTh-AM
Talk: Brain Development (Wed, Jun 9, 11:30 - 11:45 AM)
PDF: http://dbm.neuro.uni-jena.de/HBM2010/Ziegler.pdf



SURFACE FRACTAL DIMENSION METRIC FROM SPHERICAL HARMONIC ANALYSIS

R.A. Yotter, P. Thompson[5], C. Gaser

Fractal dimension (FD) is an attractive metric for measuring the complexity of brain surface meshes, since it has the advantage of being independent of surface area. The most common approach to measuring FD on surfaces is to parameterize the mesh at varying resolutions and compare the resulting surface areas to the surface area of the original mesh. However, as previously shown for volumetric images, the same FD information can be calculated in harmonic space. Here, we propose to use spherical harmonic analysis (SPH) to measure surface complexity. We show that it is possible to extract a meaningful complexity metric from spherical harmonics by analyzing the power spectrum or by reconstructing lowpass-filtered surfaces. The spherical harmonic approach is compared to the box-counting method for a series of fractal surfaces whose Hausdorff dimension is known.

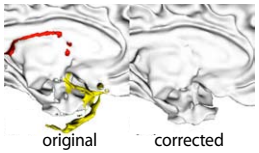


Poster: 1341 WTh-AM
PDF: http://dbm.neuro.uni-jena.de/yotter/

TOPOLOGICAL CORRECTION OF BRAIN SURFACE MESHES USING SPHERICAL HARMONICS

R.A. Yotter, R. Dahnke, P. Thompson[5], C. Gaser

Surface reconstruction methods allow advanced analysis of brain data beyond what can be achieved using volumetric images alone. Automated generation of cortical surface meshes from MRI data often leads to topological defects and geometrical artifacts that usually must be corrected to permit subsequent analysis. Topological defects prevent the surface from being homeomorphic with a sphere, while artifacts are topologically correct sharp peaks that do not represent the true cortical anatomy. Spherical harmonics (SPH) have been recently used for modeling brain surface meshes, usually in the realm of shape analysis. Here, we propose a method to repair cortical surface defects using a reconstruction based on SPH.



Poster: 1342 WTh-PM
Talk: Modelling and Analysis (Thu, Jun 10 4:00 - 4:15 PM)
PDF: http://dbm.neuro.uni-jena.de/yotter/

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3) Nikolaos Koutsouleris: Department of Psychiatry and Psychotherapy, Ludwig-Maximilians-University, Munich, Germany
4) Christos Davatzikos: Section of Biomedical Image Analysis, Department of Radiology, University of Pennsylvania, Philadelphia, PA
5) Paul Thompson: Laboratory of Neuro Imaging, Dept. of Neurology, UCLA School of Medicine, Los Angeles, CA