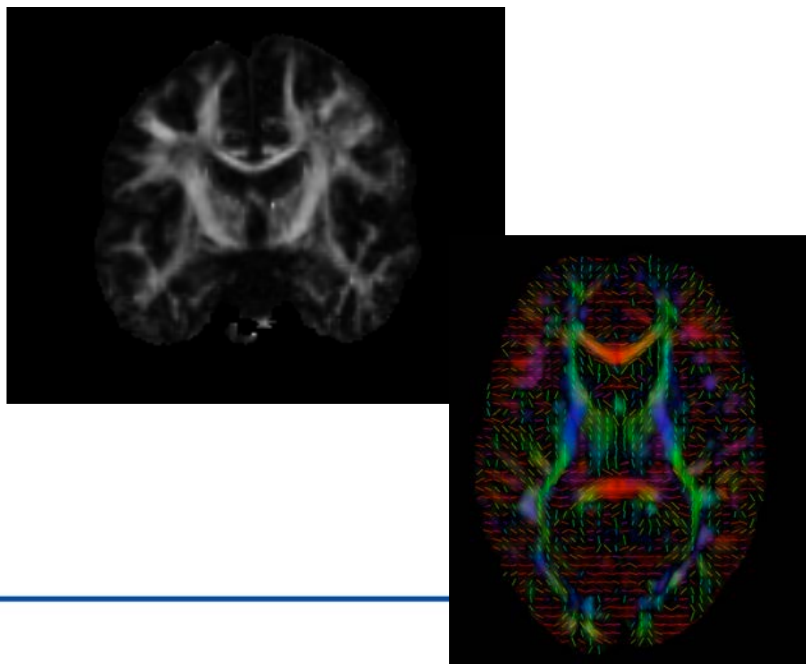
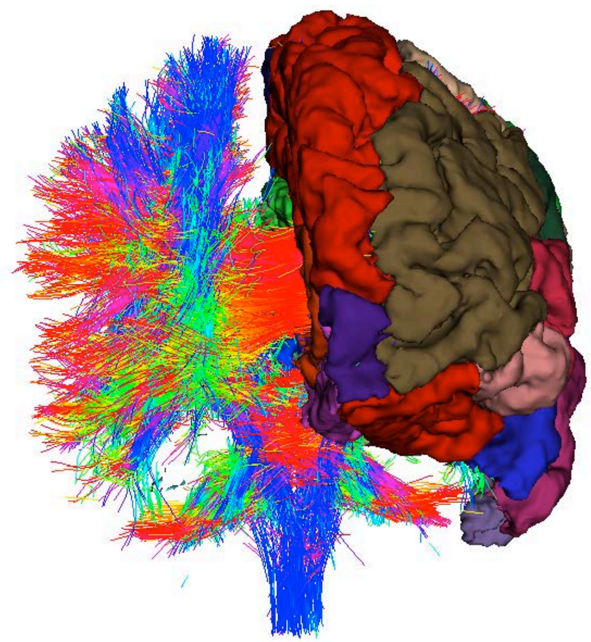
NA-MIC
National Alliance for Medical Image Computing
http://www.na-mic.org

Driving Biological Problem Huntington's Disease

THE UNIVERSITY OF IOWA



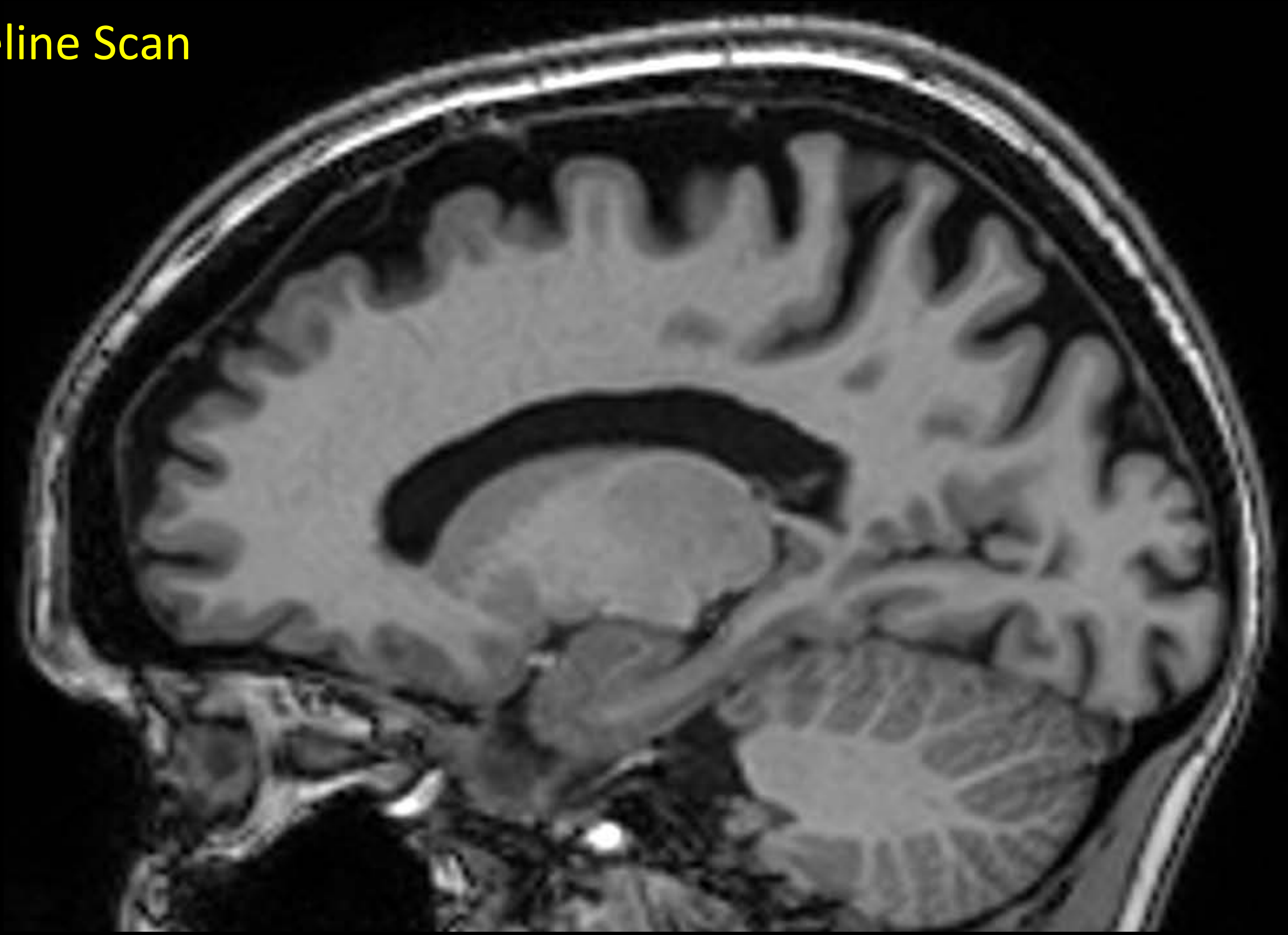


Builds on PREDICT-HD

- The NIH-funded project “Neurobiological Predictors of Huntington’s Disease” (PREDICT-HD) studies Huntington’s disease (HD), a neurodegenerative genetic disorder that affects muscle coordination, behavior, and cognitive function, and causes severe debilitating symptoms by middle age.

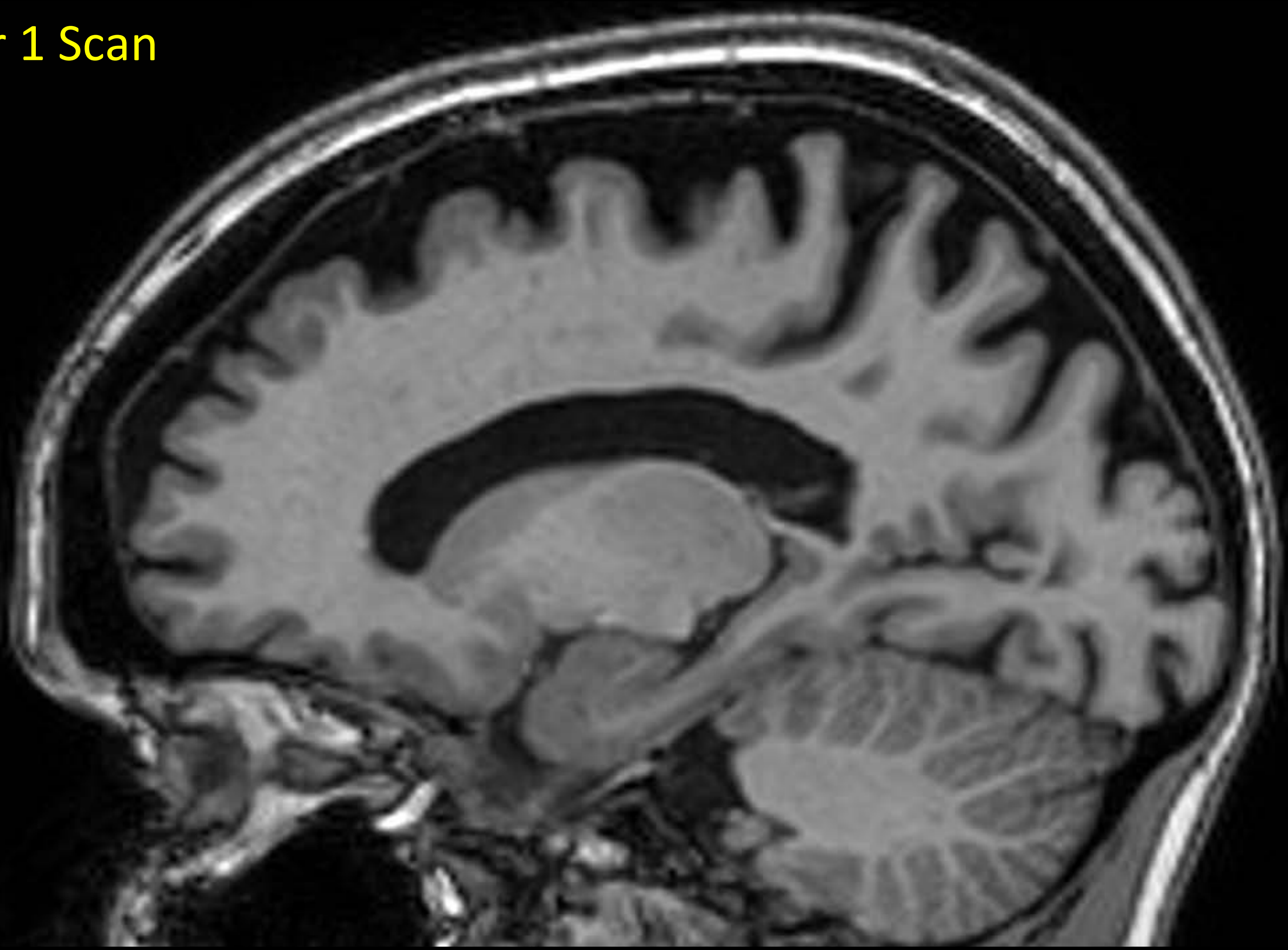
TRACK-HD Stage 1 HD Subject

Baseline Scan



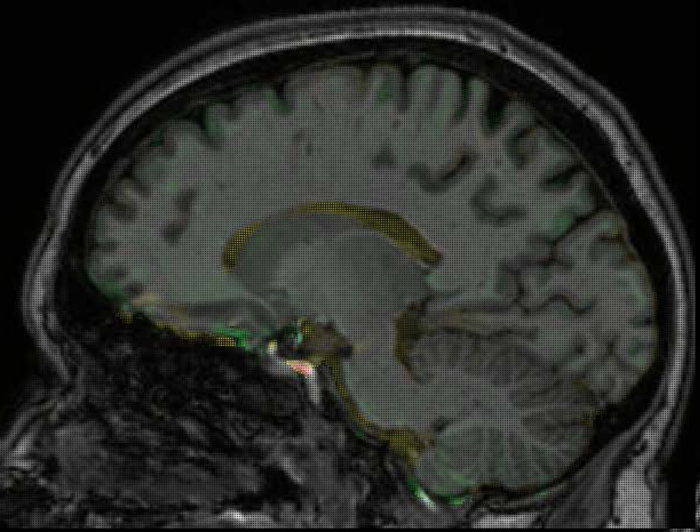
TRACK-HD Stage 1 HD Subject

Year 1 Scan

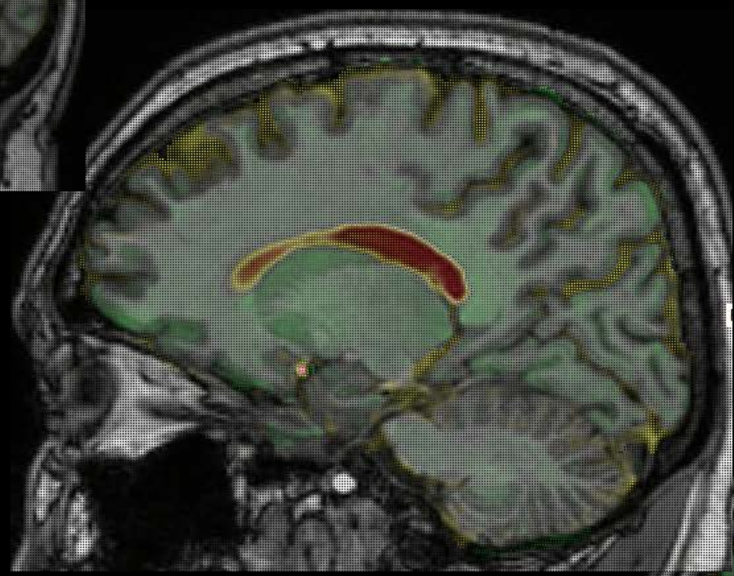


24-month voxel-compression mapping

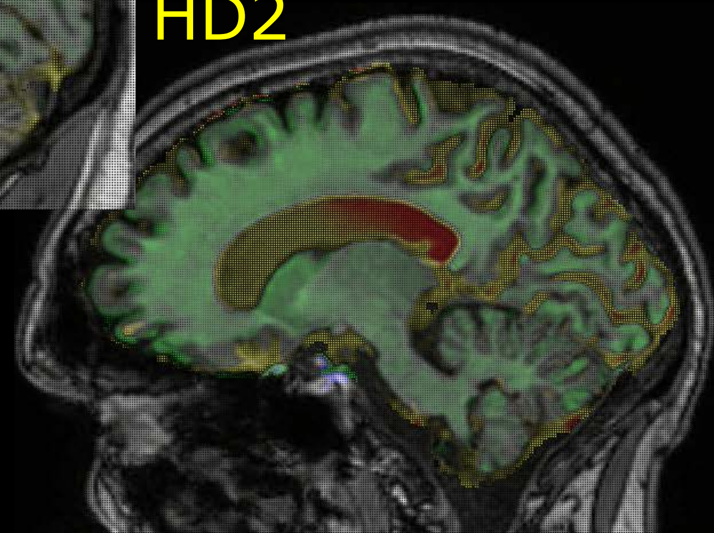
Control



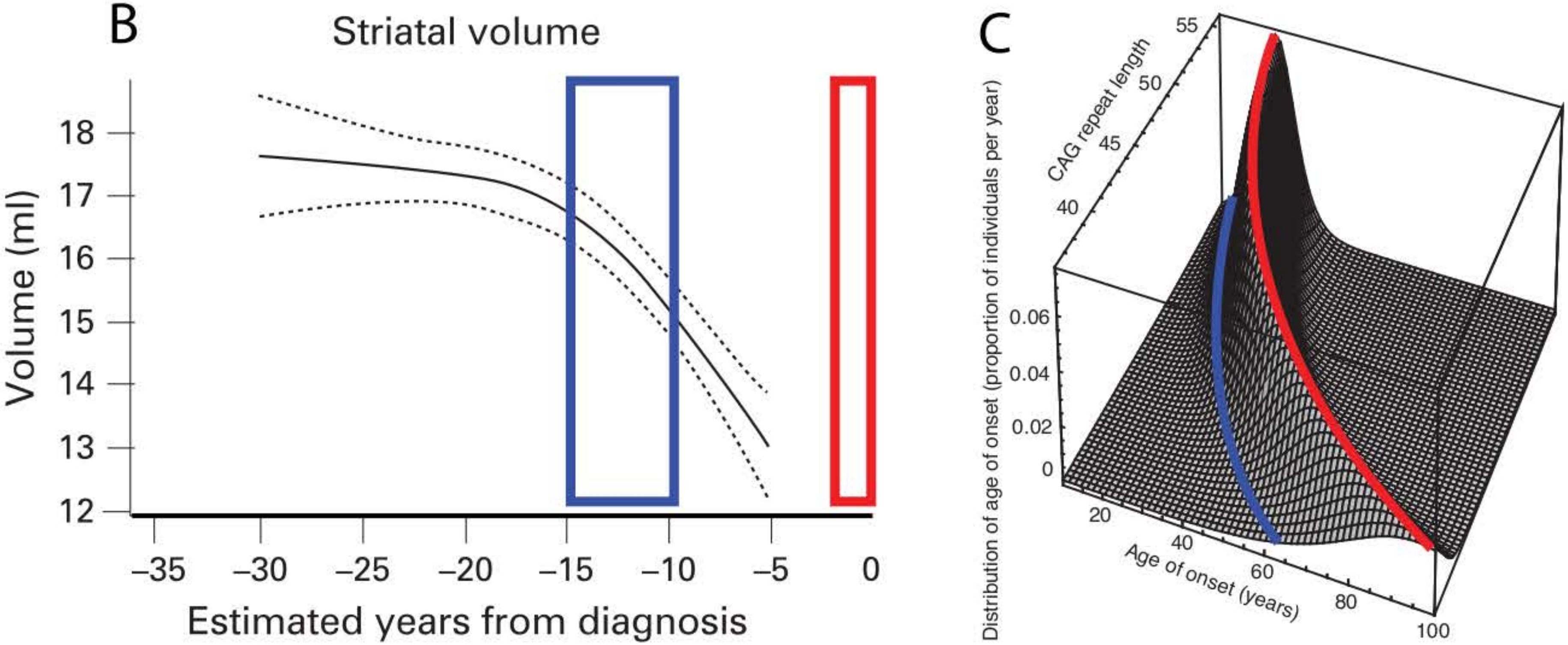
PreA



HD2



HD Background

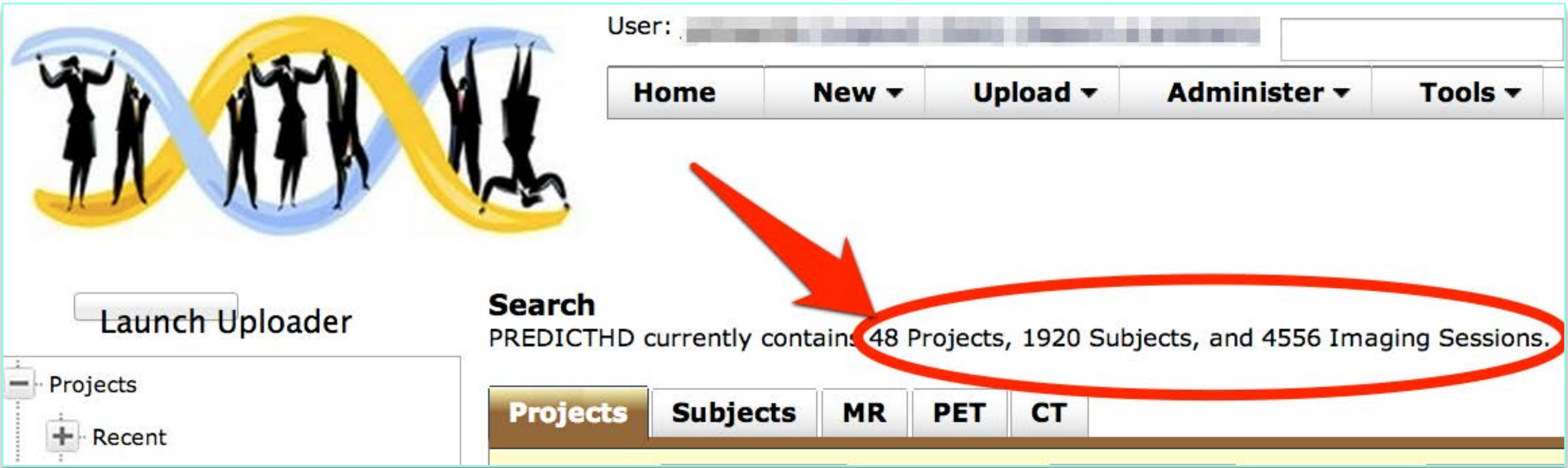


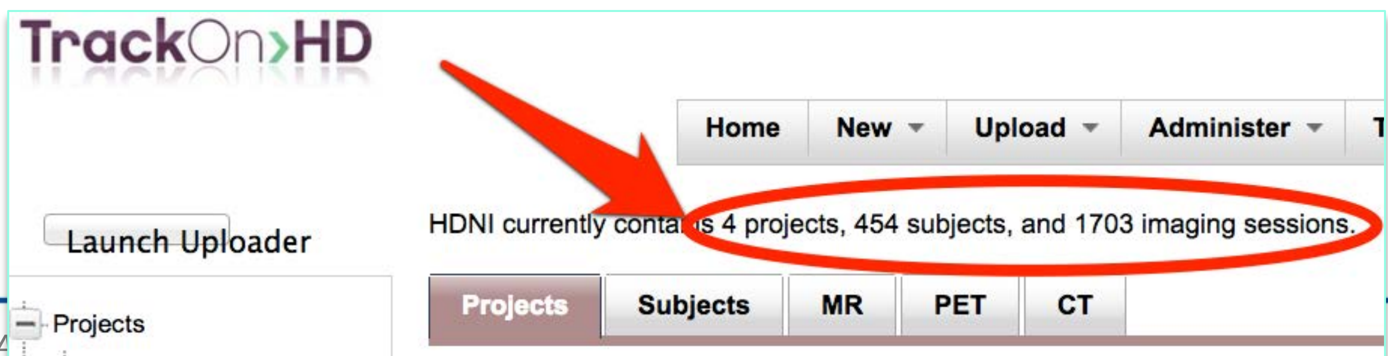
Specific Aims

- Perform individualized longitudinal shape change quantification from multi-modal data.
- Complete full brain Diffusion Tensor Imaging tractography analysis.
- Deploy extensible tools for sharing source data, derived data, algorithms and methods to multi-site analysis teams.

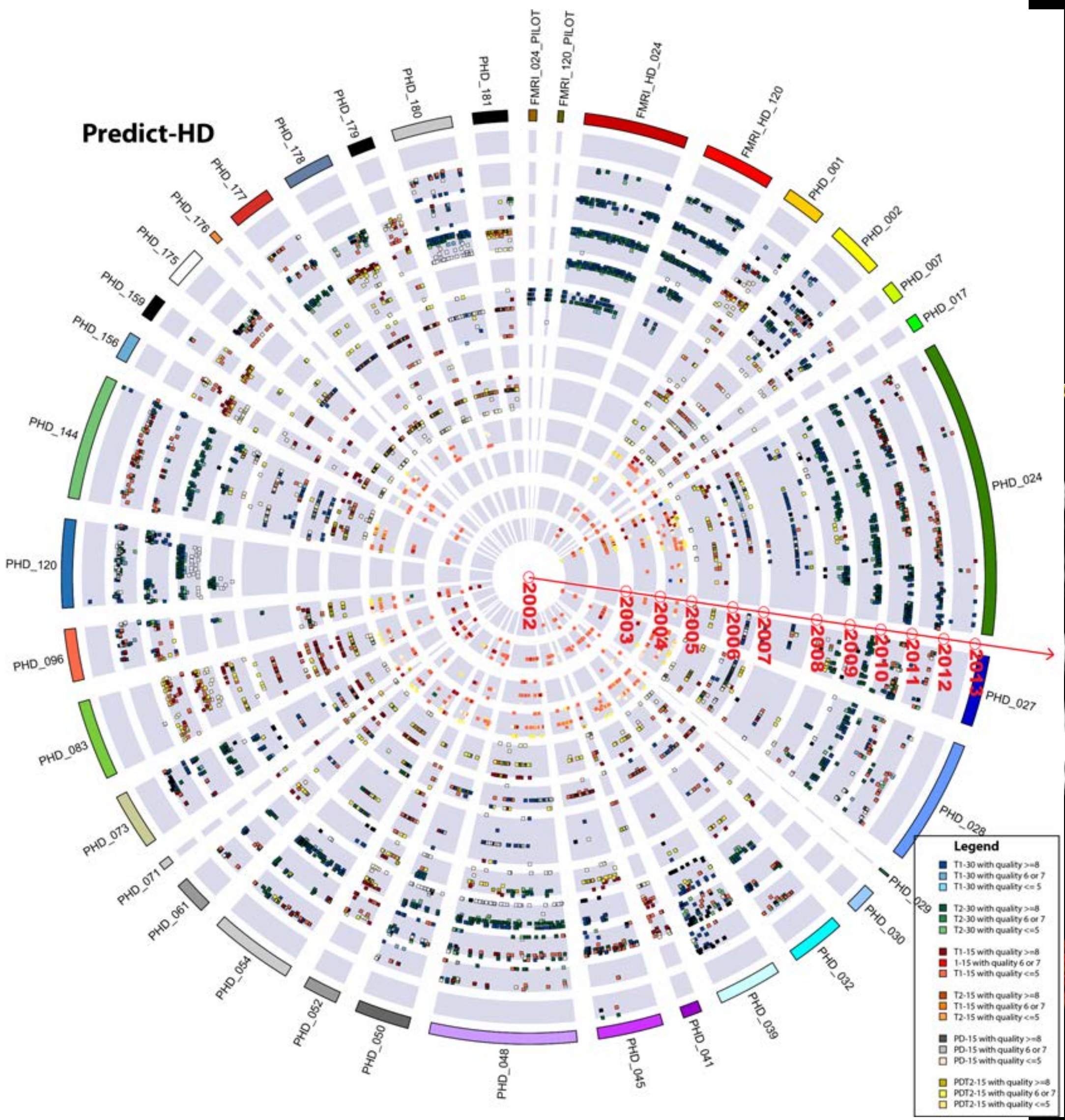
Sharing HD Data

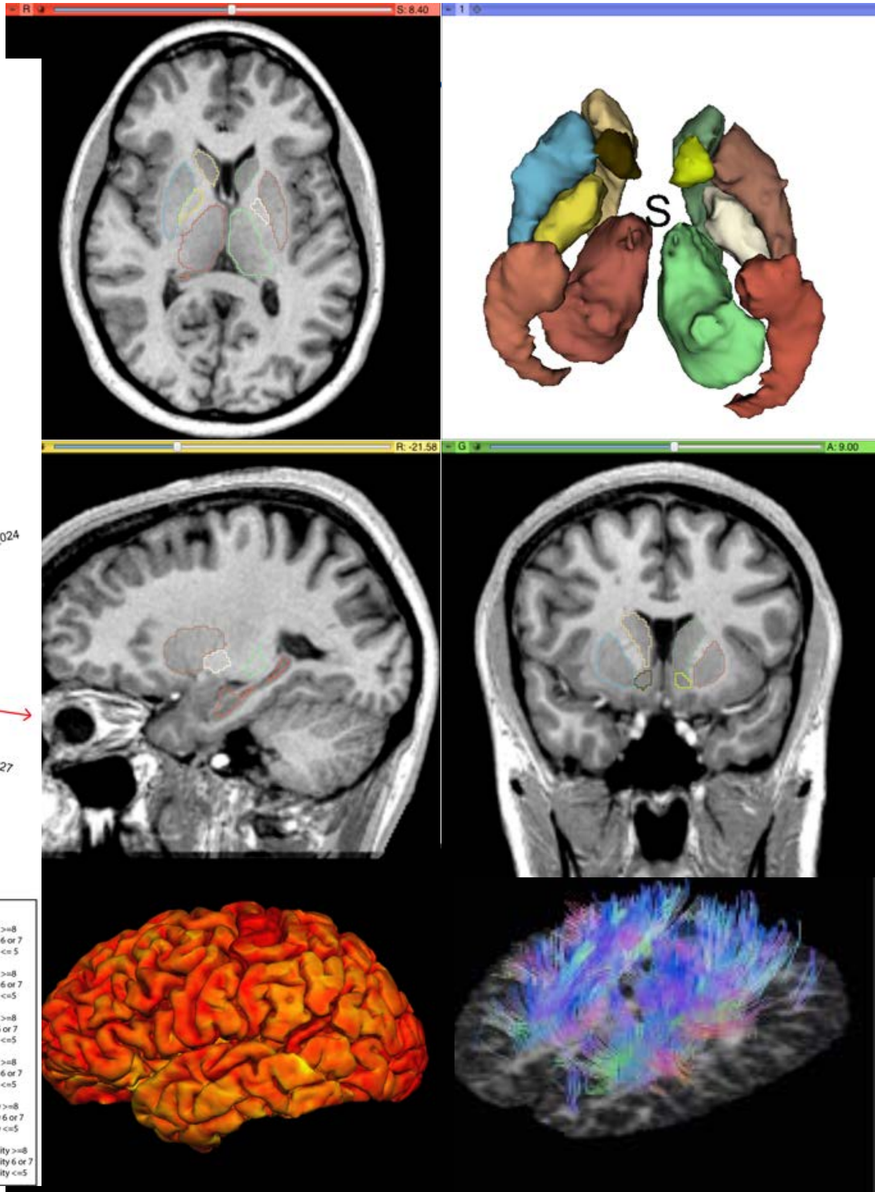
http://www.na-mic.org/Wiki/index.php/2011_Summer_Project_Week



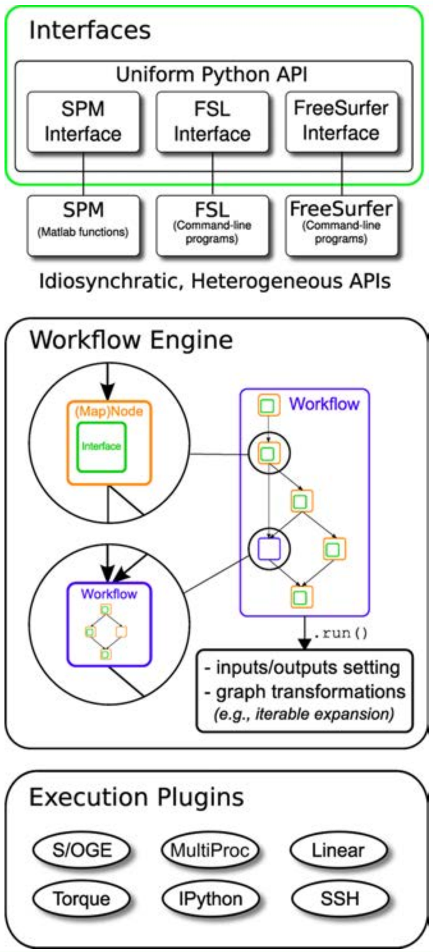


Improve Data Processing





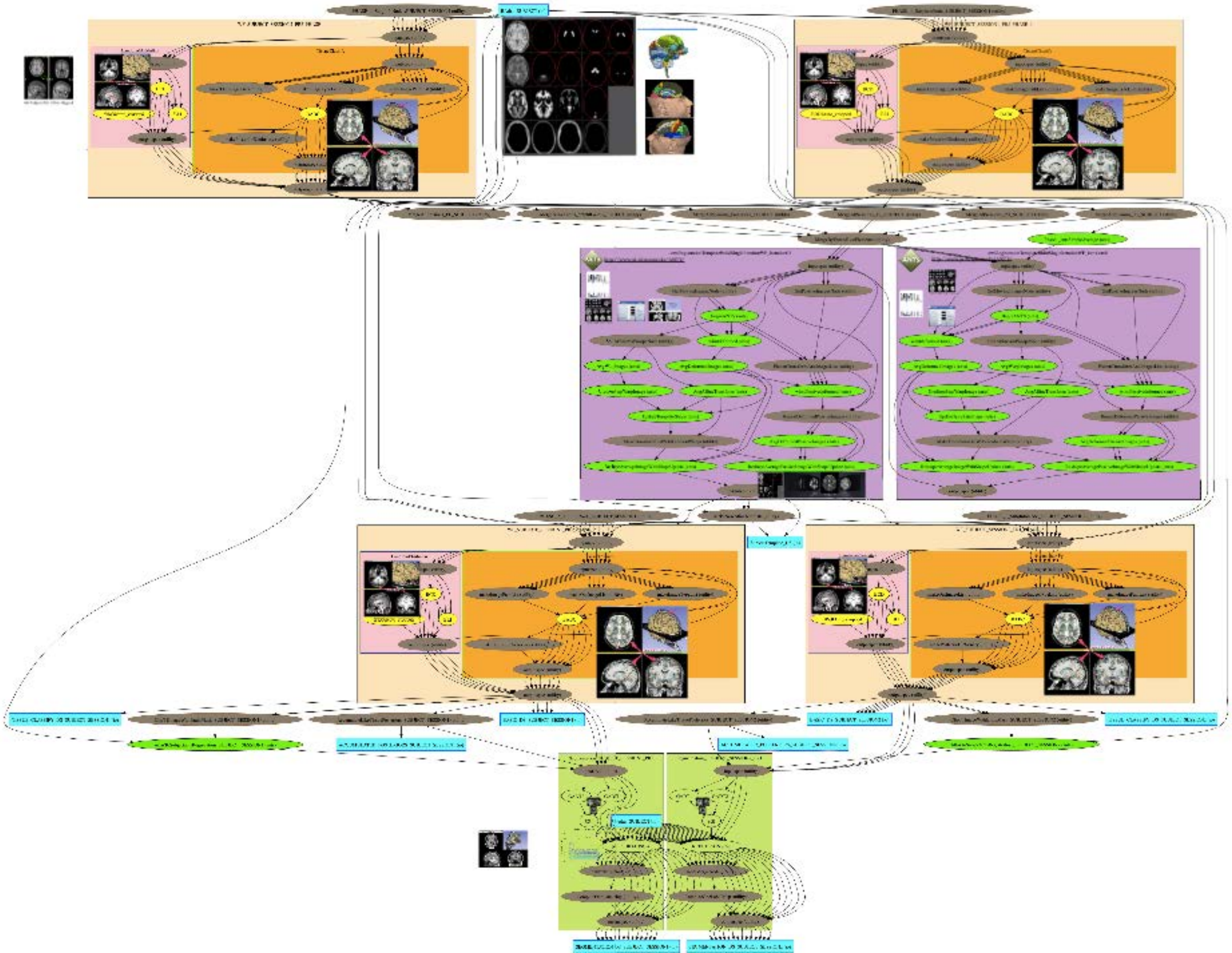
NiPype: Large catalog of tools with a uniform interface



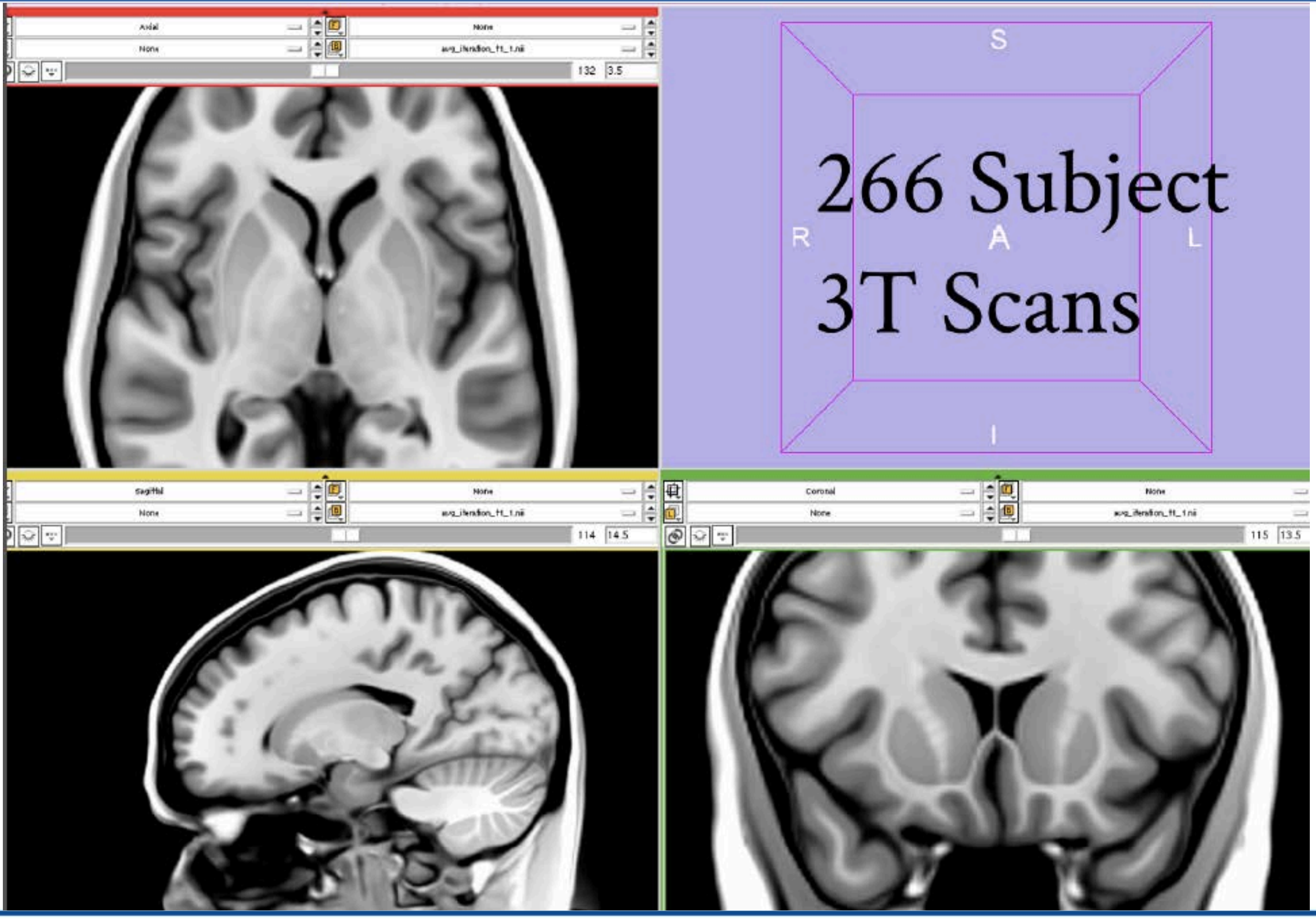
- **Batch processing**
  - Distributed processing plugins
  - Reruns affect updated/edited node connections ONLY!
- Uniform node creation
  - Stable and consistent API
  - Nipype's Function node allows easy integration of CLI tools
- **Pipeline complexity**
  - Iterables, MapNodes
  - Nested workflows

Image source: Gorgolewski K *et al.,* (2011) Nipype: a flexible, lightweight and extensible neuroimaging data processing framework in Python. Front. Neuroinform. 5:13.

Diagram of Longitudinal Processing Pipeline



Improved Template Building with ANTS

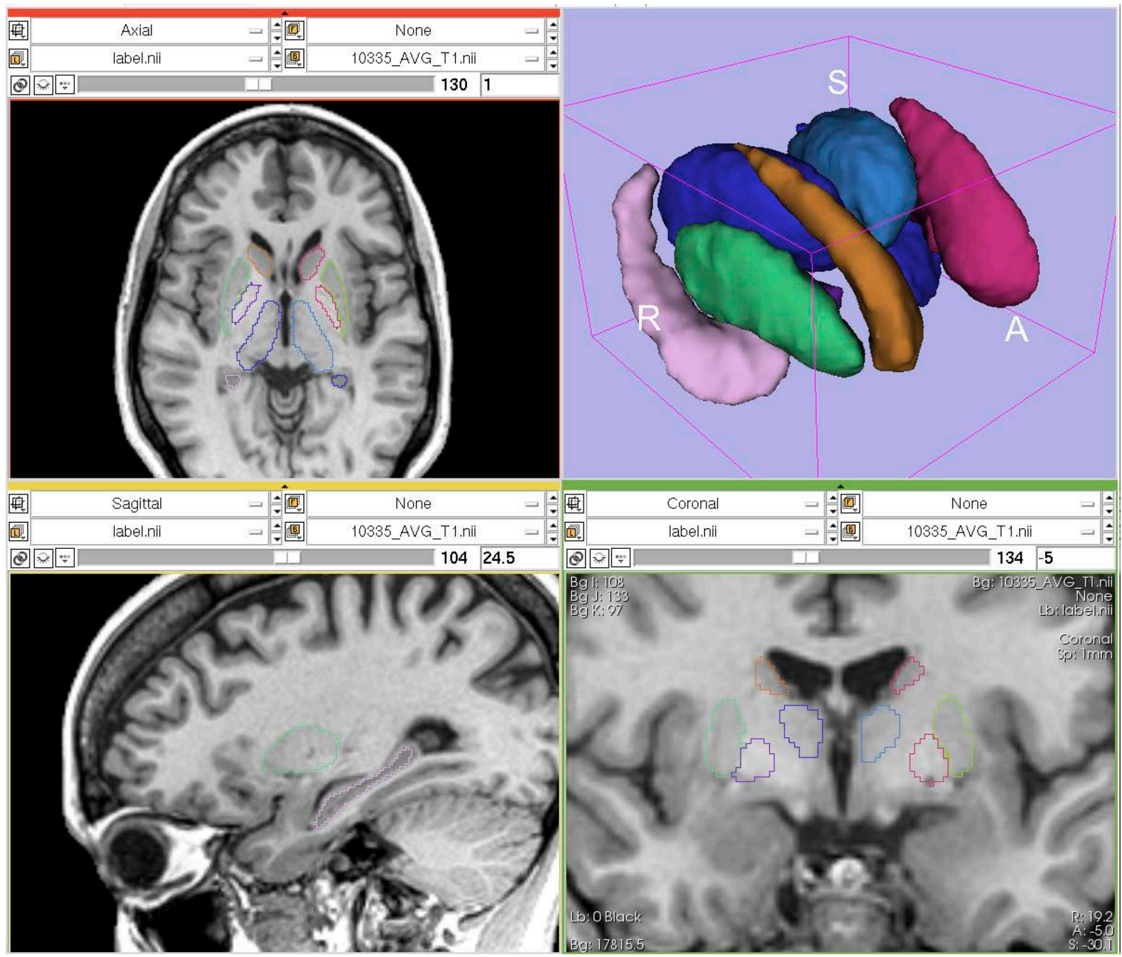


Brain Sub-Cortical Structures:
BRAINSCut (Longitudinal estimation)

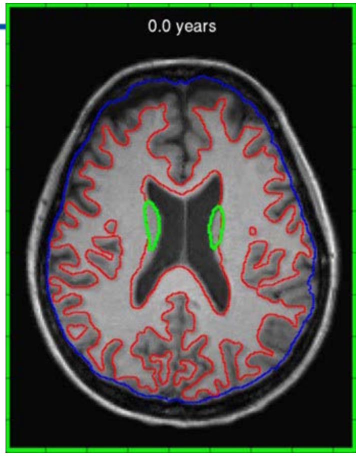
Developed
- Caudate
- Putamen
- Thalamus

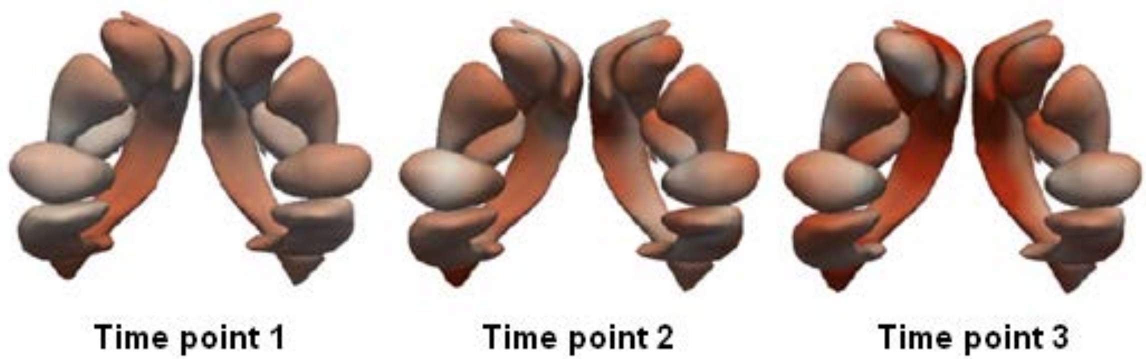
New structure
- Hippocampus

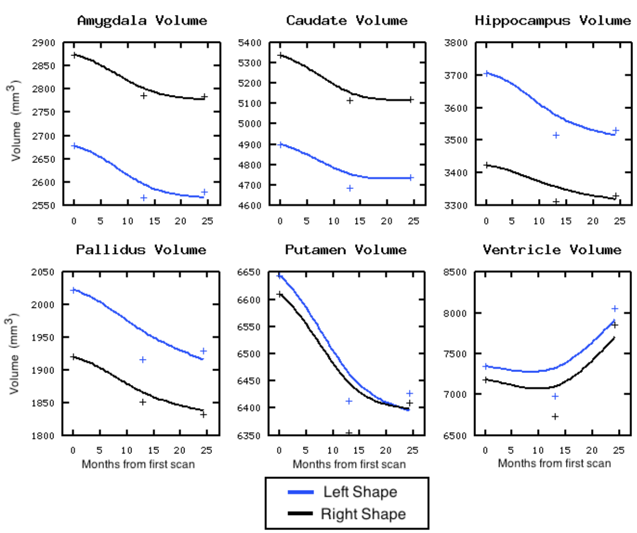
On going
- Globus
- Accumbens
- And more…

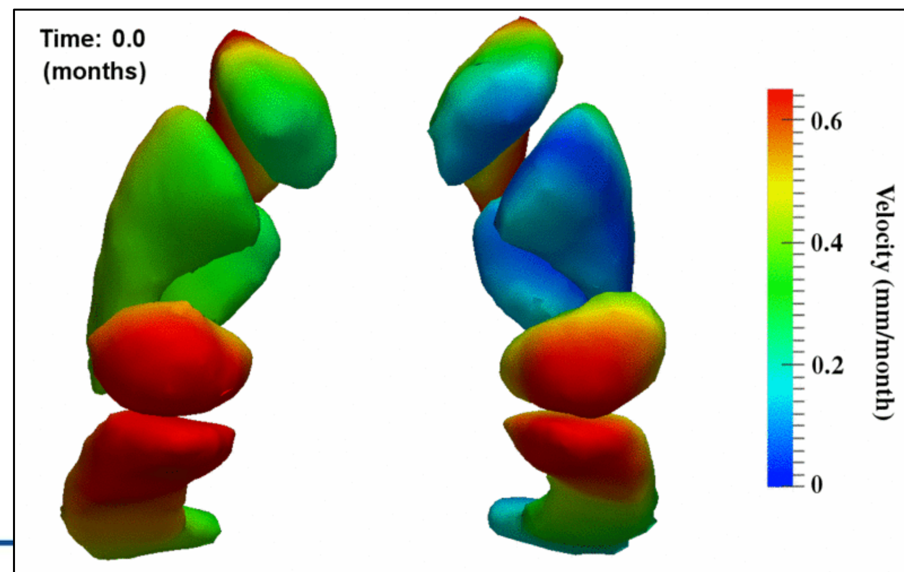


HD: Joint 4D modeling of subcortical structures from longitudinal MRI

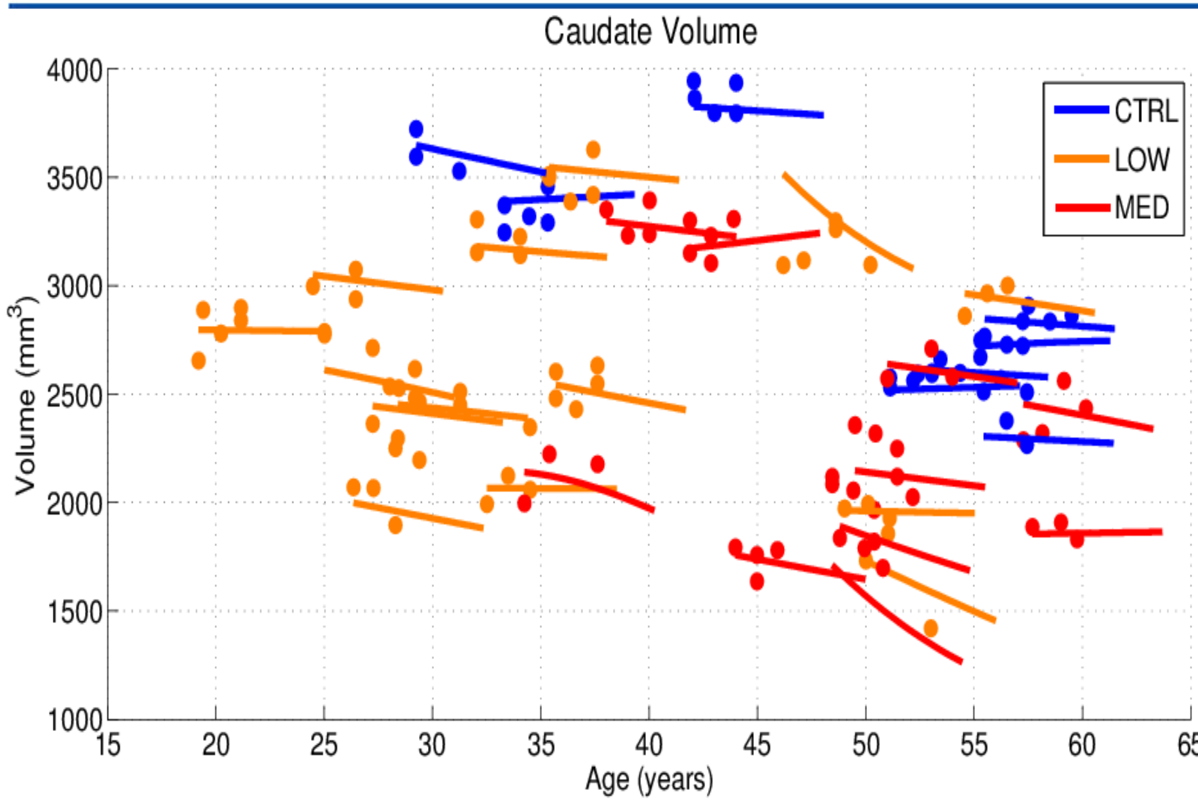


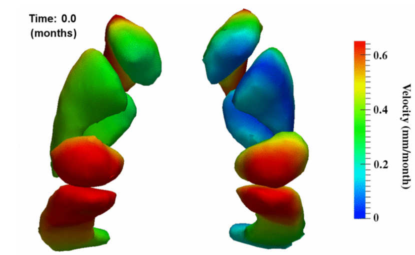






Personalized Shape Trajectory Modeling across Subjects

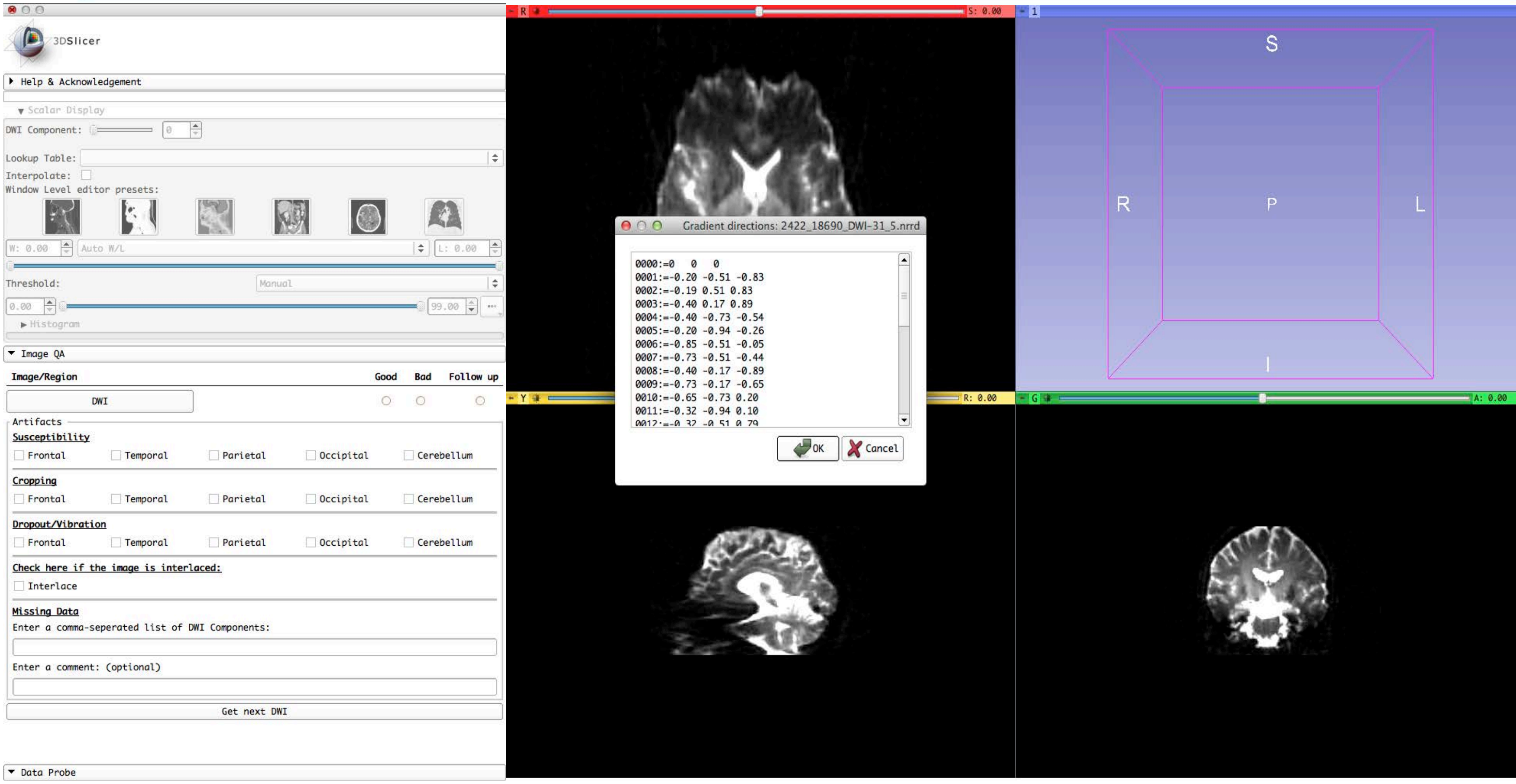




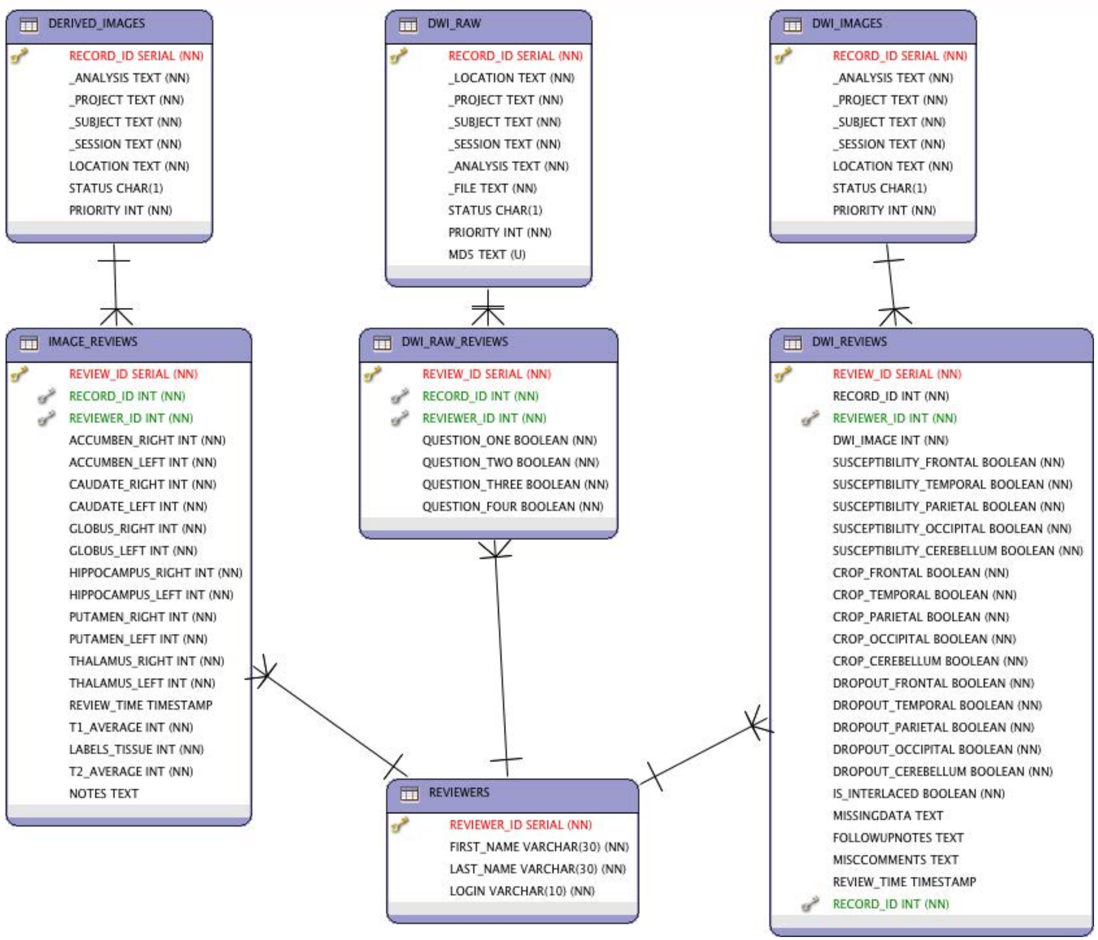
	PERCENT VOLUME CHANGE FROM SHAPE REGRESSION		
	CTRL	LOW	MED
CAUDATE	-0.78	-4.22	-6.25
PUTAMEN	-1.98	-6.76	-3.07
HIPPOCAMPUS	-0.65	-1.09	-2.17
THALAMUS	-0.74	-2.13	-1.18
ACUMBEN	-0.11	-2.13	-3.10
PALLIDUS	-3.11	-6.90	-7.07

Caudate volume for 32 subjects (3 time pts) extracted after shape regression. Observed volumes are shown as circles, which highlight the noise in segmentation.

Quality Assurance tools



Quality Assurance tools



Data Reports

	A	B	C	D	E	F
	project	subject	session	ICV_2088	l_caudate_1	r_caudate_1
	HDNI_001	015955315	015955315_20100803_30	1494658	829	
	HDNI_001	015955315	015955315_20090622_30	1498021	947	1
	HDNI_001	045416487	045416487_20110614_30	1413108	1714	1
	HDNI_001	045416487	045416487_20080522_30	1412544	1941	2
	HDNI_001	068044003	068044003_20090521_30	1770211	2580	2
	HDNI_001	068044003	068044003_20100628_30	1756838	2575	2
	HDNI_001	068044003	068044003_20080609_30	1746901	2729	2

dataset | data_dictionary | comments_scores | +

A	B	C	D	E	F
"column_descriptors_id"	"column_descriptors_descripti	"measurement_code_label"	"biological_region_label"	"experiment_label"	"tool_label"
cranial_csf_358		mm_3	cranial_csf	20130109_TrackOn_Results	BRAINSTools_20130109
r_hippocampus_162		mm_3	r_hippocampus	20130109_TrackOn_Results	BRAINSTools_20130109
ICV_20882		mm_3	ICV	20130109_TrackOn_Results	binaryBrainMask_20130401
r_caudate_134		mm_3	r_caudate	20130109_TrackOn_Results	BRAINSTools_20130109
l_thalamus_106		mm_3	l_thalamus	20130109_TrackOn_Results	BRAINSTools_20130109
l_globus_330		mm_3	l_globus	20130109_TrackOn_Results	BRAINSTools_20130109
cerebellar_white_matter_20938		mm_3	cerebellar_white_matter	20130109_TrackOn_Results	BRAINSTools_20130109

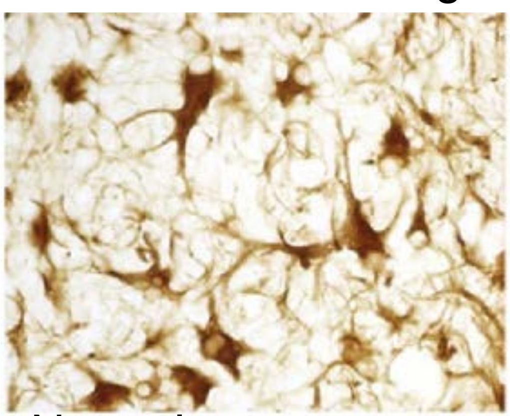
datas | data_dictionary | comments_scores | +

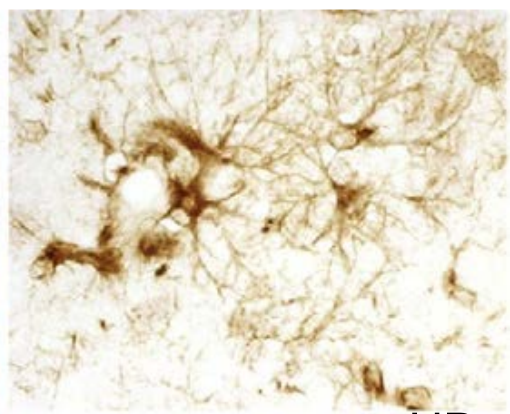
A	B	C	D	E	
project_label	subject_label	session_label	column_descriptors_id	scores	comm
HDNI_001	560216908	560216908_20090402_30	l_hippocampus_50	75	Visual in
HDNI_003	034032275	034032275_20121001_30	r_putamen_190	95	Visual in
HDNI_002	058773254	058773254_20080609_30	l_putamen_78	95	Visual in
HDNI_003	658092030	658092030_20080204_30	r_globus_302	95	Visual in
HDNI_003	867249739	867249739_20110427_30	l_thalamus_106	95	Visual in
HDNI_003	541359481	541359481_20080611_30	r_caudate_134	95	Visual in
HDNI_004	287905458	287905458_20120801_30	r_thalamus_218	95	Visual in

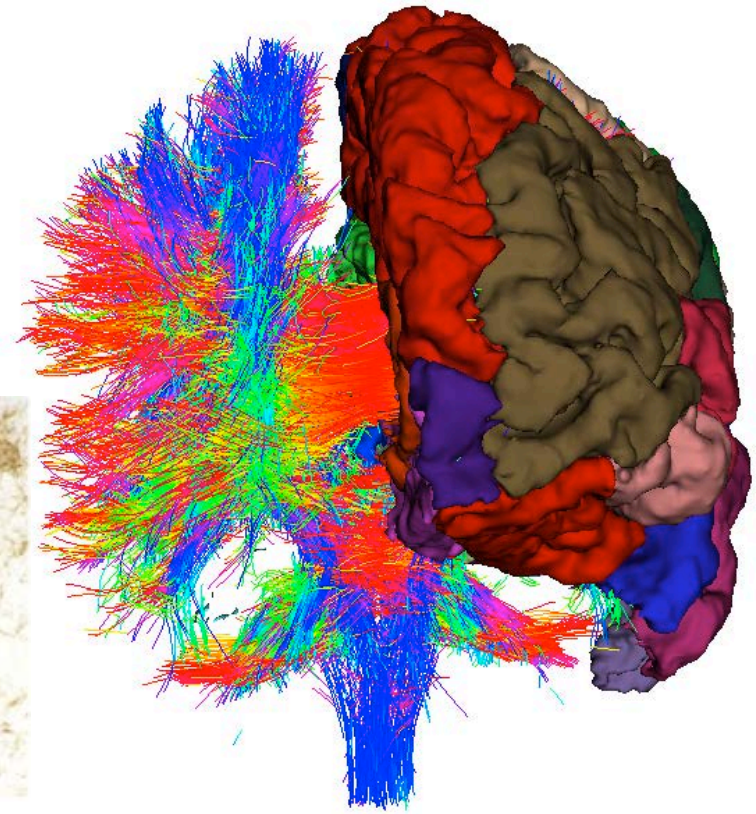
dataset | data_dictionary | comments_scores | +

Tractography

- It is clear that a more comprehensive approach is needed that could easily be extended as new questions arose. (i.e. support more exploration than direct a-priori interrogation)
- Van Camp 2012 Showed that loss of neurons can be measured by estimating “free-water” along tracks.







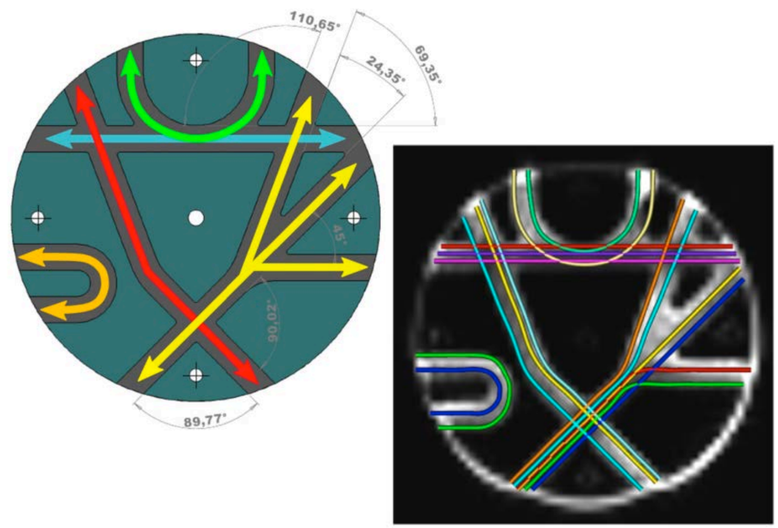
Normal HD

What is best tractography?

Quantitative evaluation of 10 tractography algorithms on a realistic diffusion MR phantom

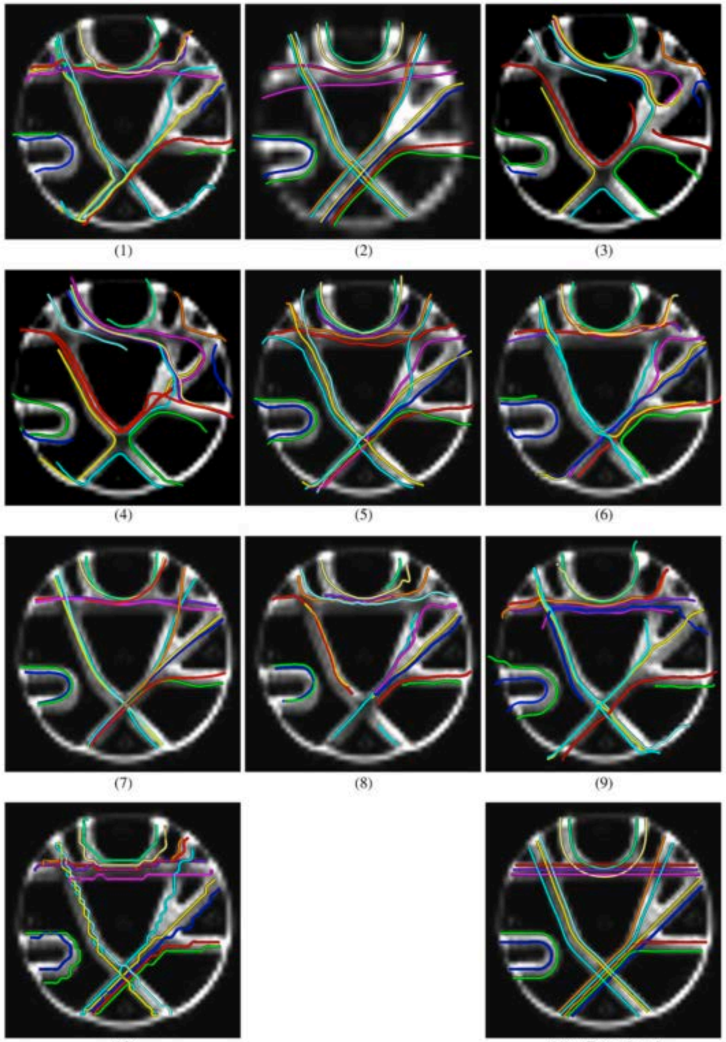
Pierre Fillard [a,b,*], Maxime Descoteaux [c], Alvina Goh [d], Sylvain Gouttard [e], Ben Jeurissen [f], James Malcolm [g], Alonso Ramirez-Manzanares [h], Marco Reisert [i], Ken Sakaie [j], Fatima Tensaouti [k], Ting Yo [l], Jean-François Mangin [b], Cyril Poupon [m]

[a] *Parietal Research Team, INRIA Saclay Île-de-France, Neurospin, France*
[b] *Laboratory of Computer-Assisted Neuro-Imaging, CEA Saclay, Neurospin, France*
[c] *MOIVRE Center, Computer Science Department, Université de Sherbrooke, Canada*
[d] *Department of Mathematics, National University of Singapore, Singapore*
[e] *Scientific Computing and Imaging Institute, University of Utah, USA*
[f] *IBBT-VisionLab, Department of Physics, University of Antwerp, Belgium*
[g] *Psychiatry Neuroimaging Laboratory, Brigham and Womens Hospital, Harvard Medical School, USA*
[h] *Mathematics Department, University of Guanajuato, Mexico*
[i] *Department of Radiology, Medical Physics, University Hospital Freiburg, Germany*
[j] *Imaging Institute, The Cleveland Clinic, Cleveland, USA*
[k] *National Institute for Medical Research, INSERM, U825, France*
[l] *Max Planck Institute for Human Cognitive and Brain Sciences, Germany*
[m] *Imaging and Spectroscopy Laboratory, CEA Saclay, Neurospin, France*



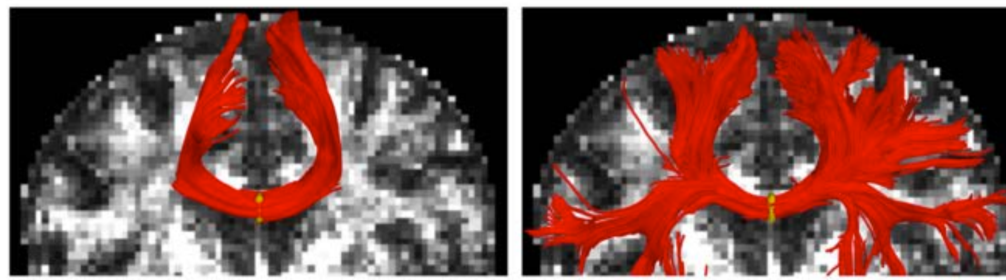
5	2-DT	Streamline tractography with filtered estimation of propagation direction	$3\times3\times3$, $b=1500$	The diffusion model estimation is guided by the previous propagation direction using unscented Kalman filtering.	(Malcolm et al., 2009; Malcolm et al., 2010)	3D Slicer	James Malcolm

From Publication To Clinical Application



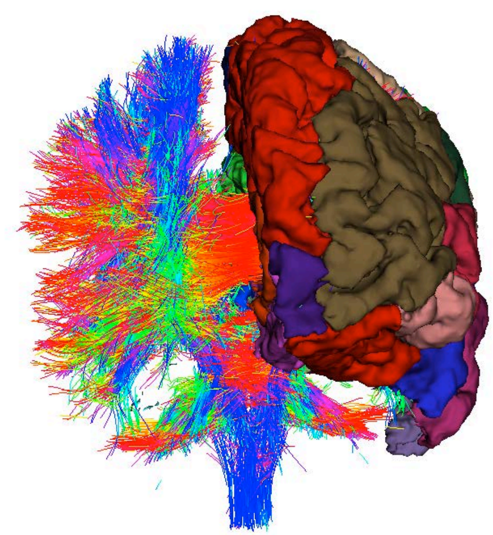
Filtered multi-tensor tractography

James G. Malcolm, **Martha E. Shenton**, and **Yogesh Rathi**
Psychiatry Neuroimaging Laboratory, Brigham and Womens Hospital, Harvard Medical School



(a) Single-tensor streamline (b) Filtered two-tensor

* We Choose the Unscented Kahlman Filter algorithm "UKFTractography"
* Improved speed and integration with Slicer

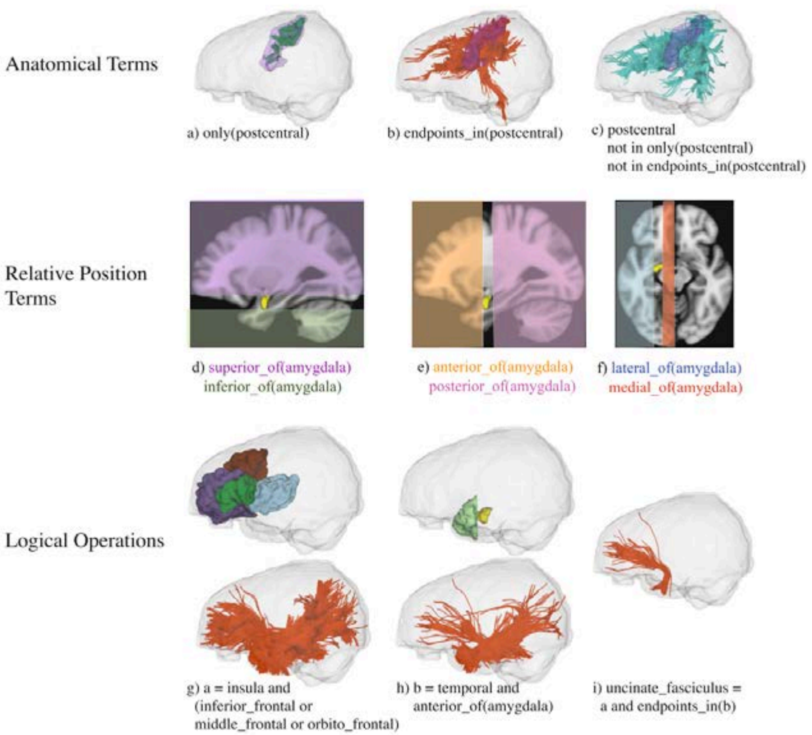


How to select tracts of interest?

- WMQL – White Matter Query Language

Table 1: Association Tract Definitions in WMQL: Cingulum bundle (CG); Extreme Capsule (EmC); and the fascicules: Superior Longitudinal (SLF) sections I to III; Arcuate (AF); Inferior occipito frontal (IOFF); Middle Longitudinal (MdLF); Uncinate (UF)

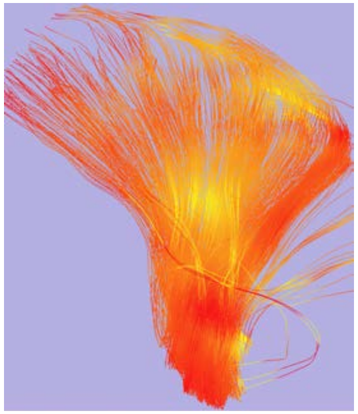
CB.side = only((cingular.**side or** cingular_cortex.**side**) **and** (middle_frontal.**side or** cuneus.**side or** entorhinal.**side or**superior_frontal.**side or** inferior_parietal.**side or** fusiform.**side or** medial_orbitofrontal.**side or** lateral_orbitofrontal.**side or** parahippocampal.**side or** precuneus.**side or** lingual.**side or** centrum_semiovale.**side**))
EmC.side = (**endpoints_in**(inferior_frontal.**side or** middle_frontal.**side**) **andendpoints_in**(inferior_parietal_lobule.**side**) **and**temporal.**side and** insula.**side**)**not in** hemisphere.**opposite**
SLF_I.side = (superior_parietal.**side and** precuneus.**side and** superior_frontal.**side**) **or**(superior_parietal.**side and** precuneus.**side and** superior_frontal.**side and** lateral_occipital.**side**) **not in** cingular.**side not in** temporal.**side not in** subcortical.**side not in** hemisphere.**opposite**
SLF_II.side =(inferior_parietal.**side or** supramarginal.**side or** lateral_occipital.**side**) **and endpoints_in**(middle_frontal.**side**)) **not in** temporal.**side not in** subcortical.**side not in** hemisphere.**opposite**
SLF_III.side = ((inferior_parietal.**side or** supramarginal.**side or** lateral_occipital.**side**) **and endpoints_in**(inferior_frontal.**side**)) **not in** temporal.**side not in** subcortical.**side not in** hemisphere.**opposite**
AF.side = (inferior_frontal.**side or** middle_frontal.**side or** precentral.**side**) **and** (superior_temporal.**side or** middle_temporal.**side**) **not in medial_of**(supramarginal.**side**)**not in** subcortical.**side not in** hemisphere.**opposite**
IOFF.side = (lateralorbitofrontal.**side and** occipital.**side**) **and** temporal.**side not in** subcortical.**side not in** cingular.**side not in** superior_parietal_lobule.**side not in** hemisphere.**opposite**
ILF.side = only(temporal.**side and** occipital.**side**) **and anterior_of**(hippocampus.**side**) **not in** parahippocampal.side

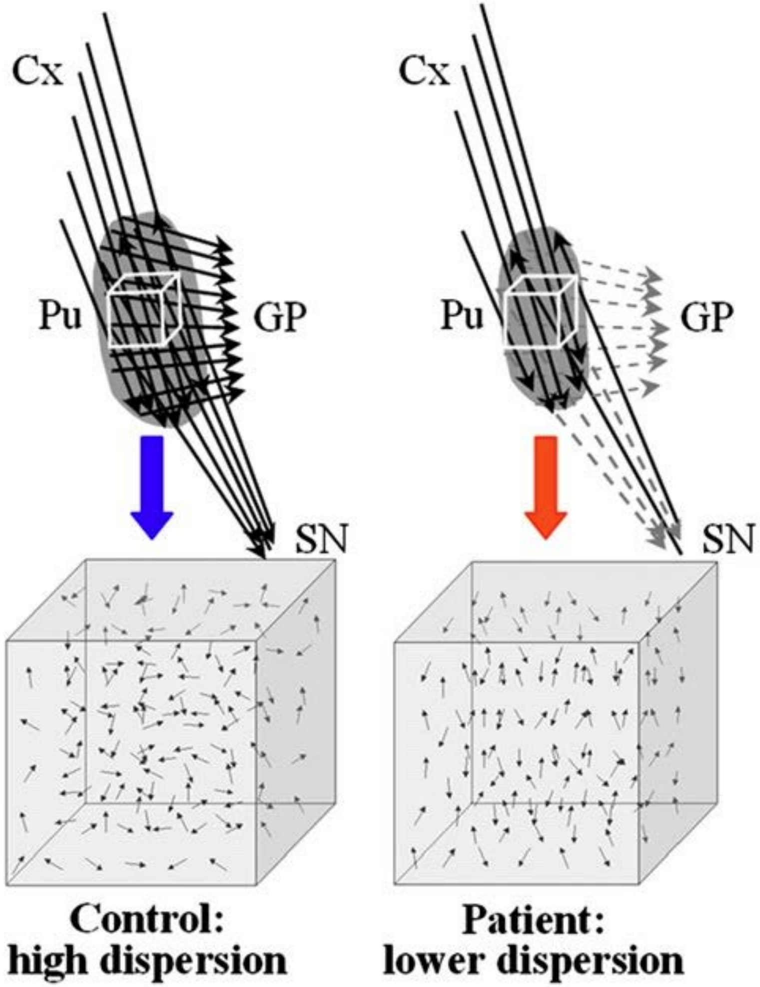


Dispersion is an important measure

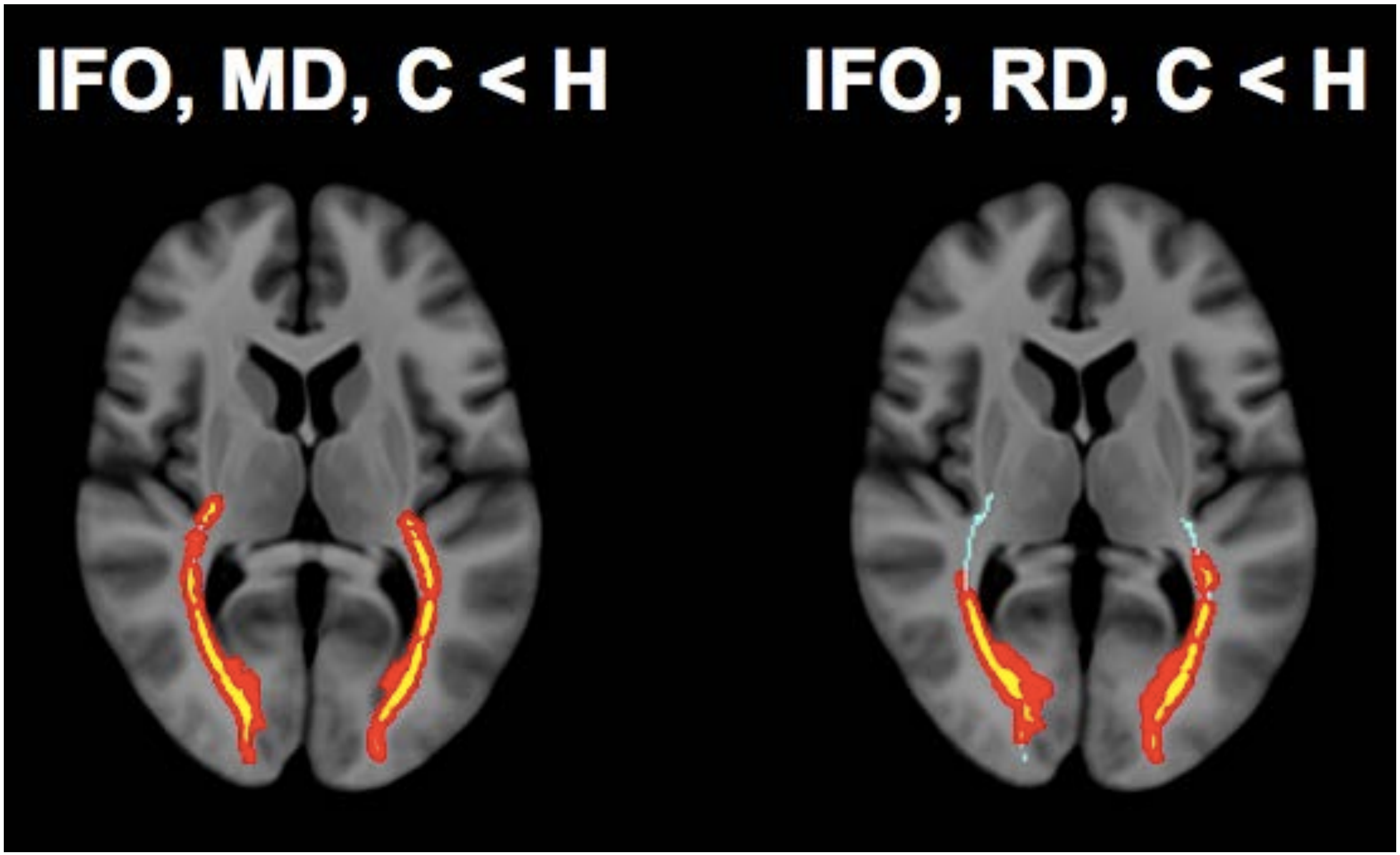
- **[Douaud09] describes the selective loss in fibers leading to lower dispersion in HD subjects (left).**
- **Need to translate methods that enable measurement of dispersion:** **A fiber tract connecting the substantia nigra in the brainstem to the striatum is colored by fiber dispersion [Savadjiev12].**

Working with Peter Savadjiev & Yogesh Rathi to transfer this methodology from prototype environment to production environment





Preliminary Longitudinal DWI Processing Results



Share the Knowledge!

frontiers in NEUROINFORMATICS

TECHNOLOGY REPORT ARTICLE
published: 09 January 2014
doi: 10.3389/fninf.2013.00051

UNC-Utah NA-MIC framework for DTI fiber tract analysis

Audrey R. Verde[1]*, Francois Budin[1], Jean-Baptiste Berger[1], Aditya Gupta[1,2], Mahshid Farzinfar[1], Adrien Kaiser[1], Mihye Ahn[3], Hans Johnson[4], Joy Matsui[4], Heather C. Hazlett[1], Anuja Sharma[5], Casey Goodlett[6], Yundi Shi[1], Sylvain Gouttard[5], Clement Vachet[1,5], Joseph Piven[1], Hongtu Zhu[3], Guido Gerig[5] and Martin Styner[1,7]

ELSEVIER
Psychiatry Research: Neuroimaging
Volume 214, Issue 3, 30 December 2013, Pages 389–394

Characterizing white matter health and organization in atherosclerotic vascular disease: A diffusion tensor imaging study

Kelly Rowe Bijanki[a], Stephan Arndt[a, f], Vincent A. Magnotta[a, b, e], Peg Nopoulos[a, c, d], Sergio Paradiso[a, g, i, j], Joy T. Matsui[a, e], Hans J. Johnson[a, e], David J. Moser[a]

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E.Y. Regina Kim[1,2], Hans J. Johnson[1,2] and Norman K. Williams[1]

Derivation of fiber tracts representing the corticospinal tract using anatomical landma…

Joy Matsui[1,2], Eun Young Kim[1], Vincent Magnotta[3,1], and Hans Joh…

[1] University of Iowa, Department of Psychiatry, Iowa City, IA, USA
[2] University of Hawaii, John A. Burns School of Medicine, Honolulu, H…
[3] University of Iowa, Department of Radiology, Iowa City, IA, US…

…cture Segmentation of Multi-m… …ificial Neural Netw…

…Kim[a,b,*] and Hans Johnson…

…402 Seamans Center for the E… …of Iowa, Iowa city, IA, USA 5… …awkins Drive, W278 GH, Iowa…

Frontiers in Neurosciences

25October 2013

Robust Multi-site MR Data Processing: Iterative Optimization of Bias Correction, Tissue Classification, and Registration

Eun Young Kim[1] and Hans J. Johnson[1,2*]
[1]University of Iowa, Biomedical Engineering Dept., Iowa…
[2]University of Iowa Hospital and Clinic, Psychiatry, Iowa…
Correspondence*:
…esponding Author
…s J. Johnson, hans-johnson@uiowa.edu

Predictors of phenotypic progression … premanifest and early-stage Huntington's disea… TRACK-HD study: analysis of 36-month observational da…

Striatal and white matter predictors of estimated diagnosis for Huntington disease

Jane S. Paulsen[a,d,*], Peggy C. Nopoulos[a,b,1], Elizabeth Aylward[f,2], Christopher A. Ross[g,h,i,3], Andrew Juhl[a,6], Ronald K. Pierson[a,7], James Mills[a,8], Vincent A. Magnotta[c,5], … the PREDICT-HD Investigators and Coordinators of…

Regionally Selective Atrophy of Subcortical Structures in Prodromal HD as Revealed by Statistical Shape Analysis

Laurent Younes,[1] J. Tilak Ratnanather,[2] Timothy Brown,[3] Elizabeth Aylward,[4] Peg Nopoulos,[5] Hans Johnson,[5] Vincent A. Magnotta,[5] Jane S. Paulsen,[5*] Russell L. Margolis,[6] Roger L. Albin,[7] Michael I. Miller,[8] Christopher A. Ross[9] and the PREDICT-D Investigators and Coordinators of the Huntington Study Group

Clinical Impairment in Premanifest and Early Huntington's Disease is Associated with Regionally Specific Atrophy

Rachael I. Scahill,[1*] Nicola Z. Hobbs,[1] Miranda J. Say,[1] Natalie Bechtel,[2] Susie M.D. Henley,[1] Harpreet Hyare,[3] Douglas R. Langbehn,[4] Rebecca Jones,[5] Blair R. Leavitt,[6] Raymund A.C. Roos,[7] Alexandra Durr,[8] Hans Johnson,[4] Stéphane Lehéricy,[8] David Craufurd,[9] Christopher Kennard,[10] Stephen L. Hicks,[10] Julie C. Stout,[11] Ralf Reilmann,[2] Sarah J. Tabrizi[1] and the TRACK-HD investigators

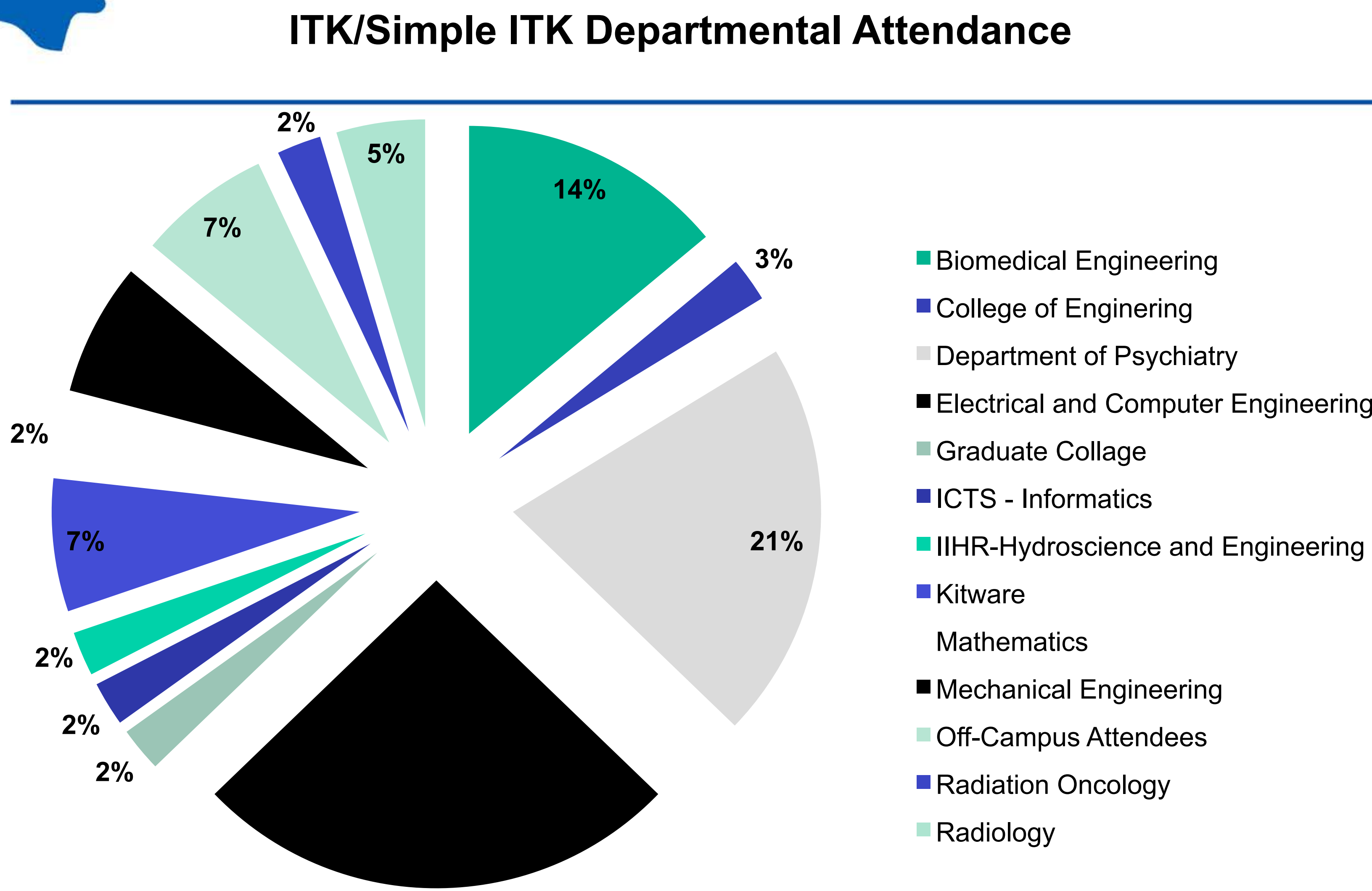
Longitudinal change in regional brain volumes in prodromal Huntington disease

Elizabeth H Aylward,[1] Peggy C Nopoulos,[2] Christopher A Ross,[3] Douglas R Langbehn,[2] Ronald K Pierson,[2] James A Mills,[2] Hans J Johnson,[2] Vincent A Magnotta,[2] Andrew R Juhl,[2] Jane S Paulsen,[2] the PREDICT-HD Investigators and Co…, the Huntington Study Group

Biological and clinical changes in premanifest and early …tage Huntington's disease in the TRACK-HD study: …clinical analysis

And Many Under…

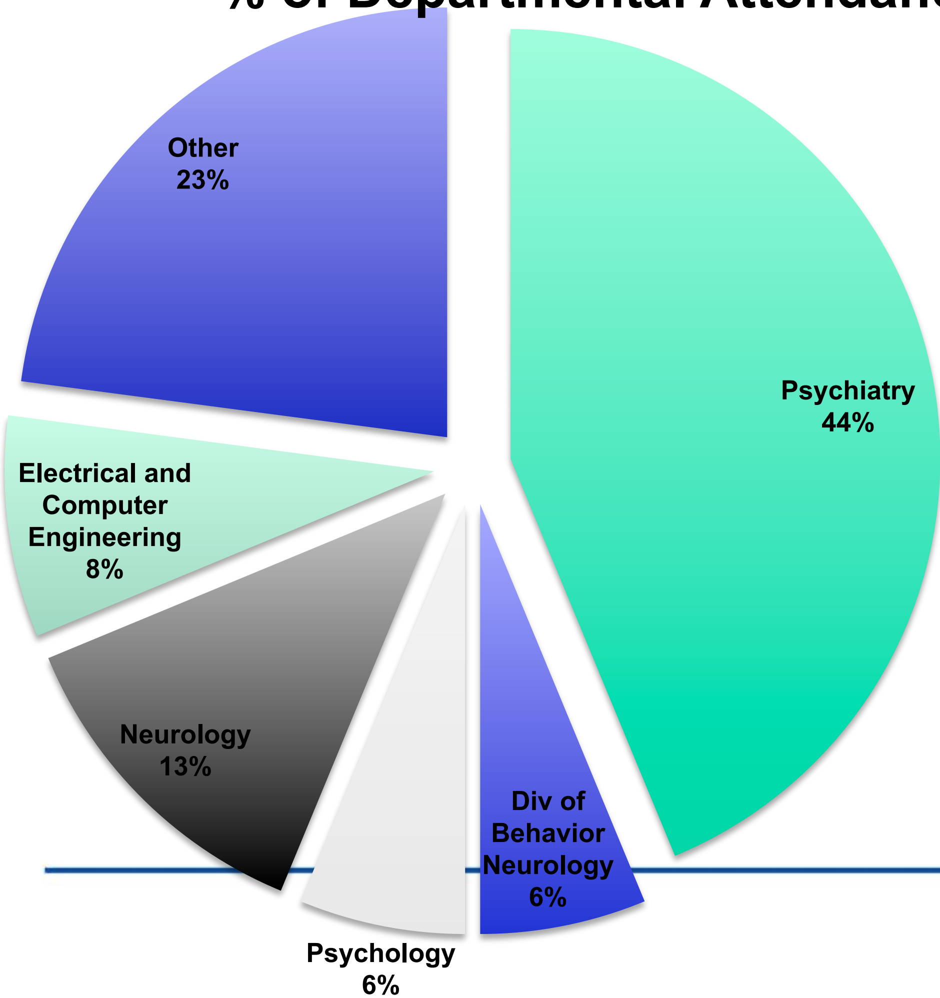
ITK/Simple ITK



BRAINSCamp 2013

NA-MIC
National Alliance for Medical Image Computing
http://www.na-mic.org

% of Departmental Attendance

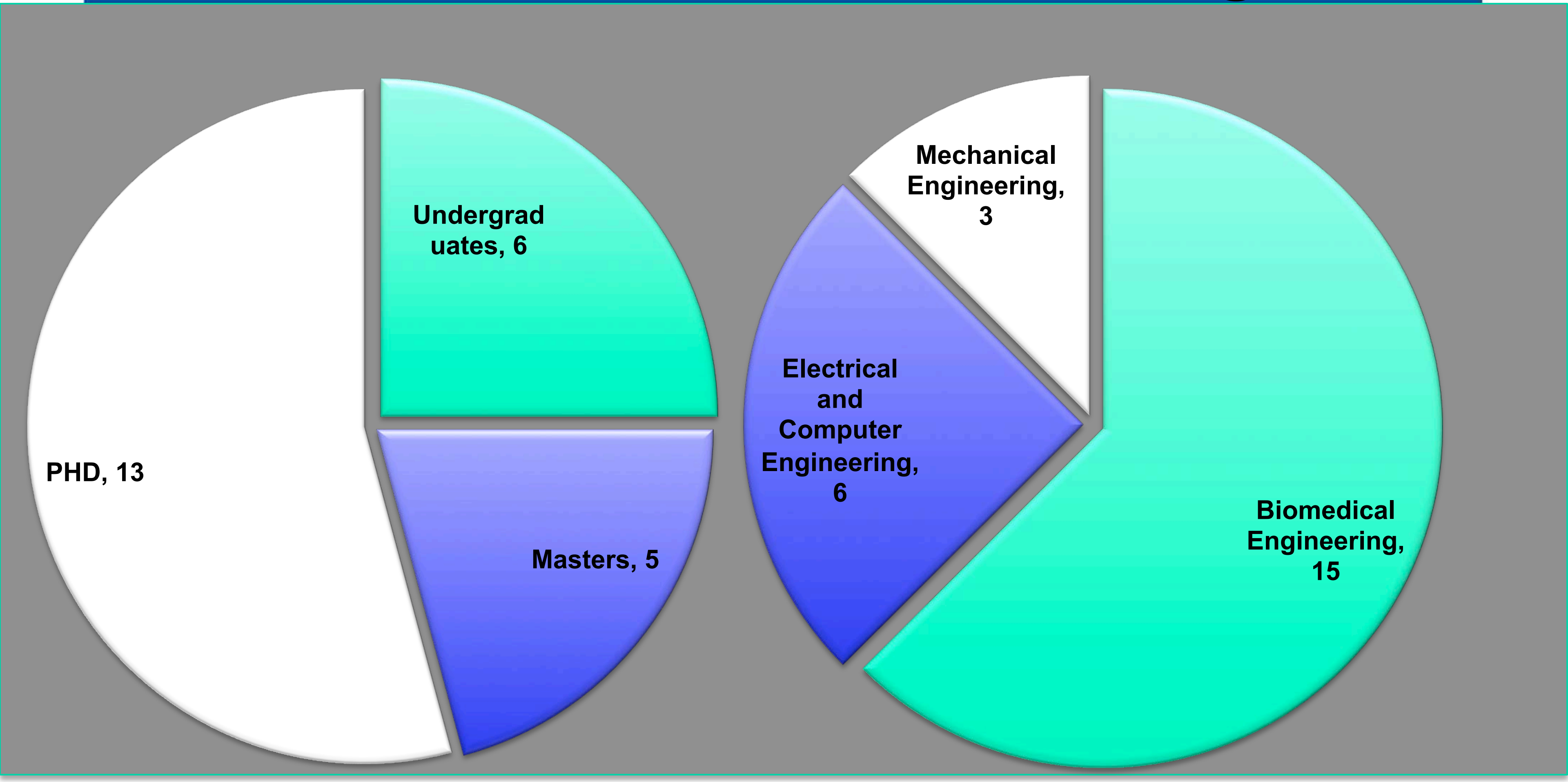


41 Attendees

4.

#	Answer	Bar
1	Very Unlikely	
2	Unlikely	
3	Undecided	
4	Likely	
5	Very Likely	
	Total	

Medical Image Processing Course
24 New "NA-MIC Certified" Engineers



Specific Aims

- Perform individualized longitudinal shape change quantification from multi-modal data. (DONE!)
- Complete full brain Diffusion Tensor Imaging tractography analysis. (DONE!)
- Deploy extensible tools for sharing source data, derived data, algorithms and methods to multi-site analysis teams. (DONE!)

Funded HD-Projects Using NAMIC DWI Processing Tools

- (CHDI) TRACK-HD/TRACK-ON (Private Foundation)
- (R01 NS040068 12S1) PREDICT-HD
  - (U01 NS082083) *Functional Connectivity in Pre-manifest HD* (Stephen Rao, Cleveland Clinic)
  - (U01 NS082085) *Study of Basal Ganglia Shape Analysis and Circuitry* (Michael Miller & Chris Ross, JHU)
  - (U01 NS082086) *4D Shape Analysis for Modeling Spatiotemporal Change Trajectories in Huntington's* (Guido Gehrig, Utah)
  - (U01 NS083223) *Characterization of White Matter in HD Using Diffusion MRI* (CF Westin, Harvard)
  - (U01 NS082074) *Imaging and Genetics in Huntington's Disease* (Jessica Turner & Vincent Calhoun, MIND Institute)
- (U54 EB005149) DBP-National Alliance For Medical Image Computing

Thank You!

- Questions?