FMRI AND MRI AT NIH

Sean Marrett / FMRIF / NIMH

Functional MRI Summer Course 2017

OUTLINE

1. MRI and neuroimaging resources
   - Functional MRI Facility
   - Scientific Statistical Computing Core
   - MEG
   - Neurophysiological Imaging Facilty
   - In-vivo NMR Facility/Mouse Imaging Facility
   - Scientific Instrumentation Branch

2. Brief history of MRI@NIH and examples of methods/studies developed here

3. Overview of research in FMRIF

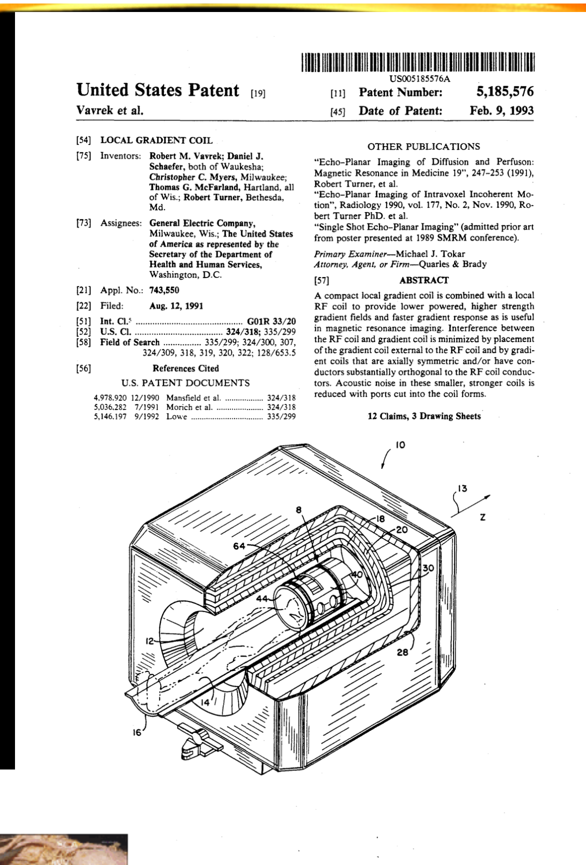
4. Postcard presentations of work by FMRIF PI

(SHORT) HISTORY OF FMRI AND BRAIN MRI AT NIH

1. In-Vivo NMR Center (established 1987)
2. Early FMRI studies in animals (Bob Turner, 1987)
3. Initial human functional studies (4T 1993)
4. Some key developments from NIH MRI researchers

1985-1990

- 1987 – NMRF Center Opens (Instigator: Ted Becker /Director:David Hoult)
- 1988 – David Hoult hires Bob Turner
- 1989 – Bob Balaban publishes magnetization transfer paper
- 1989 - Bob Turner & LeBihan implements DW-EPI on 1.5T
- 1989 – Harold McFarland – first longitudinal MS protocol (Original protocol still recruiting subjects for Neuroimmunology (Reich))



United States Patent [19]
Vavrek et al.

US005185576A

[11] Patent Number: 5,185,576
[45] Date of Patent: Feb. 9, 1993

[54] LOCAL GRADIENT COIL

[75] Inventors: **Robert M. Vavrek; Daniel J. Schaefer,** both of Waukesha; **Christopher C. Myers,** Milwaukee; **Thomas G. McFarland,** Hartland, all of Wis.; **Robert Turner,** Bethesda, Md.

[73] Assignees: **General Electric Company,** Milwaukee, Wis.; **The United States of America as represented by the Secretary of the Department of Health and Human Services,** Washington, D.C.

[21] Appl. No.: **743,550**

[22] Filed: **Aug. 12, 1991**

[51] Int. Cl.[5] G01R 33/20
[52] U.S. Cl. 324/318; 335/299
[58] Field of Search 335/299; 324/300, 307, 324/309, 318, 319, 320, 322; 128/653.5

[56] References Cited

U.S. PATENT DOCUMENTS

4,978,920	12/1990	Mansfield et al.	324/318
5,036,282	7/1991	Morich et al.	324/318
5,146,197	9/1992	Lowe	335/299

OTHER PUBLICATIONS

"Echo-Planar Imaging of Diffusion and Perfuson: Magnetic Resonance in Medicine 19", 247-253 (1991), Robert Turner, et al.
"Echo-Planar Imaging of Intravoxel Incoherent Motion", Radiology 1990, vol. 177, No. 2, Nov. 1990, Robert Turner PhD. et al.
"Single Shot Echo-Planar Imaging" (admitted prior art from poster presented at 1989 SMRM conference).

Primary Examiner—Michael J. Tokar
Attorney, Agent, or Firm—Quarles & Brady

[57] ABSTRACT

A compact local gradient coil is combined with a local RF coil to provide lower powered, higher strength gradient fields and faster gradient response as is useful in magnetic resonance imaging. Interference between the RF coil and gradient coil is minimized by placement of the gradient coil external to the RF coil and by gradient coils that are axially symmetric and/or have conductors substantially orthogonal to the RF coil conductors. Acoustic noise in these smaller, stronger coils is reduced with ports cut into the coil forms.

12 Claims, 3 Drawing Sheets

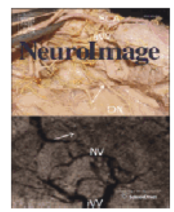
NeuroImage xxx (2011) xxx–xxx

Contents lists available at ScienceDirect

NeuroImage

journal homepage: www.elsevier.com/locate/ynimg

ELSEVIER



Review

The NIH experience in first advancing fMRI

Robert Turner *

Department of Neurophysics, Max-Planck-Institute for Human Cognitive Brain Sciences, Stephanstrasse 1A, 04103 Leipzig, Germany

A R T I C L E   I N F O

Article history:
Received 7 June 2011
Revised 19 July 2011
Accepted 22 July 2011
Available online xxxx

A B S T R A C T

The introduction of functional MRI at NIH in 1992 was the outcome of research goals first formulated by Turner in 1983. Between 1988 and 1990, Turner worked at NIH on actively-shielded gradient coils and the implementation of EPI-based techniques, especially diffusion-weighted EPI. His work on hypoxia in cat brain in 1990 directly inspired Ken Kwong's demonstration of BOLD contrast in humans at MGH in May 1991. Turner collaborated actively with this MGH team, the first group to map entirely noninvasively human brain

1991-1995

1991 – Judy Rapoport and Jay Giedde begin longitudinal pediatric study of normal brain development.

1992 – 4T installed in NHLBI in NMRF (Turner hired by Bob Balaban)

1992 – First successful FMRI @ NIH

1992 – Peter Basser publishes first DTI paper

1992 – Bandettini and Wong et al publish BOLD-EPI finger-tapping experiment (same year as Kwong et al and Ogawa et al)

1995 – Plasticity/Motor learning FMRI (Ungerleider/Turner)

1996-2000

1997 – Ungerleider, Haxby, Martin – Vision, attention, FFA etc

1999 – Alan Koretsky hired to run NMRF

1999 – Peter Bandettini hired to run newly established Functional MRI Facility (NIMH/NINDS)

1999 – Delivery of first commercial 3T (GE/VHi) MRI system to FMRIF

2000 – Routine scanning begins on FMRIF 3T

2001-2005

2001-2003 – Mood and Disorder PI's (Pine, Leibenluft, Grillon, Shen Zarate/Drevets)

2002-2003 – Expansion of FMRIF (3T-2)

2003-2004 – Purchase/installation of unshielded 7T

2002-2004 – Custom-built 16 channel coil and receiver project (Duyn, Bandettini) demonstrating utility of multi-channel coil at 3T for FMRI

2006-2010

2006-2007 – 3T-1 replaced by 3T-A & 3T-B

2010 – Upgrade of 3T-C to mr750 platform

2011-2018

2011 – Self-shielded semi-clinical Siemens 7T-830/AS Magnetom installed and becomes operational

2011 – 1.5T GE replaced by Siemens Skyra 3T
2012 – 11.7T (human) gets to field (& quenches)
2015 – NIAAA Siemens Prisma (NIMH & NINDS 25% time each)

2016 - 2017 – upgrade of 3T-A/3T-B
2018 - NMRF 7T (!!)
2018 – 11.7T returns to NIH (!!!)

In-Vivo NMR Center Magnets

FMRI STUDIES AT THE NIH..

- Epilepsy
- Visual processing
- Mood disorders
- Learning
- Genetics
- Plasticity/Recovery
- Motor Function
- Auditory processing
- Attention
- Language
- Speech
- Stroke
- Social Interaction
- Development
- Aging

Methods – FMRI, MRS, DTI
Hardware – Coils, receivers
Pulse sequences
Pre and Post-processing
Contrast agents/particles etc

All papers involving MRI from Bethesda

(TITLE-ABS-KEY (**mri** OR **"magnetic resonance imaging"**) AND AFFIL (**bethesda**)) Back to your search results

7888 document results Choose date range to analyze: 1981 to 2015 Analyze

Year | Source | Author | Affiliation | Country/Territory | Document type | Subject area

Year	Documents
2015	550
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2012	590
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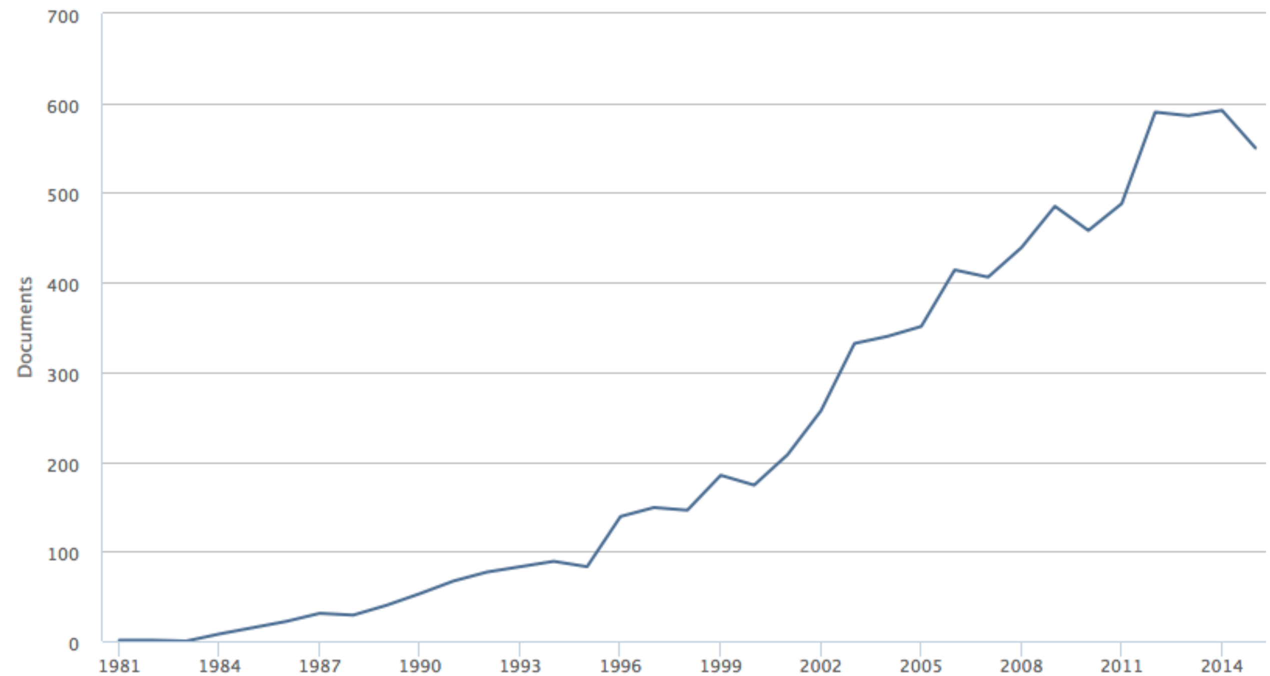
2010	458
2009	485
2008	439
2007	406
2006	414
2005	351
2004	340
2003	332
2002	257
2001	208
2000	174
1999	185

Documents by year



FMRIF
Publications: 2000-2016

- **More than 1000 papers** (31 PI's using the core)
  - 75% from NIMH
  - 20% from NINDS
  - 5-10% from other institutes

- **90000 citations**

- **H-index > 145**

- **Listing of all papers up to 2015:**

https://fmrif.nimh.nih.gov/public/FMRIF_all_Aug2015.xlsx/at_download

FMRIF Scanner History

	Time
1 Scanner	May, 2000: Installed **first GE 3T VHi**
2 Scanners	Nov, 2002: Installed **second GE 3T VHi**
3 Scanners	Aug, 2004: Inherited **GE 1.5T**
4 Scanners	Nov, 2007: Replaced **first GE 3T VHi** with **2 x GE 3T HDx**
	Jan, 2011: Replaced **GE 3T VHi** with **Siemens 7T**
5 Scanners	June, 2011: Obtained **GE 750**
	Aug, 2011: Replaced **GE 1.5T** with **Siemens Skyra 3T**
	Spring, 2015: NIAAA 3T-Prisma operational (25% NIMH, 25% NINDS)
	Jan 2017: Upgrade **2 x GE 3T HDx with 2 X GE 730**
	Summer 2018 : NMRF 7T (!)

FMRIF Scanners

3TA
GE MR750

- *GE 32-channel head coil*
- *GE HNS coil*
- *P31 loop coil*
- *Quadrature spectroscopy coil (GABA experiments)*
- *GE Quadrature head coil*

Gradient: 50 mT/m, Slew Rate: 200/m/s

3TB

- *GE 32-channel head coil*
- *GE Quadrature head coil*
- *Nova Medical 16-channel head-coil*

Gradient: 50 mT/m, Slew Rate: 200/m/s

3TC

- *GE 32-channel head coil*
- *GE Quadrature head coil*
- *Nova Medical 32-channel head coil*

Gradient: 50 mT/m, Slew Rate: 200T/m/s

3TD
Siemens Skyra

- *Siemens 20-channel head coil*
- *Siemens 32-channel head coil*
- *Siemens 12-channel spine array (built into table)*

Gradient: 45 mT/m, Slew Rate: 200T/m/s

7T
Siemens

- *Siemens 1-channel Tx / 32-channel Rx coil*
- *Siemens 8-channel Tx / 32-channel Rx coil*
- *QED dual-tuned 1H / 31P coil*

Gradient: 70 mT/m, Slew Rate: 200T/m/s

NIAAA 3T: Siemens Prisma

- *Siemens 20-channel head coil*
- *Siemens 64-channel head-neck coil*
- *Siemens 12-channel spine array (built into table*

Gradient: 80 mT/m, Slew Rate: 200T/m/s

other resources

The NIH Record
November 17, 1987
Vol. XXXIX No. 23
U.S. Department of Health and Human Services
National Institutes of Health

New NMR Center Opens

By Blair Gately

The NIH In Vivo NMR Research Center has opened in a one-story building adjacent to the Clinical Center's "D" wing.

The new facility, which was dedicated late last month, is the first centralized NMR facility on campus and will be the focus of biomedical NMR research, according to Dr. Cherie Fisk, Office of Research Services. It houses three nuclear magnetic resonance imaging and spectroscopy instruments, two for animal studies and one for patients.

Nuclear magnetic resonance is used to study anatomical and physiological processes in living systems. The new center has a 1.5 Tesla whole-body instrument and two wide-bore animal NMR machines, one with a 2 Tesla field and the other with a 4.7 Tesla field, and associated data stations and computer facilities. In addition, a 7 Tesla 10-cm spectrometer is there for special applications in NMR spectroscopy.

By having machines for both animal and human images in the center, researchers will be able to conduct directly analogous experiments.

The center also has a small patient care area with waiting, dressing and preparation rooms.

"This is a day many of us have been looking

(See NMR, Page 8)

NMR

(Continued from Page 1)

forward to for a long time," Dr. Edwin D. Becker, NIH associate director for research services, said at the dedication ceremony in the ACRF Amphitheater. "This facility is a cooperative and collegial effort by NIH's institutes."

The keynote speaker at the ceremony, Dr. E. Raymond Andrew, professor of physics and radiology, University of Florida, spoke about the impact of "NMR in Biomedicine."

"Nuclear magnetic resonance has become more important in biology and medicine over the last 10 years," he said. "Initially it was the province of the physicist, then the chemist, and

Dr. E. Raymond Andrew, professor of physics and radiology at the University of Florida, gave the keynote address at the opening of the NMR Center.

it has moved across the disciplines."

Andrew showed a series of slides of his own head and abdomen to illustrate the results of NMR imaging.

Dr. S. Morry Blumenfeld of General Electric Medical Systems, the prime contractor for establishment of the center, told the audience, "Our goal is the creation of a new diagnostic modality to bring to the clinician not only the physical attributes of a patient, but also information on the chemistry and biochemistry of abnormal tissues." GE designed, built, and equipped the new center.

Both imaging and spectroscopy make use of the magnetic quality of certain atomic nuclei.

The NMR phenomenon occurs when nuclei containing an odd number of protons and/or neutrons are introduced into a strong magnetic field. These nuclei behave as if they were spinning charges, and precess (gyrate like a top) in a preferred orientation in a strong magnetic field.

When a radio frequency (RF) pulse is introduced by a transmitter—often for only millionths of a second—the nuclear spins will reorient in the field and, as a whole, will absorb energy. Following the pulse, the nuclei "relax" to their original state. The time it takes the stimulated nuclei to relax after a burst of RF energy is a measurable quantity, charac-

Blending in evenly with the brick exterior of the Clinical Center is the one-story In Vivo NMR Research Center, adjacent to the CC's D wing.

teristic of a particular molecular environment.

The relaxation times of these nuclei and the RF frequency for resonance are of use in physics, chemistry, and biochemistry. The distribution in space of these nuclei can be used to obtain images.

While imaging of human anatomy is perhaps the most widely known aspect of NMR, the procedure has been used at NIH for more than 30 years for basic research in organic and physical chemistry, and, more recently, for biochemistry and physiology. NMR can provide information on the structure of molecules.

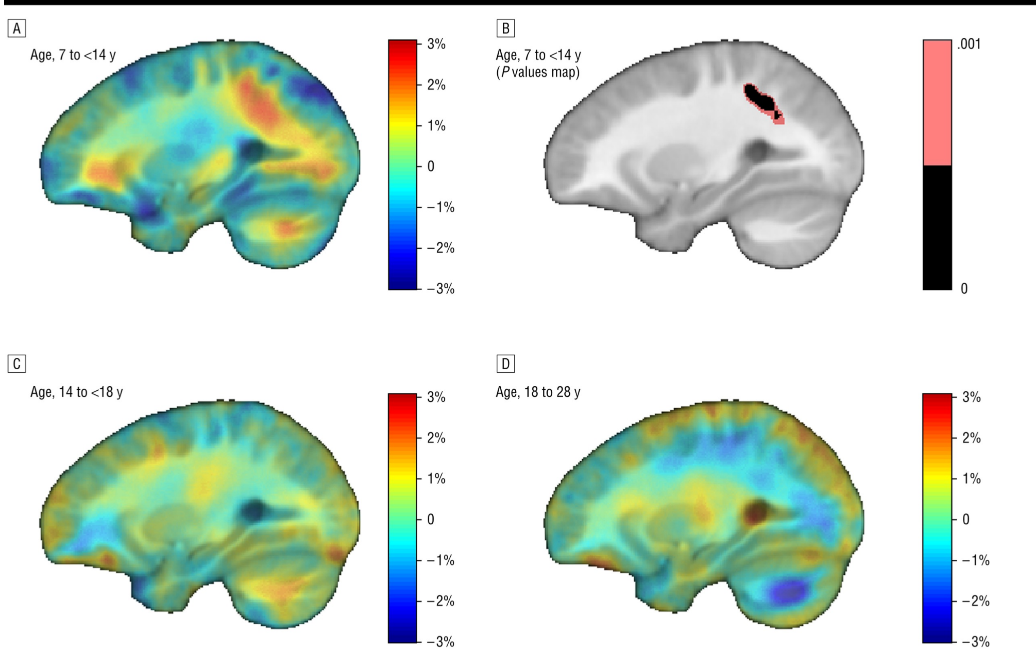
"I was introduced to NMR 30 years ago by Dr. Becker and I was impressed then and have been ever since with the power of this technique," said Dr. Joseph Rall, NIH deputy director for intramural research. "NIH is a good community for a center because of both the expertise and the clinical need that we have."

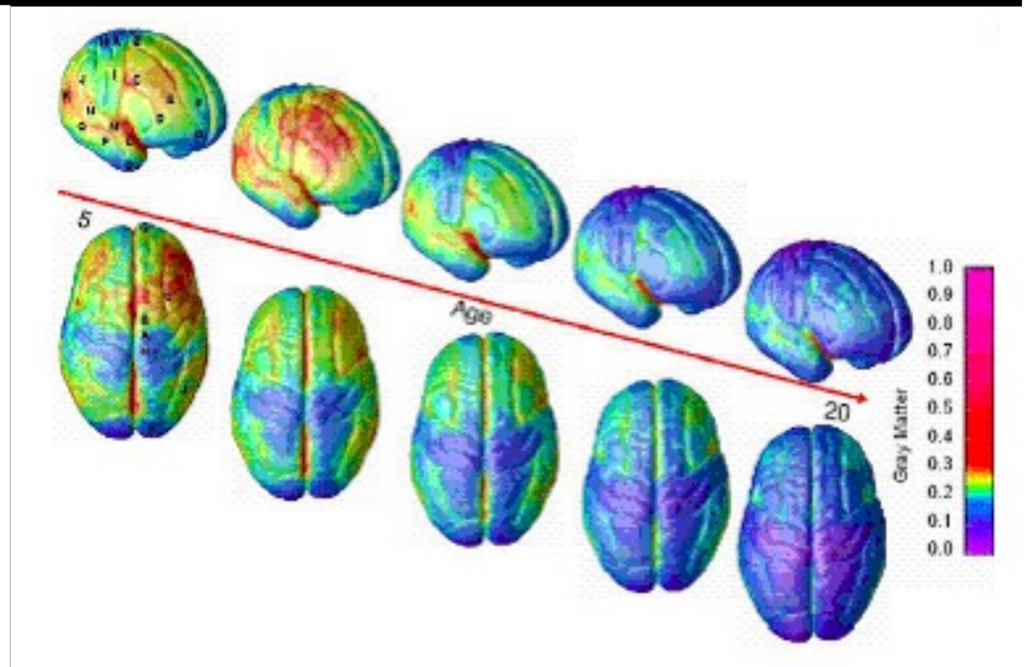
NMR was discovered in 1946 by two American scientists, Felix Bloch and Edward Purcell, who were awarded the Nobel prize in physics in 1952 for their work.

Inspecting the facilities in the recently opened In Vivo NMR Research Center are (from l) Dr. David Hoult and Dr. Ching-Nien Chen, BEIB; Judie Ireland, ORS; Dr. Andrew Dwyer and Dr. Joseph Frank, CC-Diagnostic Radiology Department.

JUDY RAPOPORT/CHILDHOOD PSYCHIATRY

- Early studies of brain development
- Longitudinal studies of childhood onset schizophrenia
- Longitudinal studies of normal brain development

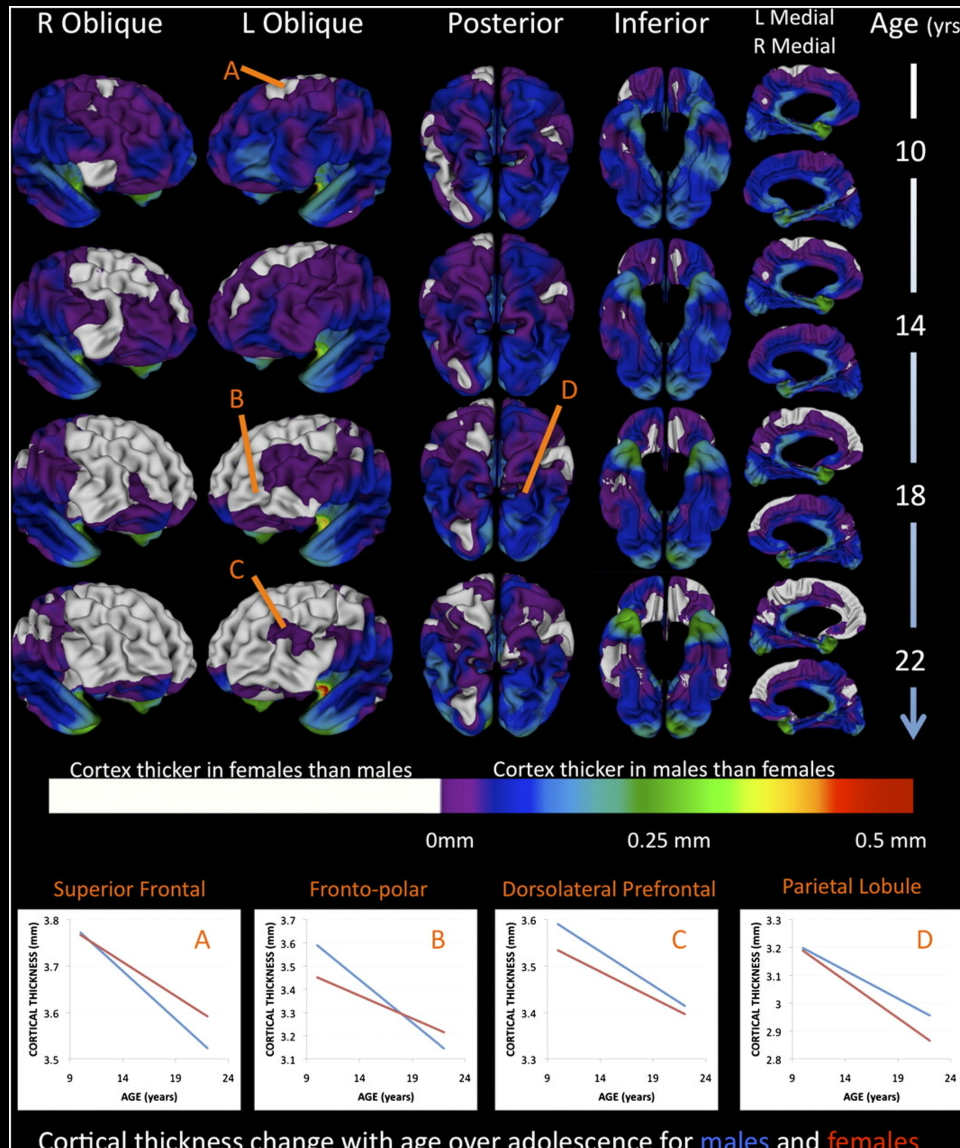




Longitudinal MRI, genomics

ARMIN RAZNAHAN (DEVELOPMENTAL NEUROGENOMICS – AKA @BOGGLERAPTURE)

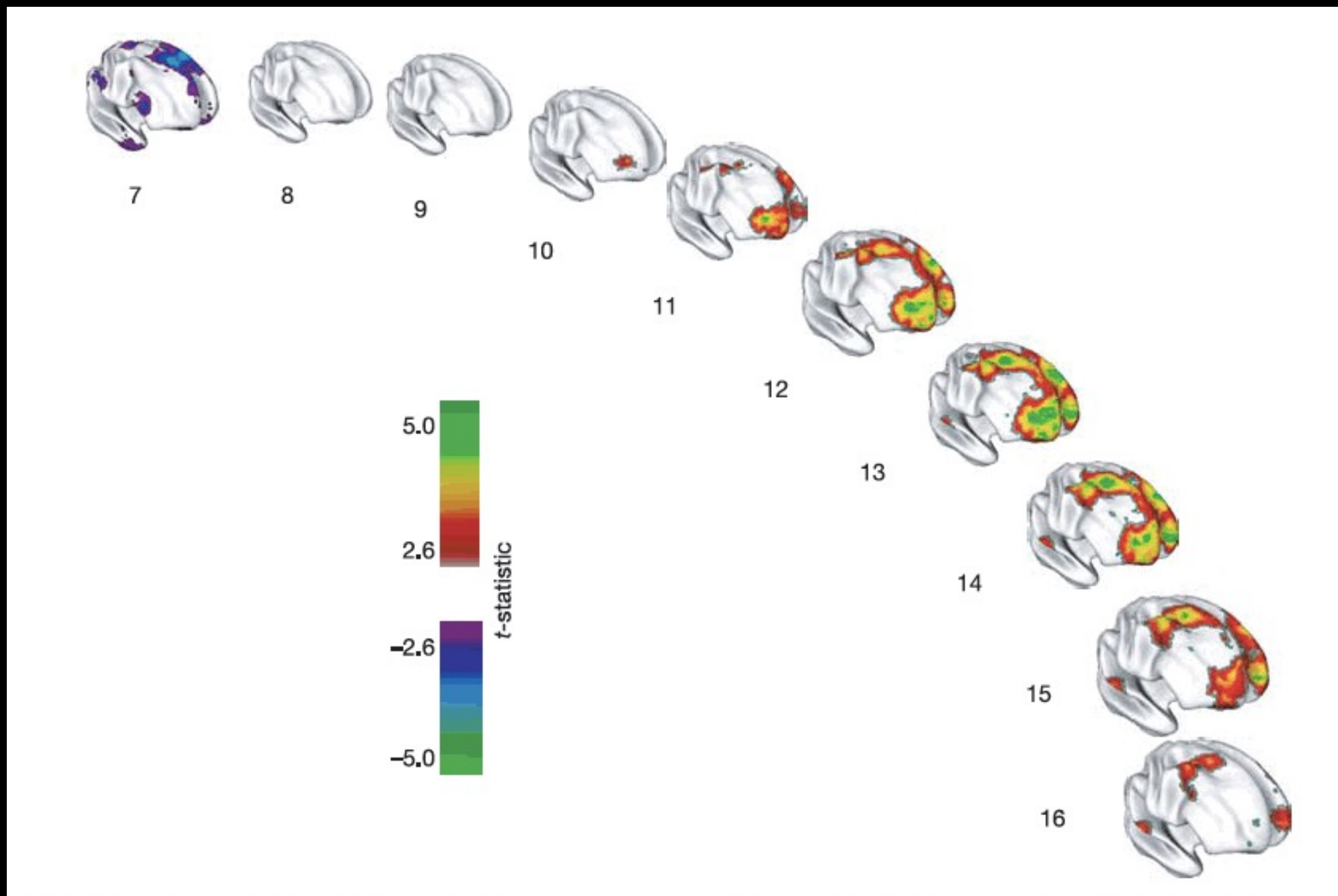
- Longitudinal MRI studies of brain development in children
- Linking genetics and environment to brain development
- Methodology – impact of motion on imaging-derived phenotypes



PROMO, longitudina

PHIL SHAW/NHGRI NEUROBEHAVIORAL UNIT

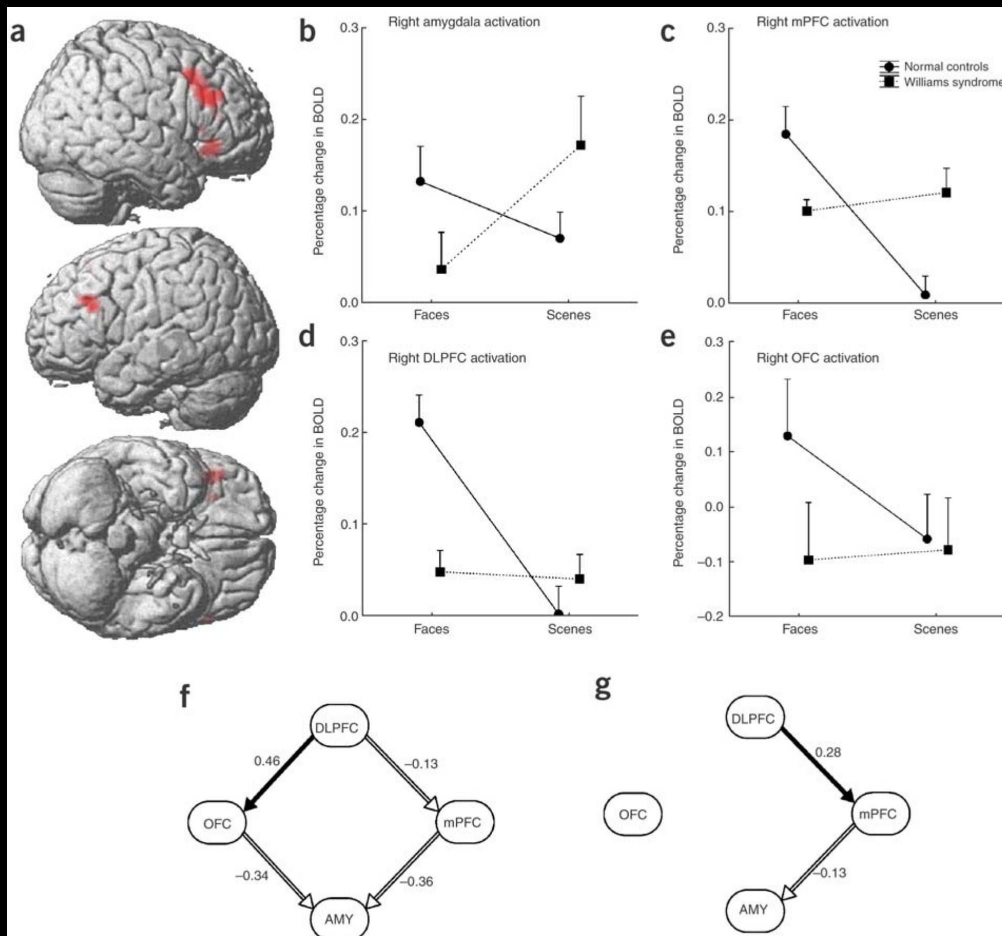
- Longitudinal studies of brain development in youths with ADHD
- CPB Alumnus / Well known studies of brain development & IQ etc
- Cortical development trajectories



- Intellectual ability and cortical development in children and adolescents , Shaw, P., et al (2006) Nature, 440 (7084), pp.
- Attention-deficit/hyperactivity disorder is characterized by a delay in cortical maturation Shaw, P., et al (2007) PNAS
- Neurodevelopmental trajectories of the human cerebral cortex Shaw, P., et al, (2008) Journal of Neuroscience
- Longitudinal mapping .. children and adolescents with ADHD, Shaw, P., et al, (2006) Archives of General Psychiatry, 63

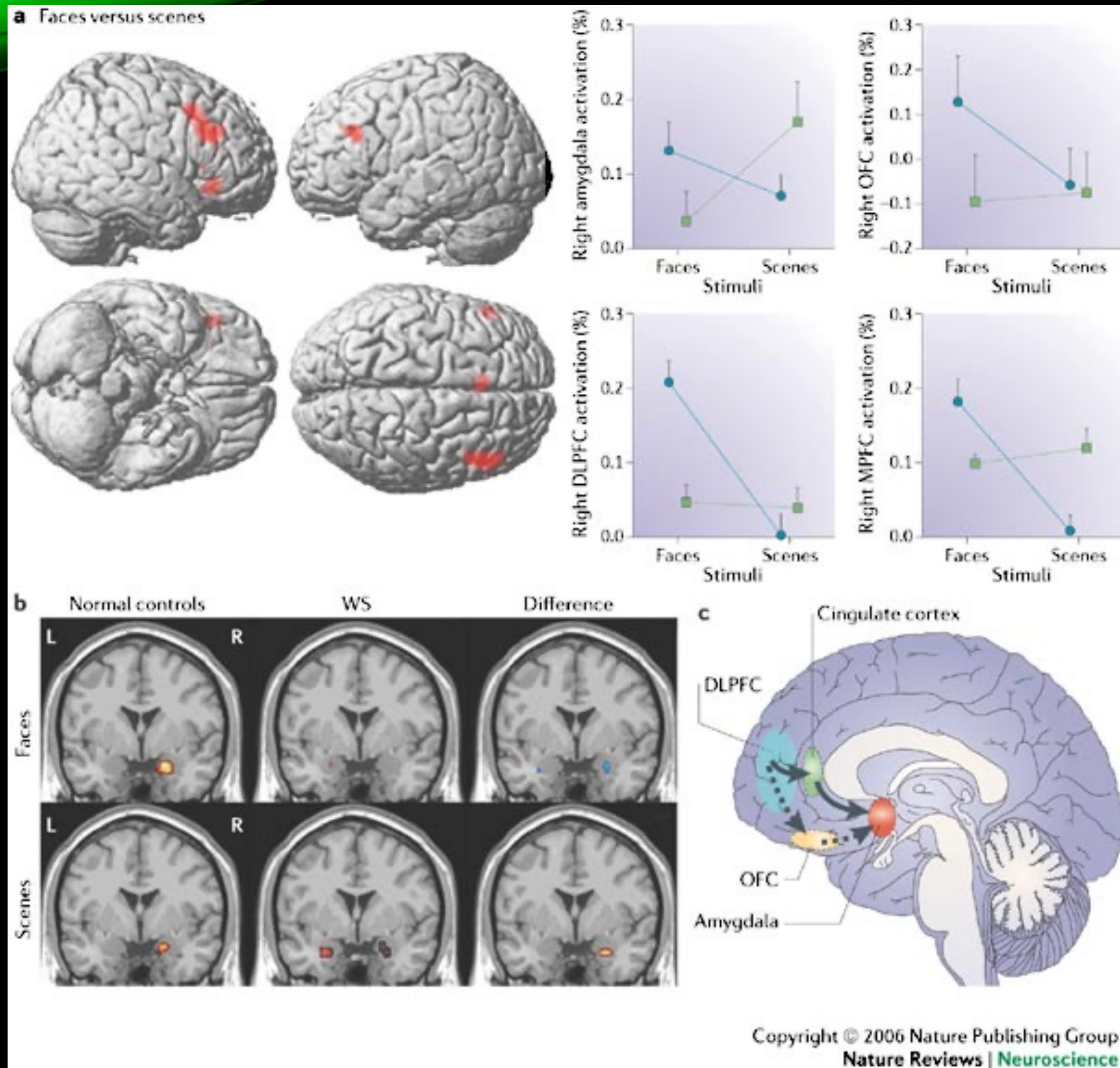
KAREN F. BERMAN / SECTION INTEGRATIVE NEUROIMAGING

- Developmental neuropsychiatric disorders
- Genetics of social cognition(esp. Williams Syndrome)
- Multi-modality imaging



Use: eye-tracking, auditory
In young children

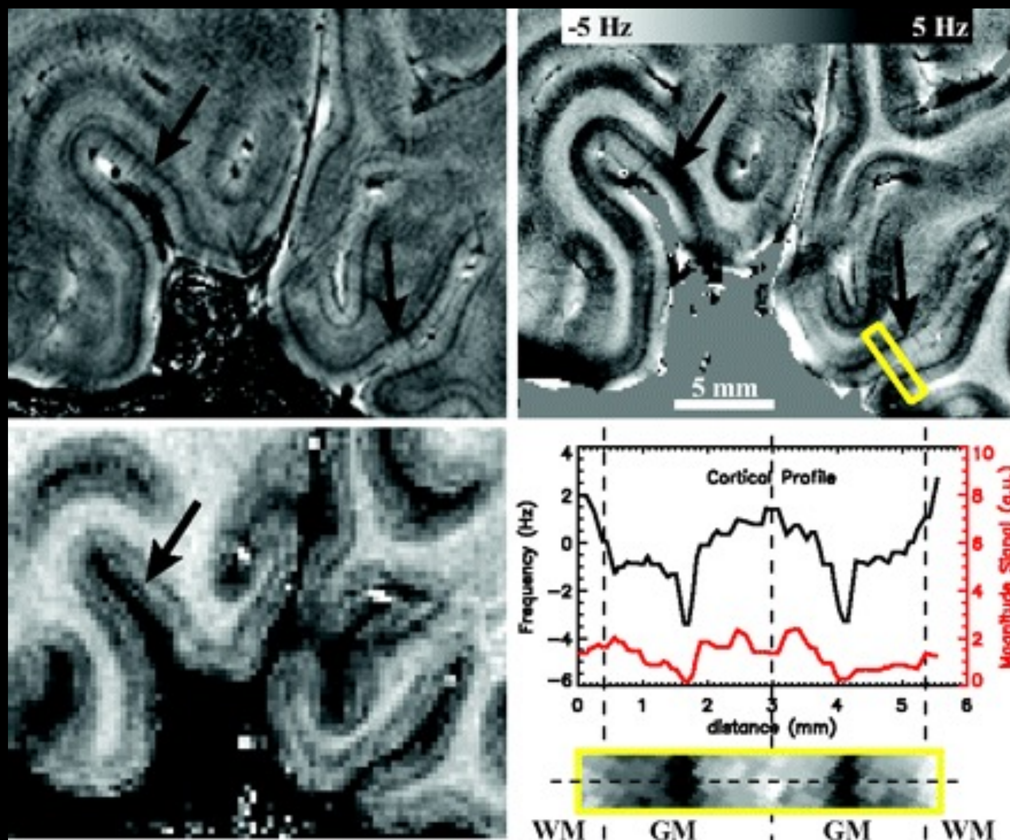
Williams syndrome chromosome ...hypersocial, anxious personality… altered insula structure….. Jabbi M, Kippenhan JS et al, . Proc Natl Acad Sci U S
Variation in dopamine genes influences responsivity of the human reward system. Dreher JC et al,. Proc Natl Acad Sci U S A. 2009
Neural correlates of genetically abnormal social cognition in Williams syndrome. Meyer-Lindenberg A et al Nat Neurosci. 2005
Human dorsal and ventral auditory streams subserve rehearsal-based and echoic processes during verbal working memory. Buchsbaum et al, Neu



From Berman Group:. *Nature Reviews Neuroscience* **7**, 380–393 (May 2006)

JEFF DUYN/ADVANCED MRI (METHODS DEVELOPMENT)

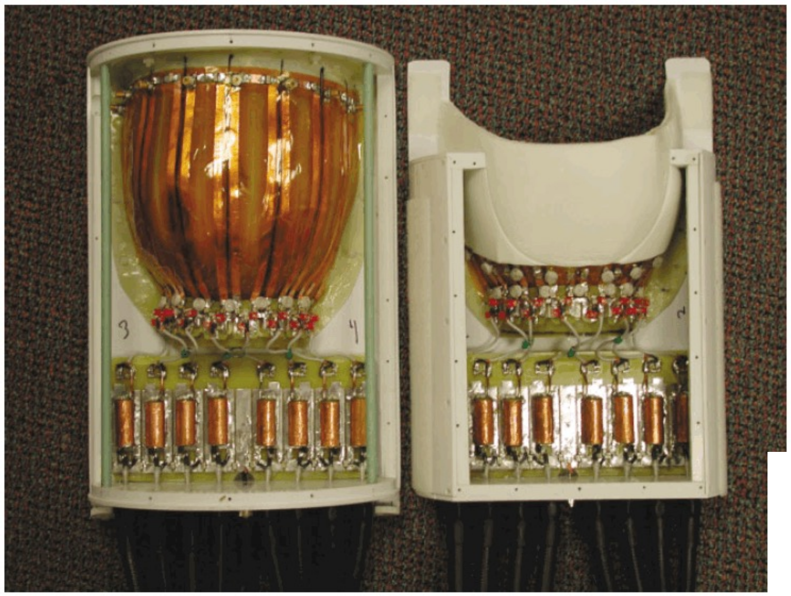
- Imaging methods/technology especially parallel imaging
- Magnetic susceptibility contrast imaging – mechanisms & applicati
- Physiological basis of spontaneous brain activity
- pulse sequences and techniques esp for UHF imaging (7T & 11.7T)



Use: EEG/MRI,
eye tracking (7T),
custom pulse seq&reco

- High-field MRI of brain cortical substructure based on signal phase, Duyn, J.H. et al (2007) PNAS
- Low-frequency fluctuations … as a source of variance in the resting-state fMRI BOLD signal Shmueli, K. etal (2007) Neur
- Susceptibility contrast in high field MRI of human brain as a function of tissue iron content Yao, B. et al (2009) NeuroImag
- Layer-specific variation of iron content in cerebral cortex as a source of MRI contrast, Fukunaga, M et al (2010) PNAS

PARALLEL IMAGING -16 CHANNEL COIL FOR 3T



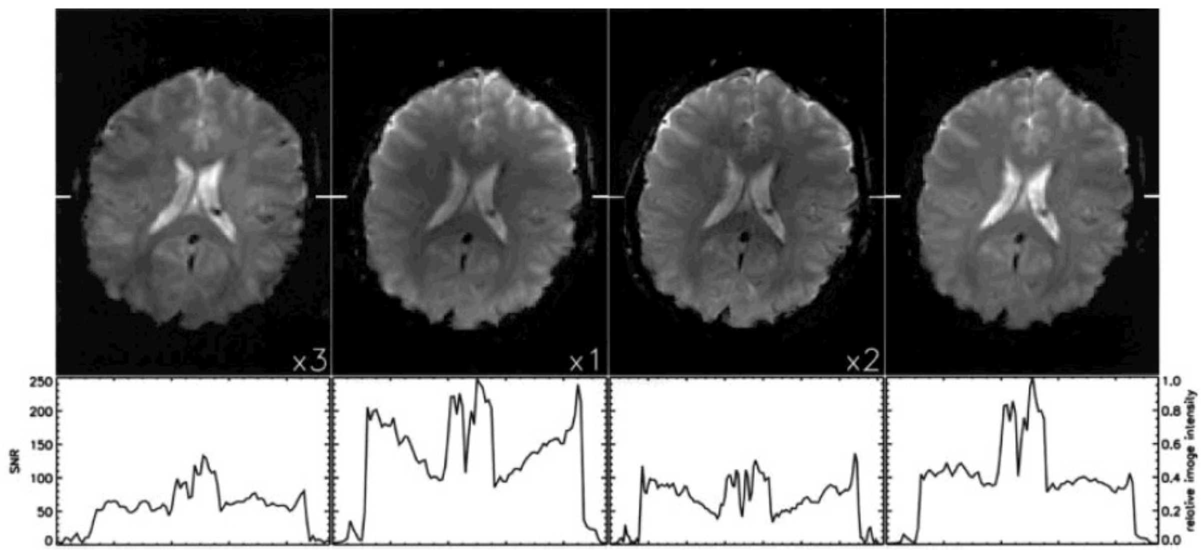
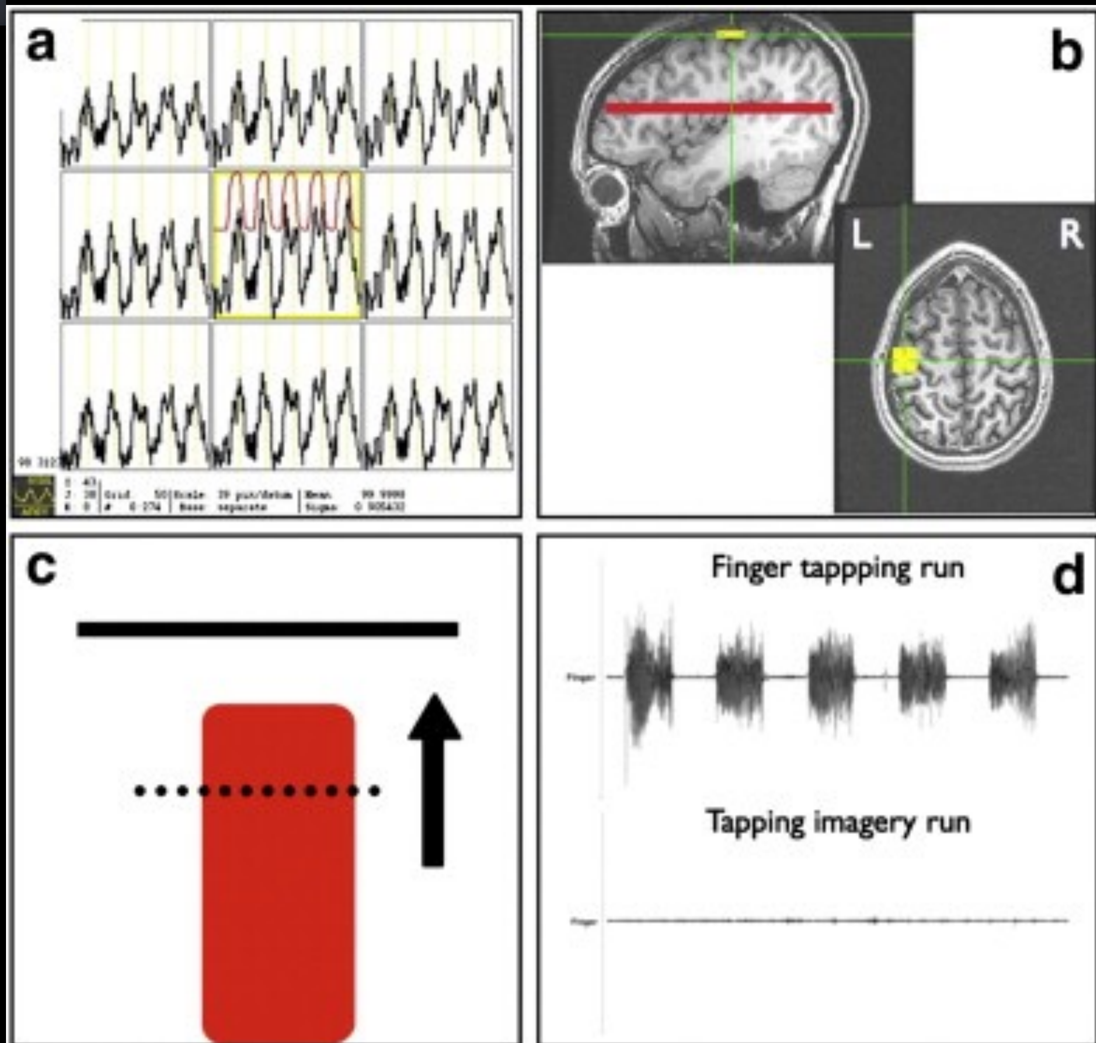


FIG. 2. Performance of the 16-channel coil compared to the standard 28-cm GE birdcage head coil. The top row shows a single slice of the acquired EPI data. The three leftmost images are SNR maps. Their relative scaling factor is indicated in the lower right corner of the image. The rightmost image shows the same data as in the second image, after intensity correction. Tick marks left and right in each image indicate the location of the profile shown below it. The first column shows single-shot EPI data from the birdcage head coil (128 × 96 resolution). Data in all other columns were acquired with the 16-channel coil. Data in the second and third columns were acquired at respectively the same (128 × 96) and higher (192 × 144, rate-2 SENSE) spatial resolution. Note that the scaling of the rightmost column is arbitrary. See text for more details.

MARK HALLETT/HUMAN MOTOR CONTROL SECTION

- Evaluating motor disorders with FMRI, rsMRI, MRS
- FMRI neurofeedback / treating movement disorders
- Motor learning in dystonia and healthy controls

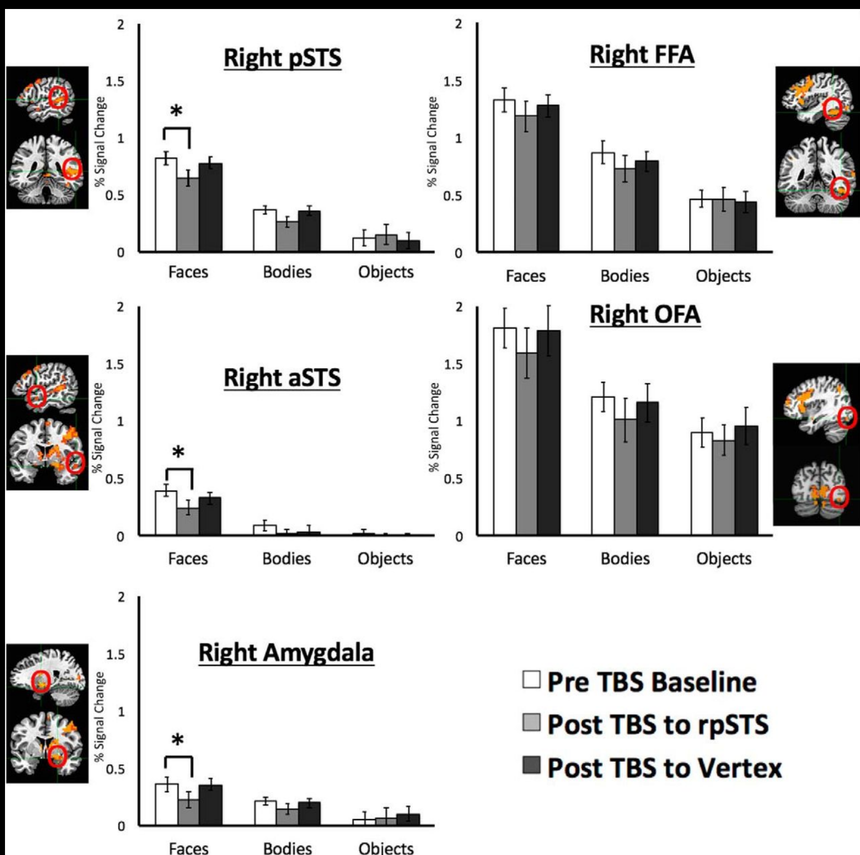


- Voon et al, Dopamine and impulse control

Use: eeg/fmri, RT-feedback stimulators, force-measurement

LESLIE UNGERLEIDER/NEUROCIRCUITY SECTION

Early FMRI adopter
Functional architecture of perceptual and attentional systems
Functional anatomy of face processing
Primate imaging/anatomical studies
Combining TMS and fMRI
First studies with concurrent ultrasonic stimulation



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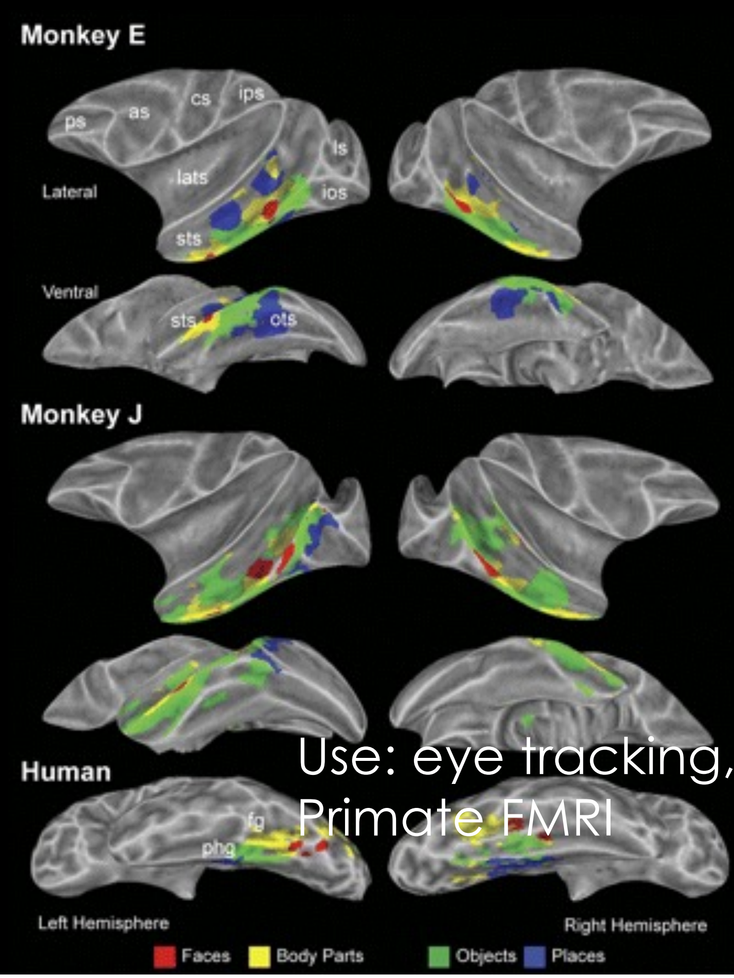
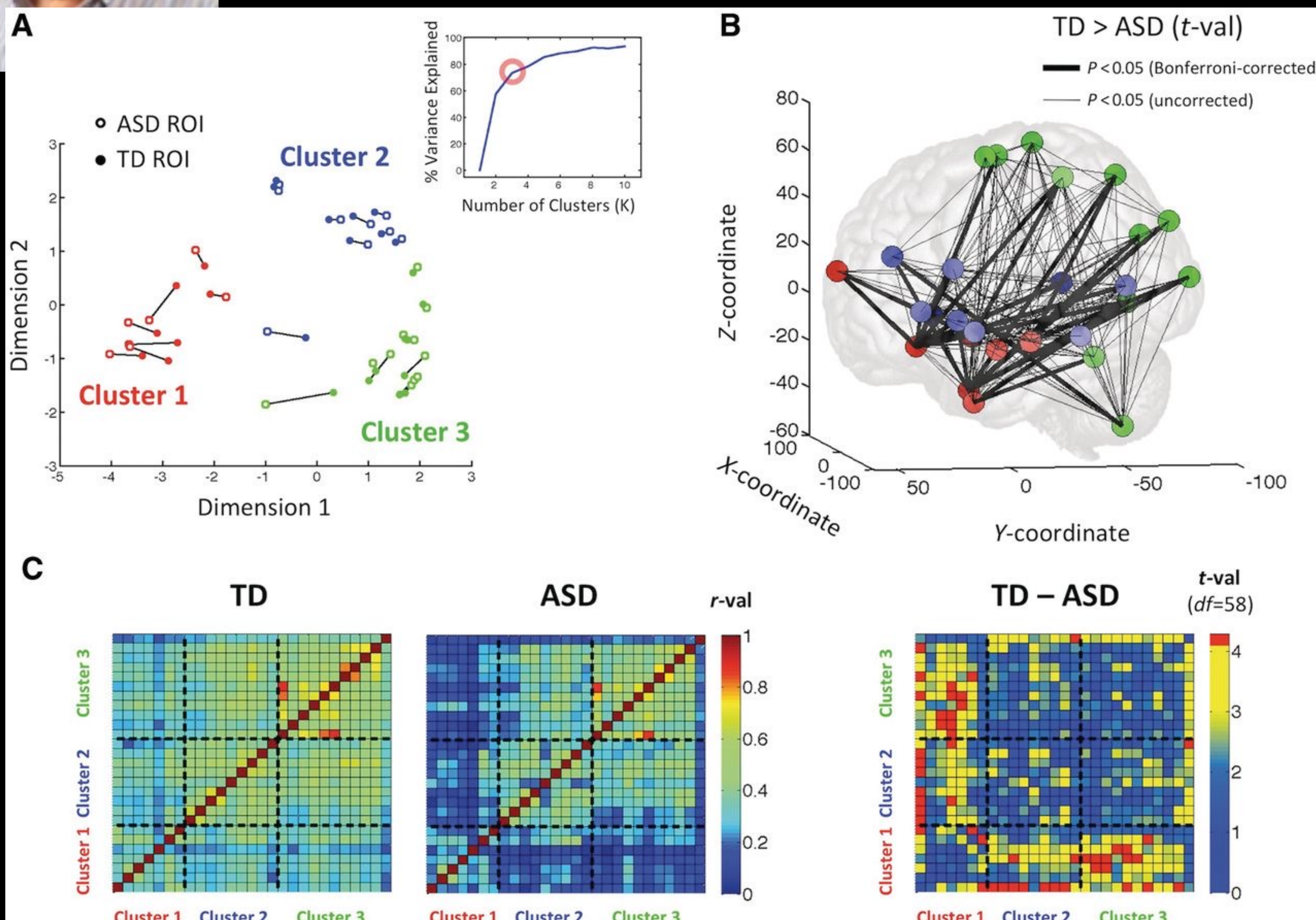


Use: eye tracking, TMS
Primate FMRI

ALEX MARTIN/SECTION ON COGNITIVE NEUROPSYCHOLOGY

- Object and category semantic representation in cortex
- Representation of social network information in normals & autistics



- **Gotts S J et al. Brain 2012;135:2711-2725**

Use: gustatatory input, speech output (noise cancelling microphone, etc)

Unraveling multisensory integration: patchy organization within human STS multisensory cortex

Michael S Beauchamp[1], Brenna D Argall[1], Jerzy Bodurka[2], Jeff H Duyn[3] & Alex Martin[1]

Although early sensory cortex is organized along dimensions encoded by receptor organs, little is known about the organization of higher areas in which different modalities are integrated. We investigated multisensory integration in human superior temporal sulcus using recent advances in parallel imaging to perform functional magnetic resonance imaging (fMRI) at very high resolution. These studies suggest a functional architecture in which information from different modalities is brought into close proximity via a patchy distribution of inputs, followed by integration in the intervening cortex.

The human superior temporal sulcus multisensory area (STS-MS) is important for integrating auditory and visual information about objects, speech, letters and other behaviorally relevant stimuli[1–4]. Electrophysiological recording studies from macaque monkeys demonstrate that individual neurons in monkey STS may respond only to auditory stimuli, only to visual stimuli, or both to auditory and to visual stimuli[5,6]. Although it is reasonable to assume that similar neuronal response properties exist in human STS-MS, there has been no direct evidence for this. Additionally, electrophysiological and functional neuroimaging studies to date have provided no information on the topographic organization of these different types of neurons.

One possibility is that the STS-MS is organized as a homogeneous mixture of auditory, visual and auditory-visual neurons. Arguing against this idea is the observation from tracer injection studies that auditory and visual projections to monkey STS lie in non-overlapping domains[7]. This patchy organization is on a scale of 1–2 mm (ref. 8). Owing to technical limitations, standard-resolution fMRI uses voxels that are too large (40–70 mm^3) to observe fine structure within cortical areas. Recent advances in multichannel MRI receivers[9] and whole-brain surface coil phased arrays[10] provide improved signal-to-noise ratio and permit the acquisition of high-resolution fMRI data with significantly more flexibility than single surface coils[11,12], making them ideally suited to study the STS-MS.

We mapped the STS-MS in human subjects using standard-resolution fMRI and either videos of tools (for example, a hammer making a hammering motion), recordings of

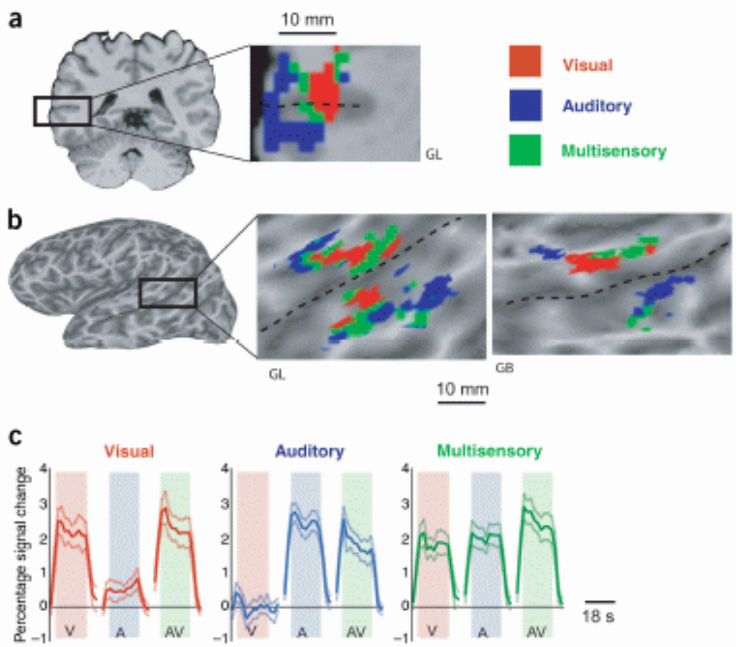


Figure 1 Patchy organization within the STS-MS. (a) Coronal section with enlargement of the left STS (dashed line). Colors show relative response to unisensory visual (V) and auditory (A) tools. Orange (visual patches): V > A, $P < 0.05$. Blue (auditory patches): A > V, $P < 0.05$. Green (multisensory patches): A = V, $P < 0.05$. Two-letter code (GL) indicates subject identity. (b) Lateral view of the left hemisphere of an inflated cortical surface model, with enlargement showing the STS-MS in two subjects. Same color scale as in a. (c) Average MR time series across subjects ($n = 8$). Three graphs showing the response in visual (left), auditory (middle) and multisensory (right) patches to the three stimulus types (pink shaded region, V, response to visual tools; blue shaded region, A, response to auditory tools; green shaded region, AV, response to multisensory tools) and fixation baseline (non-shaded regions). Thick line, mean response; thin line, s.e.m.

[1]Laboratory of Brain and Cognition and [2]Functional MRI Facility, National Institute of Mental Health, and [3] Section on Advanced MRI, Laboratory of Functional and Molecular Imaging, National Institute of Neurological Disorders and Stroke, National Institutes of Health, Bethesda, Maryland, USA. Correspondence should be addressed to M.S.B. (mbeauchamp@nih.gov).

Published online 10 October 2004; doi:10.1038/nn1333

PETER BANDETTINI/FUNCTIONAL IMAGING METHODS

- Maximizing information that can be extracted from FMRI time seri
- Multi-echo EPI for improved fMRI & rs-fMRI clustering
- Mass averaging reveals widespread BOLD activation
- Understanding rsFMRI mechanisms and confounds
- Information mapping/decoding FMRI

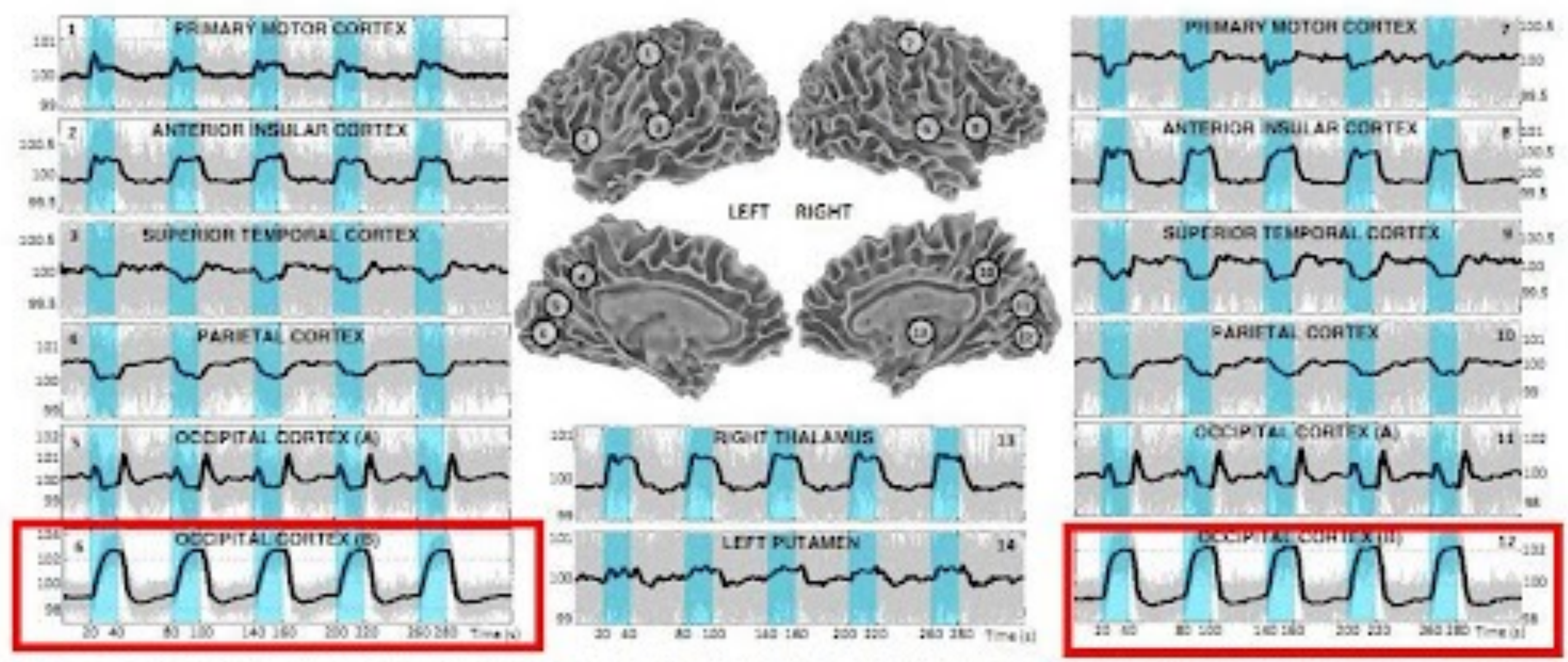
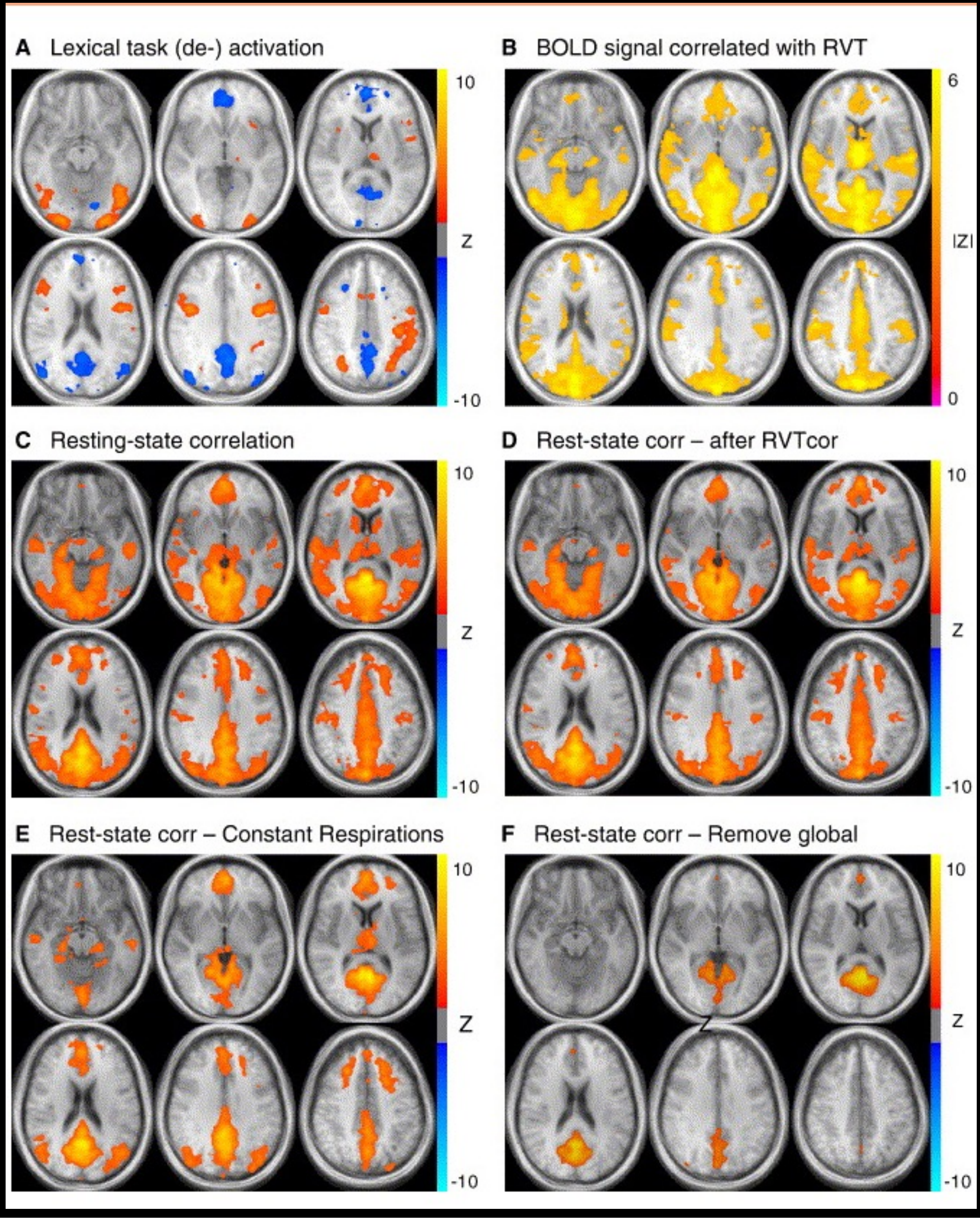
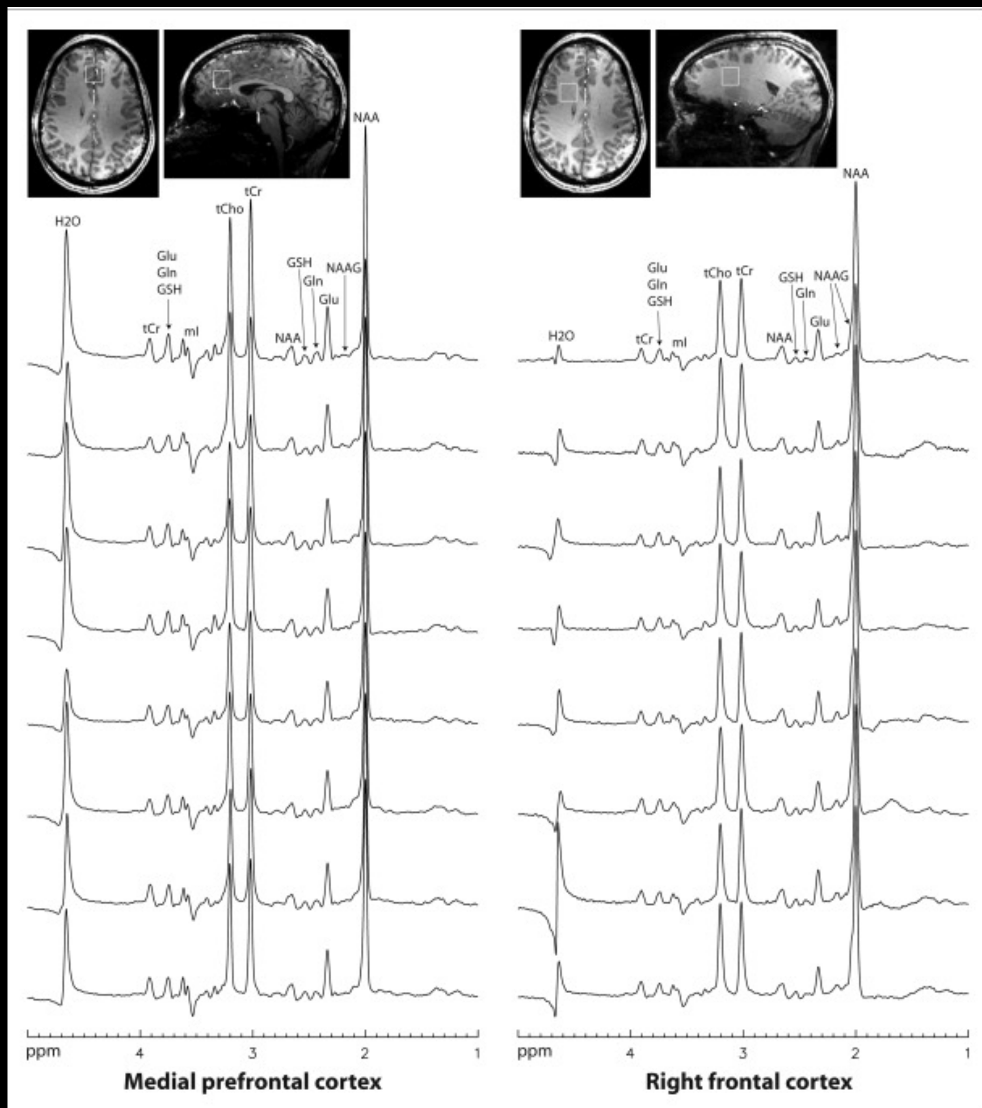


Fig. 2. Time-series for a subset of statistically significant voxels. For each voxel the 100 individual measures are plotted in gray and their average in black.

SEPARATING RESPIRATORY-VARIATION-RELATED FLUCTUATIO FROM NEURONAL-ACTIVITY-RELATED FLUCTUATIONS IN FM (BIRN ET A



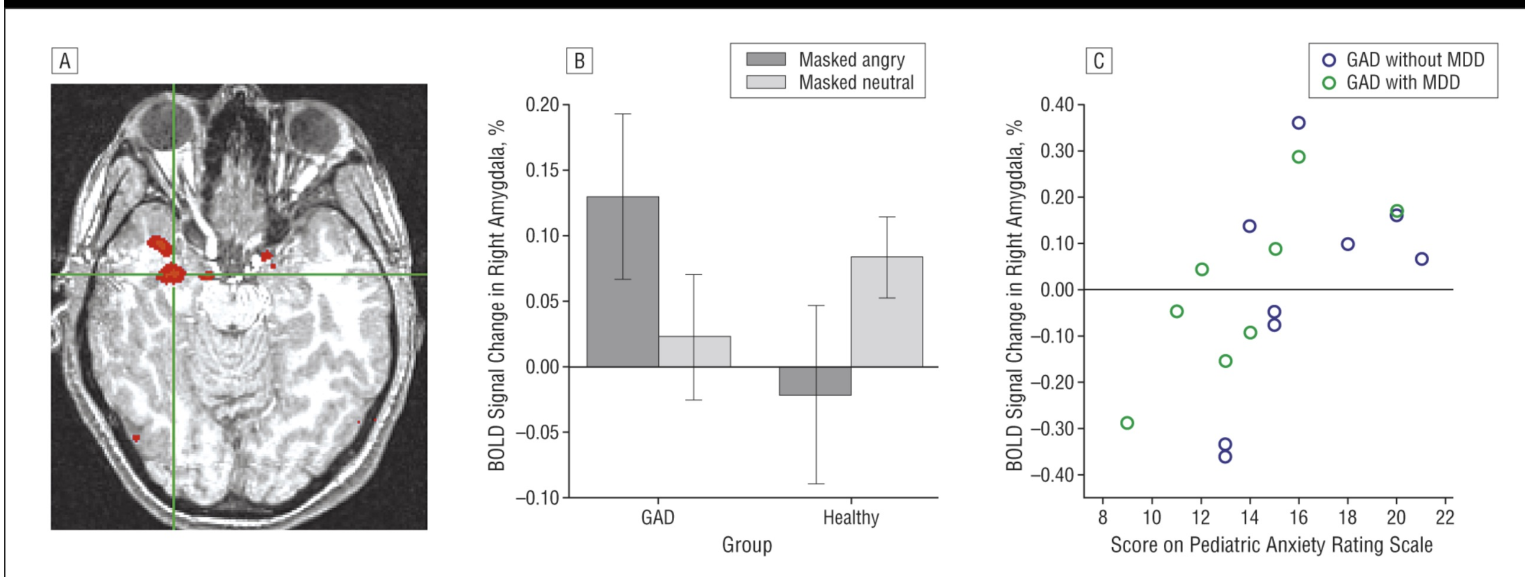
- MRS methods development
- 13C / Glu / Gln / GSH (glutathione) quantification



(use: everything MRS)

DANIEL PINE/ DEVELOPMENTAL &AFFECTIVE NEUROSCIENCE

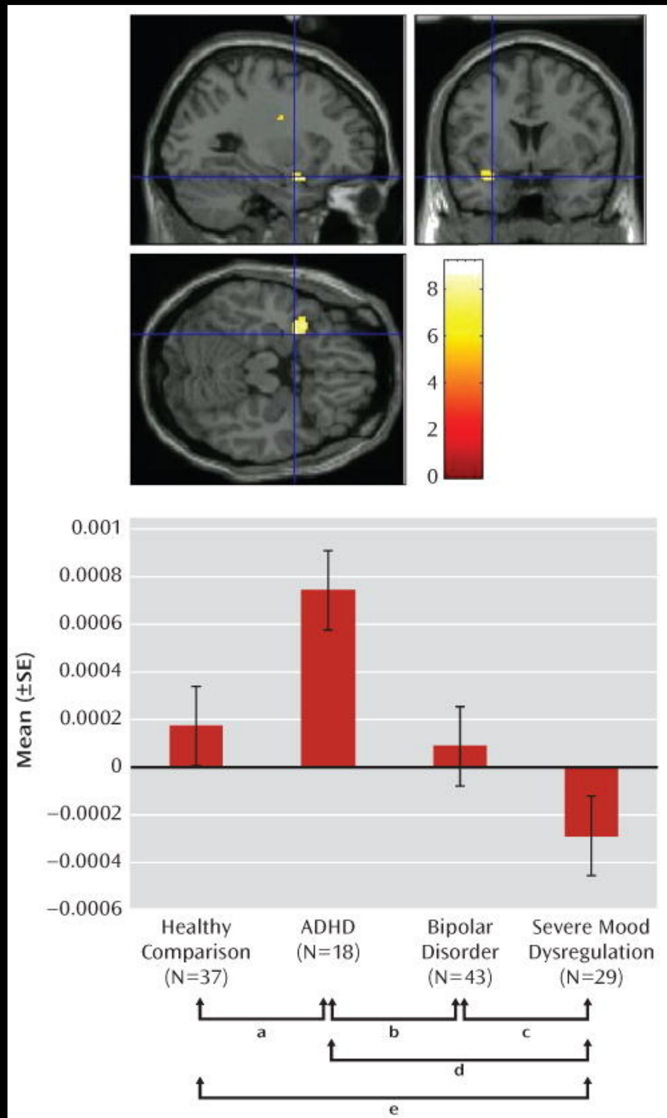
- fMRI studies pediatric & adolescent anxiety
- Fear and threat processing in adolescent patient groups



Use: eye tracking, skin conductar

ELLEN LEIBENLUFT/BIPOLAR DISORDERS

- Brain mechanisms in childhood bipolar
- FMRI of adolescents with severe irritability

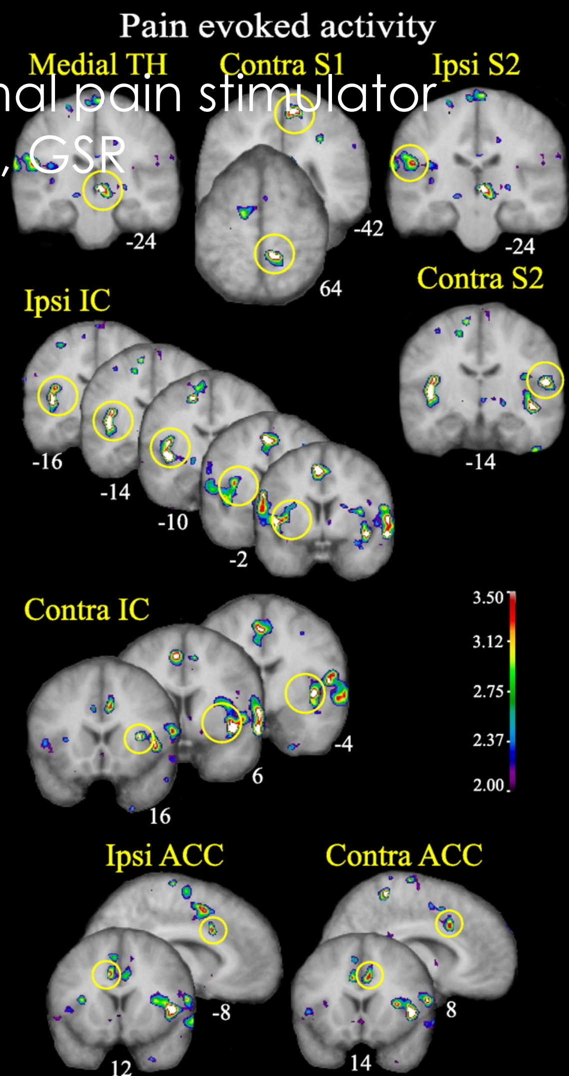


- **Cross-sectional & longitudinal abnormalities in brain structure in children with SMD or BD (Adelman et al, 2012)**
- **Amygdala activation during emotion processing of neutral faces in children with severe mood dysregulation versus ADHD or bipolar disorder (Brotman et al, AM. J Psychiatry, 2010)**

Catherine Bushnell/NCCIH

- Recruited from McGill in 2013
- Pioneer in imaging studies of pain perception and cognition

Uses: thermal pain stimulator
Analgesics, GSR



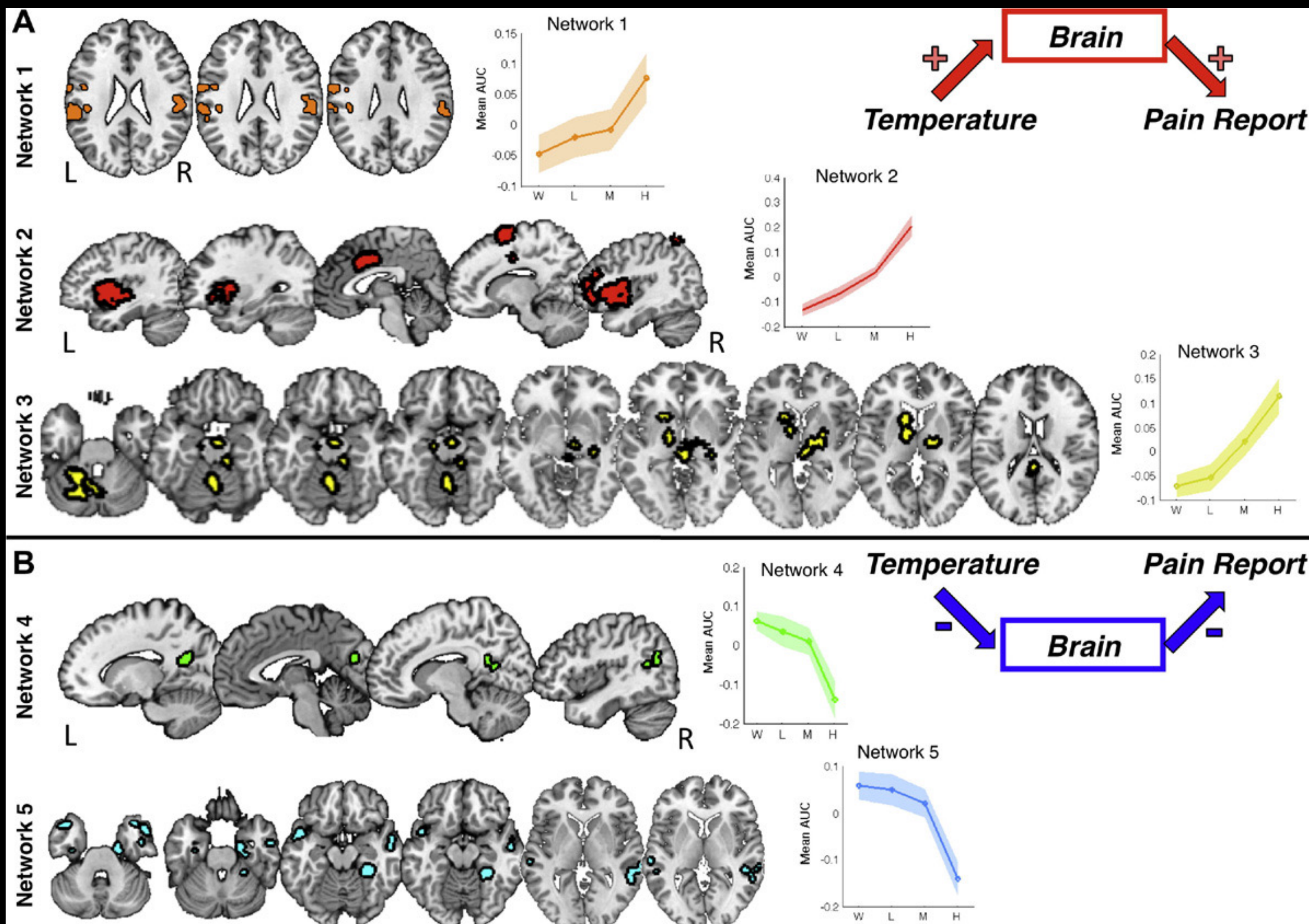
Thalamic and cortical activity evoked by heat pain in the alternating warm/pain task.

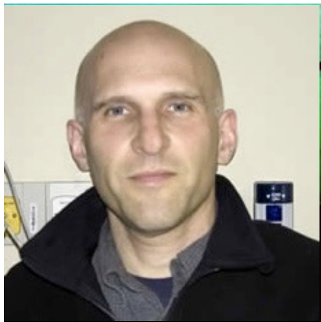
Chantal Villemure, and M. Catherine Bushnell J. Neurosci. 2009;29:705-715

Lauren Atlas/NCCIH
(Affective Neuroscience&Pain)

Recruited from NYU in 2015
studies of how belief and expectation influence pain perception

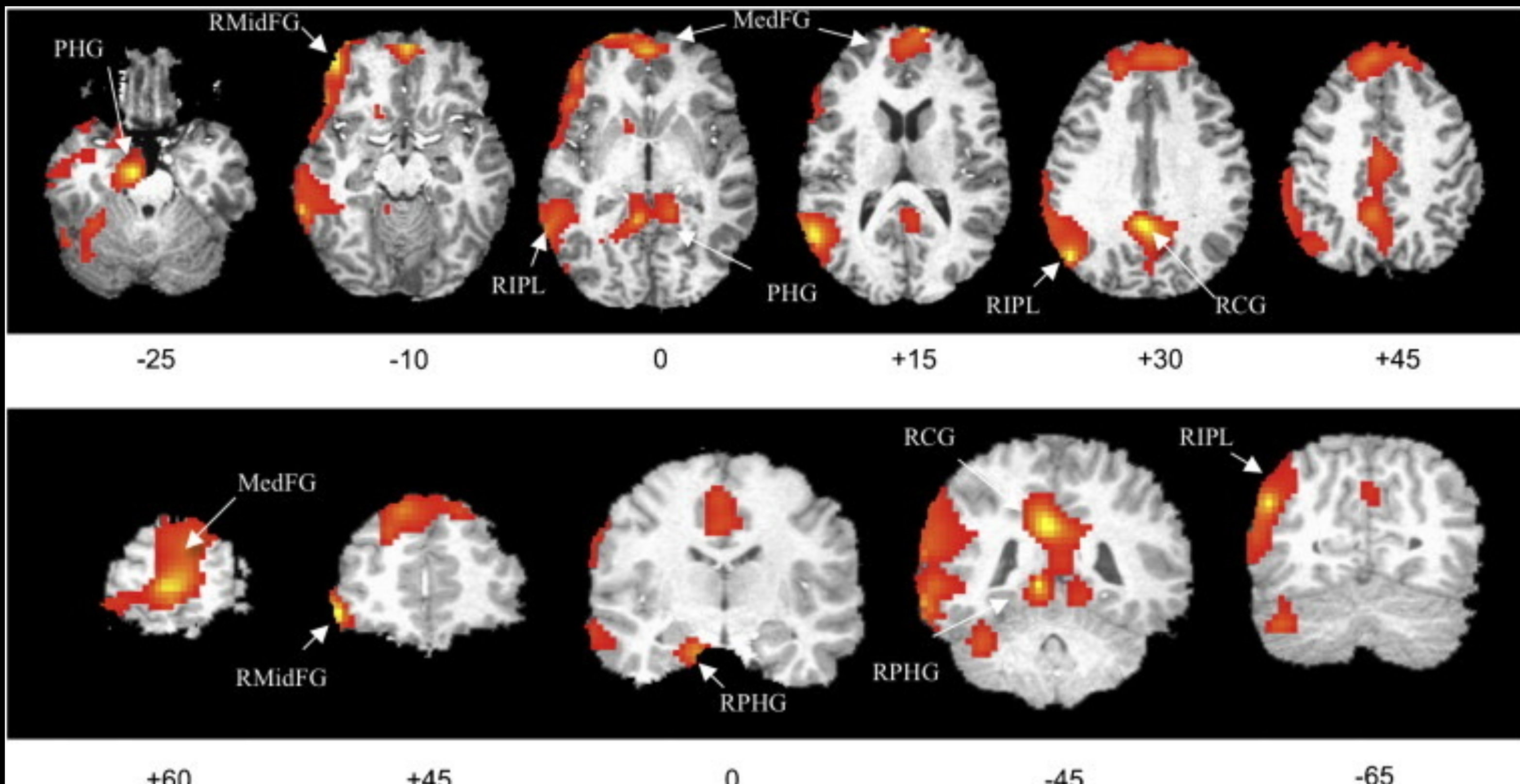
Uses: thermal pain stimulator
Analgesics, eye tracking, GSR





ERIC WASSERMAN/BEHAVIORAL NEUROLOGY UNIT

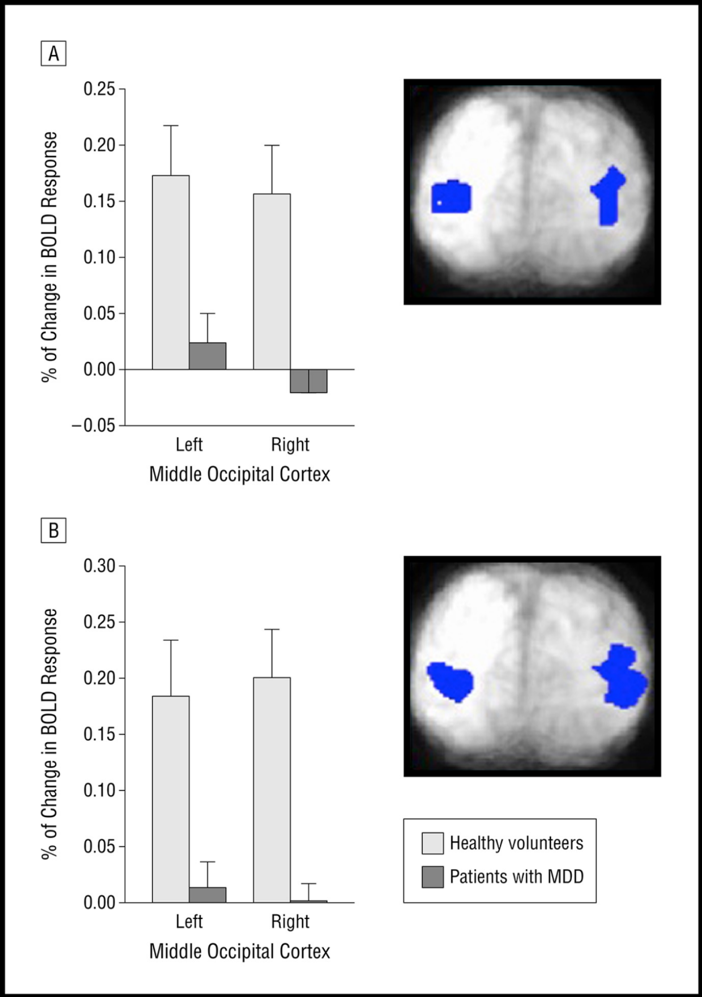
- FMRI Studies of brain stimulation (TMS / tcDCS)
- Validating NIRS with FMRI
- Interventional studies of neural plasticity with tcDCS



Use: TMS, tDCS, NIRS

CARLOS ZARATE/EXPERIMENTAL THERAPEUTICS

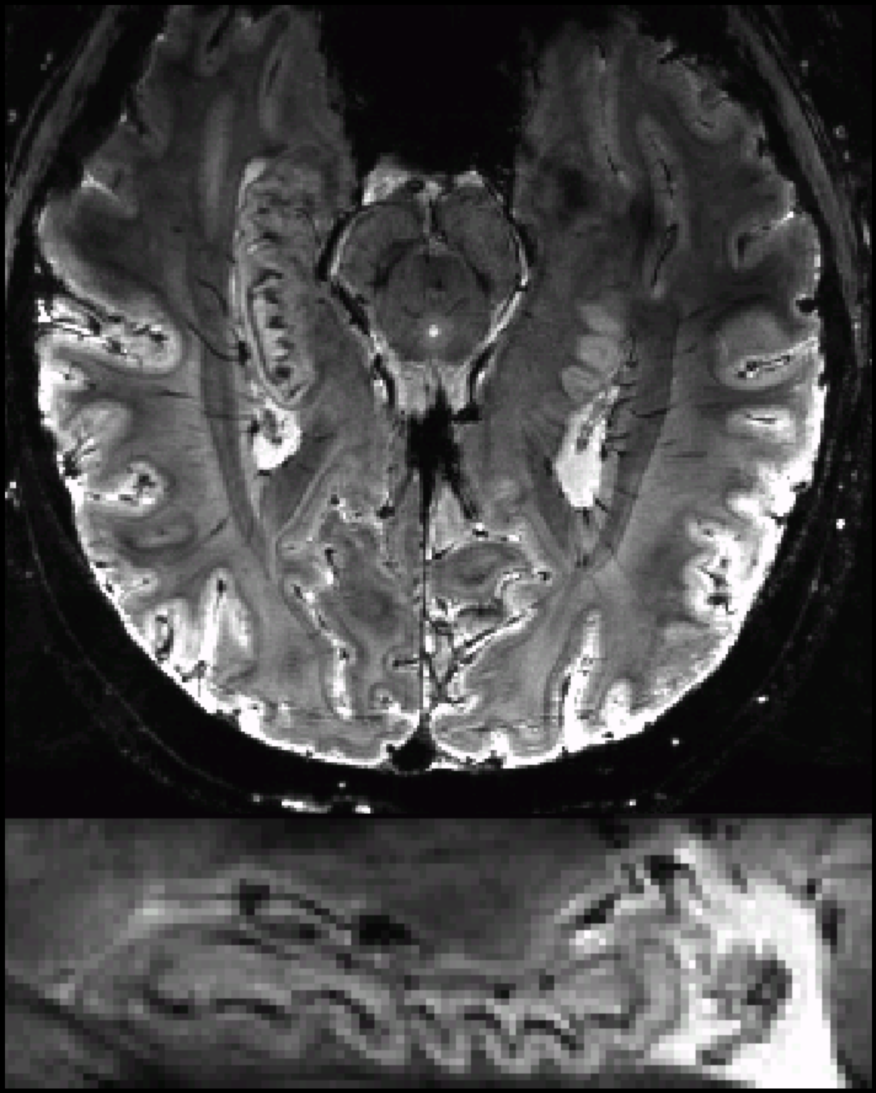
- Multimodal studies of fast-acting glutamatergic antidepressants
- Functional MRS
- High resolution studies of hippocampal structures linked to MDD



Use: High-res 7T anatomy
fMRS,

MAJOR DEPRESSIVE DISORDER (MDD) AND BRAIN STRUCTURE

- High resolution hippocampal mapping at 7T
- Assessing curvature, surface area, and shape
- 0.5mm iso, T2* weighted (48 slices, 7min acq)



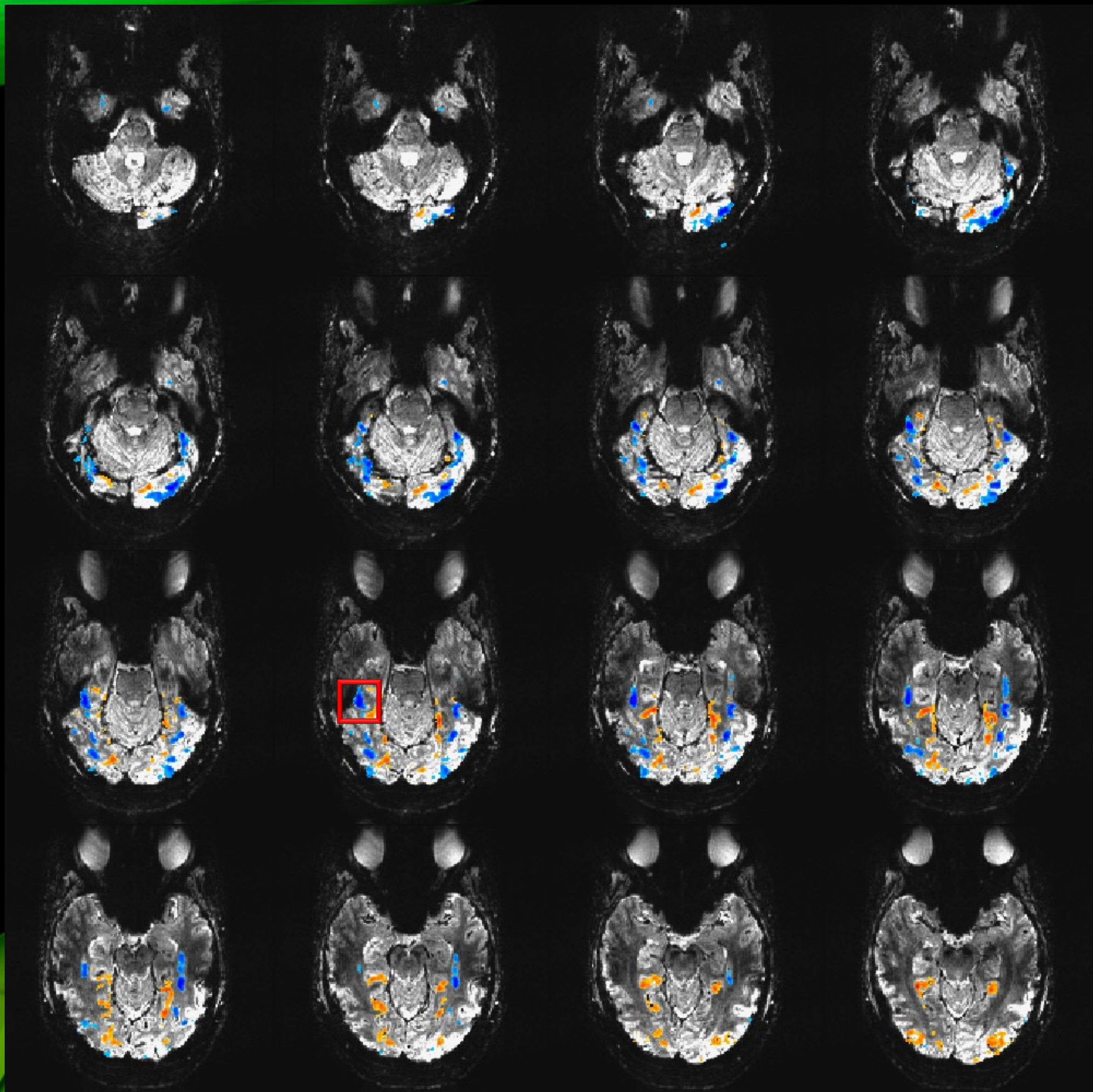
Zarate & Nugent & Thomas.

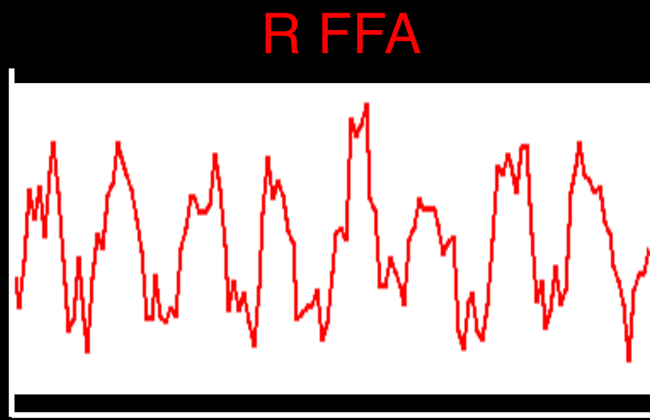
7T MRI (FMRIF) – 2011

- ❖ Actively shielded, body gradient
- ❖ Sub-mm anatomical (T1, T2)
- ❖ EPI (0.8 – 1.6mm^3)

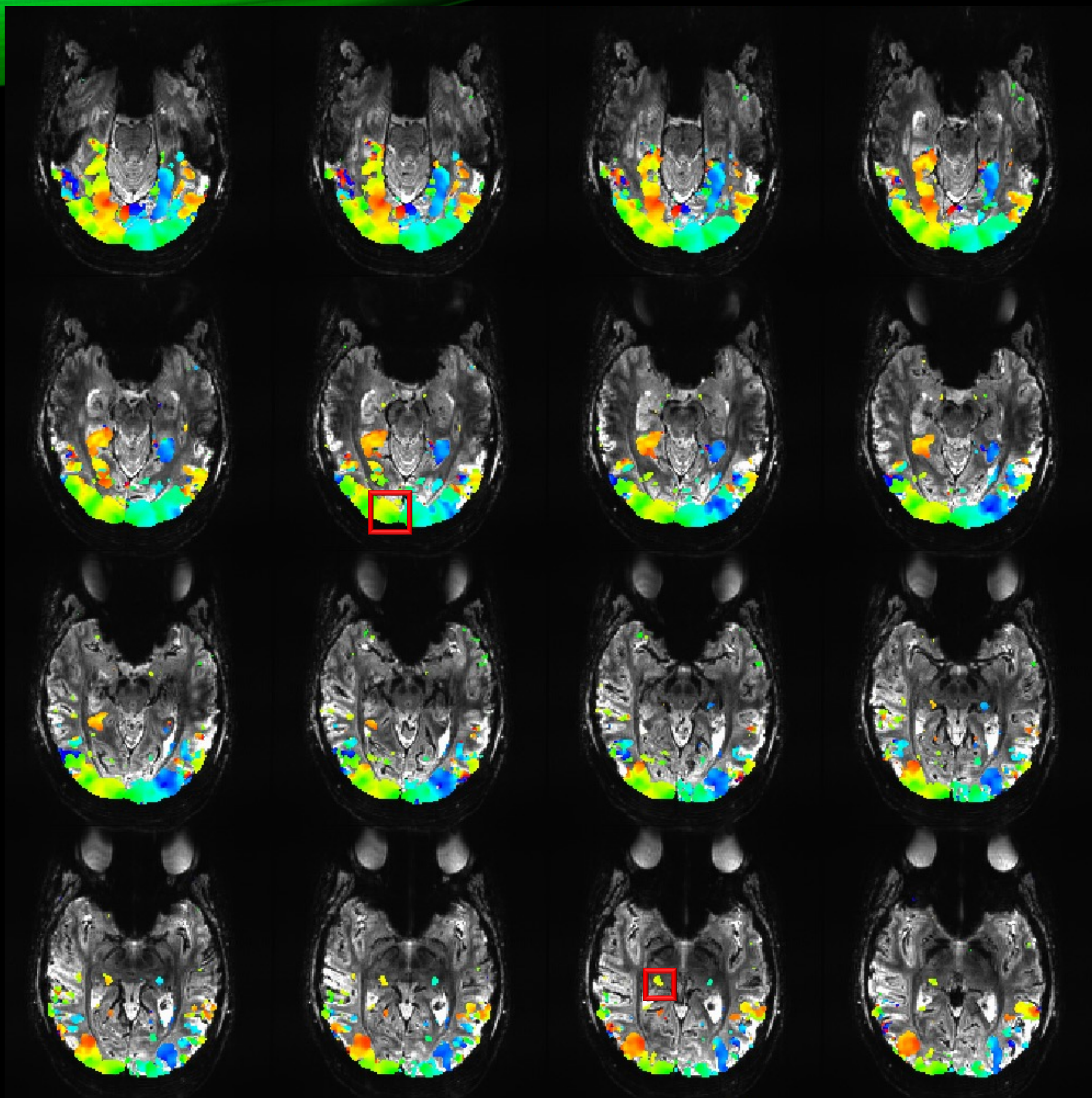
Actively-shielded 7T MRI

32-channel head coil

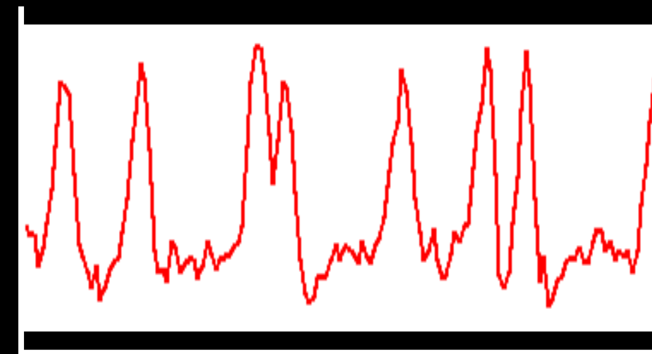




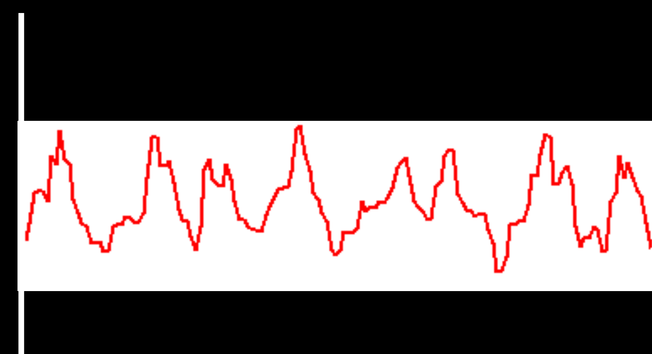
Courtesy: Silson & Bake



R V1



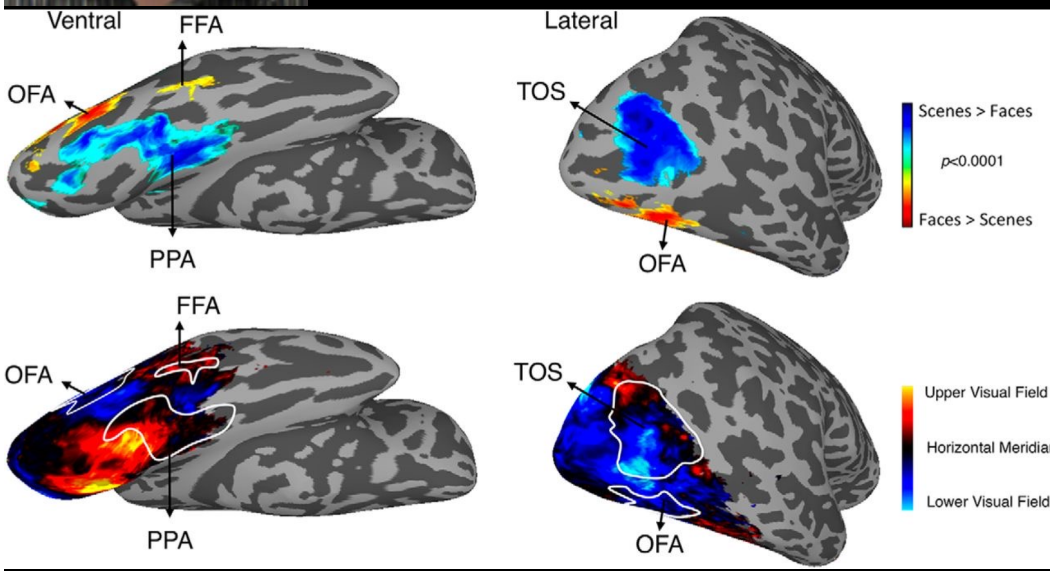
R LGN

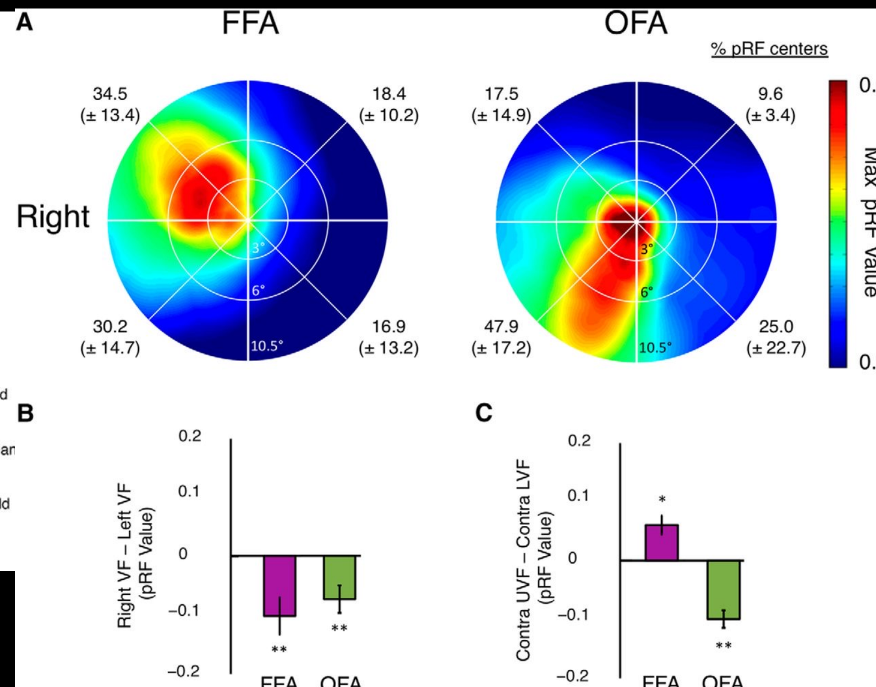


Courtesy: Silson & Bak

CHRIS BAKER/UNIT ON LEARNING AND PLASTICITY

- Object, face and body representations in the human brain/task eff
- Neural basis of visual object learning/
- Interaction between bottom-up & top-down processing
- Engaged in debate on circularity artifacts / 7T methods





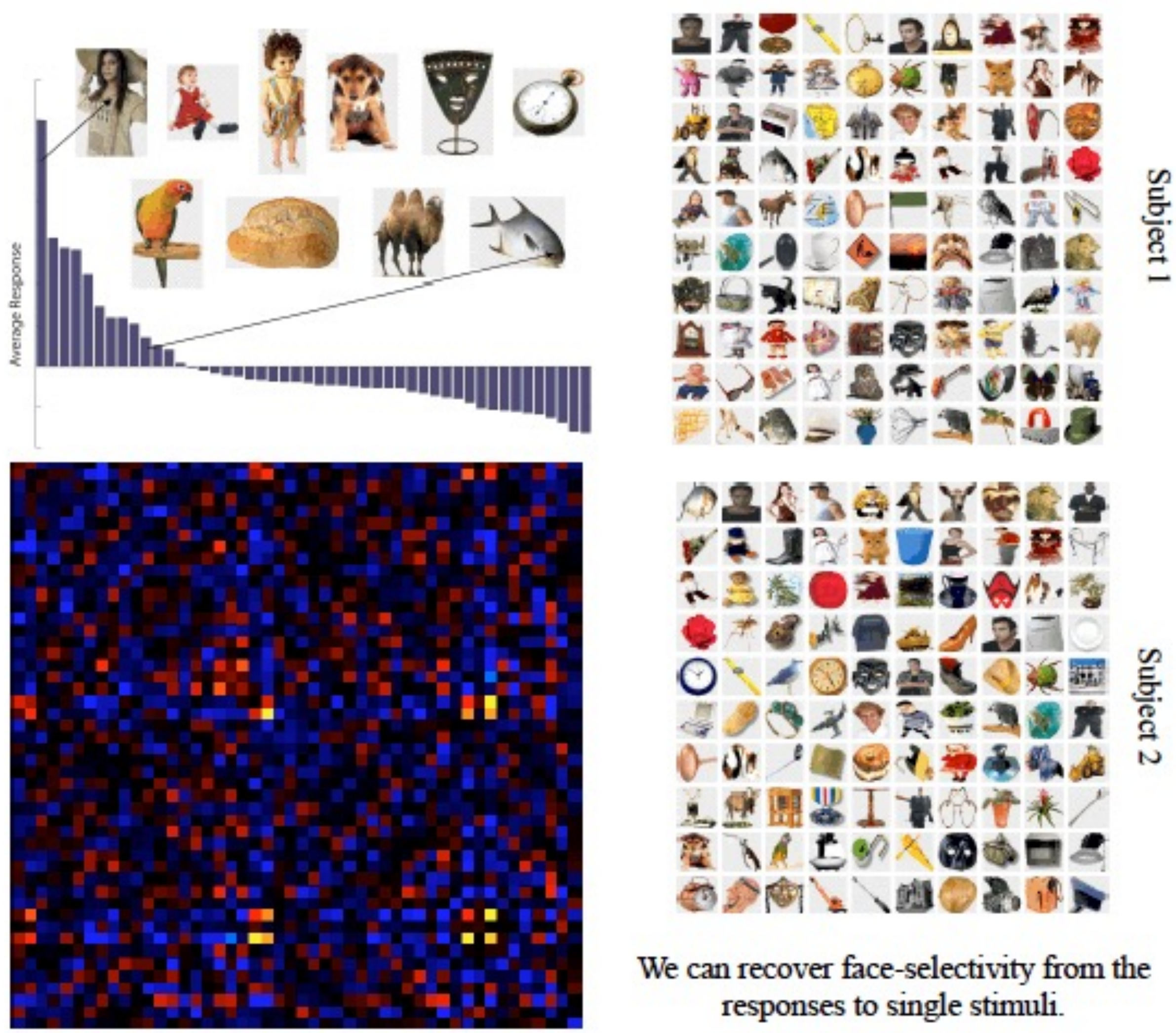
- Circular analysis in systems neuroscience: the dangers of double dipping. Kriegeskorte, N., et al (2009) Nature neuroscience,
- A new neural framework for visuospatial processing Kravitz, D.J., et al (2011) Nature Reviews Neuroscience,
- Real-world scene representations in high-level visual cortex: It's the spaces more than the places Kravitz, D.J., et al (2011) Journal of Neuroscien
- Goal-dependent dissociation of visual and prefrontal cortices during working memory Lee, S.-H., Kravitz, D.J., Baker, C.I. (2013) Nature Neurosci

SINGLE-ITEM SINGLE-EVENT

Probing representations with 768 unique conditions

To avoid bias in our sample we chose 768 stimuli from a commercial object database (48 categories * 16 exemplars). We then extracted responses from our independently defined ROIs.

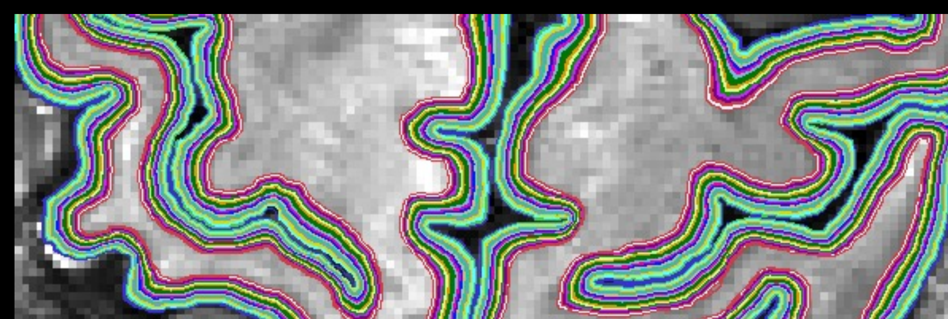
Right FFA



We can recover face-selectivity from the responses to single stimuli.

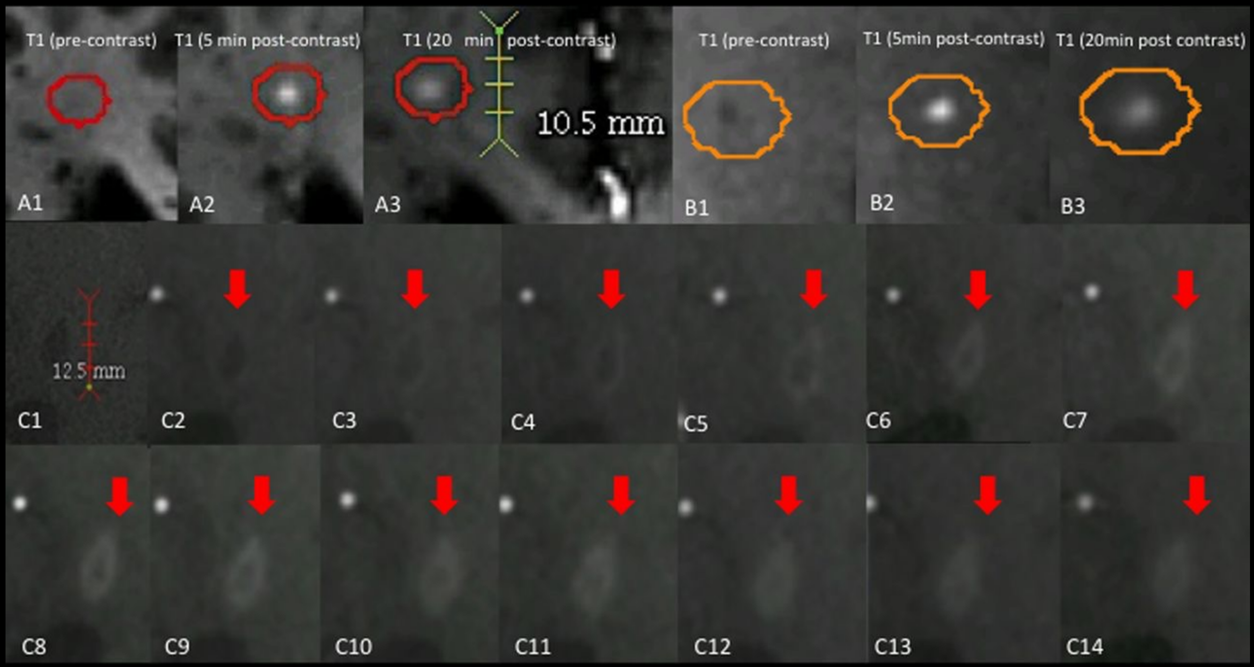
7T FMRI
HIGH-RESOLUTION FMRI AT 7T

0.8mmx0.8mmx1.5mm
(Huber/Bandettini)



DANNY S REICH/TRANSLATIONAL NEURORADIOLOGY UNIT

- Imaging parechymal venules and their relationship to MS lesions
- Novel methods for quantitative imaging of myelin with T2*susceptib
- Using DTS to image axonal damage in patients with MS
- High resolution studies of MS at 7T

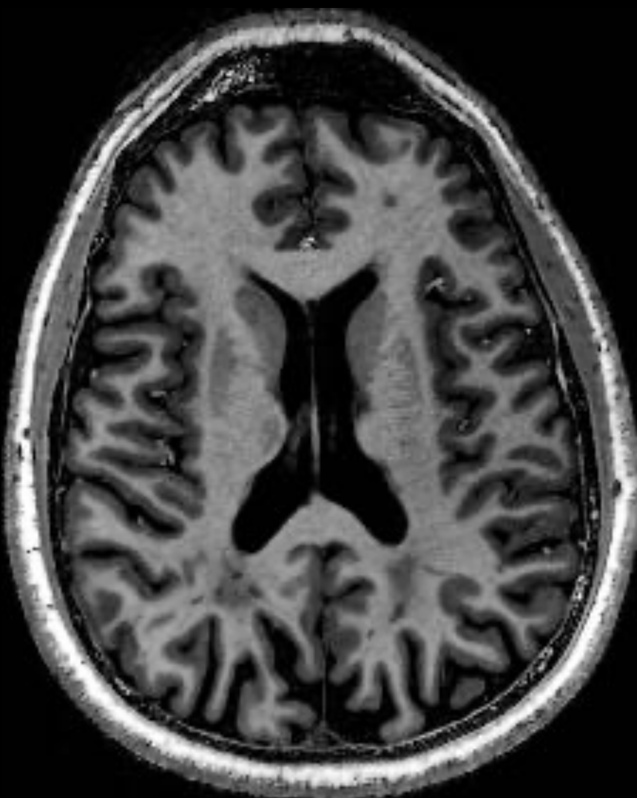


Use: custom pulse sequences, contrast injection, ex-vivo tissu

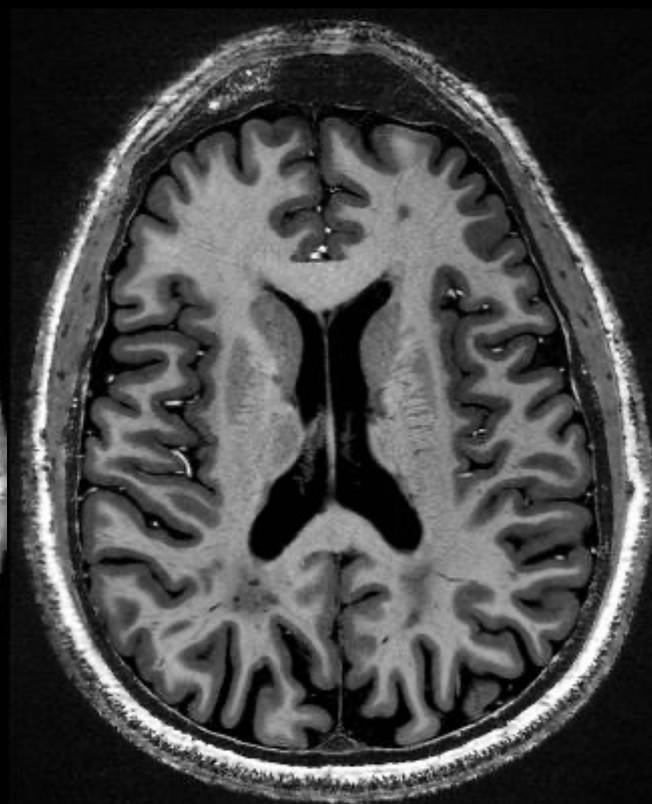
- **Dynamics of lesion enhancement measured at 7T / Gaitán M I et al Mult Scler 2012;19:1068-1073**

Pushing the resolution of in vivo anatomical imaging

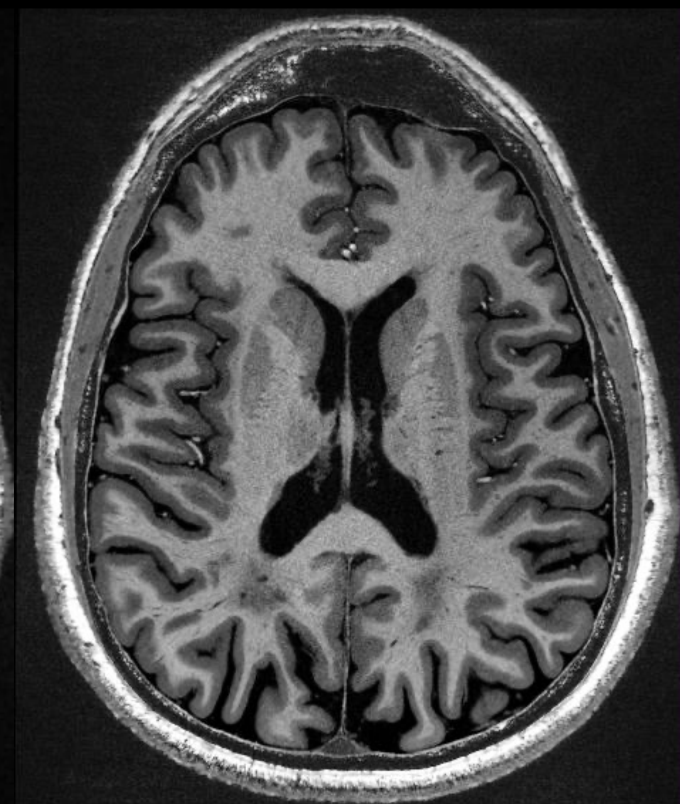
T1-weighted 3D MP2RAGE @ 7T



700 μm iso
(10 min)



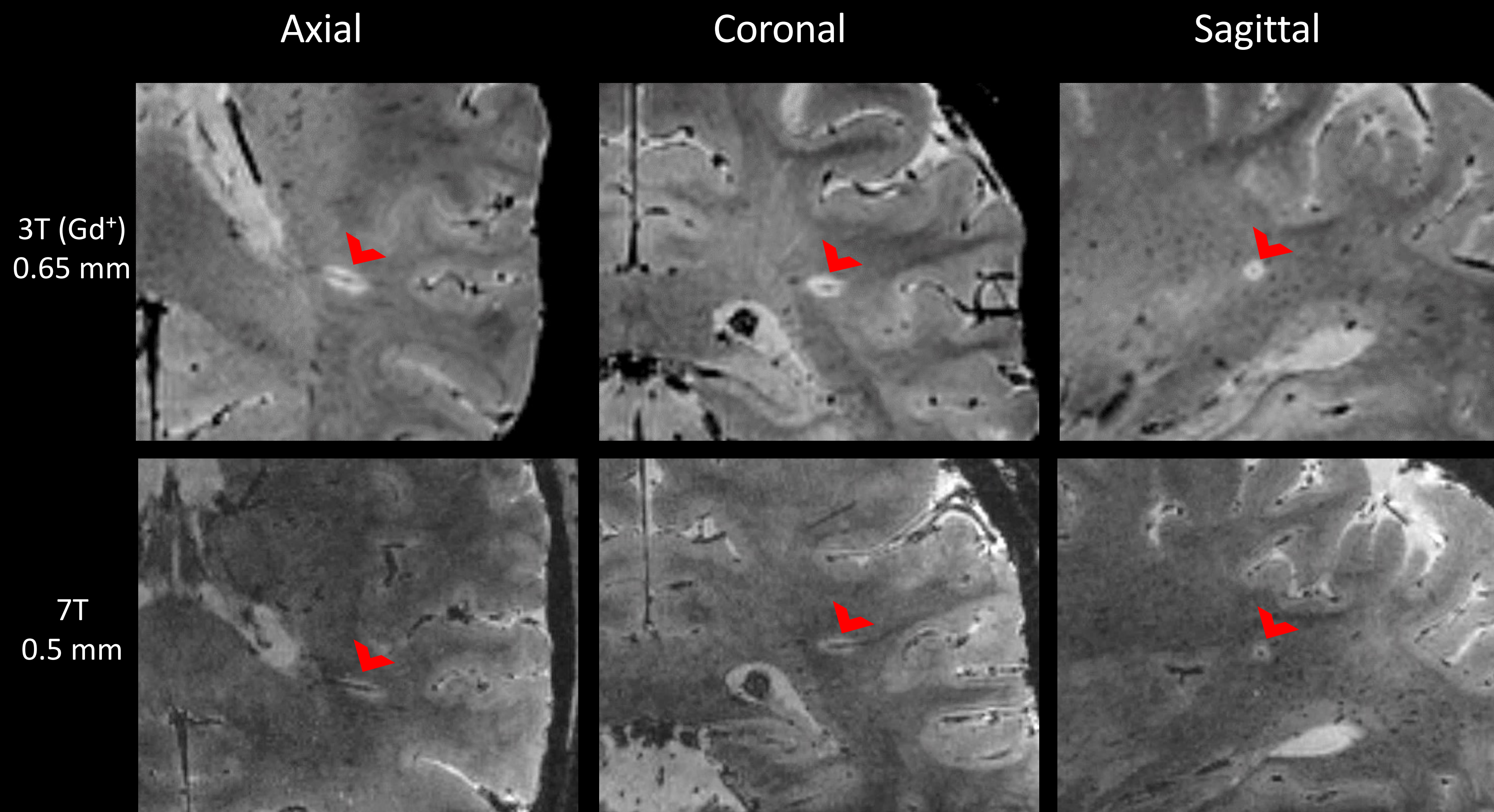
500 μm iso
(40 min)



350 μm iso
(60 min)

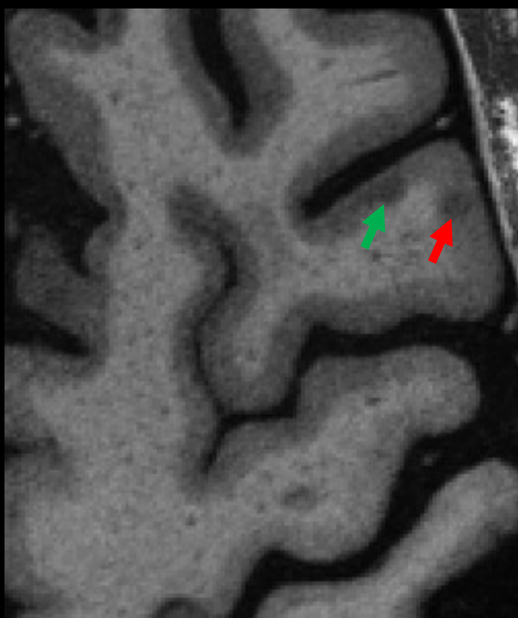
In vivo detection of central veins inside MS lesions

T2-weighted 3D segmented EPI*



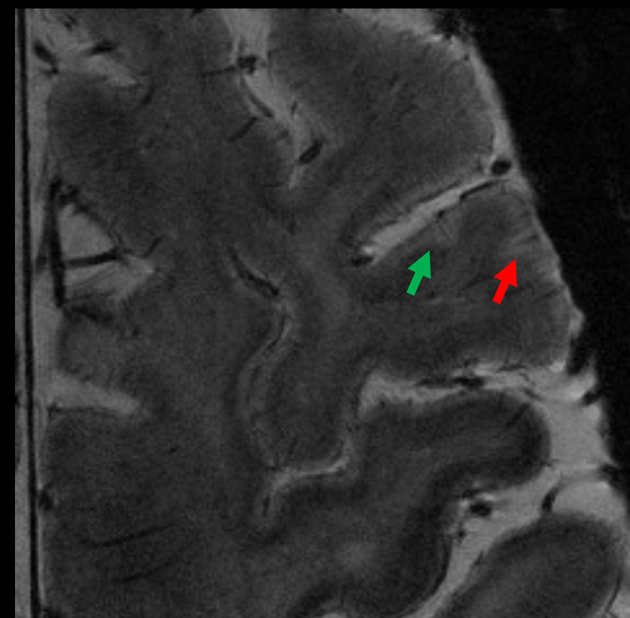
In vivo detection of cortical MS lesions @ 7T

Subpial lesion
Intracortical lesion



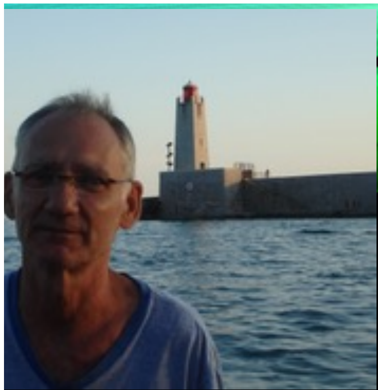
T1w MP2RAGE (350 μm iso)

T1 map MP2RAGE (350 μm iso)

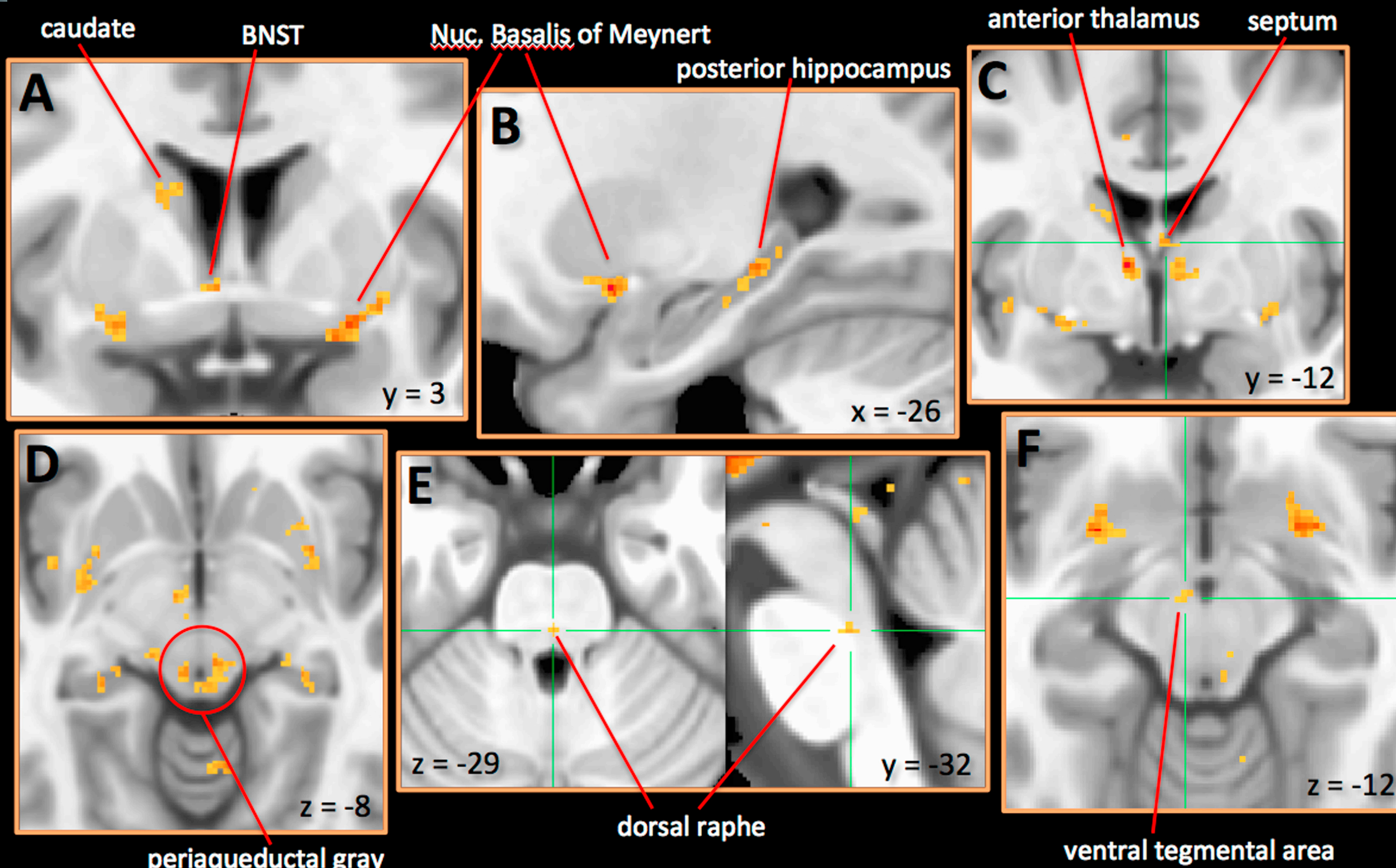


T2*w 2D GRE (250 μm in-plane)

CHRISTIAN GRILLION/NEUROBIOLOGY OF FEAR AND ANXIETY



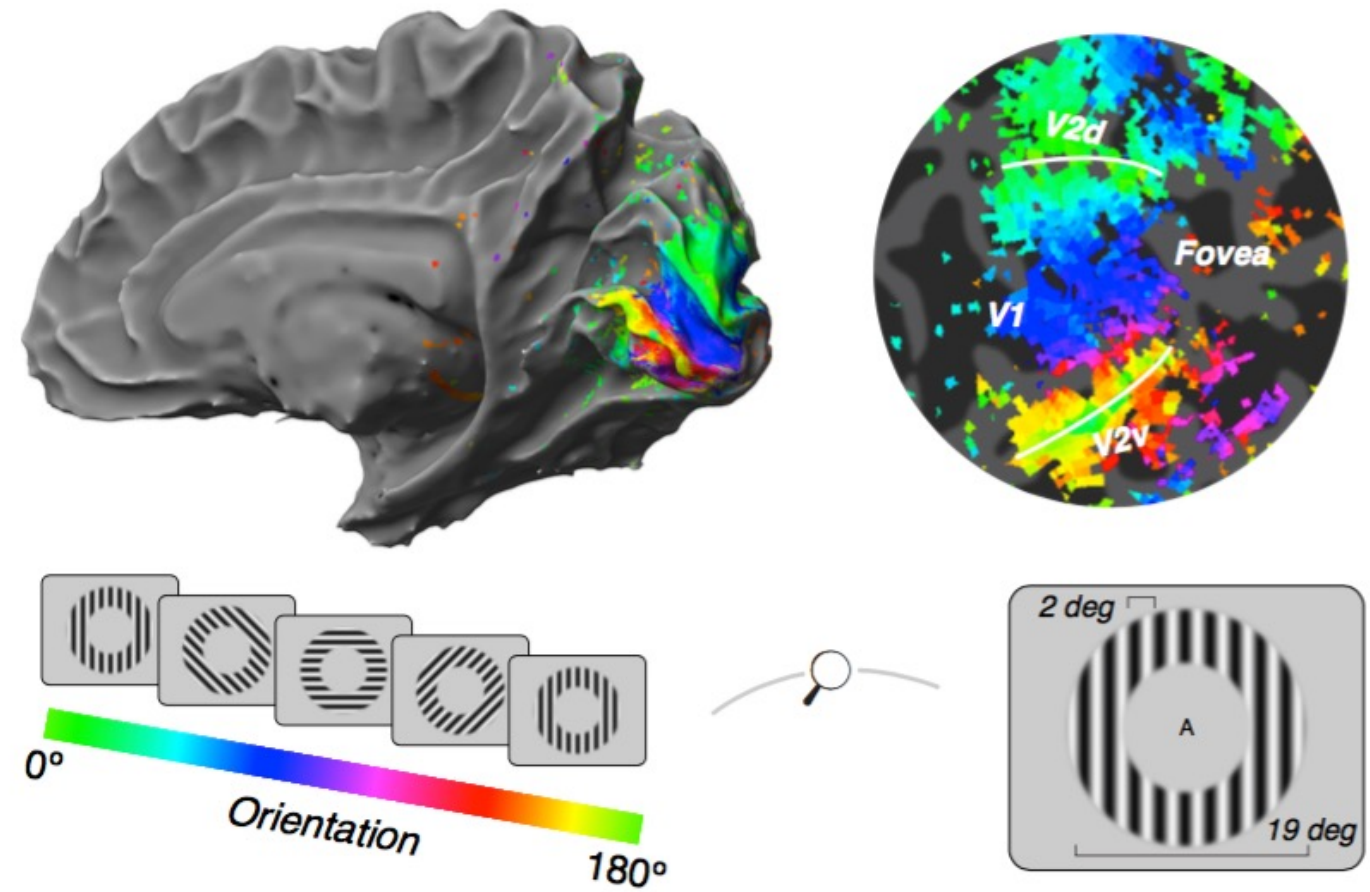
- Phasic and sustained threat
- Electric shock in the magnet
- Virtual reality and FMRI & 7T studies(!)



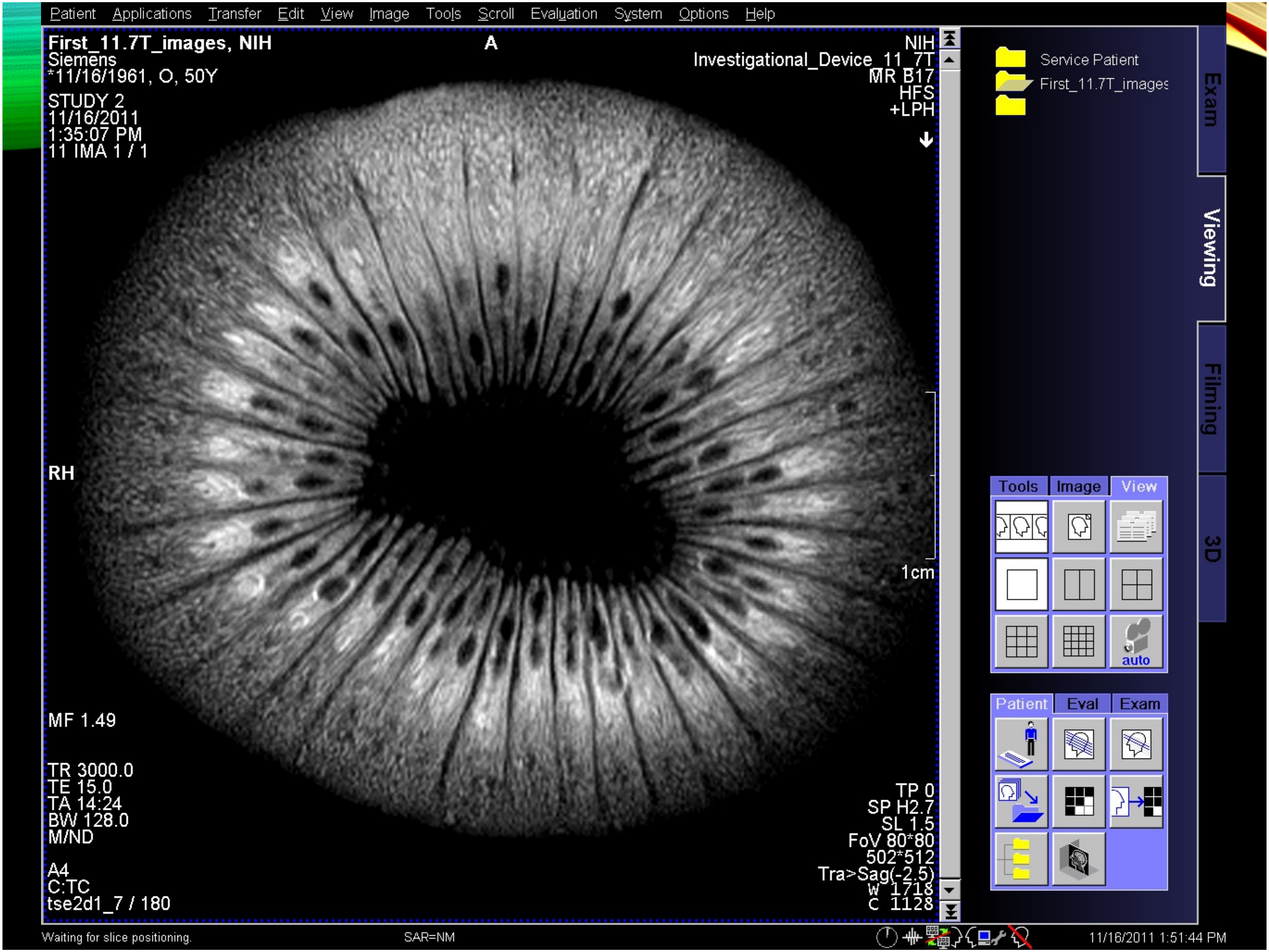
- H

FMRI OF SPATIAL VISION

- STRIATE & EXTRA-STRIATE CORTEX
- SPATIAL MAPS
- SPATIAL REMAPPING / EYE MOVEMENTS
- HIGHEST RESOLUTION ROUTINE SCANNING




SIEMENS
MAGNETOM Terra



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CONCLUSION:

RESOURCES FOR MRI - HUMAN

1. NIH MRI Research Facility (NMRF)
    - 3T-Siemens-Skyra (Sep 2011)
2. FMRIF (NIMH & NINDS – 470 hrs/week of scan time)
    - 2 x 3T GE HDx
    - 1 x 3T-GE-mr750 (June 2011)
    - 1 x 3T-Siemens-Skyra (Sep 2011)
    - 7T Siemens/Magnex (Jan 2011)
3. NINDS/NIMH
    - 11.7T Siemens/Magnex (world's first 2011-2012)
4. Clinical Center (Radiology & Imaging Sciences, TBI)
    - 2 x 3T & 1.5T Philips & 3T Siemens
    - 3T-Siemens Biograph (MR/PET)
5. NHLBI (Cardiac)
    - Multiple 3T Siemens Scanners NCI
    - 3T Phillips

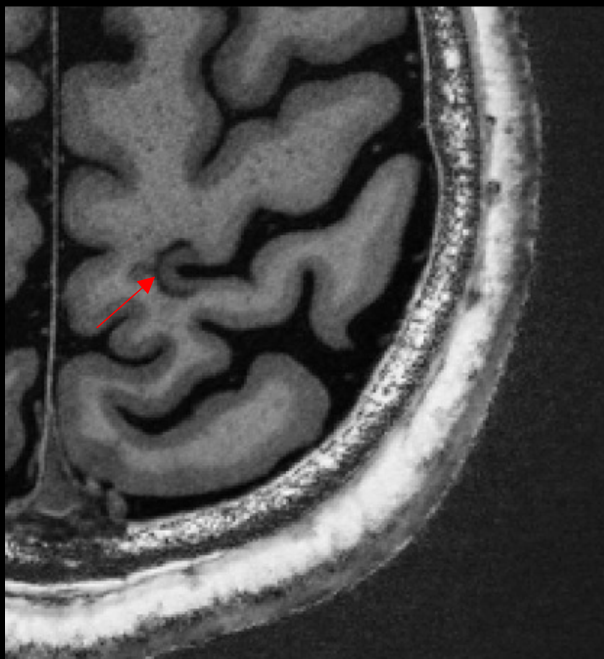
- Etc

(SHORT) HISTORY OF FMRI AND BRAIN MRI AT NIH

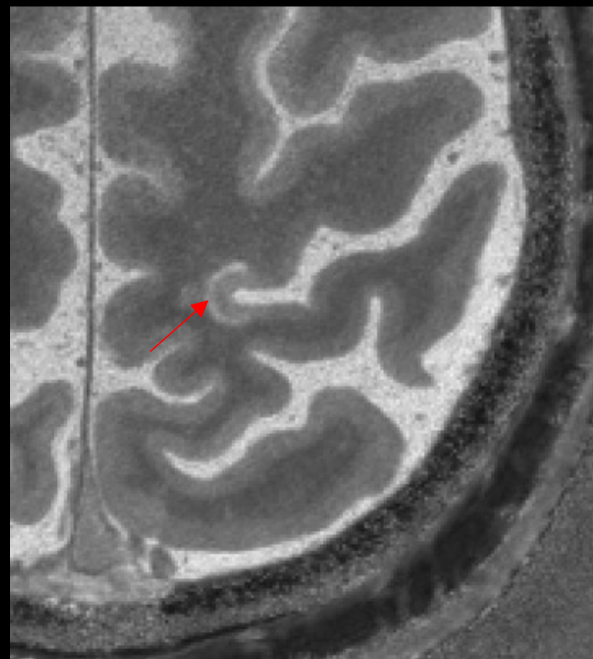
1. In-Vivo NMR Center (established 1987)
2. Early FMRI studies in animals (Bob Turner, 1987)
3. Initial human functional studies (4T 1993)
4. Key developments from NIH MRI researchers
   - DTI (LeBihan, Baser (1992), Pierpaoli etc)
   - High-field imaging (4 Tesla, 7 Tesla and now 11.7T)
   - Magnetization Transfer
   - Perfusion imaging (ASL)
   - Large scale longitudinal studies of brain development
   - Imaging genomics
   - FMRI/BOLD
   - Decoding/Multivoxel Pattern Analysis
   - High resolution anatomical imaging
   - Real-time FMRI / analysis Software

In vivo detection of cortical MS lesions @ 7T

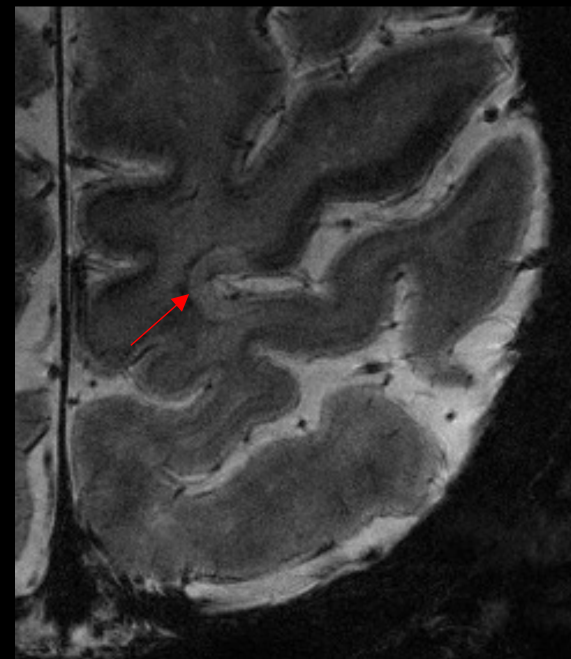
Leukocortical lesion



T1w MP2RAGE (350 μm iso)



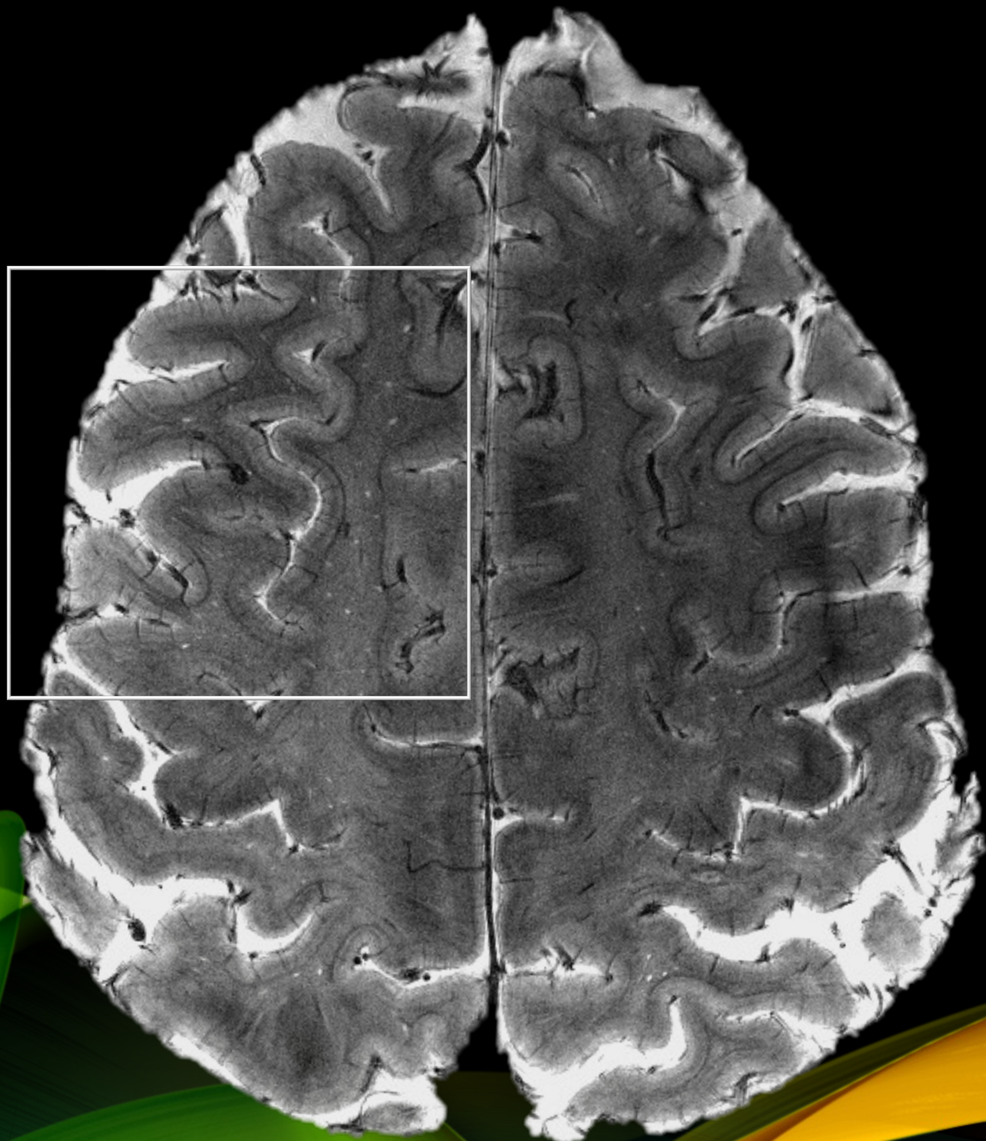
T1 map MP2RAGE (350 μm iso)

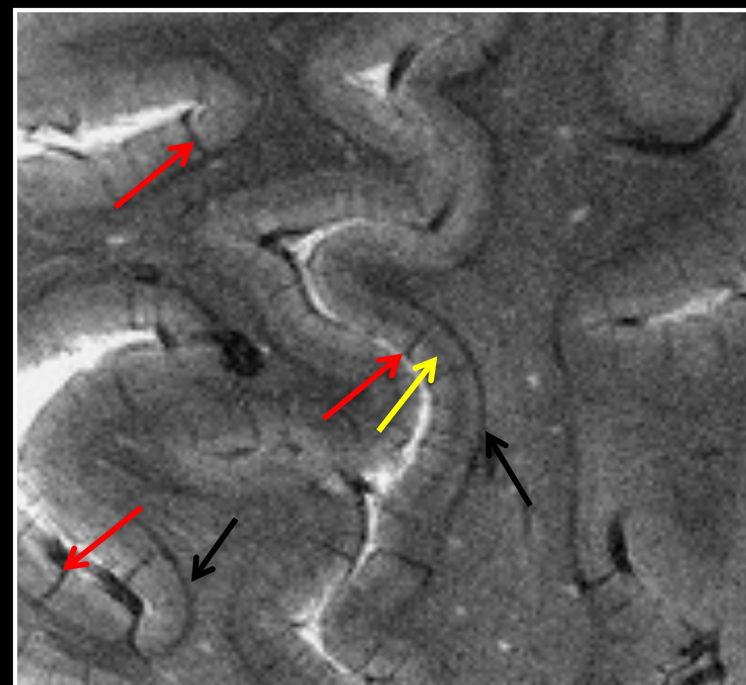


T2*w 2D GRE (250 μm in-plane)

Cortex imaging with 7T MRI

MS patient, T2*w, 0.2 x 0.2 x 1mm





in-plane resolution = 200 μm x 200 μm

7T @NIH