



Researcher/ Assoc Prof Renate Grüner, HUS/ UIB



FMRI RESEARCH & DATA

MRI bilder i forskning – eksempler fra Bergen fMRI gruppe

IT Forum 2017 – Solstrand – May 10th 2017



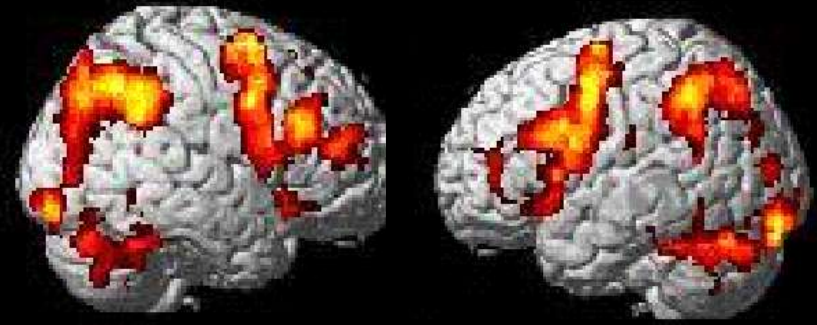
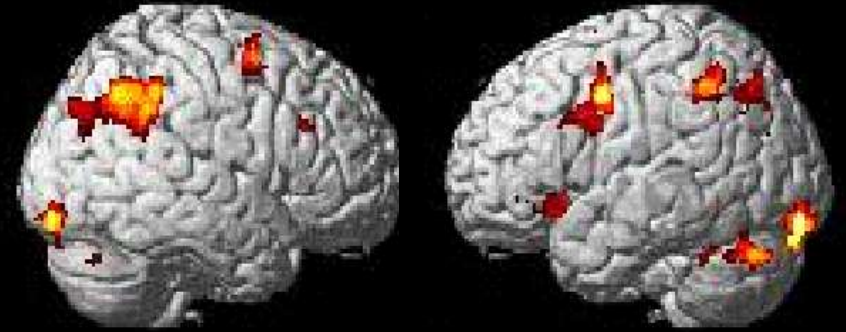
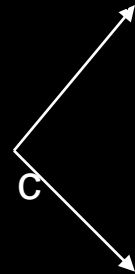
IBMP Department, UIB

3T MRI: Our most important computer (~ 25000kg)

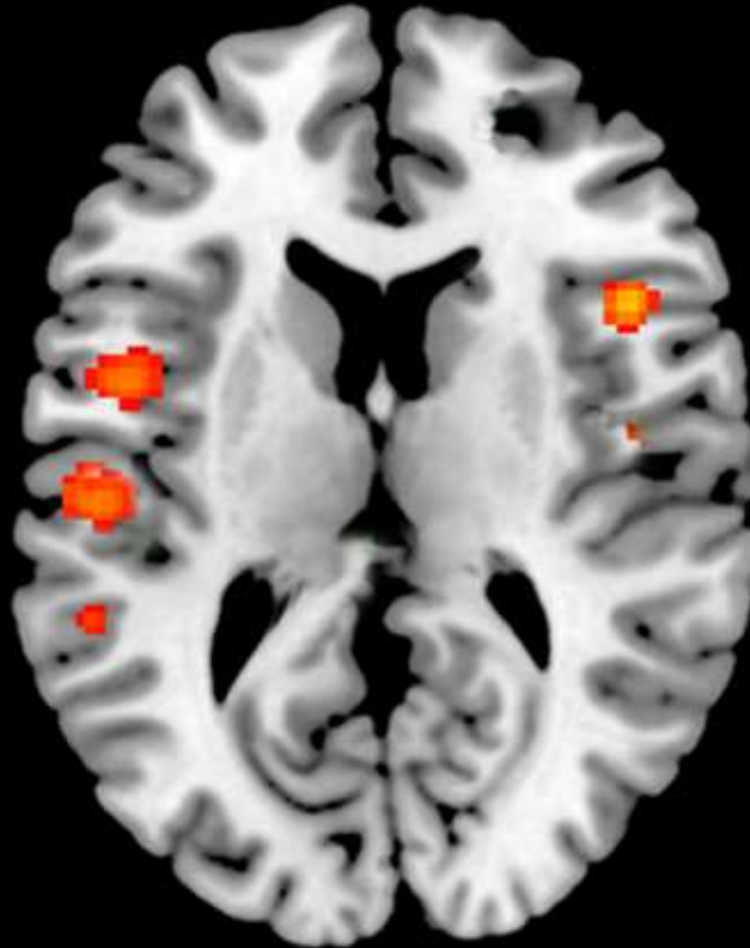


Photo: Eivind Senneset, University of Bergen

RØD GUL GRØNN BLÅ HVIT
GRØNN BLÅ HVIT RØD GUL
GUL RØD GRØNN HVIT BLÅ



Auditory hallucinations: Perception of sounds that do not exist



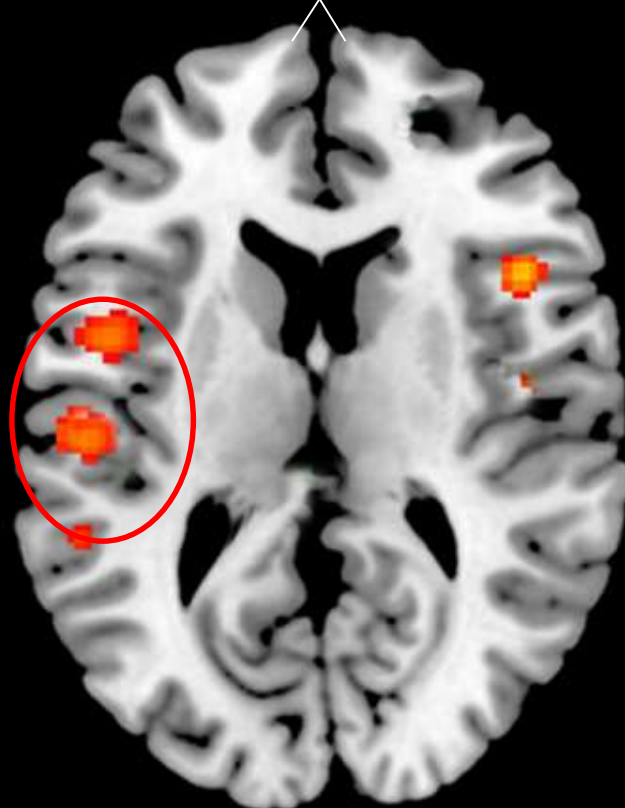
N = 103



K. Kompus, R. Westerhausen, K. Hugdahl *Neuropsychologia* (2011)

Courtesy Prof Kenneth Hugdahl, Faculty of Psychology, UIB

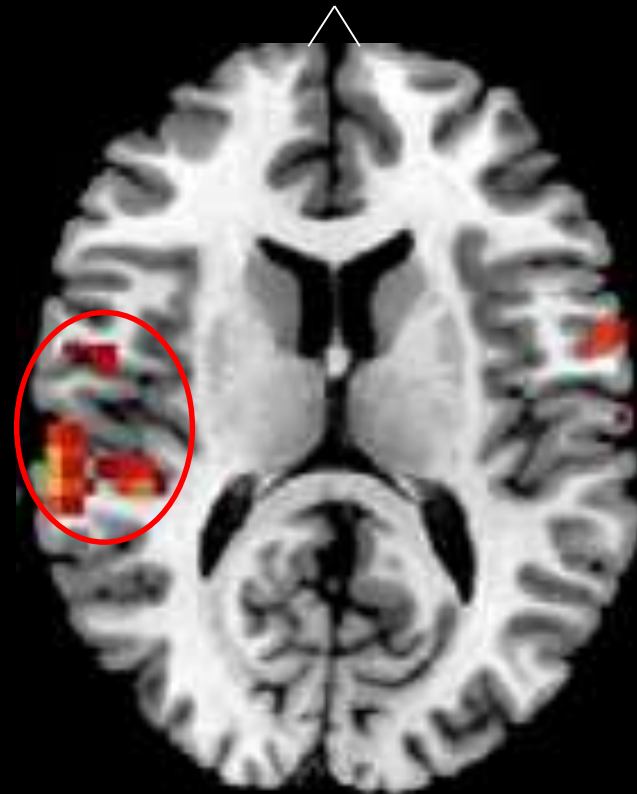
Neuronal activation in hallucinating patients in the *absence* of an external speech sound



N = 103

Kompus, Westerhausen, Hugdahl,
Neuropsychologia (2011)

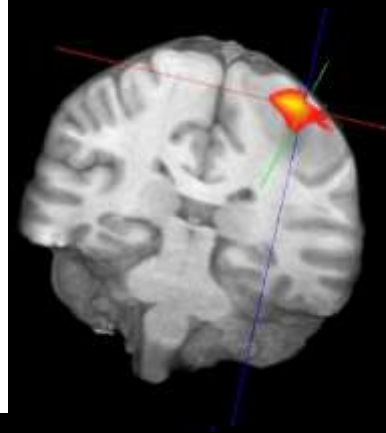
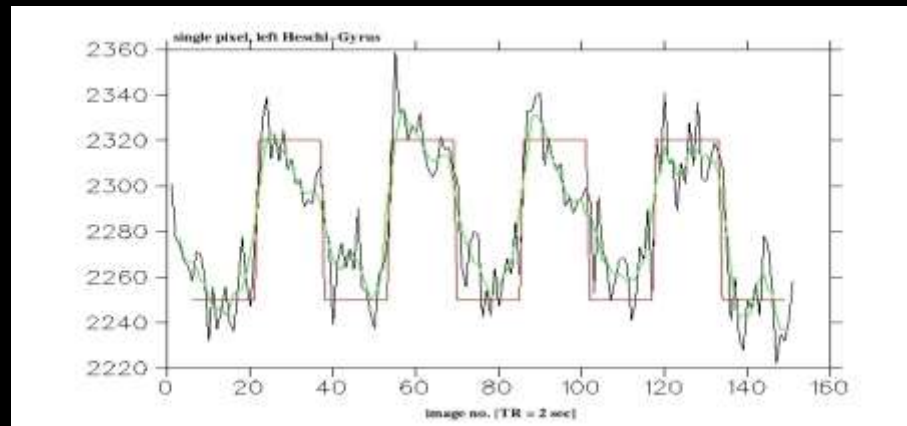
Neuronal activation in healthy subjects in the *presence* of an external speech sound



N = 12

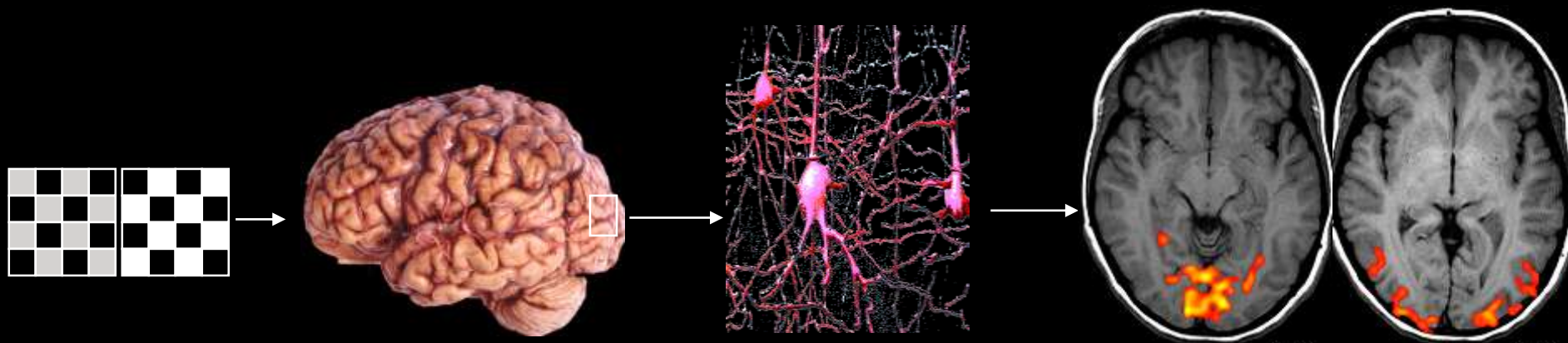
van den Noort, Specht, Rimol., et al.,
Neuroimage (2008)

fMRI in presurgical planning

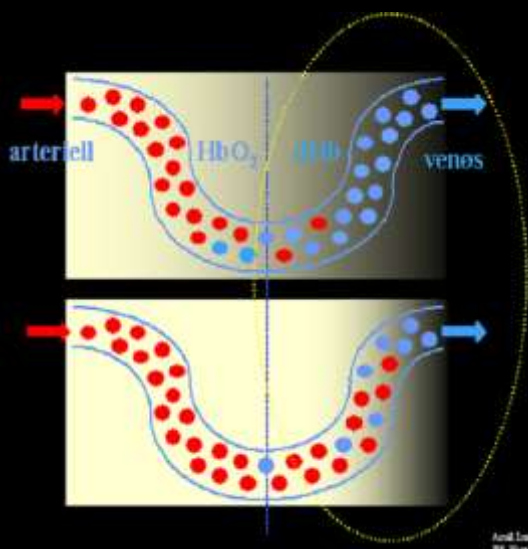


Data acquisition - Physical/ Mathematical/ Statistical Modeling – Interpretation

fMRI: The BOLD contrast

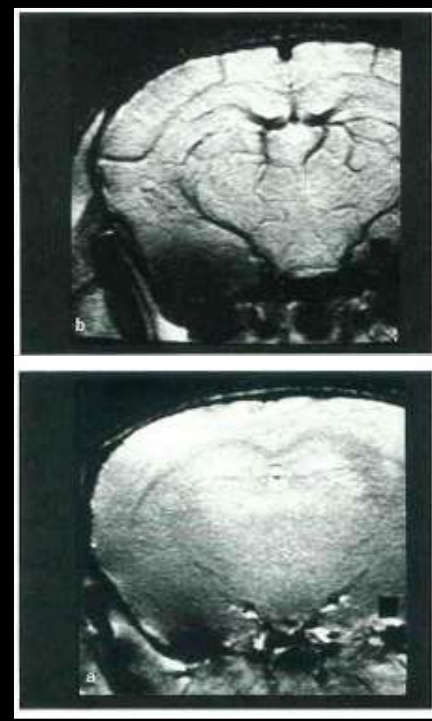


OFF



ON

Andersen & Skovgaard 2000

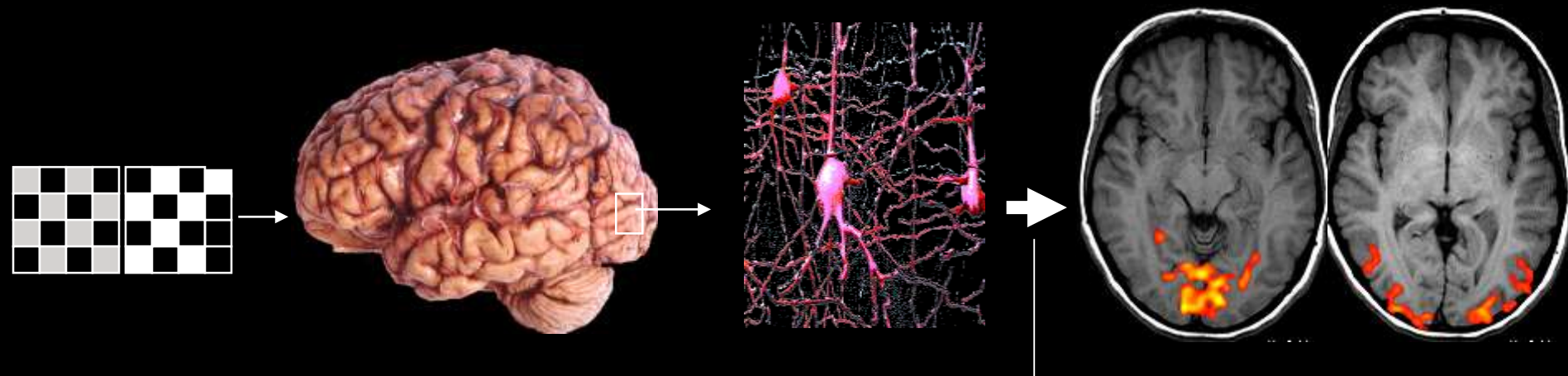


Ogawa, Lee 1990;
(gradient echo img)

Rat brain;
- normal air

-100% oxygen

Neurovascular Coupling



**Cerebral blood flow
(CBF)**

Increase in Hb inflow
Increased T2* signal

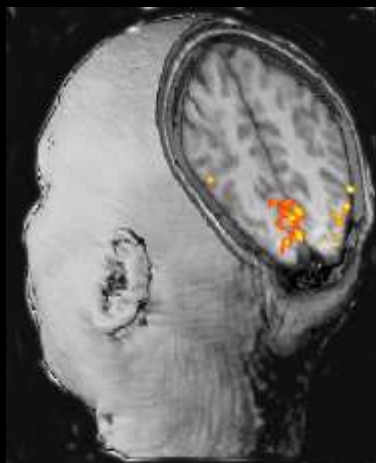
**Cerebral blood volume
(CBV)**

Change partial volume effect
Decreased T2* signal

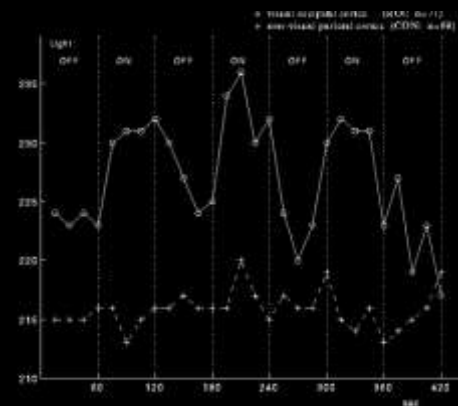
Oxygen consumption (CMRO₂)

Increase in dHb
Decreased T2* signal

Starting fMRI in Bergen/Norway (1993)

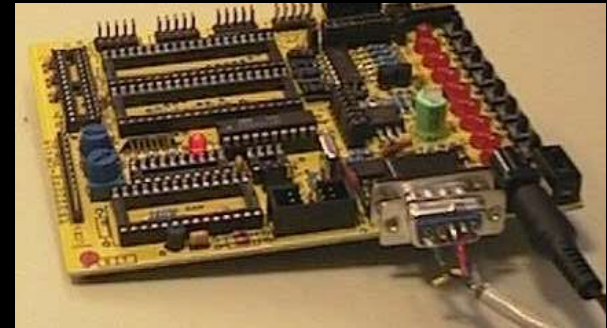


Belliveau et al., Science, 1991



Lundervold et al. (1995) Int. J. Neuroscience, **81**, 151-168

..how it all started in Norway, Haukeland University Hospital, Bergen, 1993



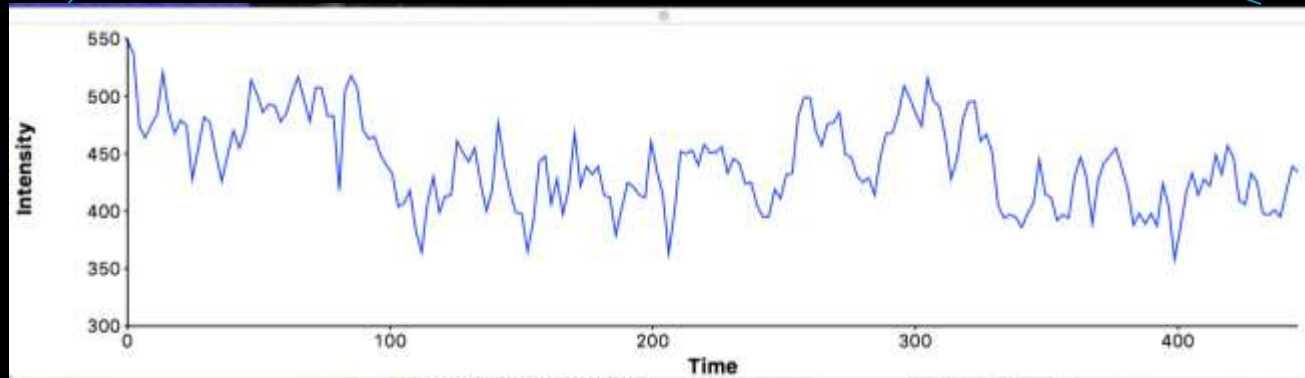
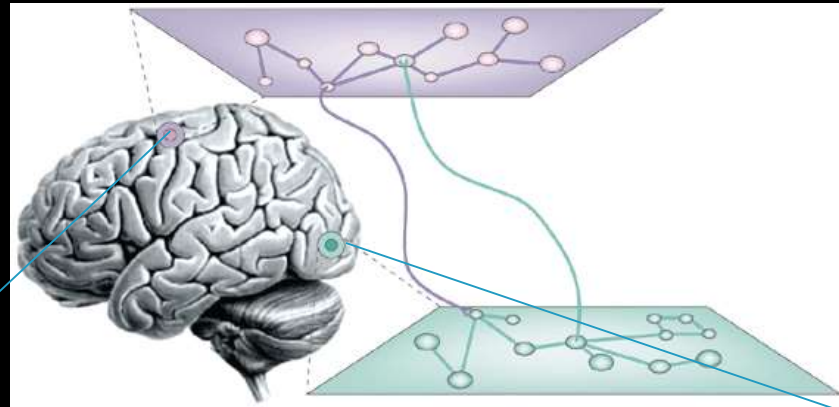


World leading producer of fMRI hardware add-on products and software. Established 2001, ~25 employees, ~EUR 5.0 mill. in turn-over 2014

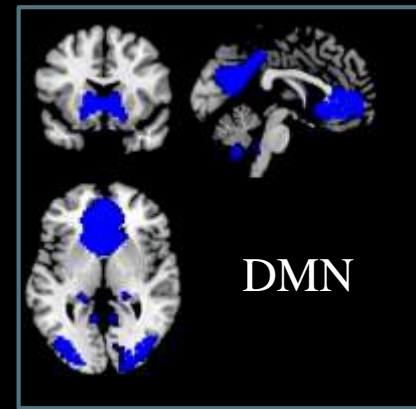
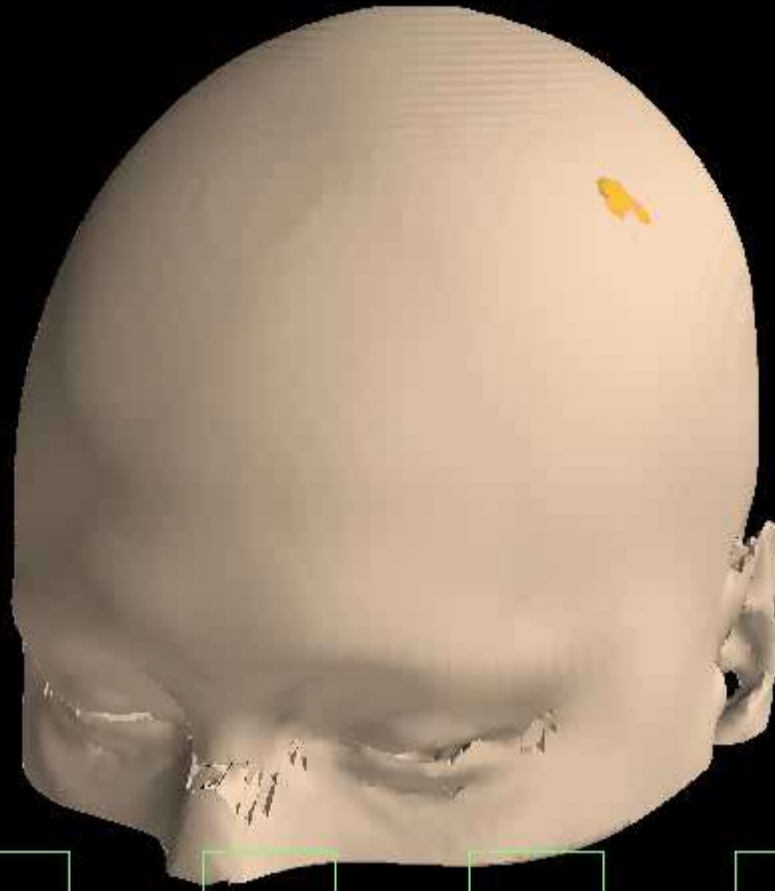
http://www.nordicneurolab.com/Products_and_Solutions/nordic_fmri_solution/index.aspx



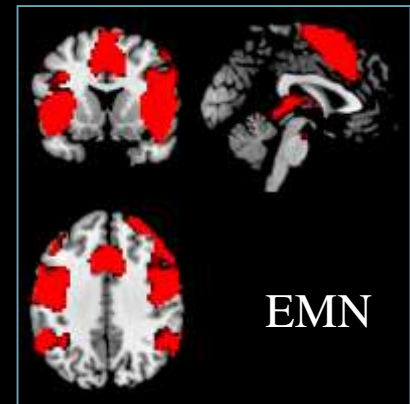
But, is the brain quiet until called on to carry out some specific task?



Functional network



Raichle, et al., 2001;
Raichle, 2010; 2015

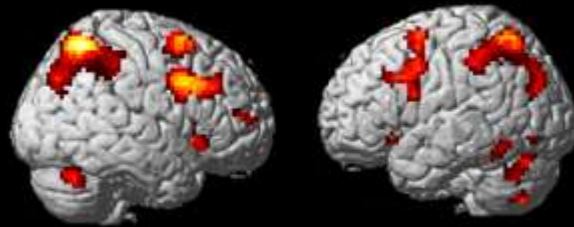
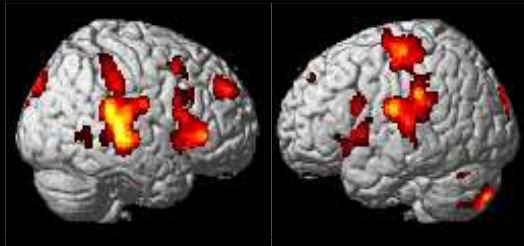


Hugdahl, Raichle,
Mitra, Specht, 2015

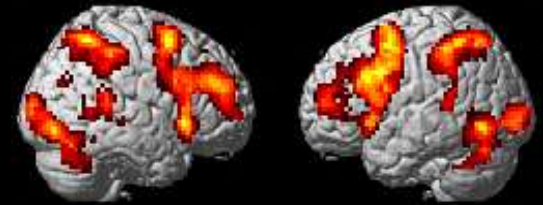
Animation by Alex Craven and Kenneth Hugdahl

Data re-analyzed from Kompus, Specht, Ersland, Juvodden et al., *Brain and Language*, 2012

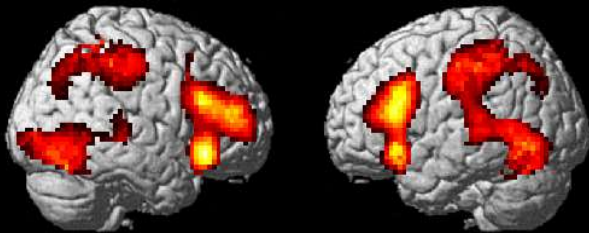
Sensitivity versus Specificity



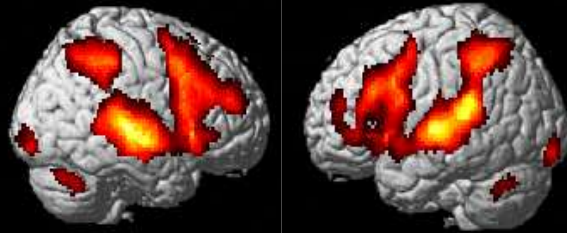
Abstract symbols /Harald Beneventi 2005



Go/No-Go / Hilde Gundersen 2005



Mental arithmetics /Landrø et al. 2001



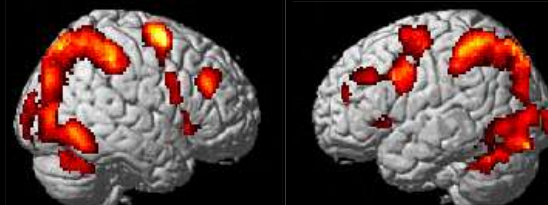
Executive function/ Specht/Hjelmervik 2008



Double Digit 2-back / Pfizer study 2002



Spatial working memory/ Christine Lycke 2004



Mental rotation/ Specht/Hjelmervik 2010



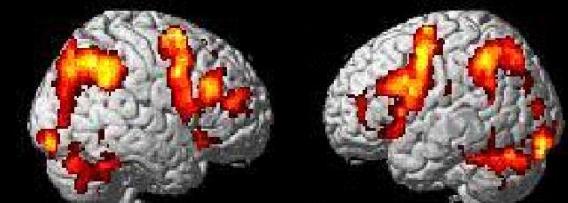
Auditory Oddball /Tom Eichele 2005



Context updating, Sætrevik & Sörvkvist, 2008

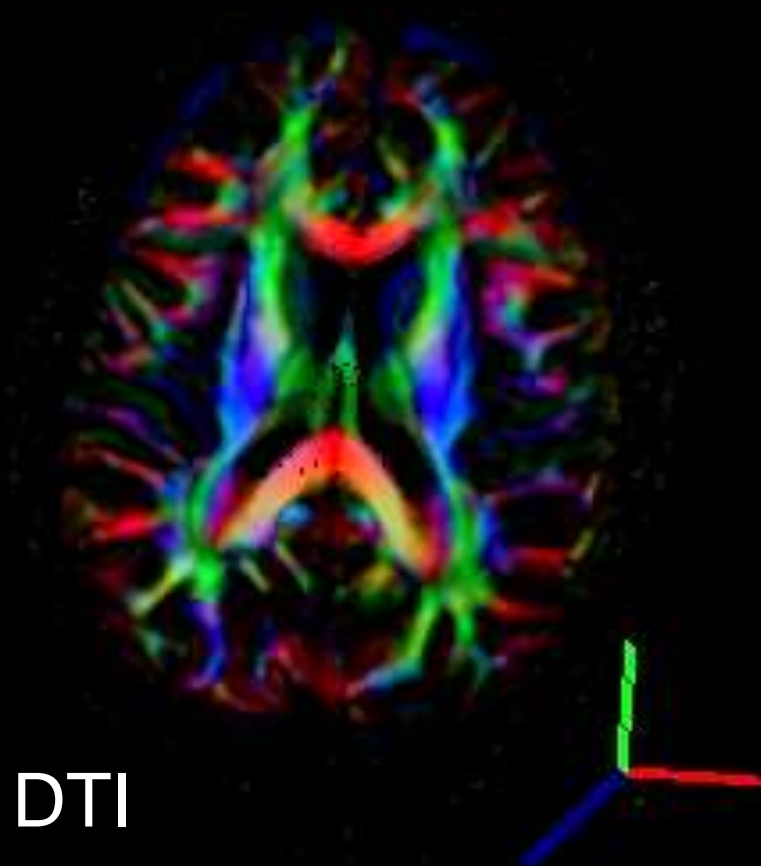


Cogn Control/Falkenberg/Westerhausen, 2011

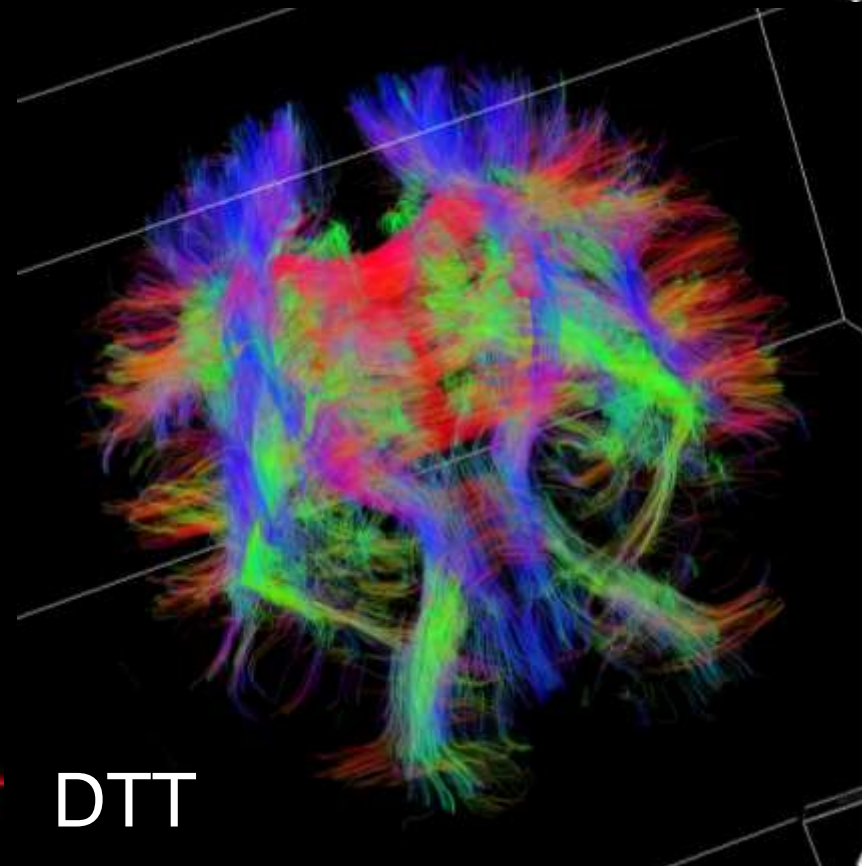


Stroop/Incongruent words /Ole Viken 2006

Microstructural network

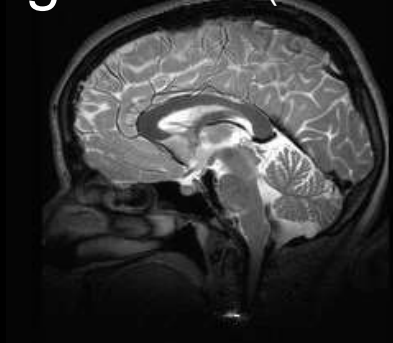
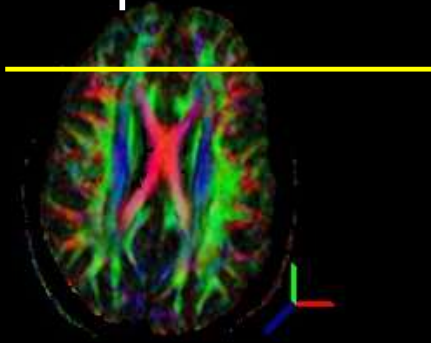


DTI

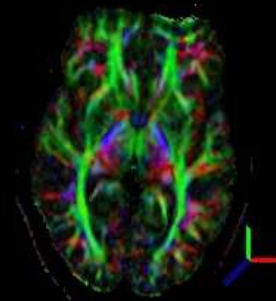


DTT

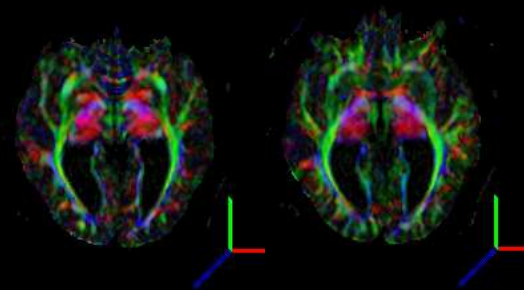
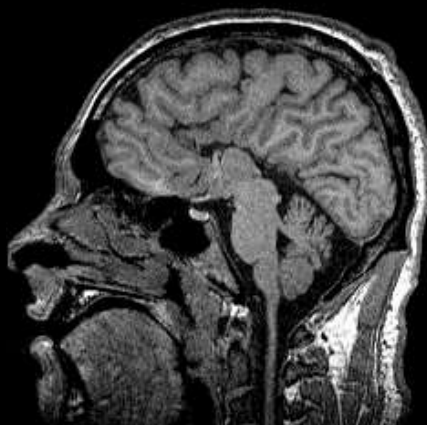
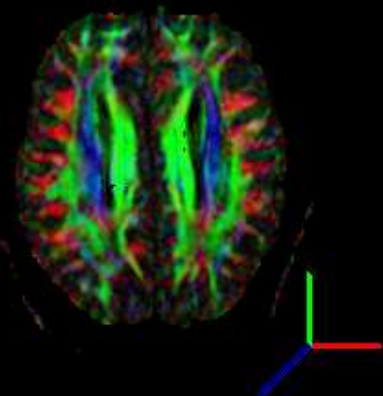
Corpus callosum agenesis (data from 2003)



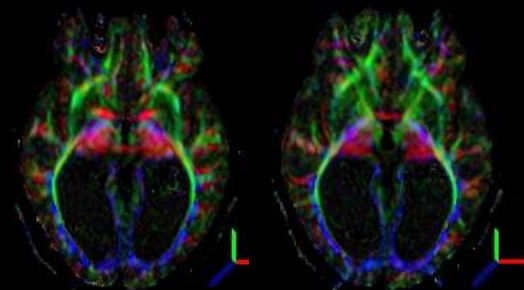
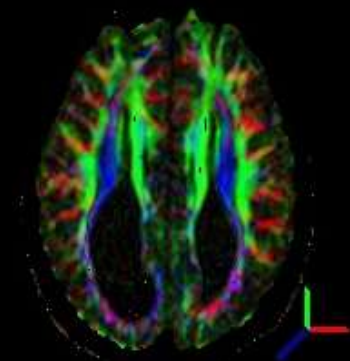
Control



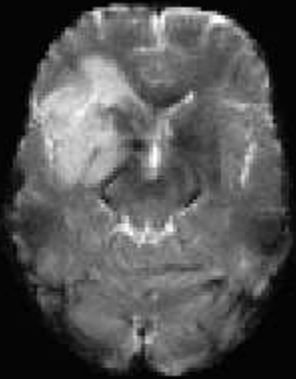
male, b. 1975



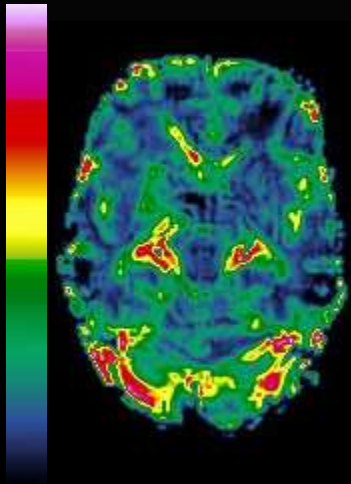
female, b. 1975



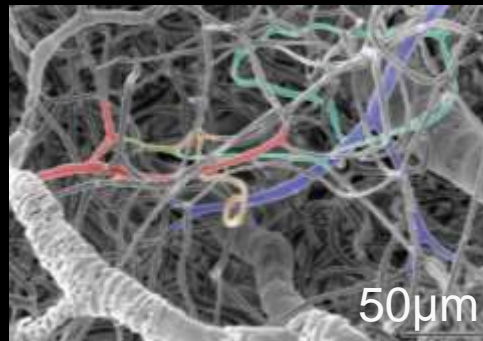
Microvasculature network



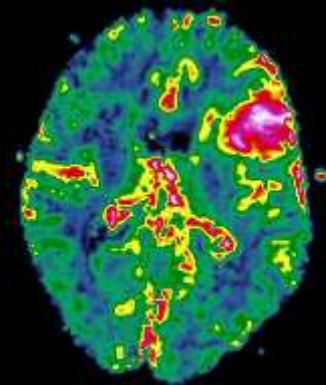
Diagnosis and grades?
Patient prognosis?
Response to treatment?
Delineate tumor boundaries?
Stereo tactic biopsy?



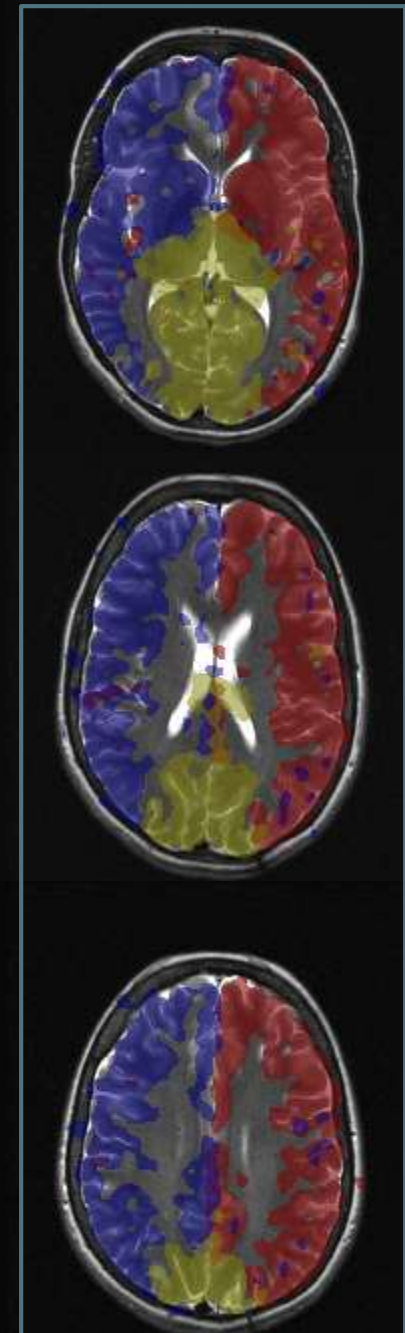
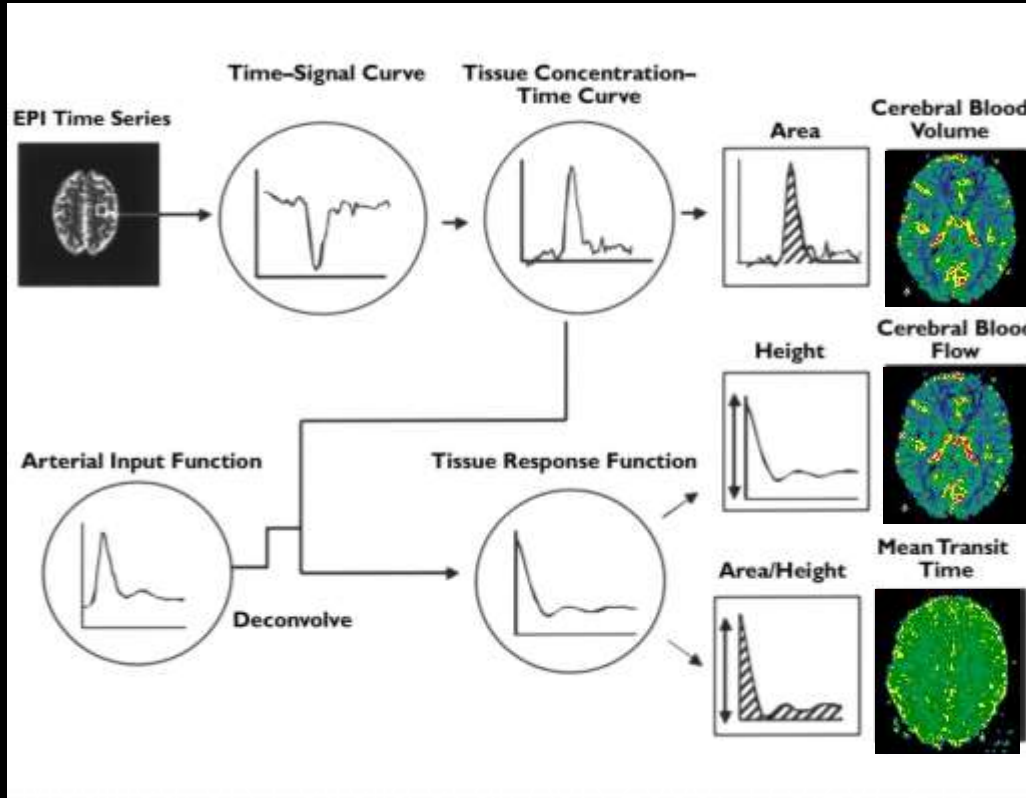
Low grade gliom
front basal
Stable since 1998.
Increasing
Epileptic problem



High grade:
 $CBV > 2 \times CBV \text{ WM}$
Low grade:
 $CBV < 1.5 \times CBV \text{ WM}$



Anaplastic
oligoastrocytom.
Problems with vision,
language
and severe headache



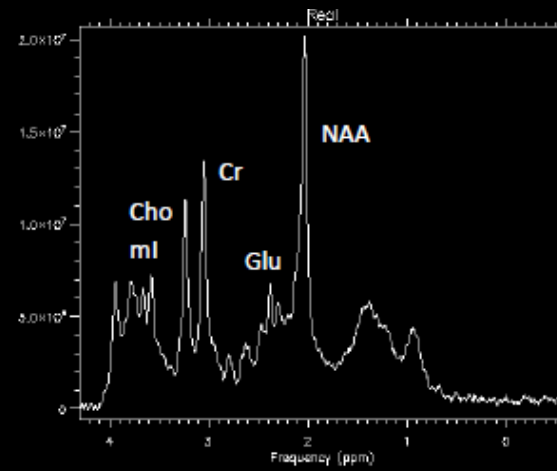
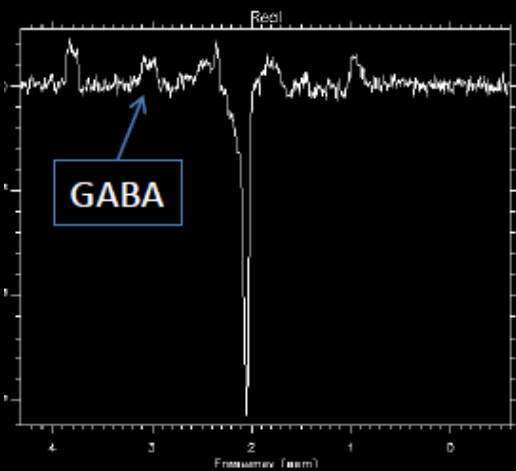
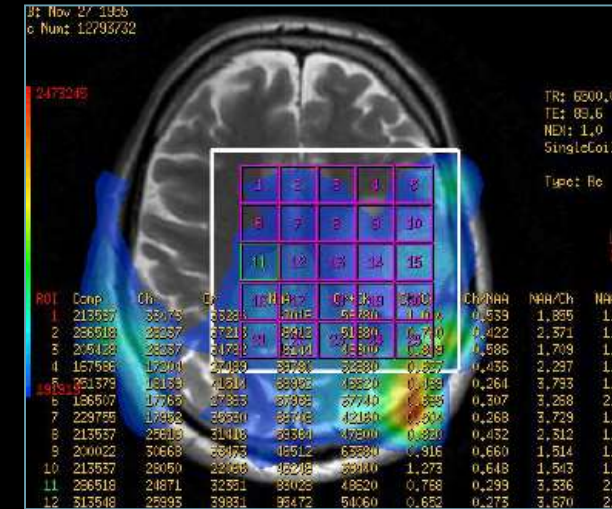
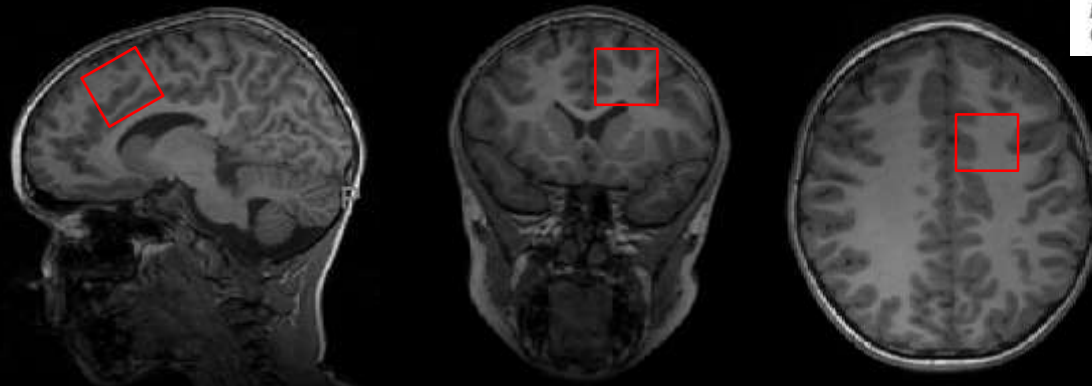
Ongoing work:
 Hypo/ hyperperfusion, Permeability BBB

Arterial spin labelling

Biochemistry: MRS

“Brain MR spectroscopy in autism spectrum disorder – the GABA excitatory/inhibitory imbalance theory revisited”

Maiken K. Brix^{1,2*}, Lars Ersland^{3,4}, Kenneth Hugdahl^{1,4,5,6}, Renate Grüner^{1,4,7}, Maj-Britt Posserud⁸, Asa Hammar⁵, Alexander R. Craven^{4,5}, Ralph Noeske⁹, C. John Evans¹⁰, Hanne B. Walker¹¹, Tore Midtvedt¹² and Mona K. Beyer^{13,14}



MEGA PRESS:
TE=68, TR=1500,
TA=7min.

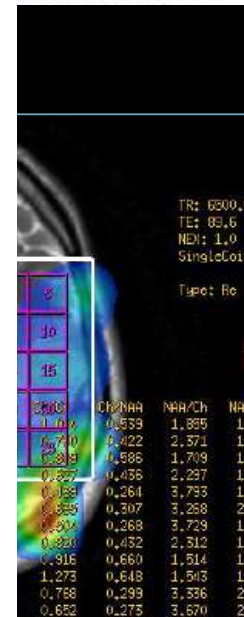
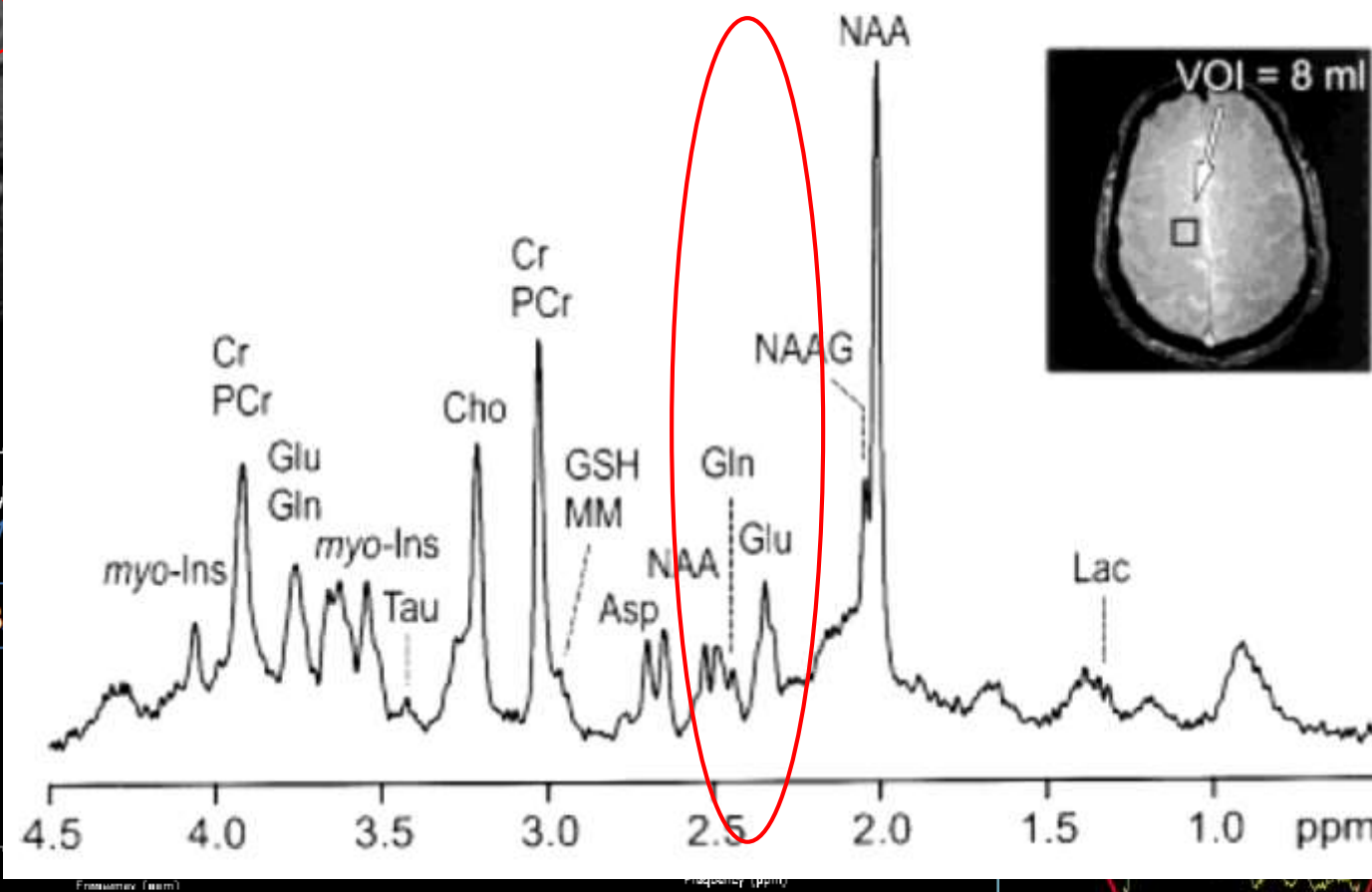
PROBE (PRESS):
TE=35, TR=1500,
TA=4min.

PhD project: Dwyer G. Ongoing

Biochemistry: MRS

“Brain MR spectroscopy in autism spectrum disorder—the GABA excitatory/inhibitory imbalance theory revisited”

Maiken K. Brix^{1,2*}, Lars Erland^{3,4}, Kenneth Hugdahl^{1,4,5,6}, Renate Grüner^{1,4,7},
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Mona K. Beyer^{13,14}



MEGA PRESS:
TE=68, TR=1500,
TA=7min.

PROBE (PRESS):
TE=35, TR=1500,
TA=4min.

PhD project: Dwyer G. Ongoing

PNAS 2012

Resting-state glutamate level in the anterior cingulate predicts blood-oxygen level-dependent response to cognitive control

Liv E. Falkenberg^{a,1}, René Westerhausen^{a,b}, Karsten Specht^{a,c}, and Kenneth Hugdahl^{a,b}

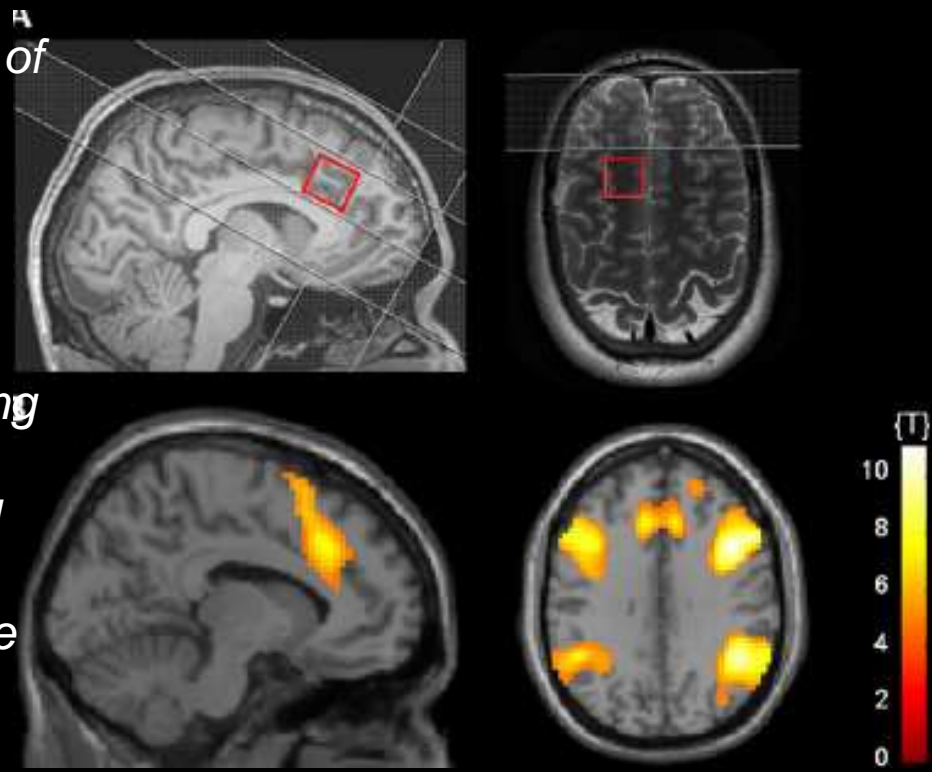
^aDepartment of Biological and Medical Psychology, University of Bergen, 5009 Bergen, Norway; and ^bDivision of Psychiatry and ^cDepartment of Clinical Engineering, Haukeland University Hospital, 5021 Bergen, Norway

Edited by Marcus E. Raichle, Washington University in St. Louis, St. Louis, MO, and approved February 21, 2012 (received for review September 22, 2011)

PNAS



Interindividual differences of glutamate levels in the dACC during resting-state predict the strength of the blood-oxygen level-dependent (BOLD) response to a task requiring cognitive control. This relationship was observed in the retrosplenial cortex, the orbitofrontal cortex, the inferior parietal lobe, and the basal ganglia.





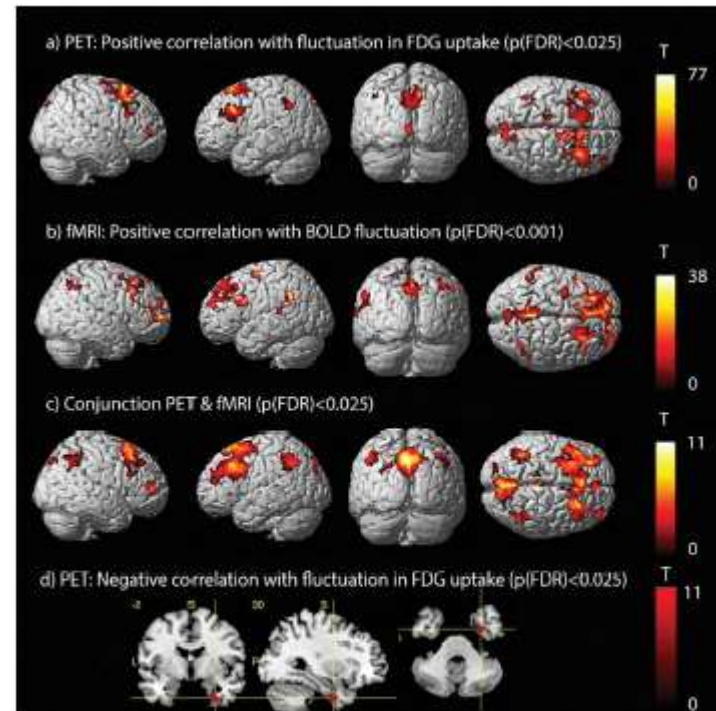
Human Brain Mapping

PET/MRI

Human Brain Mapping Default-Mode Network Functional Connectivity Is Closely Related to Metabolic Activity



Susanne Passow^{a,b,*}, Karsten Specht^{a,c,*}, Tom Christian Adamsen^{d,e}, Martin Biermann^{d,f}, Njal Brekke^{d,g}, Alexander Richard Craven^{a,b}, Lars Ersland^{b,c}, Renate Gruner^{b,d,h}, Nina Kleven-Madsen^d, Ole-Heine Kvernenes^d, Thomas Schwarzlmüller^{d,f}, Rasmus Aamand Olesenⁱ, Kenneth Hugdahl^{a,b,d,j}



Spatial maps for seed-based correlations, with the dorsal posterior cingulate cortex as seed region. (A-C) Spatial maps display positive correlation with fluctuations within the seed region for (A) FDG-uptake, measured with PET, (B) BOLD signal, measured with resting-state fMRI, (C) Conjunction of the two modalities, (D) Negative correlation for FDG-uptake. All results are displayed with corrected thresholds, as indicated in the figure, with at least 50 voxels per cluster.

Research imaging protocol



- Morphology (macrostructure)
- Physiology
 - Diffusion based imaging
 - Perfusion based imaging
 - fMRI (task/ rest)
 - Structural/functional connectivity (-> DCM)
- Metabolites (MRS) & metabolism and biochemistry (PET/ NM)
- New approaches

Traditional cross sectional:

- "Purity of diagnosis"*
- Sample size
- Control group (age, gender, ...)
- Medication (native vs washout)
-

Versus:

- Big data, deep learning
- XXXomics/
Imaging genetics

-> personalized medicine

eInfrastructure challenge 1: Collection and storage of data





MRI data on fileserver/PACS
- DICOM format (~20000 img/us)

MRS data on the MRI scanner
- vendor specific format

Respos data on standalone PC
- ASCII file format

Physiology data recorder device
- ASCII file format

Multimodal data/ Data merging
(genetics ++)

Different file formats, different levels of sensitive information, and all in different computers!



DATA STORAGE:

- Handling various data formats (DICOM, MR raw data, MRS data, Metadata (patient/ medicinal history, image processing details), data that have been processed, secondary captures (inkl. jpg). Solutions for long term storage
- User friendly/ easy access to store/ retrieve/ export data (despite firewalls etc) (even grandma can do it! Drag n drop?)
- Delete (single images, single examinations, entire studies)
- Presentation of data (image/ data visualization)
- Possibility to export data and data compression
- Deidentification i) different levels (name, birth date, acquisition date, modality, ++)
ii) delete information in the image («Black box»)
- Handle large data sets and integration with other databases
- Compatibility with various technical solutions (scanner systems, PACS etc)

eInfrastructure challenge 2: Transfer of data (HUS/UIB)



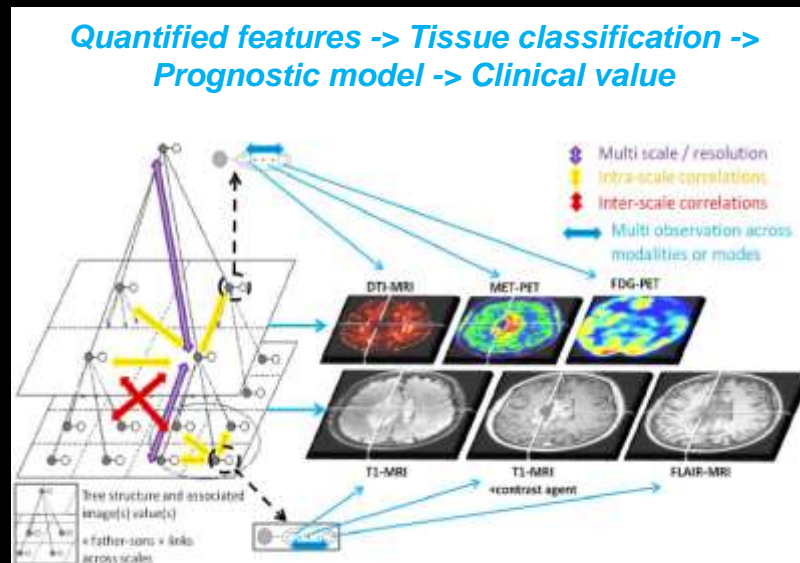
“Ask me no questions and I will tell you no lies”

VPN tunneling?
SSH?

Responsibility for risk assessment? (researcher or IT?)
Administrator access? (Download SW at home?)

eInfrastructure challenge 3: Processing complex data

- Multiscale integration time & space
- Feature extraction & prediction



DATA PROCESSING:

FLEXIBILITY:

- Allow installation of plugins/ updates, preferably programs (og home to download?)
- General IT solutions versus researchers freedom
- Availability of customized solutions are limited (development requires mirror)
New functionality should be allowed to be added

EASY ACCESS:

- «Same as working from own laptop»
- Accessible from other computers
- GUI? (X11? Database?)

PROCESSING/ DATA PRESENTATION

- Processing capabilities scalable according to needs
- Storage of processed data back to data storage solution (PACS or other)
- Handling large/ multiple/ complex data (search/ tagging/ merging database info)

Opportunities?

SAFE: The GEMRIC sample



15 sites

- MRI and clinical data; before, during and after ECT
- RAW data
- Standardized data processing and analysis
- Processing in Docker Containers

Current analysis

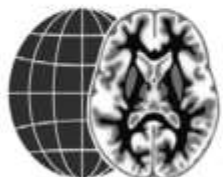
- 283 patients (10 sites)
- 97 healthy controls

European Sites (10)

Norway: University of Bergen (coordinator), Belgium: KU Leuven,
Denmark: Copenhagen University, Sweden: Linköping and Lund University,
The Netherlands: VUmc Amsterdam, Radboudumc Nijmegen, UMC Utrecht,
Germany: University of Münster, Switzerland: University of Lausanne

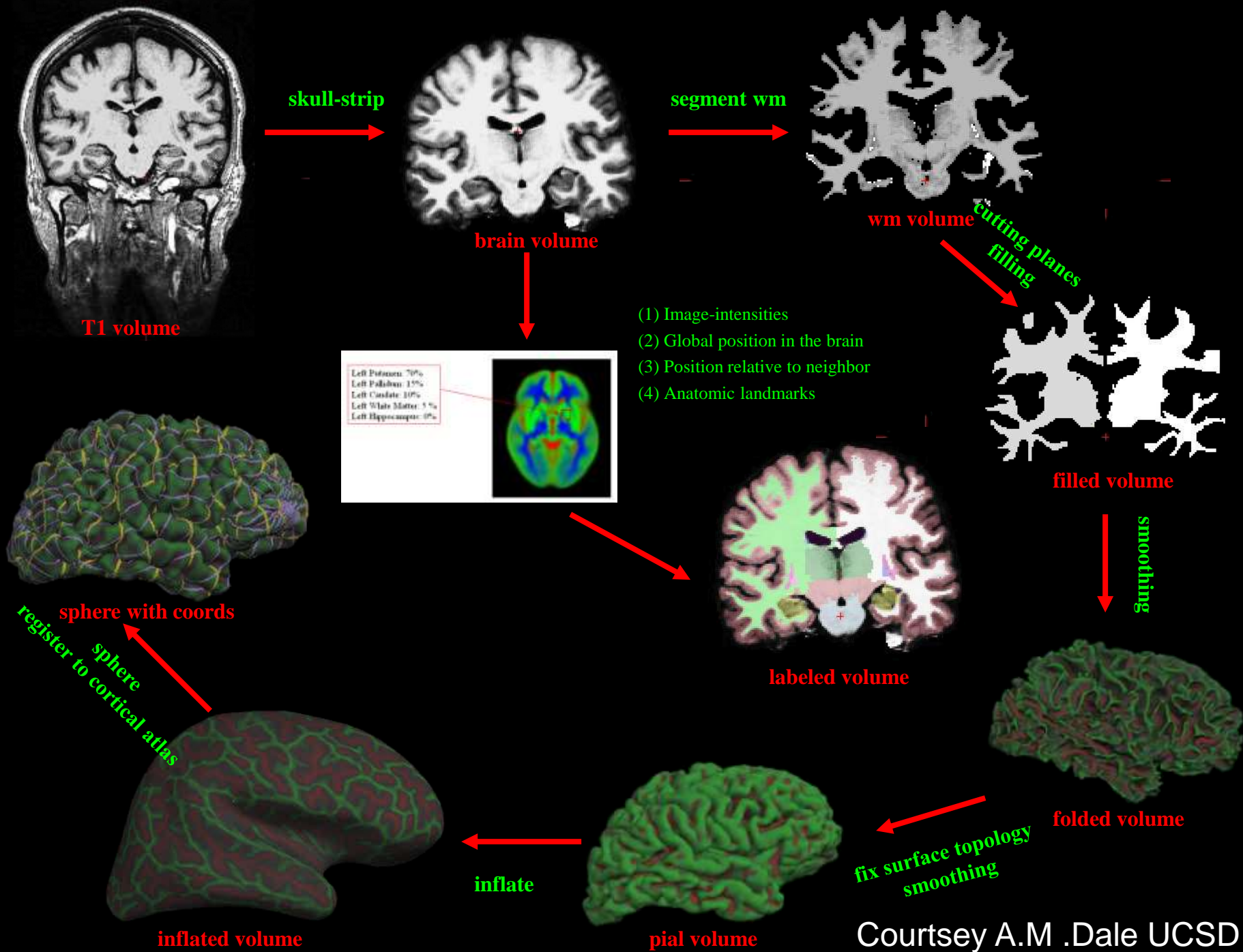
North American Sites (5)

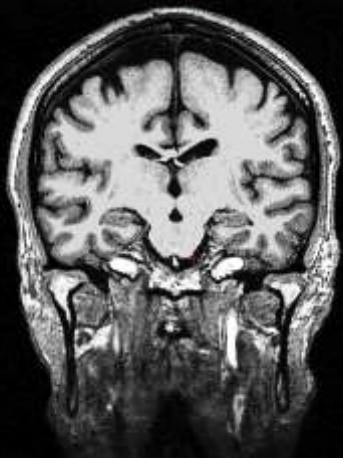
Cleveland Clinic, UCLA Los Angeles, University of New Mexico,
The Feinstein Institute for Medical Research New York,
UC San Diego (Imaging Core)



GEMRIC

The Global ECT-MRI Research Collaboration





T1 volume

NeuroQuant®

Age Related Atrophy Report

CorTechs Labs, Inc.
4690 Executive Dr., Ste 250
San Diego, CA 92121
Tel: 858-459-9700

PATIENT INFORMATION

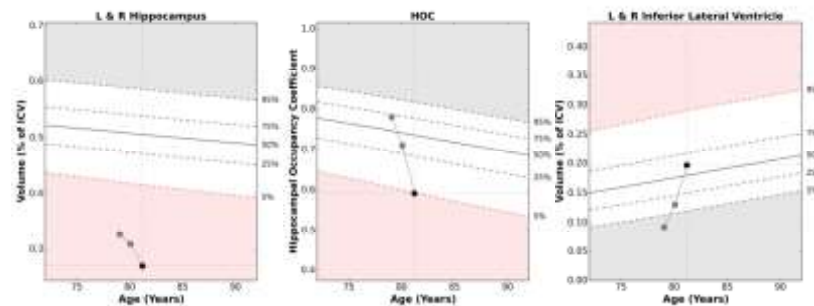
Patient ID:	Patient Name:	Sex: F	Age: 81
Accession Number:	Referring Physician:	Exam Date:	

MORPHOMETRY RESULTS

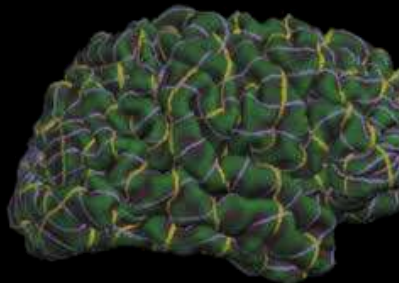


Brain Structure	Volume (cm ³)	% of ICV (5%-95% Normative Percentile*)	Normative Percentile*
Hippocampi	3.73	0.27 (0.42-0.59)	< 1
Lateral Ventricles	39.96	2.89 (1.45-4.73)	66
Inferior Lateral Ventricles	2.73	0.20 (0.12-0.29)	64

AGE-MATCHED REFERENCE CHARTS*



*Charts and normative values are provided for reference purposes only.



sphere with coords

register to cortical atlas

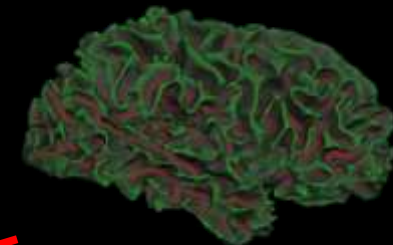
inflated volume

cutting planes
filling



filled volume

smoothing

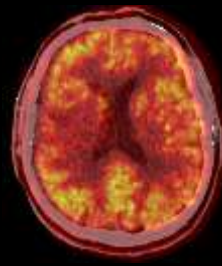


folded volume

topology
ing

pial volume

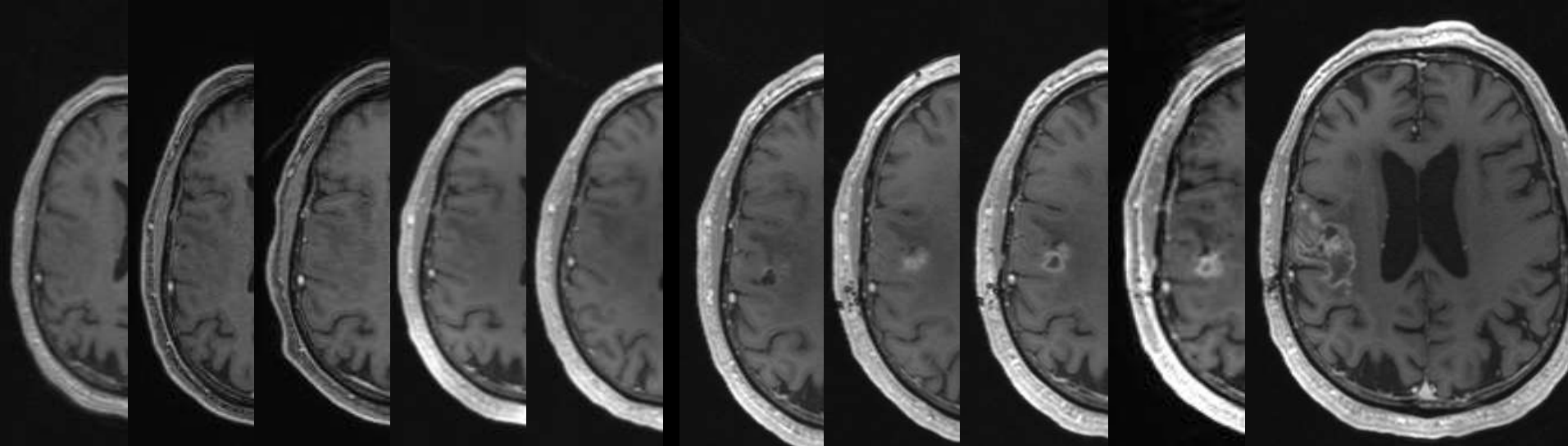
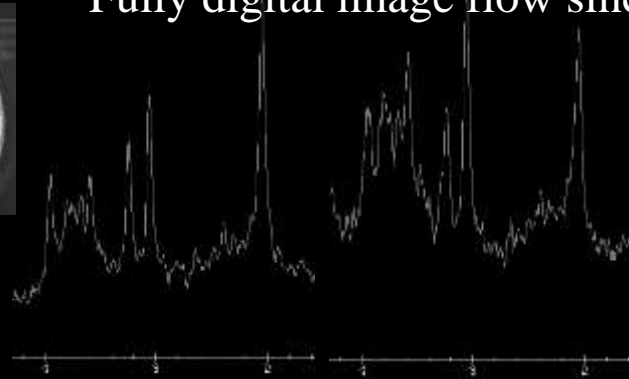
Fully digital image flow since 2002 (PACS)



PET

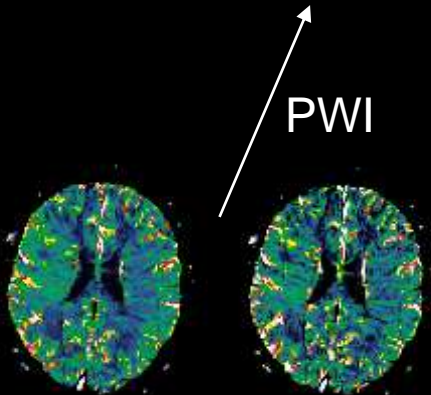


MRS



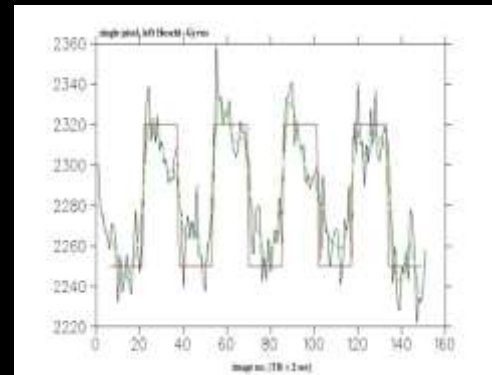
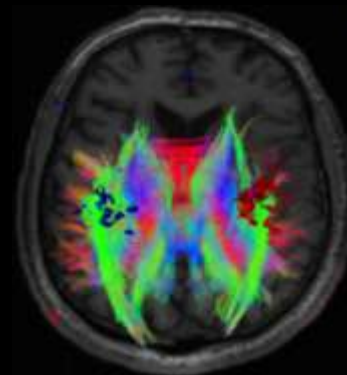
t=0

+3years



PWI

DTI/
fMRI



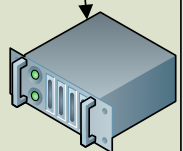
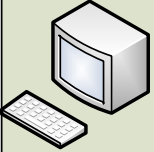
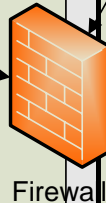
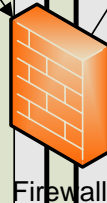
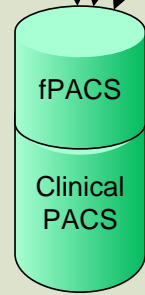
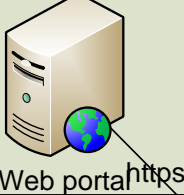
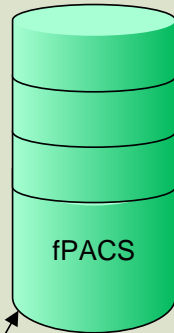
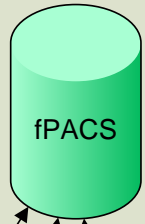
Patient sensitive information zone

De-identified data zone

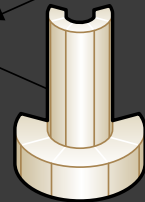
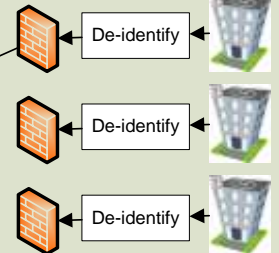
DMZ De-identified data only



De-identify



Multi-center studies



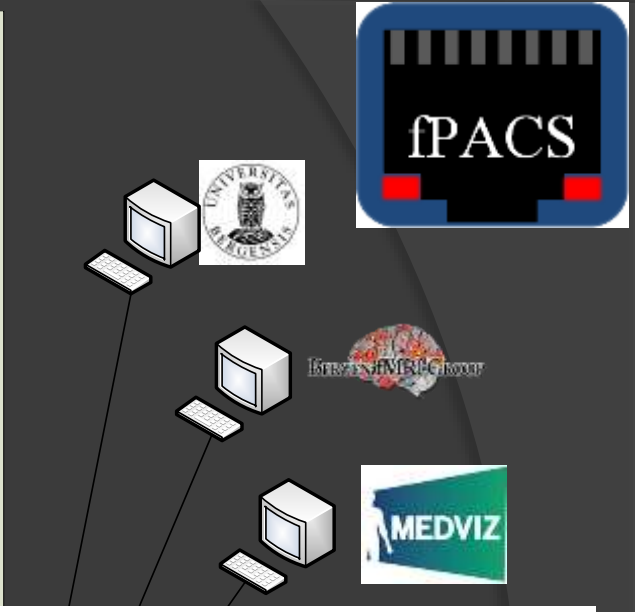
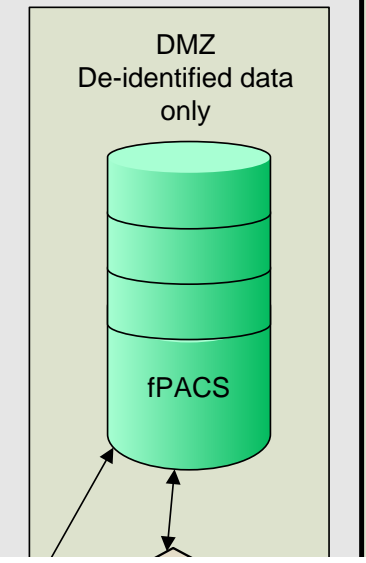
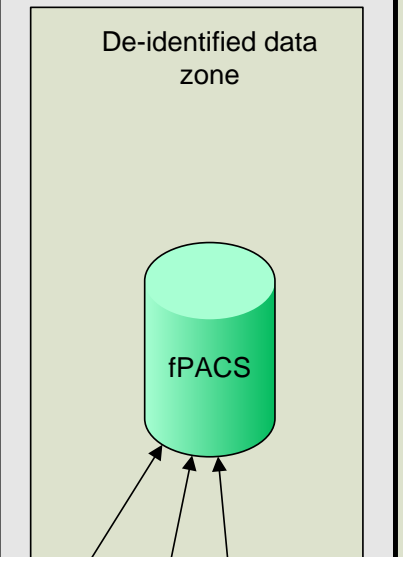
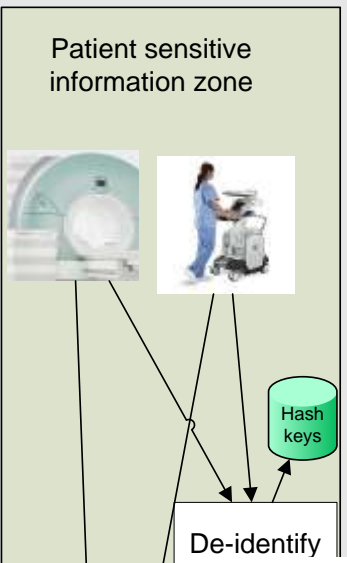
National grid (NOTUR)



ihelse.net
HVIKTAS

Infrastructure for medical imaging research

Helse Bergen HF Medisinsk-teknisk avdeling	23.02.2012	Erling Andersen
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Aim at solution for clinical imaging in individual patients («black box») and research imaging (group assessment).

- Components being developed (Medical Imaging and Visualization Centre):
- xnat/ pyxnat storage of multiformat data/ user control
 - Docker processing
 - Gearman/ Docker swarm/ k8s
 - Docker repository
 - Multi core CPU/GPU



Helse Bergen
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Infrastructure for medical imaging research		
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Thank you for your attention!

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