The Functional MRI Core Facility

MRI Scanners:

June	2000	"3T-1"	GE 3T
November	2002	"3T-2"	GE 3T
September	2004	"FMRIF 1.5T"	GE 1.5T
January	2007	3T -1 decommissioned	
November	2007	"3T-A"	GE 3T
November	2007	"3T-B"	GE 3T
November	2007	"3T-2" named "3T-C"	
July	2007	3T-C upgraded to HD.	

1.5T

3T-A

3T-B

3T-C

Staff:

Peter Bandettini, Ph.D.	– Director
Sean Marrett, Ph.D.	– Staff Scientist
Jerzy Bodurka, Ph.D.	– Staff Scientist
Wen-Ming Luh, Ph.D.	– Staff Scientist
Vinai Roopchansinch, Ph.D.	-Staff Scientist
Adam Thomas	– IT Specialist
Kay Kuhns	– Administrative Lab Manager
Janet Ebron	– Technologist
Ellen Condon	– Technologist
Sahra Omar	– Technologist
Paula Rowser	– Technologist
Chung Kan	– Technologist
Debbie Tkaczyk	-Technologist
Sandra Moore	-Technologist
Marcela Montequin	-Technologist

Users

NIMH:
Peter Bandettini, Ph.D.
Chris Baker, Ph.D.
Karen Berman, M.D.
James Blair, Ph.D.
Mary Kay Floeter, M.D., Ph.D.
Jay Giedd, M.D.
Christian Grillon, Ph.D.
Wayne Drevets, M.D.
Ellen Liebenluft, M.D.
Alex Martin, Ph.D
Mort Mishkin, Ph.D
Elizabeth Murray, Ph.D
Daniel Pine, M.D.
Judith Rapaport, M.D.
Jun Shen, Ph.D.
Susan Swedo, M.D.
Leslie Ungerleider, Ph.D.
Daniel Weinberger, M.D.

NINDS:
Leonardo Cohen, M.D.
Jeff Duyn, Ph.D.
Jordan Grafman, Ph.D.
Mark Hallet, Ph.D.
John Hallenbeck, M.D.
Alan Koretsky, Ph.D.
Christy Ludlow, Ph.D.
Henry F. McFarland, M.D.
Edward Oldfield, M.D.
William Theodore, M.D.

NICHD:
Peter Basser, Ph.D.
Allen Braun, M.D.

NCI:
Kathy Warren, M.D.

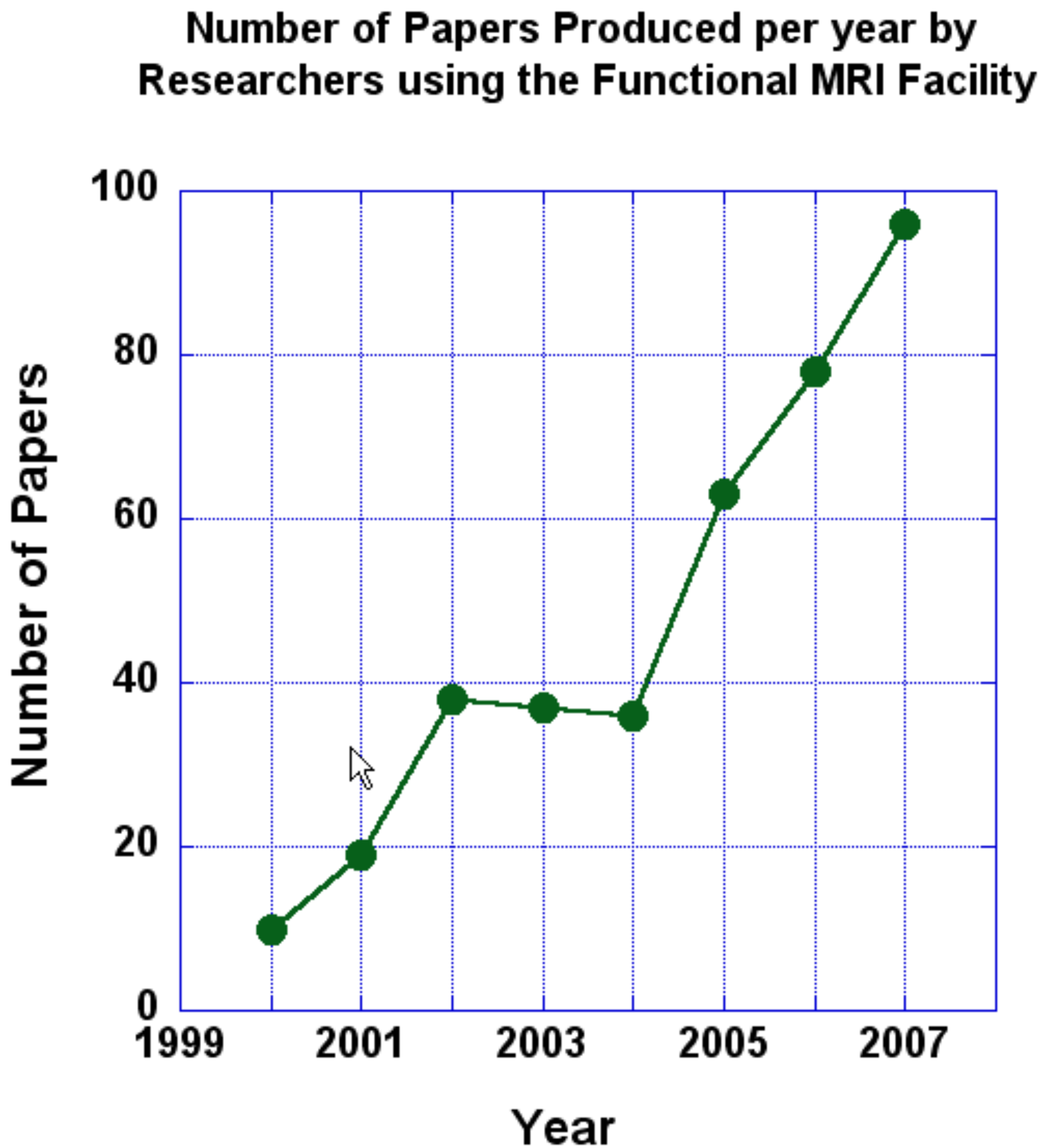
Services:

1. State of the art MRI technology.
2. Maintenance and support of daily MRI scanner operation.
3. Trained MRI technologist coverage during all prime time hours and most off hours and weekends.
4. Training by technologists in scanning techniques and protocols.
5. Updated scheduling and a means for exchanging scan time between users.
6. The FMRIF website (http://fmrif.nimh.nih.gov/).
7. Weekly fMRI discussion groups that focus on recent research and issues.
8. State of the art subject interface devices.
9. Short and long term automatic archiving of fMRI data.
10. Consulting with users on the best fMRI scanning and processing approaches.

Summary:

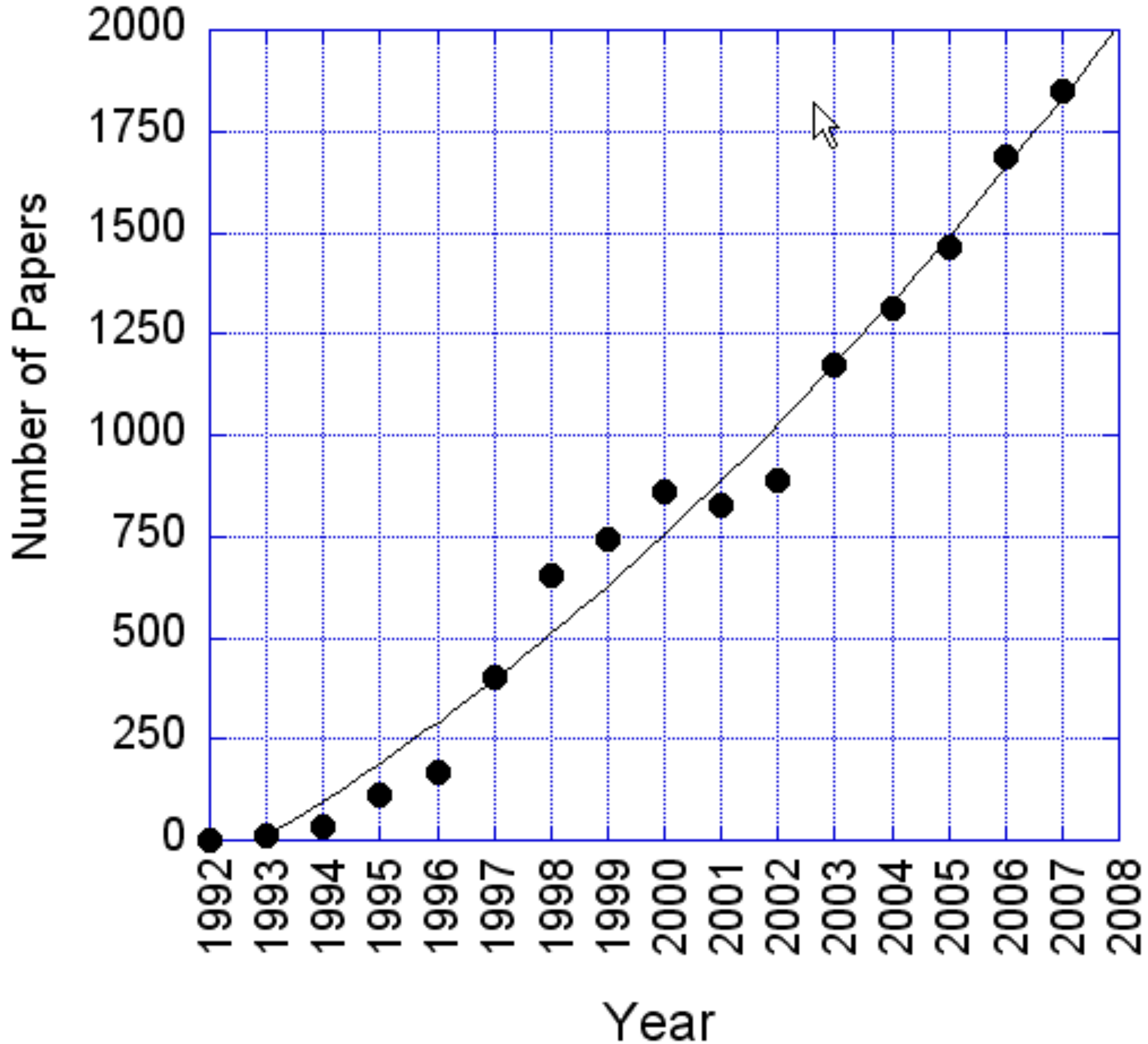
Inception:	1999
Current annual budget (2009):	$2.21 M
Personnel budget:	$1.76 M
Supplies, equipment and services budget:	$450K*
# of staff:	15
# of Principle Investigators Served:	34
# of active protocols using FMRIF:	60
# of subjects scanned per year:	5000

*excludes maintenance contracts (rises to $890K next year when maintenance is included)

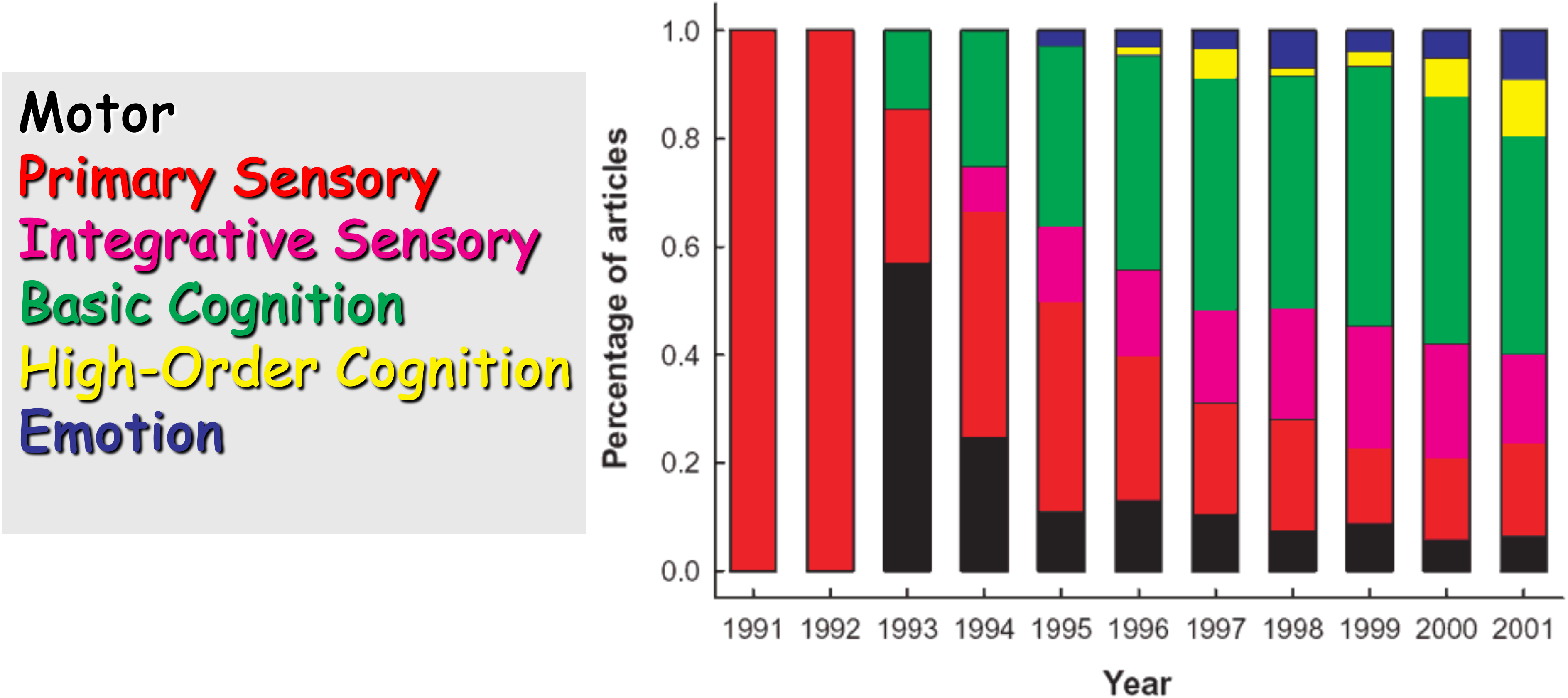

Number of Papers Produced per year by
Researchers using the Functional MRI Facility
Number of Papers
100
80
60
40
20
0
1999
2001
2003
2005
2007
Year

Scopus: Articles or Reviews Published per Year

"fMRI" or "functional MRI"



Type of fMRI research perfor



J. Illes, M. P. Kirschen, J. D. E. Gabrielli,
Nature Neuroscience, 6 (3) p.205, 2001

What fMRI Is Currently Being Used For

Research Applications

-map networks involved with specific behavior, stimulus, or performance
-characterize changes over time (seconds to years)
-determine correlates of behavior (response accuracy, etc…)
-characterization of groups or **individuals**

Clinical Research

-clinical population characterization (probe task or **resting state**)
-assessment of recovery and plasticity
-attempts to characterize (classify) **individuals**

Clinical Applications

-presurgical mapping (CPT code in place as of Jan, 2007)

Technology

- Coil arrays
- High field strength
- High resolution
- Novel functional contrast

Methodology

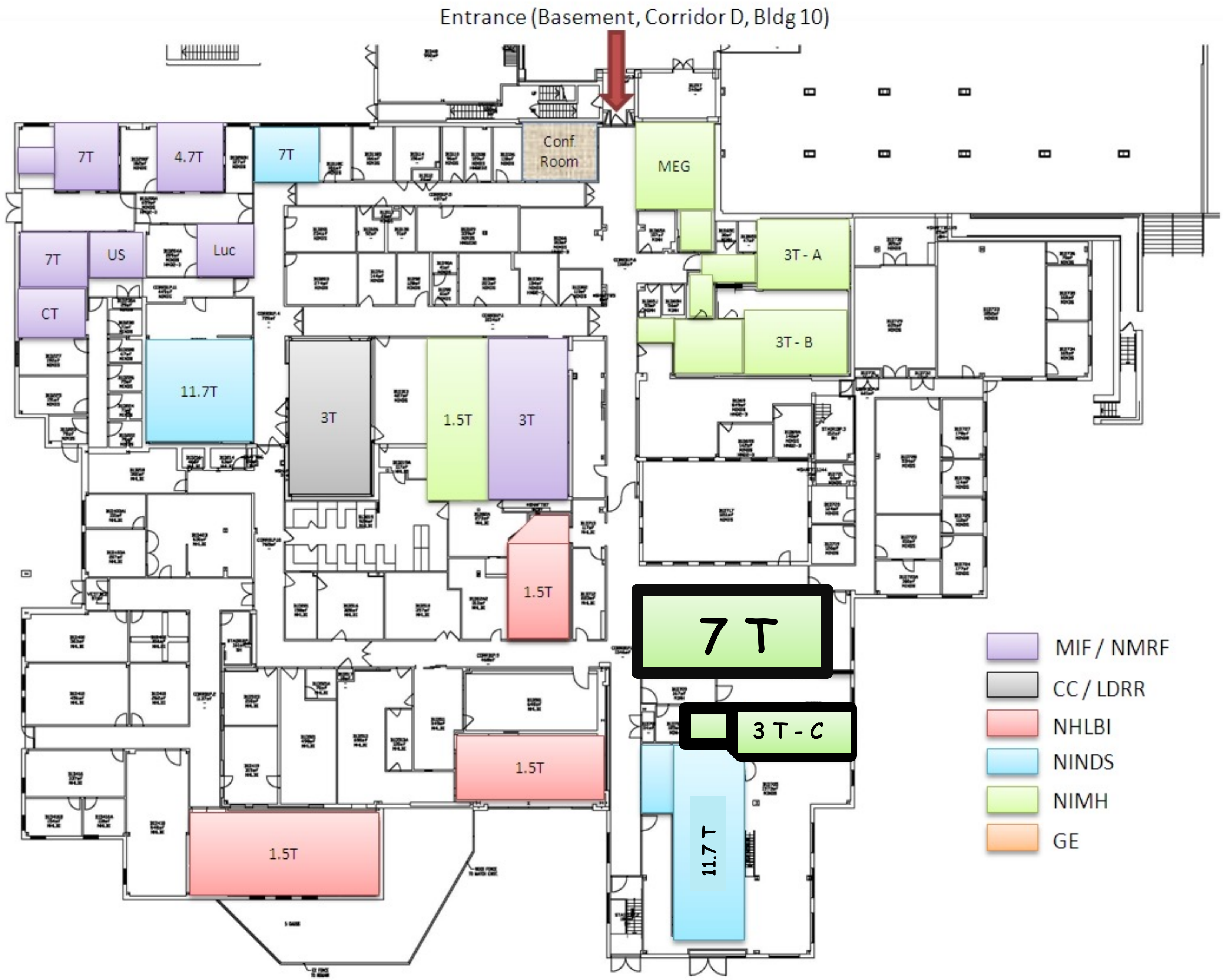
- Functional Connectivity Assessment
- Multi-modal integration
- Pattern classification
- Real time feedback
- Task design (fMRIa…)

Interpretation

- Fluctuations
- Dynamics
- Spatial patterns

Applications

- Basic Neuroscience
- Behavior correlation/prediction
- Pathology assessment


Entrance (Basement, Corridor D, Bldg 10)
7T
4.7T
7T
Conf. Room
MEG
7T
US
Luc
CT
3T - A
3T - B
11.7T
3T
1.5T
3T
1.5T
7 T
3 T - C
1.5T
1.5T
11.7 T
MIF / NMRF
CC / LDRR
NHLBI
NINDS
NIMH
GE

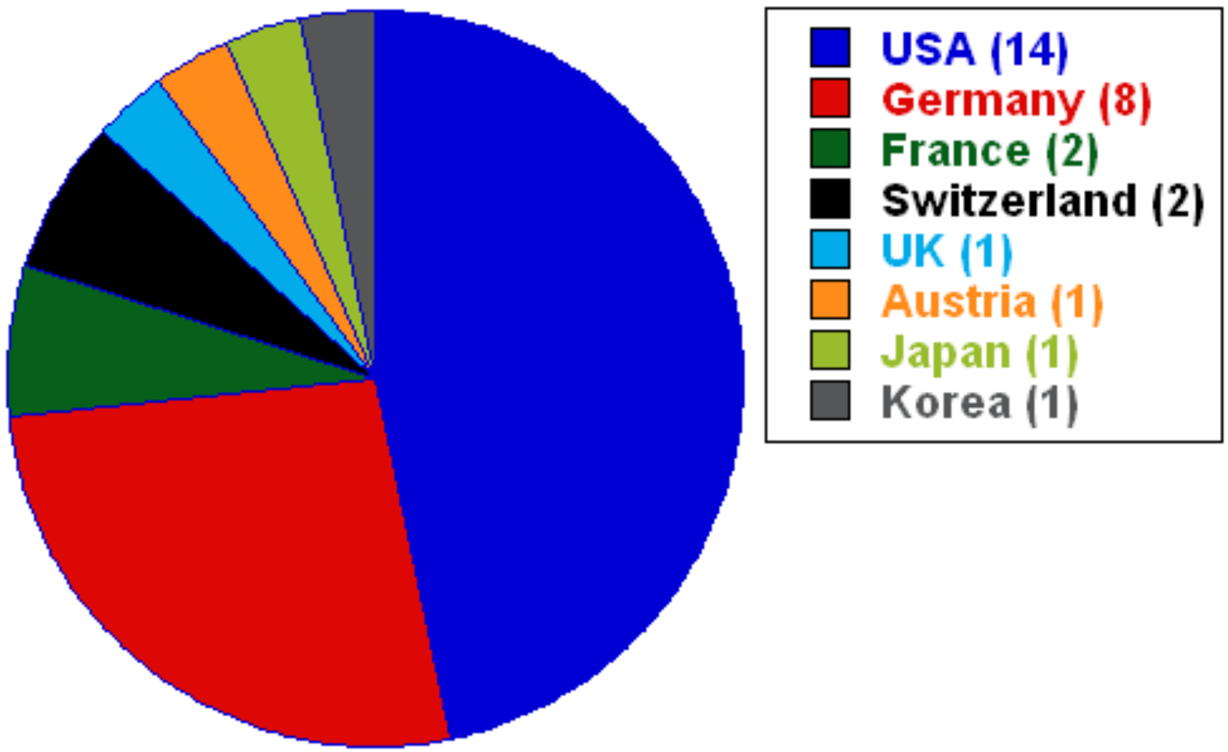
The Challenge Regarding the New 7 T

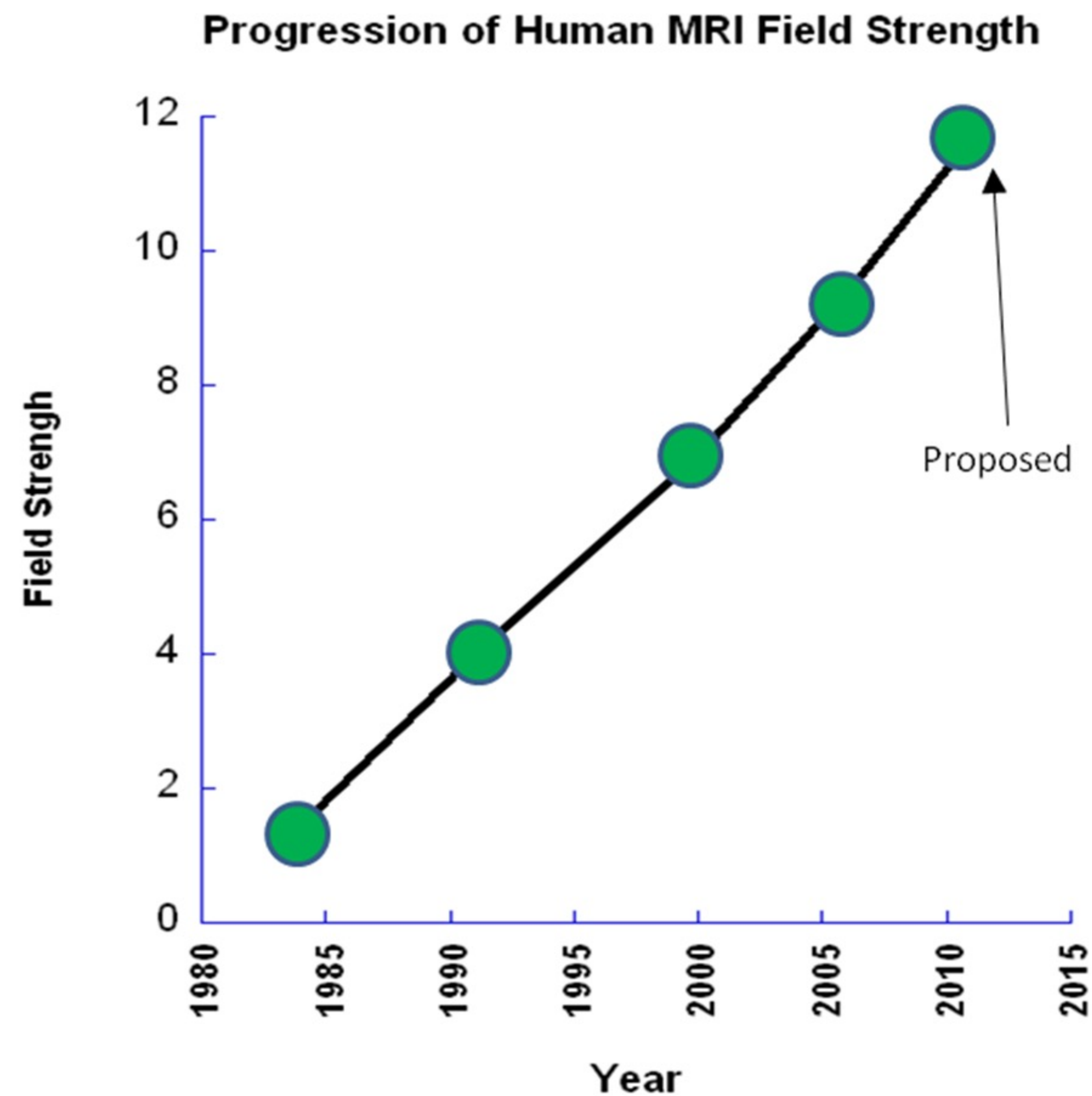
To create a robust, user-friendly system

(Staff of physicists who have benefited from the experience of Jeff Duyn's group)

- Field inhomogeneities are greater (and vary more over space and time)
- RF power is higher (limits certain sequences)
- RF penetration is less homogeneous (inhomogeneous images)
- T2* is shorter (less time for DTI, multi-echo, high res)
- T1 is longer (have to go to longer TR)
- Fluctuations are greater

7 Tesla Human Scanner Distribution





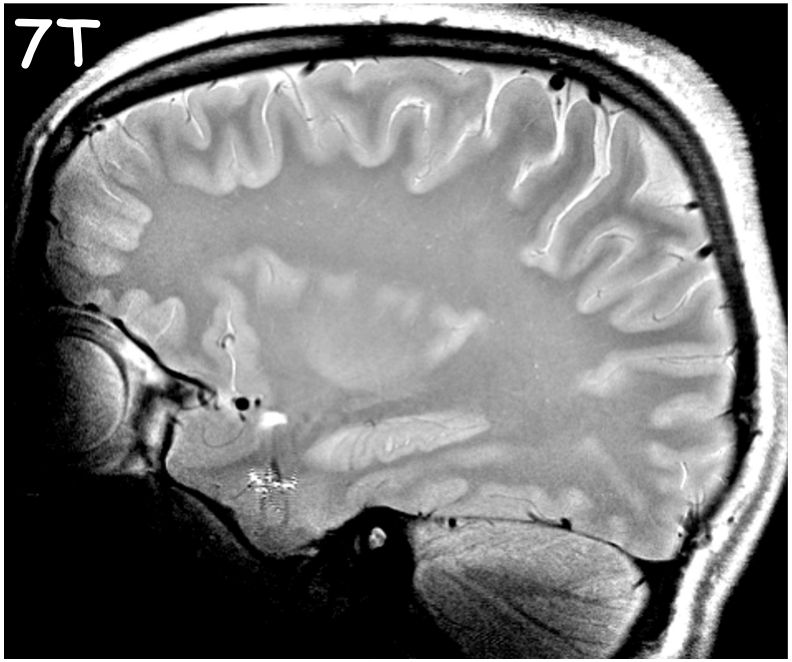
Progression of Human MRI Field Strength
Field Strengh
0
2
4
6
8
10
12
1980
1985
1990
1995
2000
2005
2010
2015
Year
Proposed

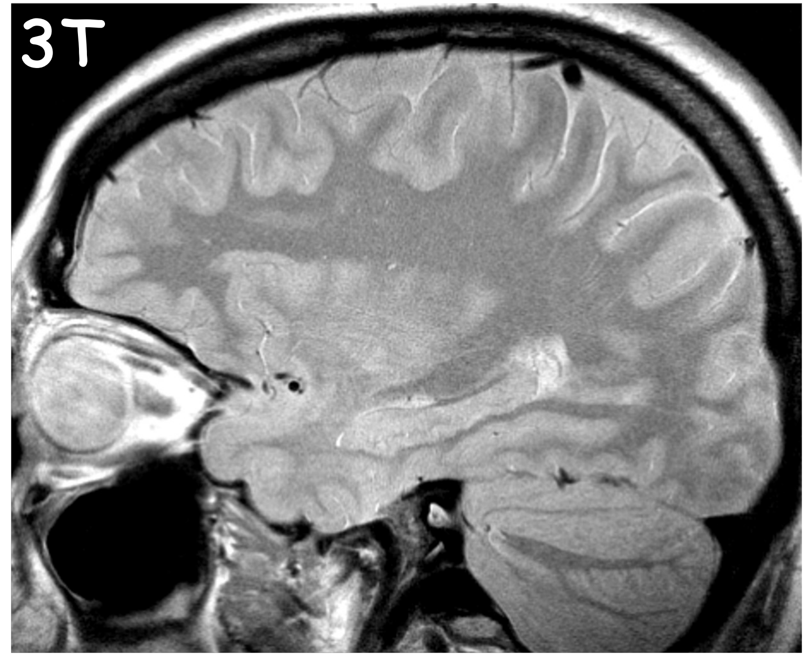
Why High Field?

- Increased SNR
- Increased functional and anatomical contrast
- New contrasts

- Higher resolution
- Shorter scan times (wider range of patients and studies)
- Better sensitivity to fluctuations (i.e. connectivity)
- More information from individuals (rather than group averaging)

Higher SNR





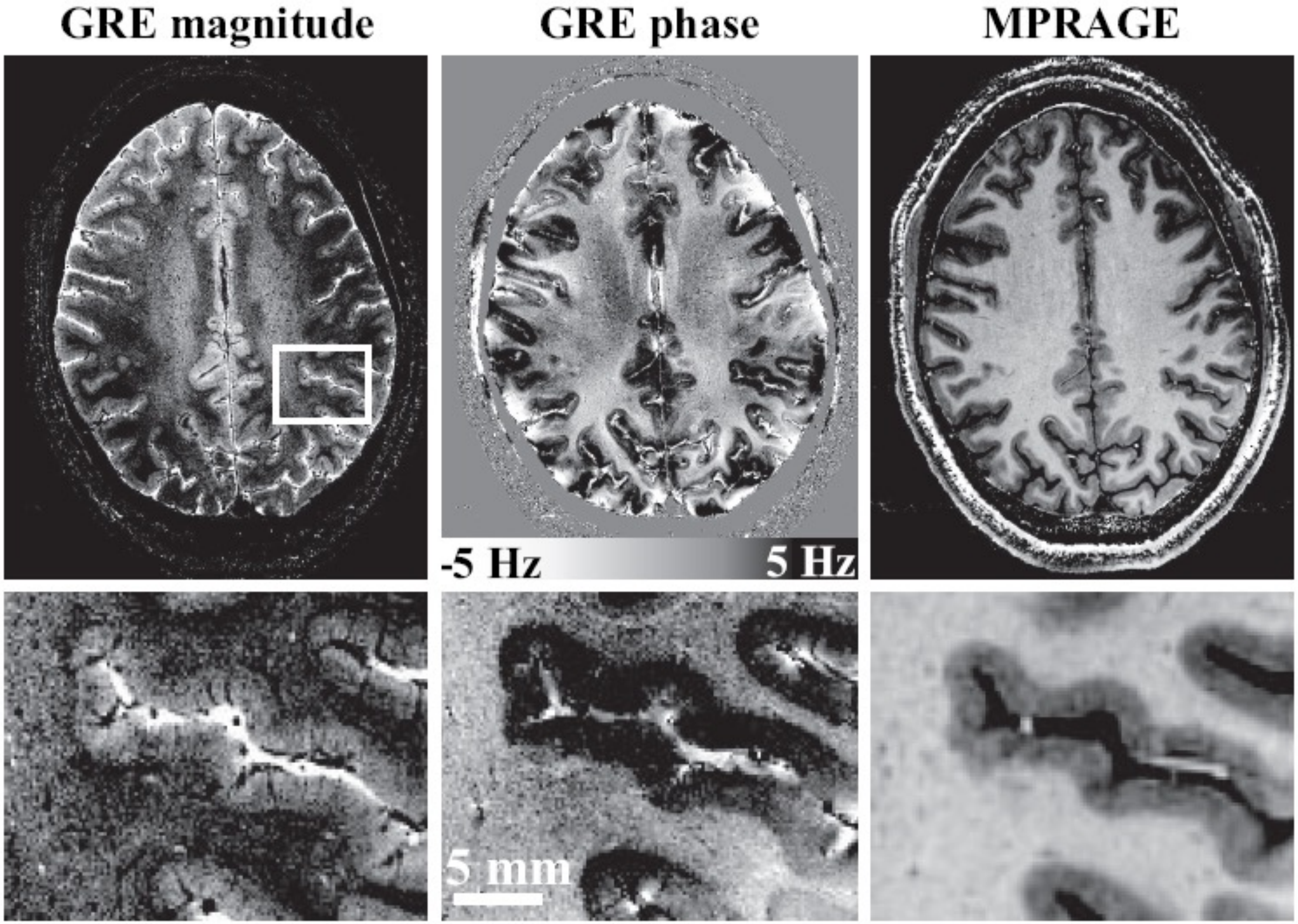
TSE, 11 echoes, 7 min exam, 20cm FOV, 512x512 (0.4mm x 0.4mm), 3mm thick slices.

white matter SNR = 65
Gray matter SNR = 76

white matter SNR = 26
Gray matter SNR = 34

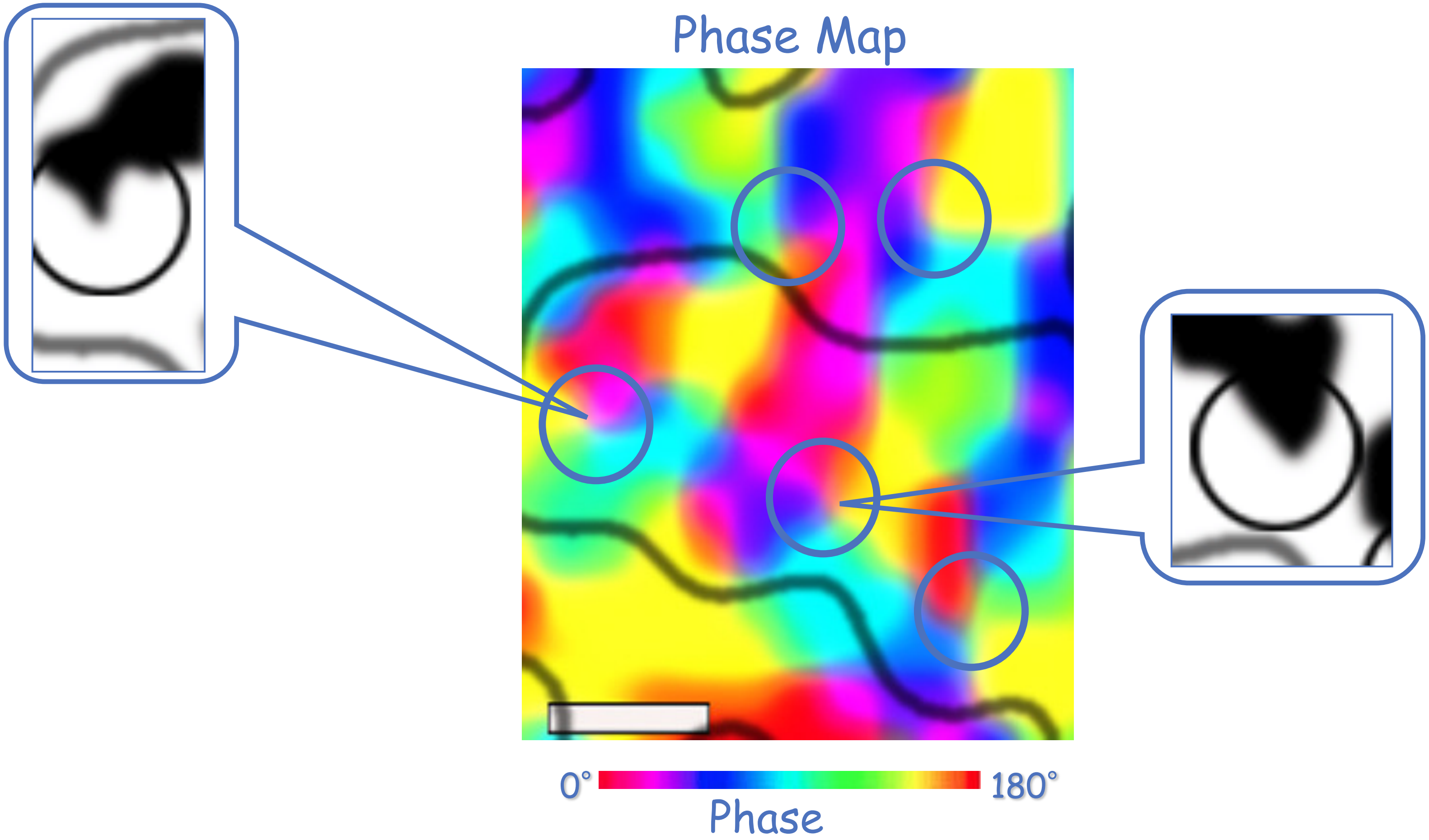
Courtesy of L. Wald, MGH, Boston

Novel Contrast



Duyn et al. PNAS, 2007

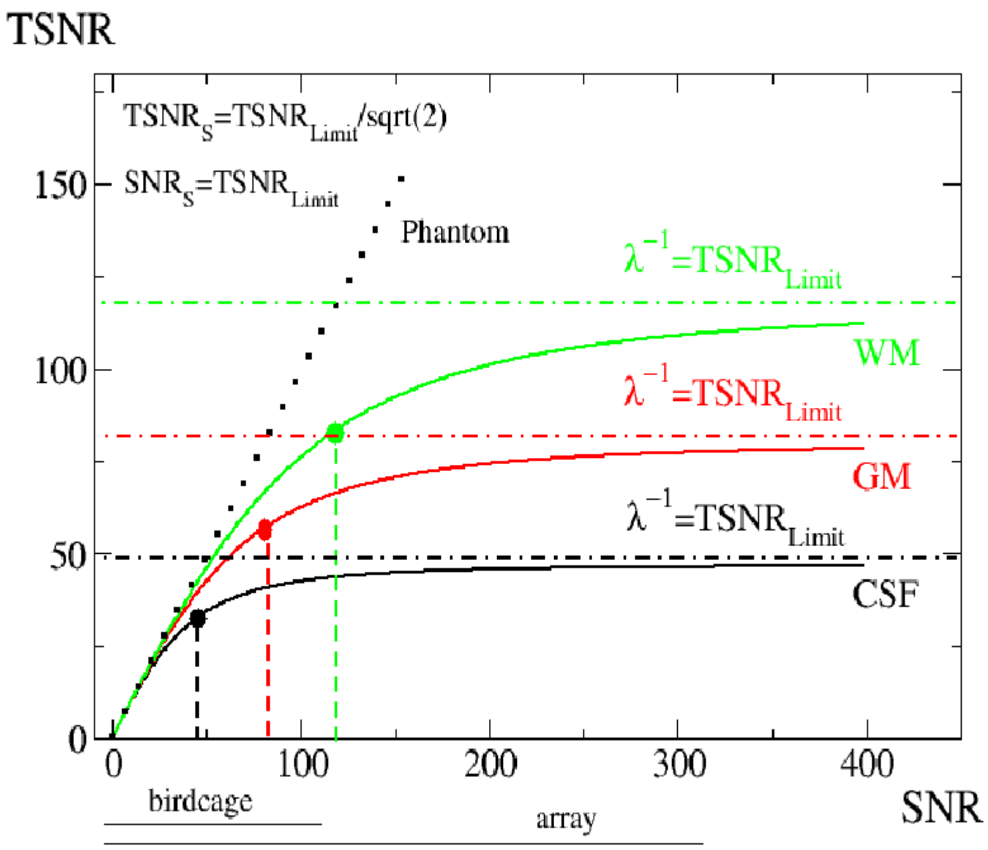
Orientation Columns in Human V1 as Revealed by fMRI at 7T



Scalebar = 0.5 mm

Yacoub, et al. PNAS, 2008

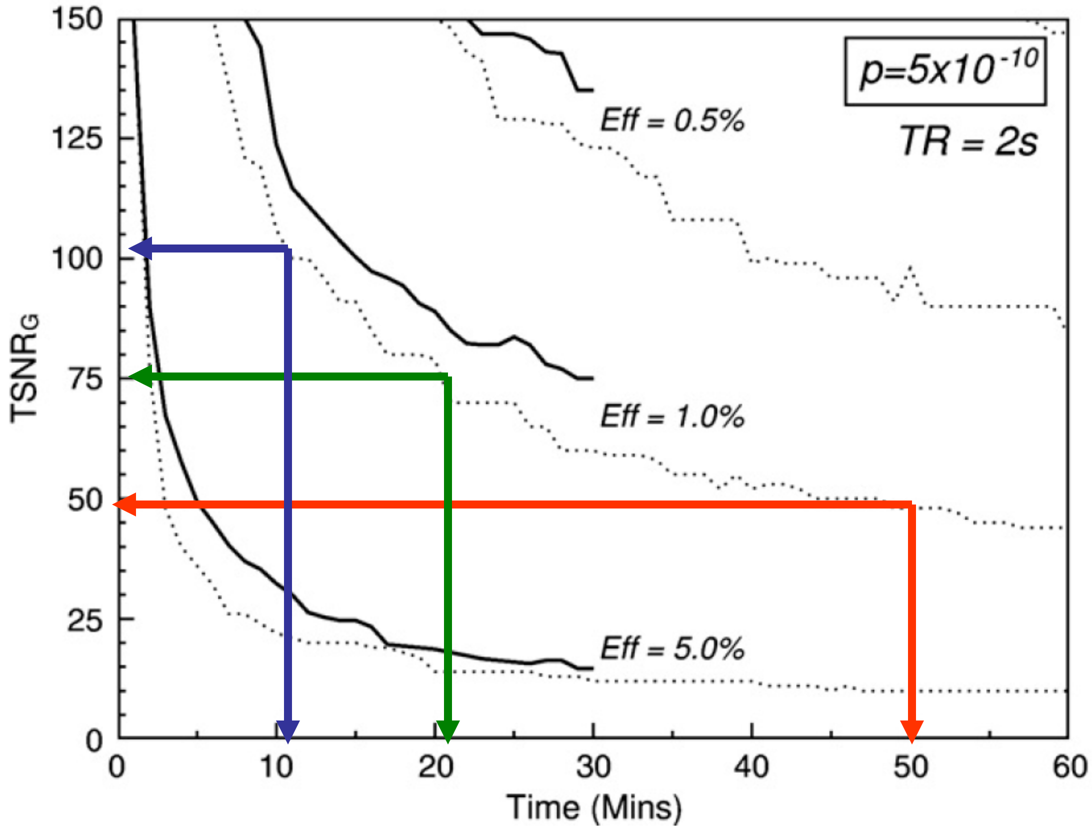
Temporal Signal to Noise Ratio (TSNR) vs. Signal to Noise Ratio (SNR)



3T, birdcage: 2.5 mm^3
3T, 16 channel: 1.8 mm^3
7T, 16 channel: 1.4 mm^3

J. Bodurka, F. Ye, N Petridou, K. Murphy, P. A. Bandettini, *NeuroImage,* 34, 542-549 (2007)

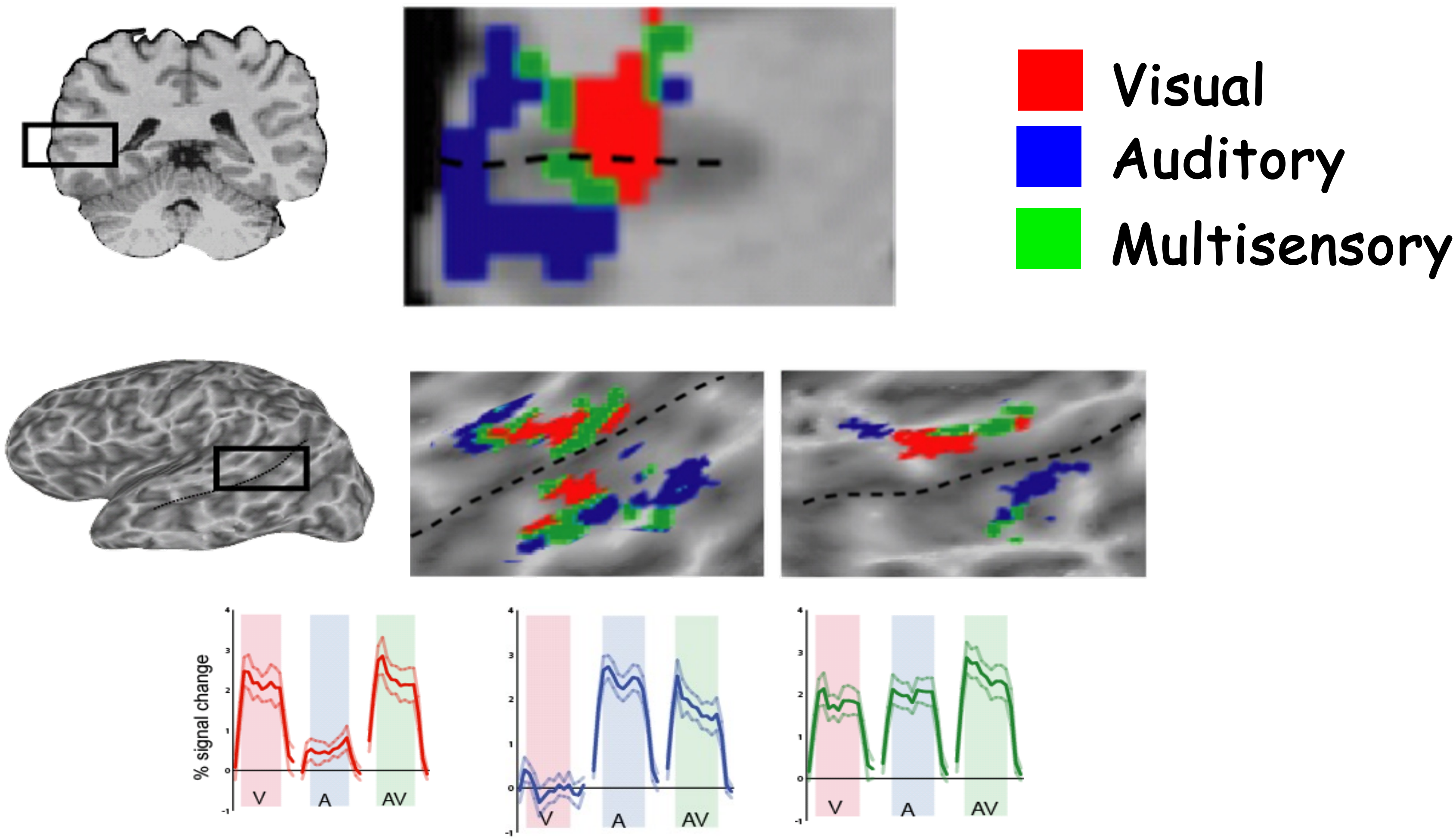
Scanning Individuals



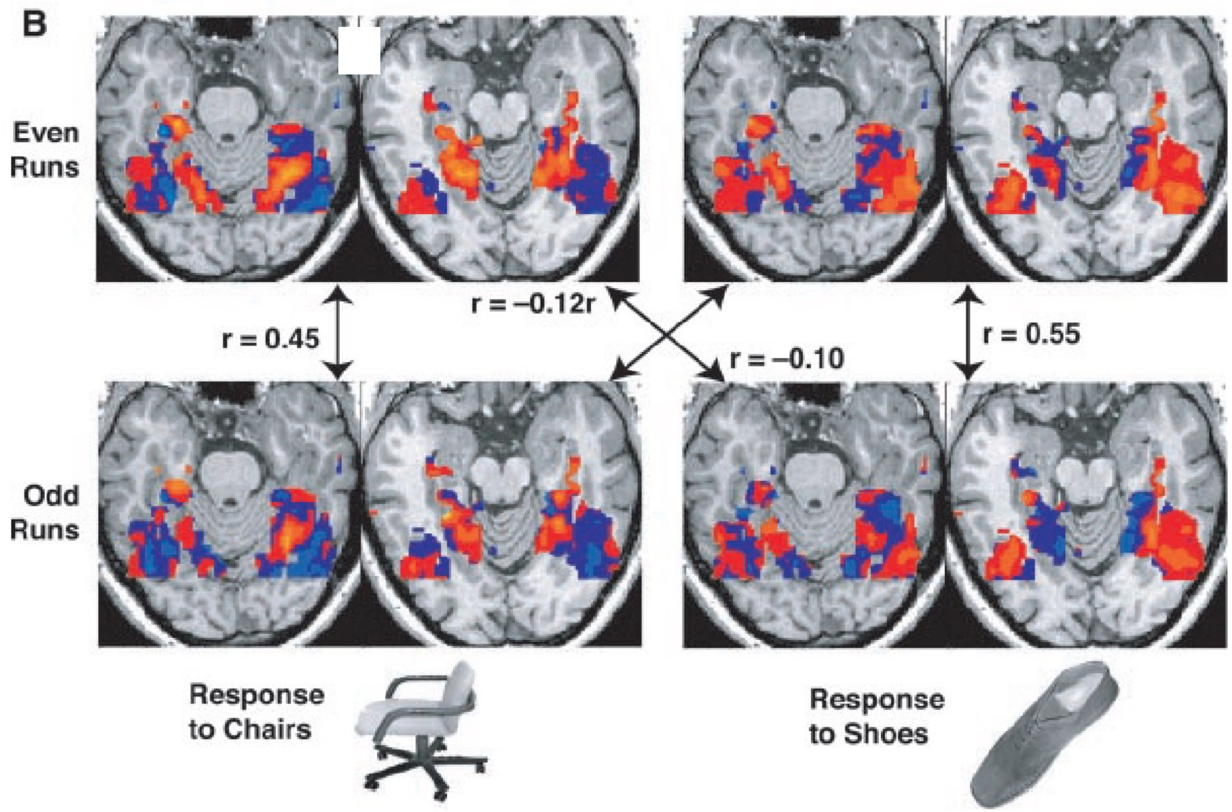
K. Murphy, J. Bodurka, P. A. Bandettini, How long to scan? The relationship between fMRI temporal signal to noise and the necessary scan duration. *NeuroImage*, 34, 565-574 (2007)

Multi-sensory integration

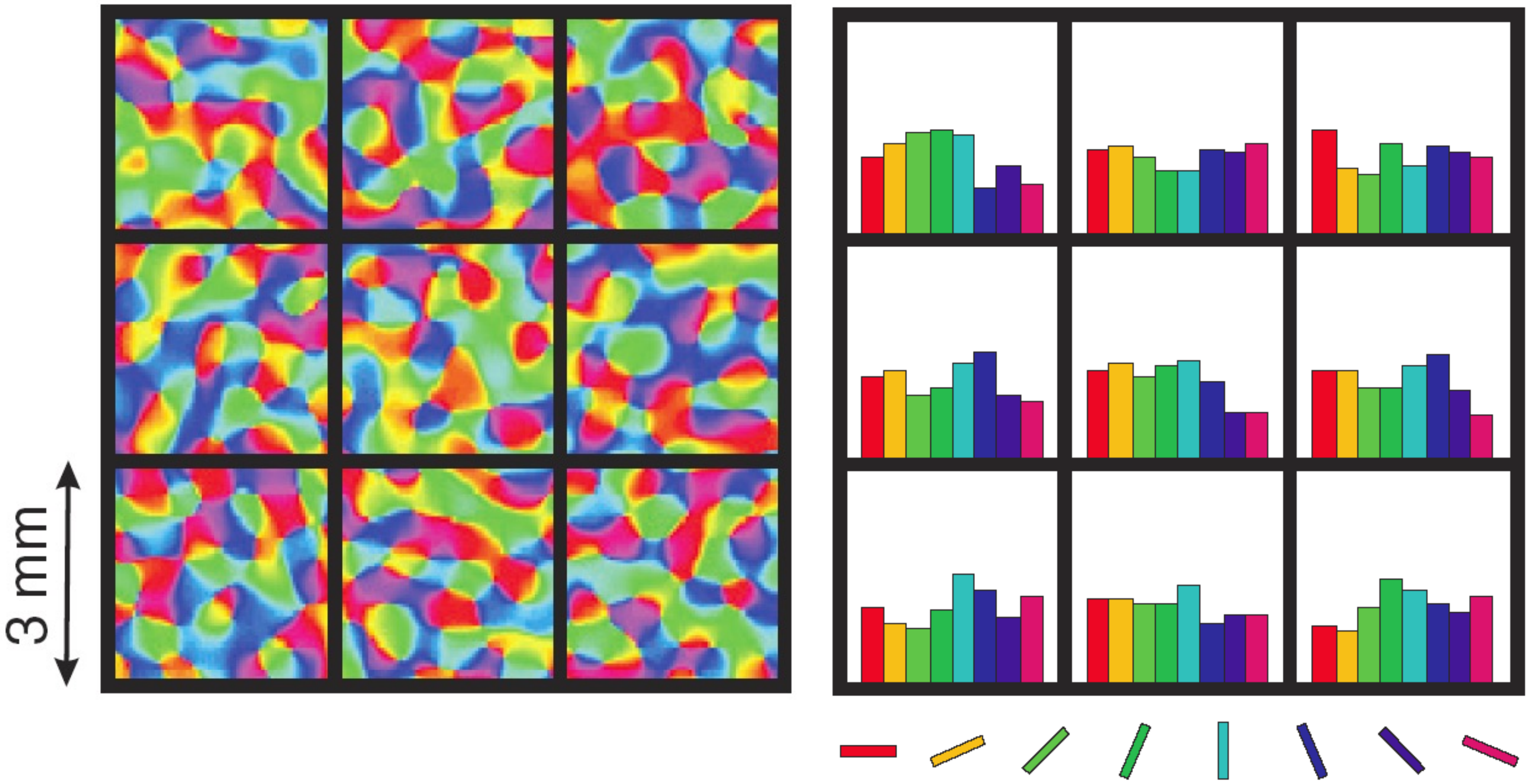
M.S. Beauchamp et al.,



Object categories are associated with distributed representations in ventral temporal cortex

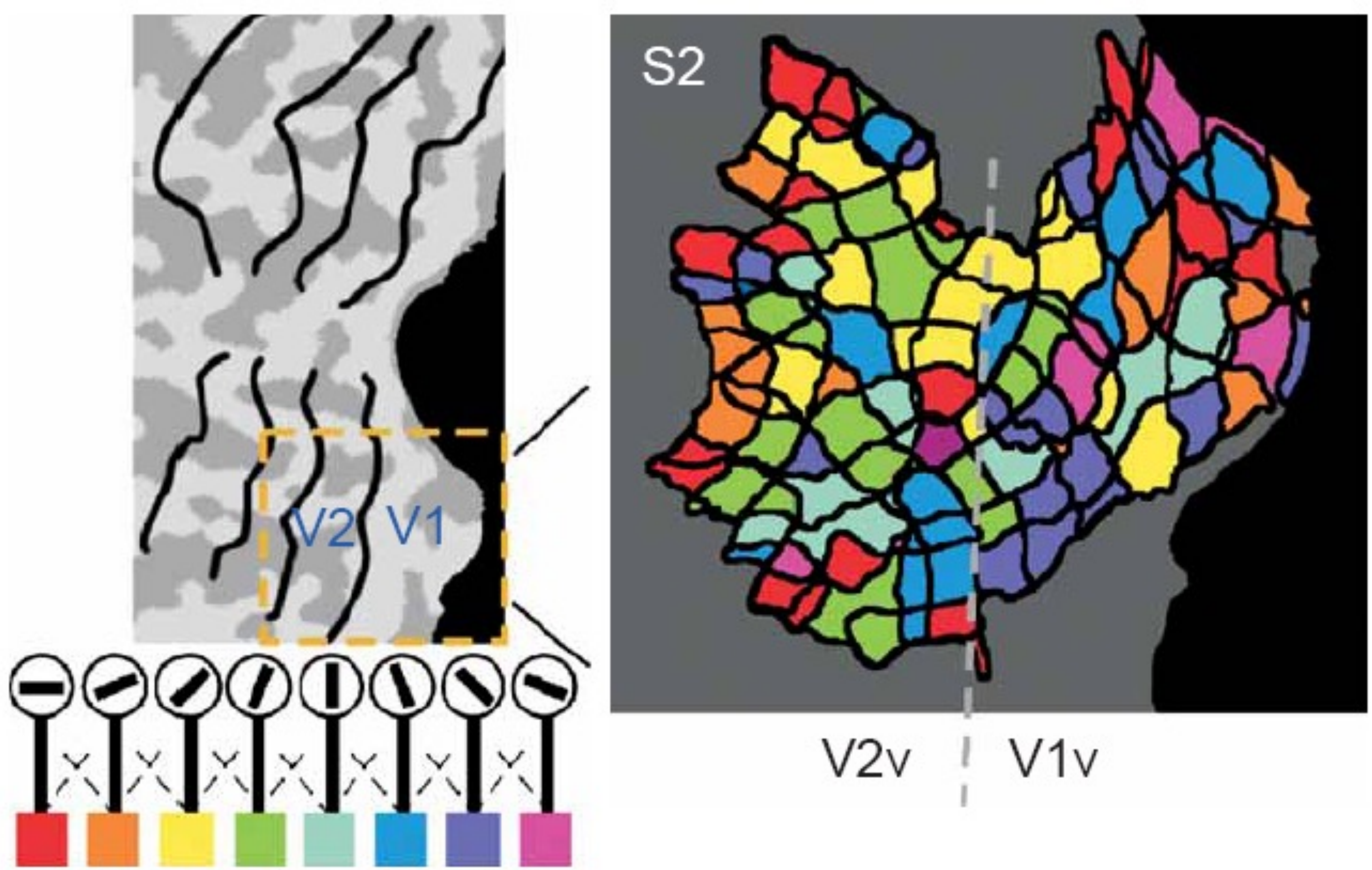


Haxby et al. 2001

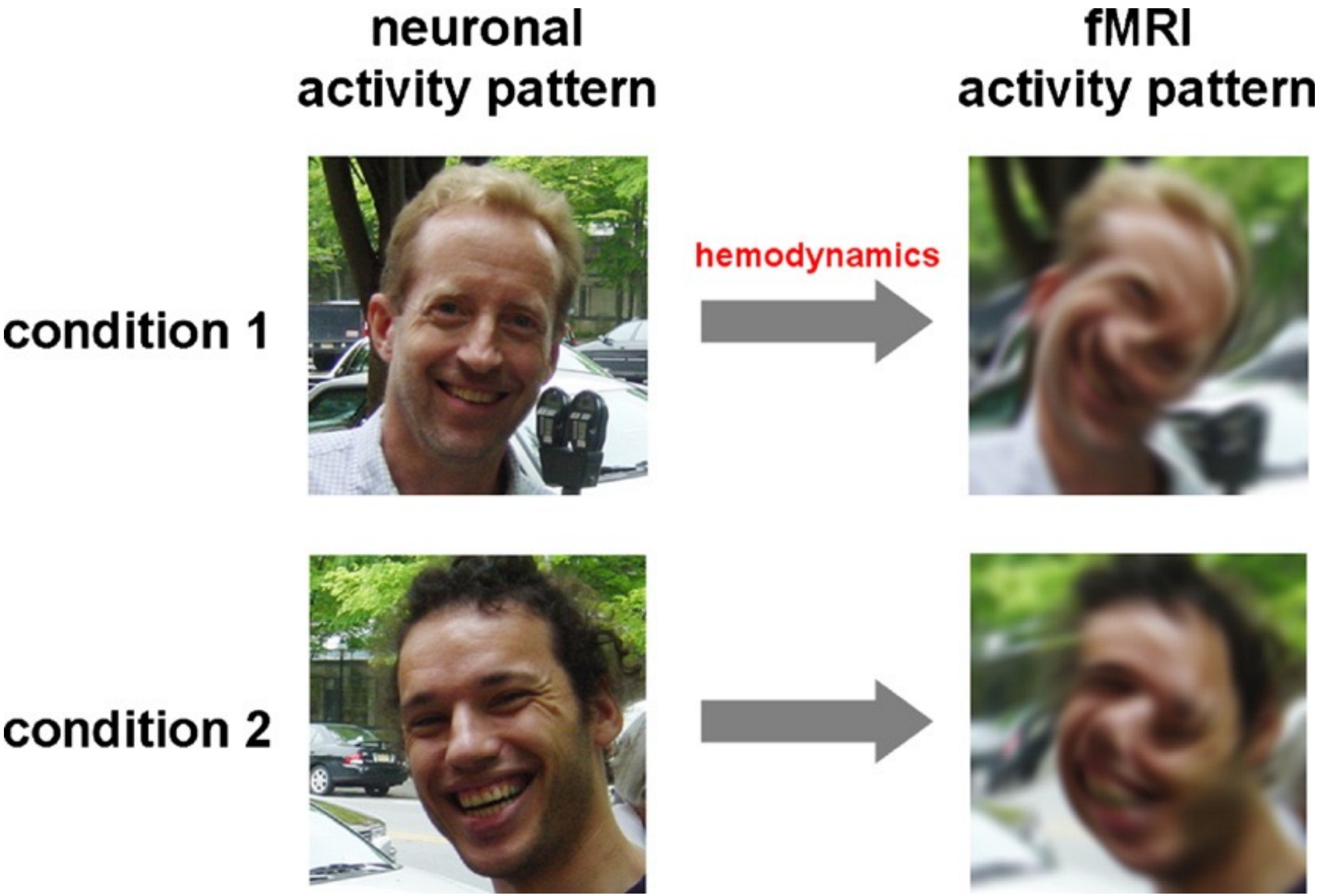


Boynton (2005), News & Views on Kamitani & Tong (2005) and H

Lower spatial frequency clumping

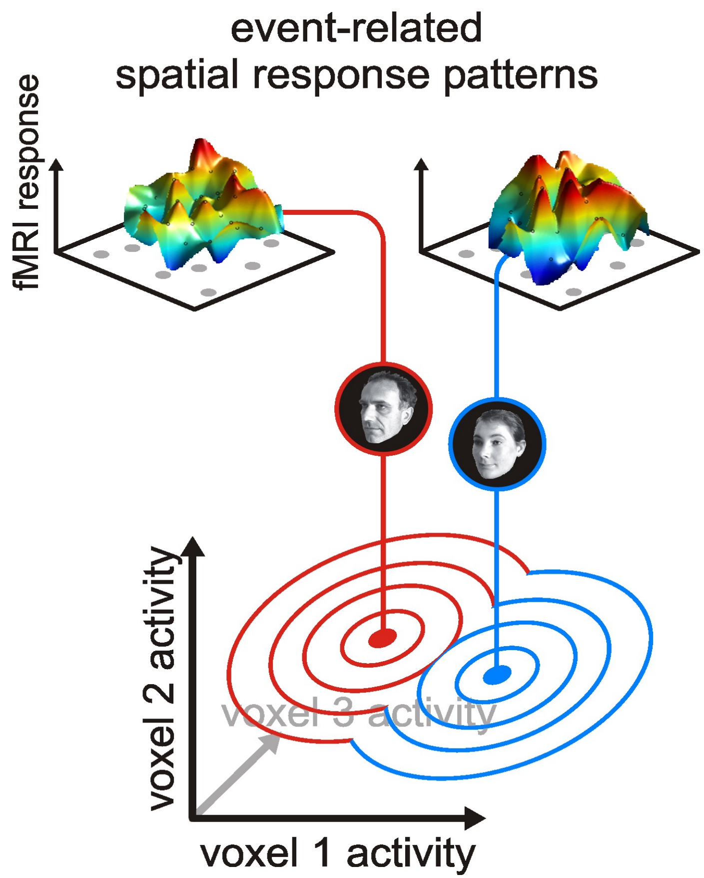


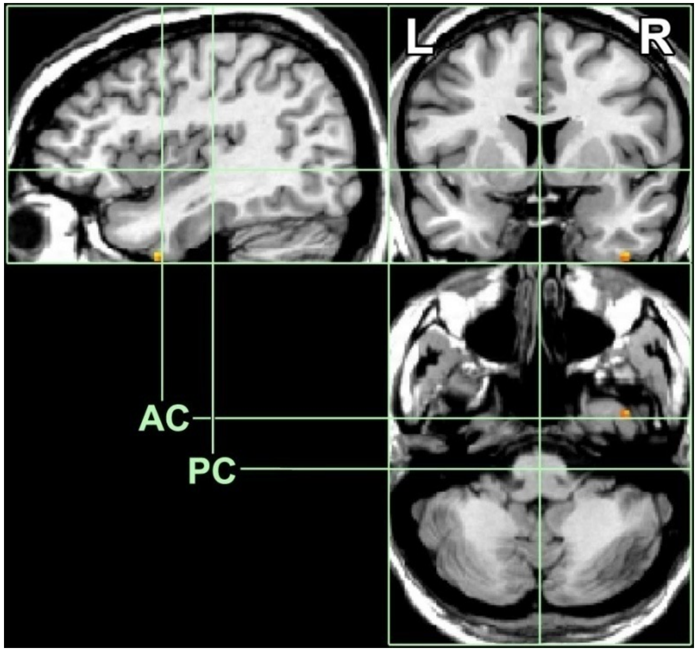
Kamitani & Tong (2005)


neuronal
activity pattern
fMRI
activity pattern
condition 1
hemodynamics
condition 2

Pattern Information Mapping

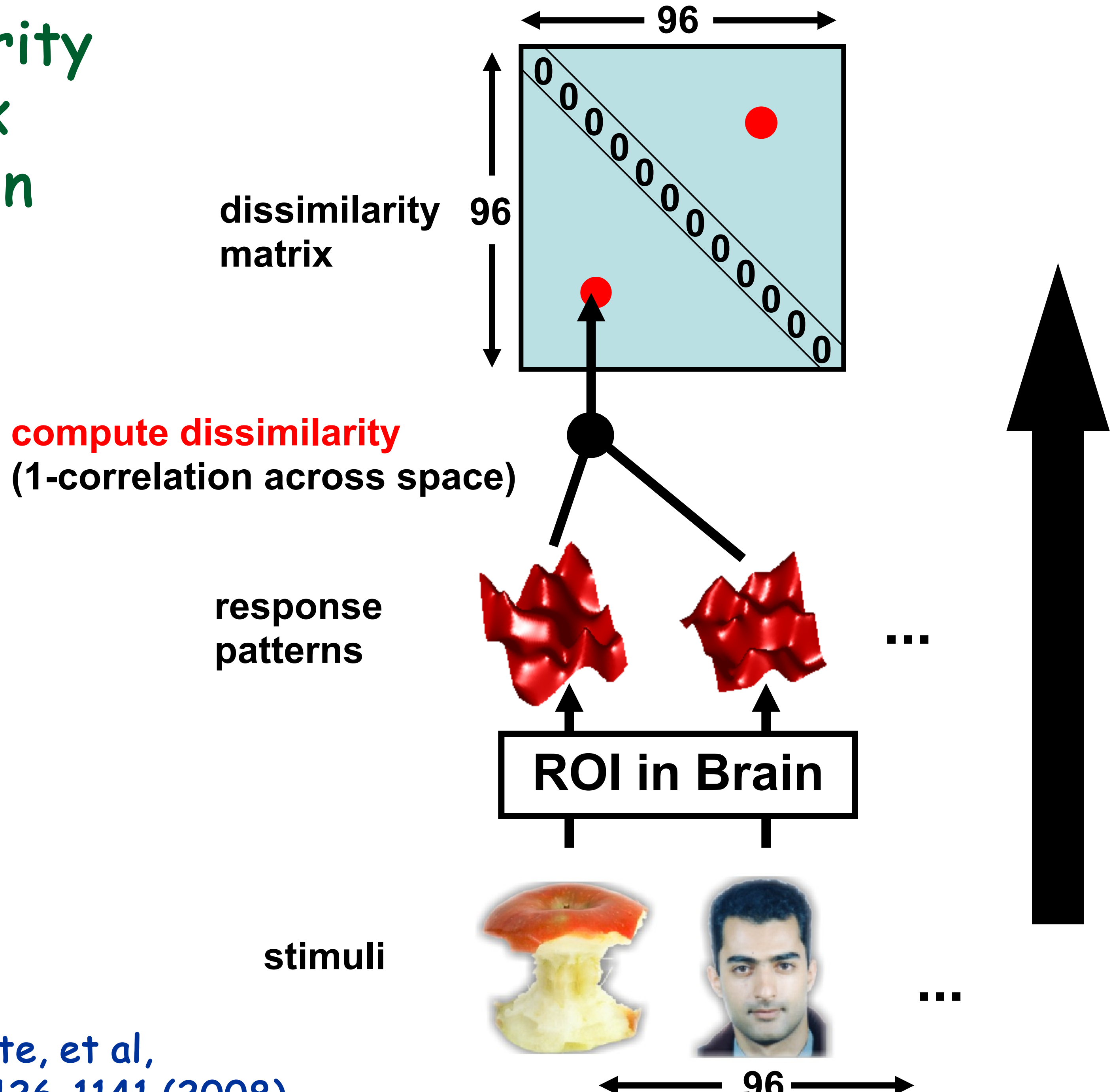
From fixed ROI





N. Kriegeskorte, E. Formisano, B. Sorger, R. Goebel, *Proc. Nat'l. Acad. Sci. USA*, 104, 20600-20605 (2007)

Dissimilarity Matrix Creation



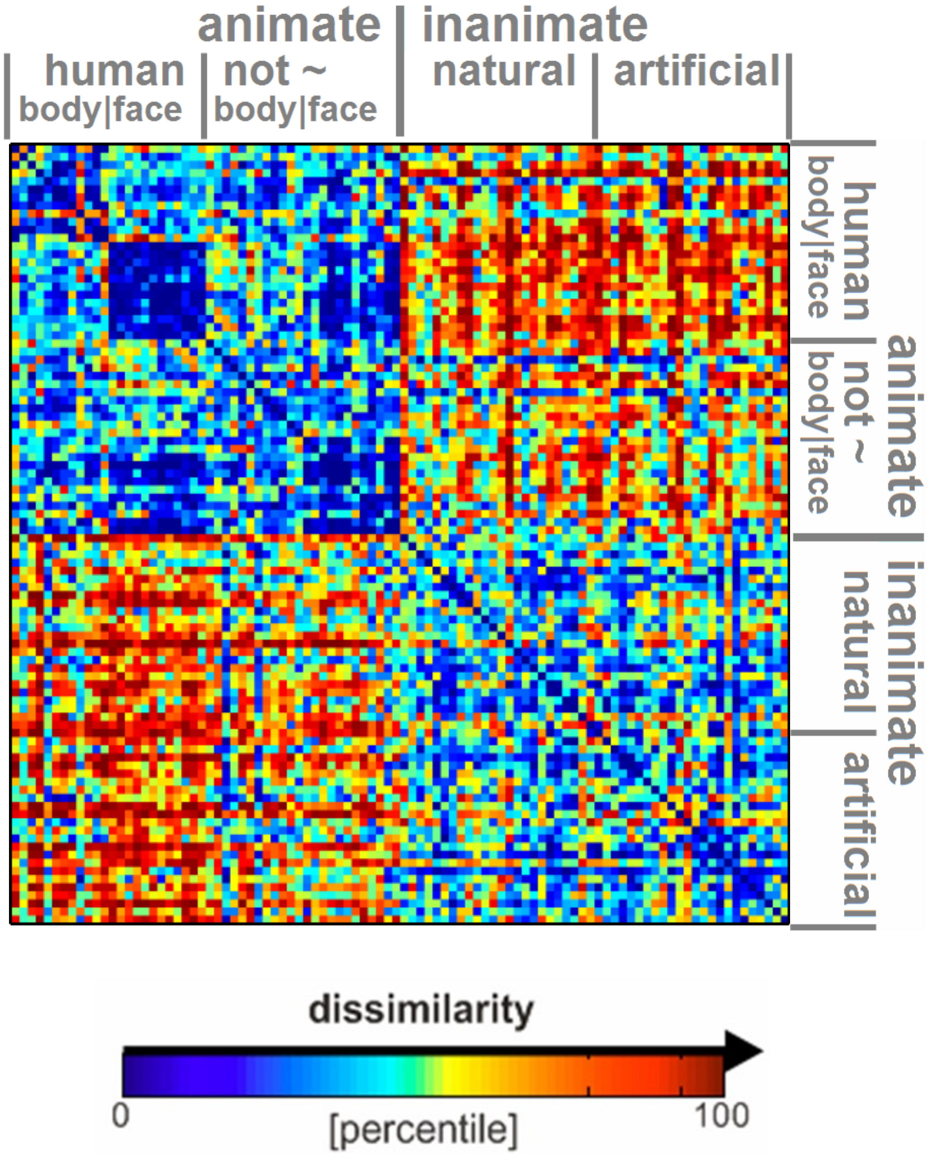
N. Kriegeskorte, et al,
Neuron, 60, 1126-1141 (2008)

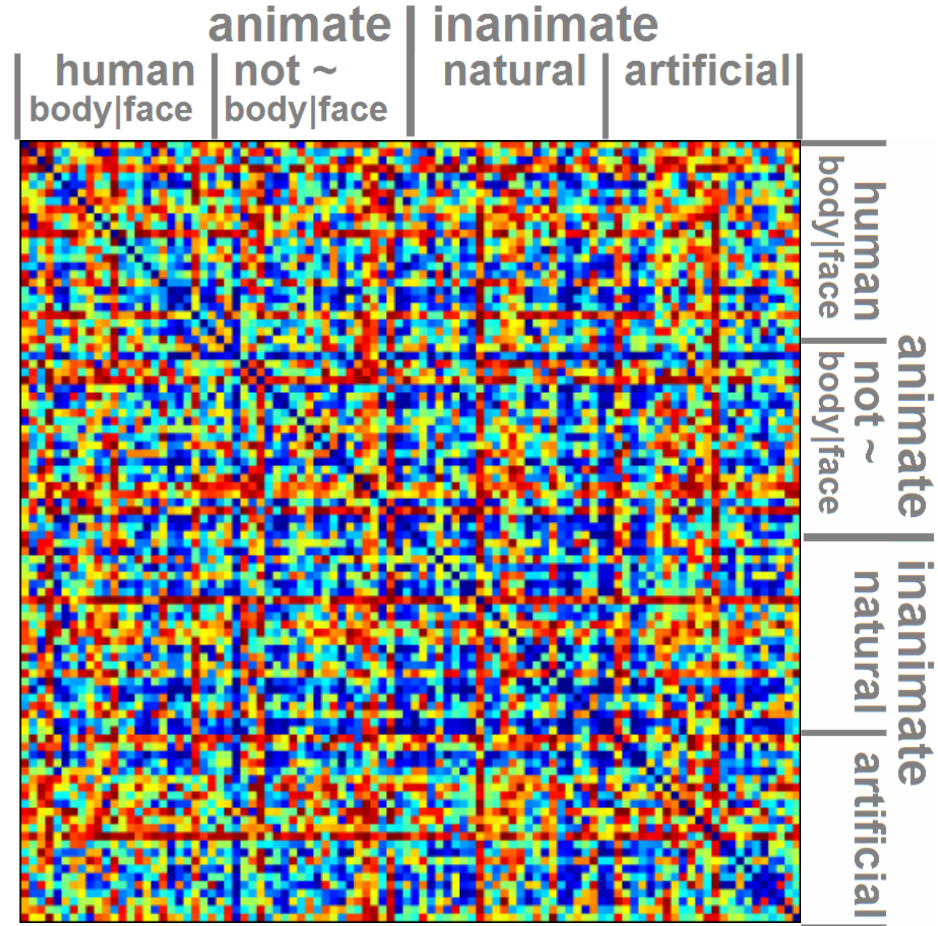
Visual Stimuli

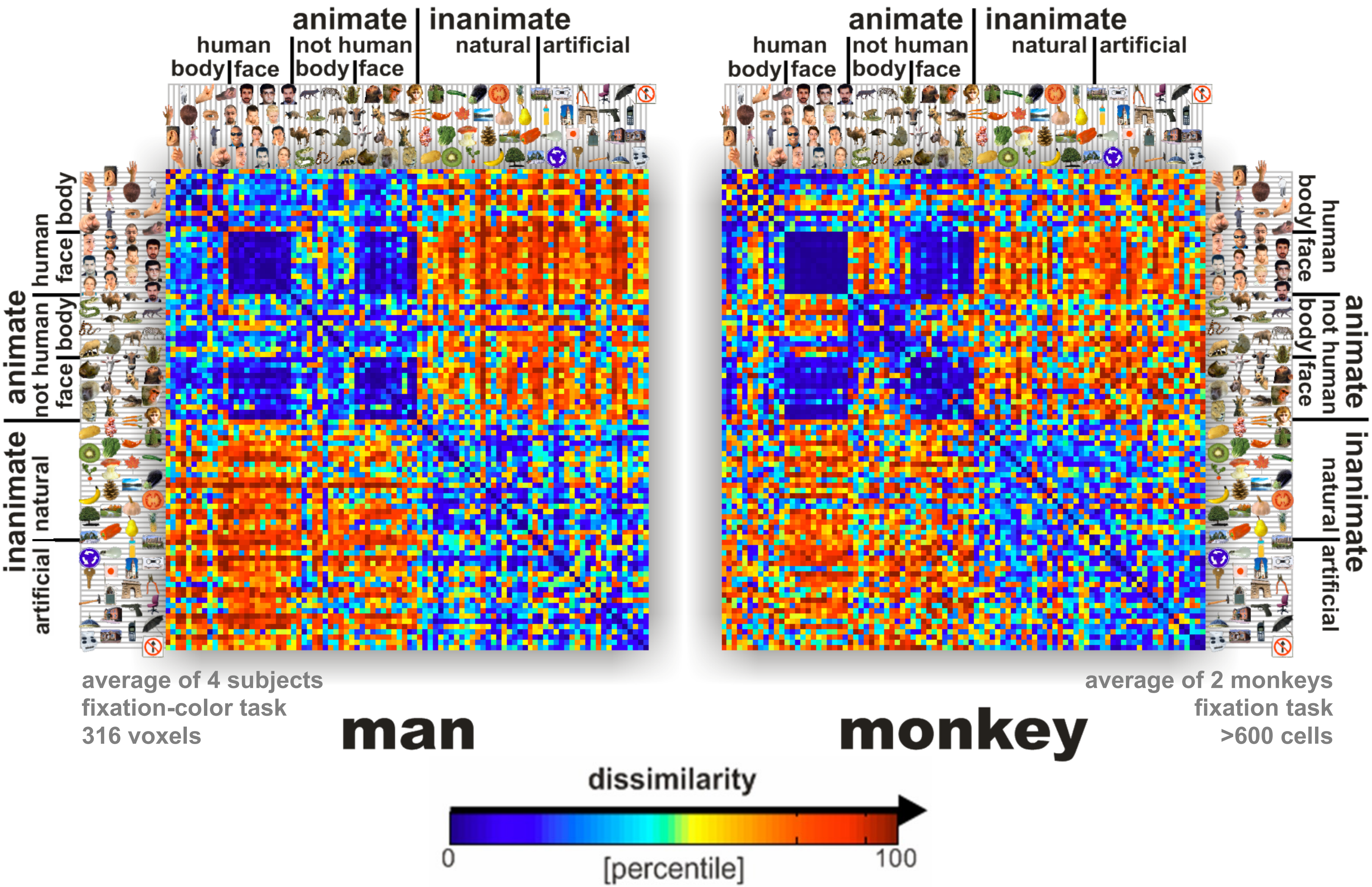
Human IT

Human Early Visual Cortex

0 visually most responsive(1057ls)visually most responsive voxel



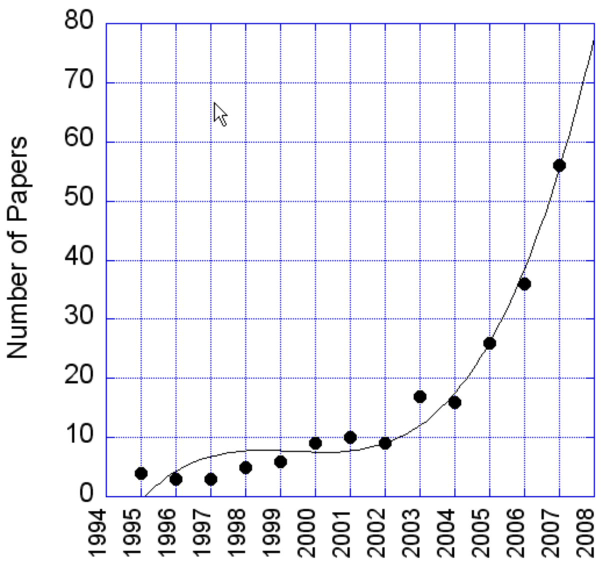


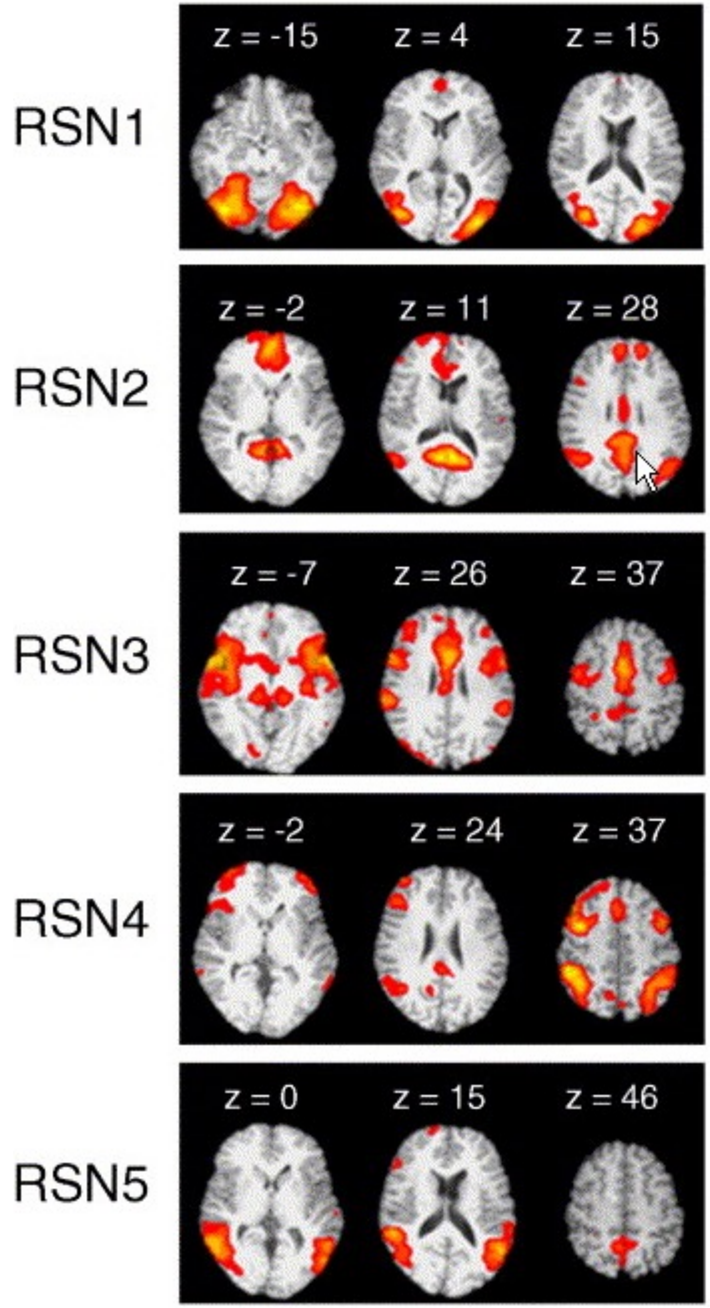


animate | inanimate
human | not human | natural | artificial
body | face | body | face
average of 4 subjects
fixation-color task
316 voxels
man
monkey
average of 2 monkeys
fixation task
>600 cells
dissimilarity
0
[percentile]
100

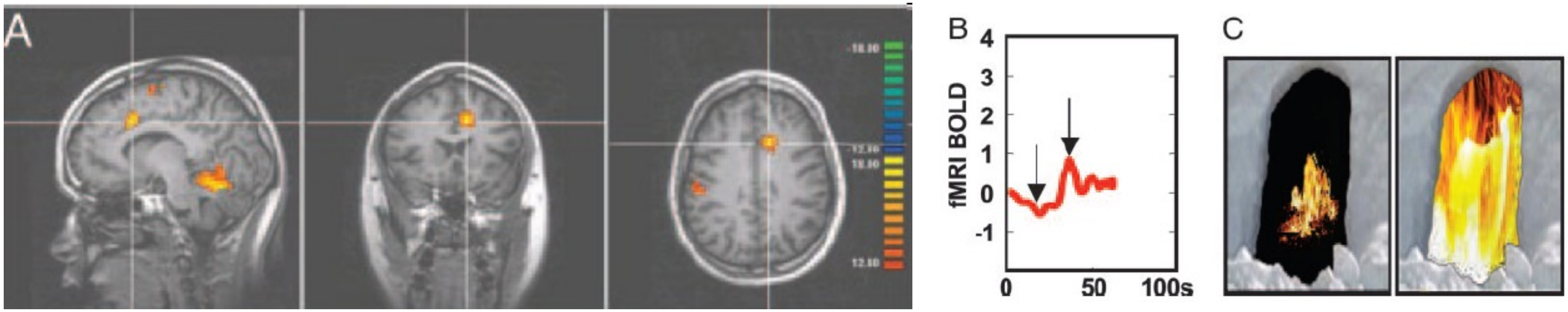
Resting state networks identified with ICA

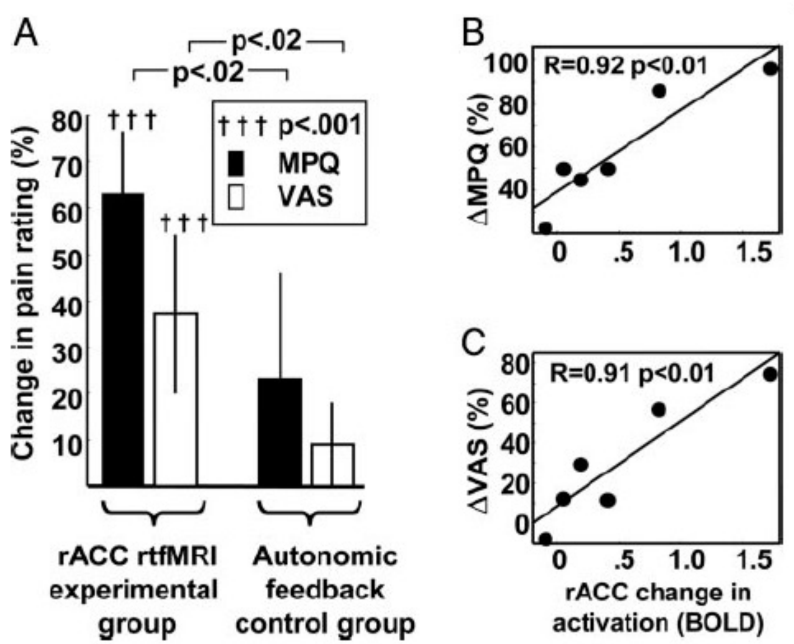
M. DeLuca, C.F. Beckmann, N. De Stefano,
P.M. Matthews, S.M. Smith,
fMRI resting state networks define distinct modes of long-distance interactions in the human brain.
NeuroImage, 29, 1359-1367





Real time fMRI feedback to reduce chronic pain





Control over brain activation and pain learned by using real-time functional MRI, R. C. deCharms, et al. PNAS, 102; 18626-18631 (2005)