NCBC Collaboration
1 R01 EB008171-01A1
3D Shape Analysis for Computational Anatomy

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Computational Functional Anatomy is the study of structure and function of populations in anatomical coordinates.

One thing that is hard is that Anatomical coordinates are curved.

We compute statistics using Gaussian random fields on the response variables and complete orthonormal bases indexed over the anatomical coordinates.
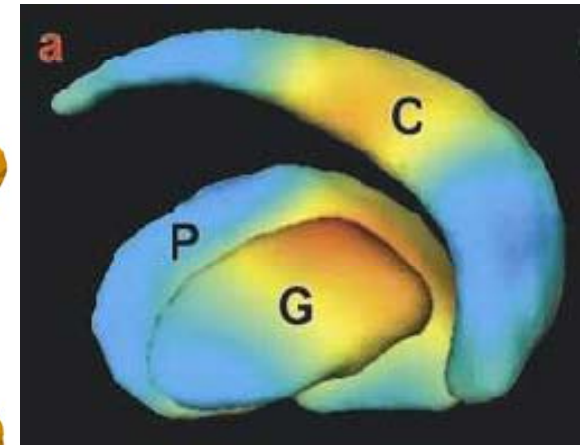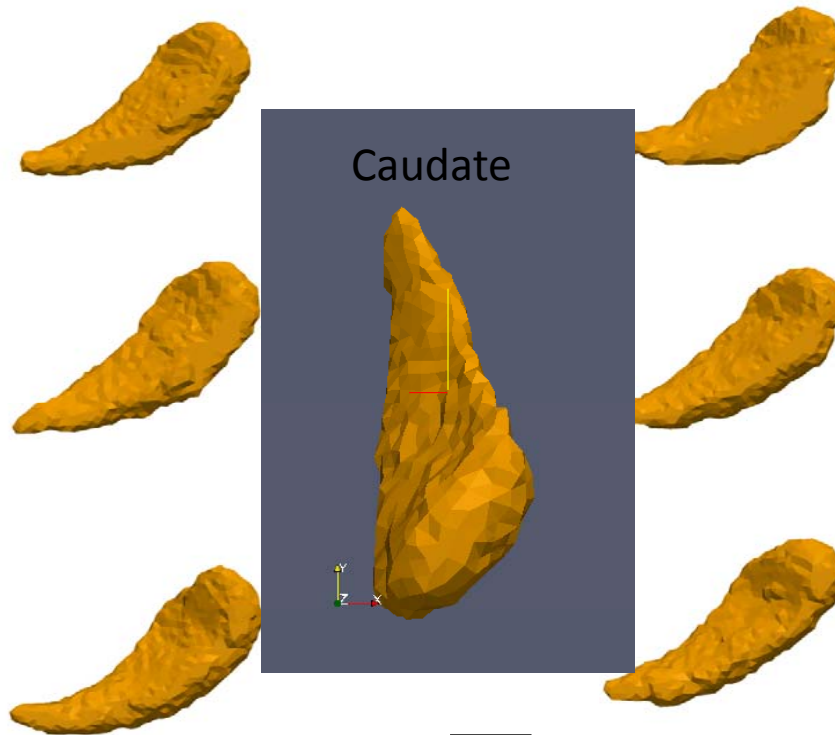
The Statistical Paradigm

MRI Target

Template

Caudate Template Injected into Targets

Caudate

Shape Encoded on Template Surface Structures via Random Field Models
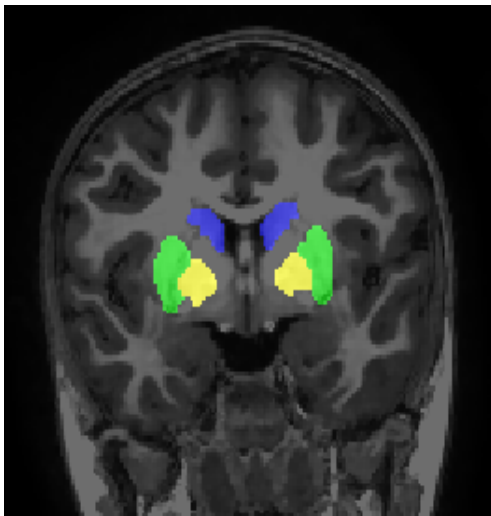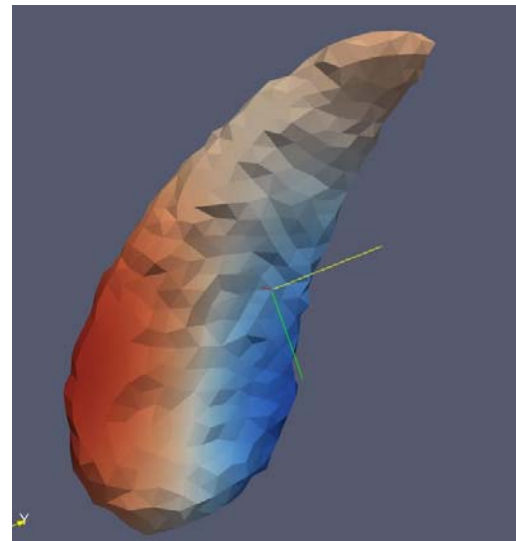
caudate
hippocampus
pallidus
putamen
thalamus
ventricle

$$F = \sum_k \underbrace{F_k}_{\substack{\text{structure-function} \\ \text{response-variables}}} \quad \underbrace{\phi_k}_{\substack{\text{Laplace-Beltrami or} \\ \text{PCA Basis}}}$$
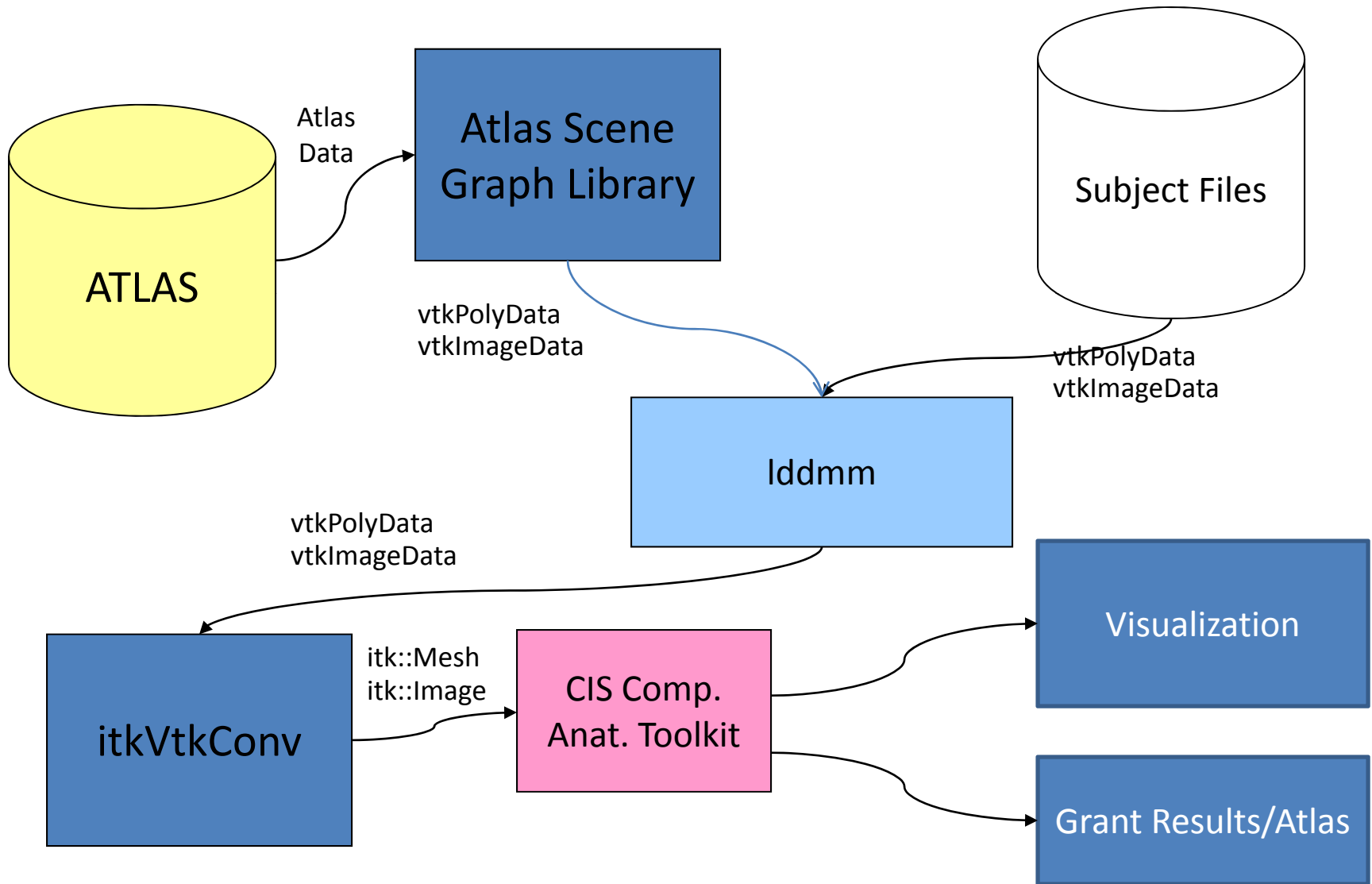
Laplace-Beltrami Operator Orthonormal Base
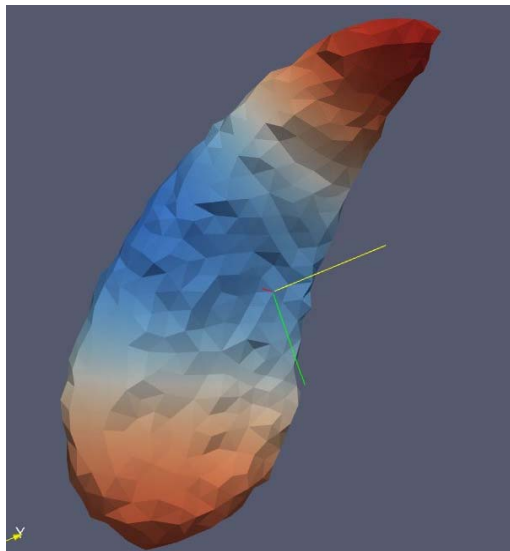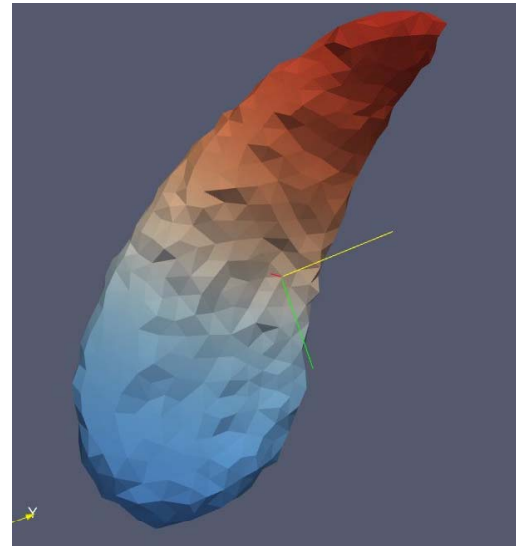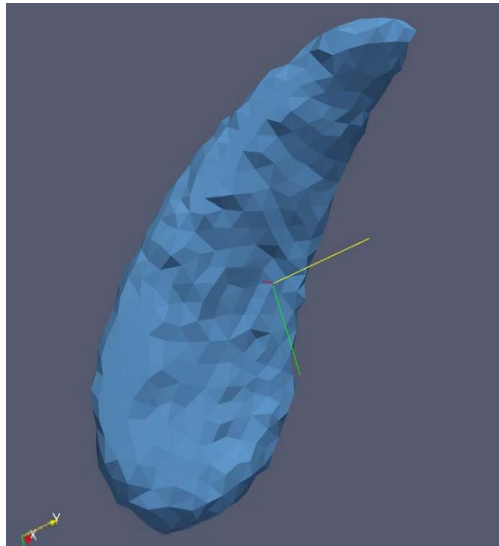
Computational Anatomy Analysis Toolkit

CIS Contribution to ITK

Years 1&2

- Laplace Beltrami
- PCA

NCBC Pipeline Data Flow

CA Analysis Example cont.: Laplace-Beltrami Operator

- Implement as itk::QuadEdgeMeshToQuadEdgeMeshFilter

- Eventually add to itk:: under BasicFilters

- Use existing itk and vnl functions (i.e., no new dependencies such as ARPACK)

- Add capability for closed and open surfaces

- Add capability for PCA base

The CFA Program: Calculate Bijections Between Anatomical Coordinate Systems
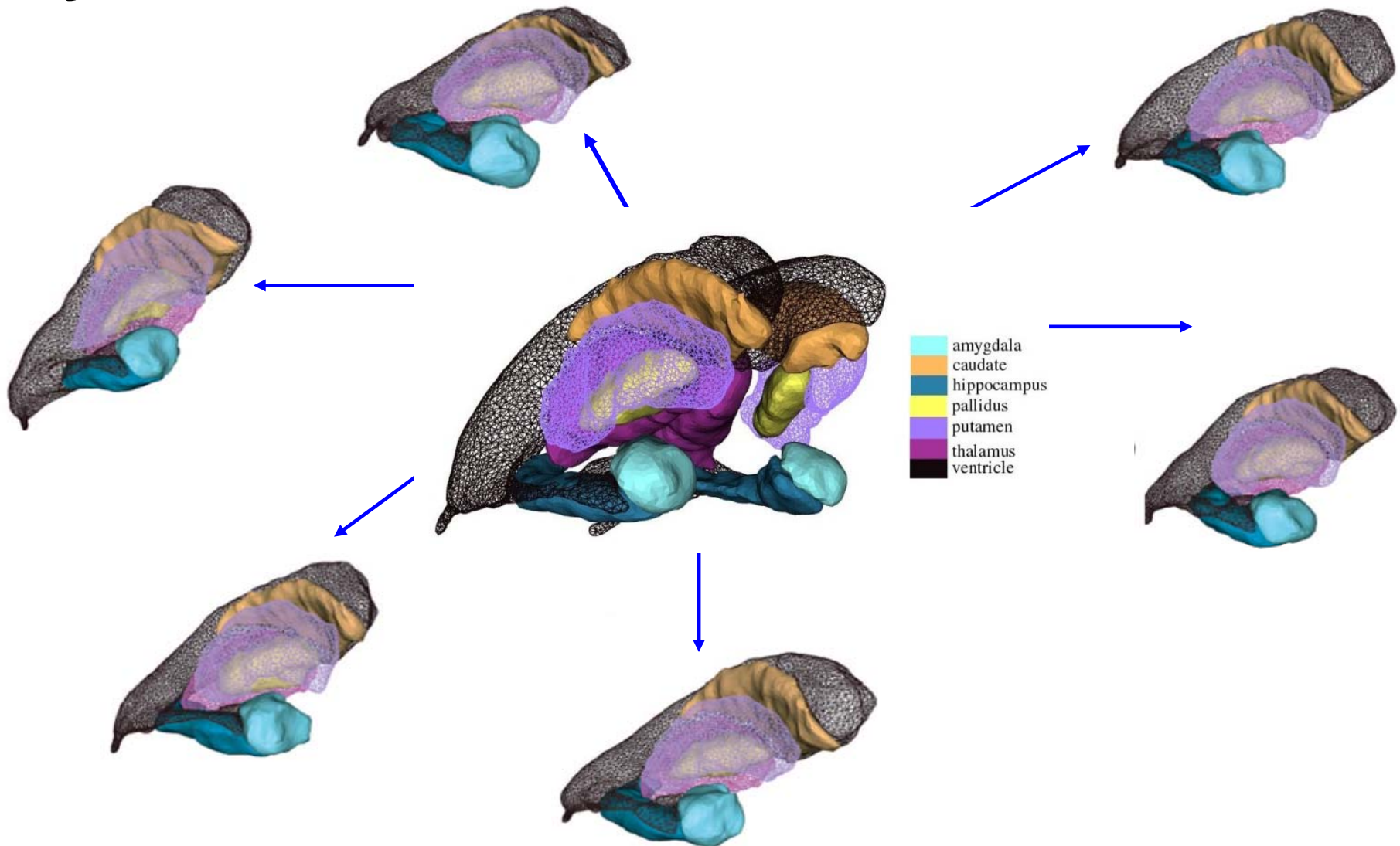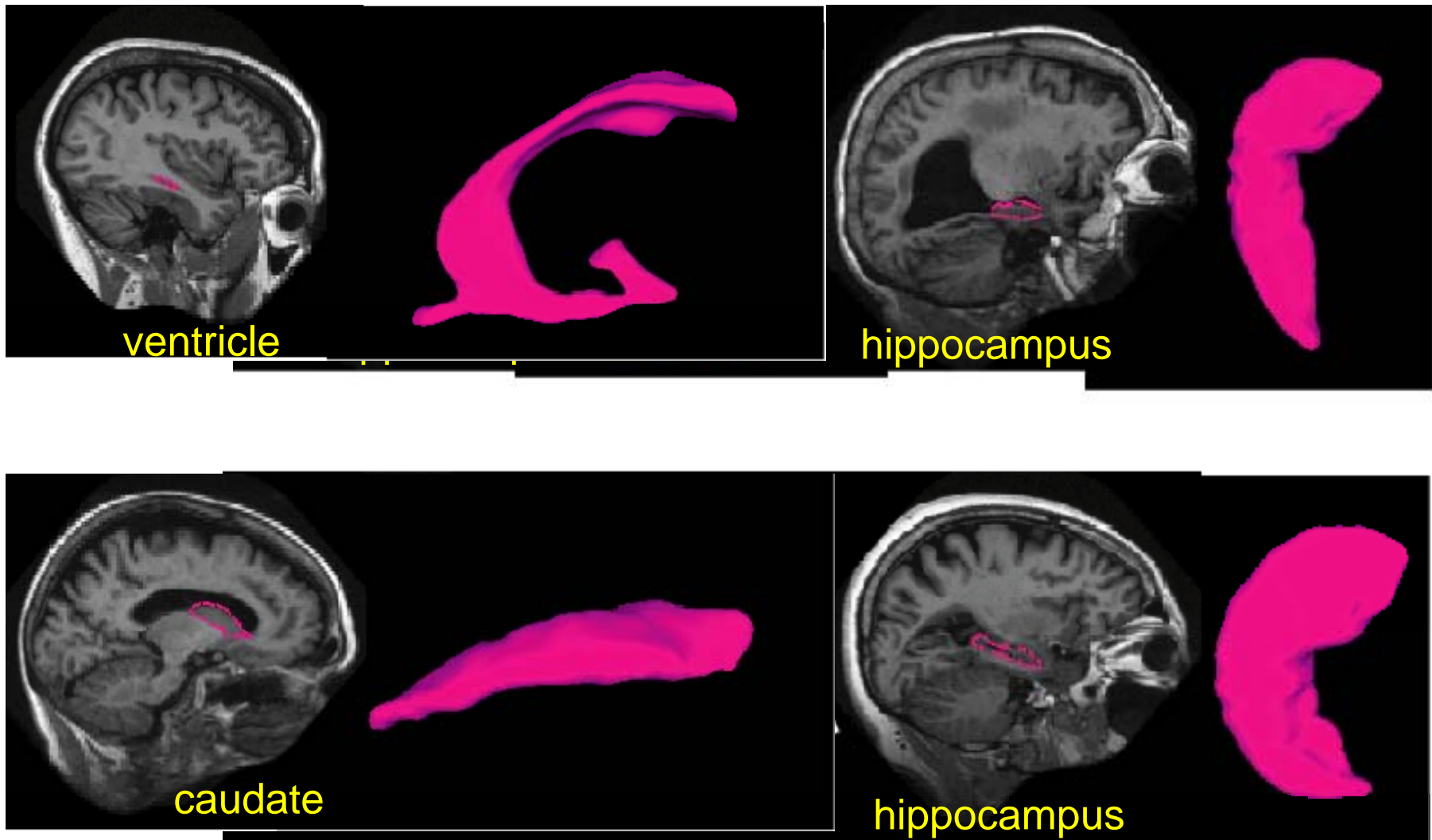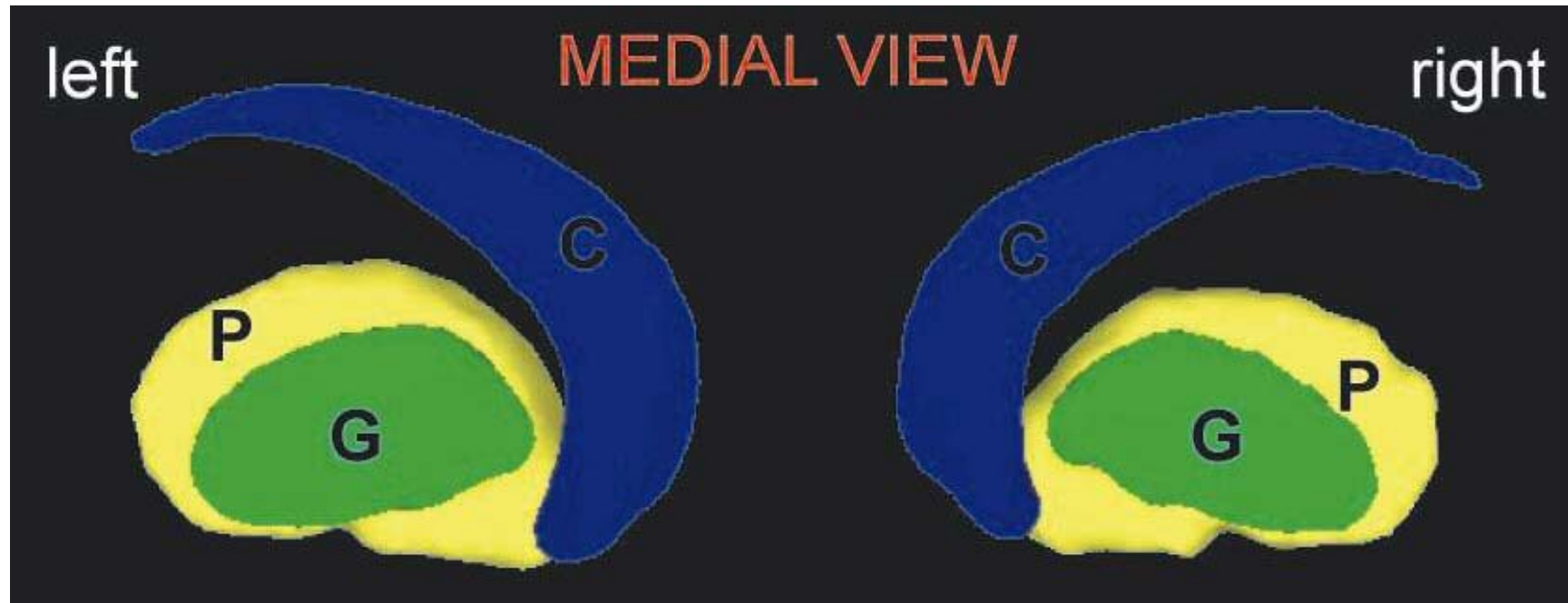
Surface Harmonics

Amygdala

Hippocampus
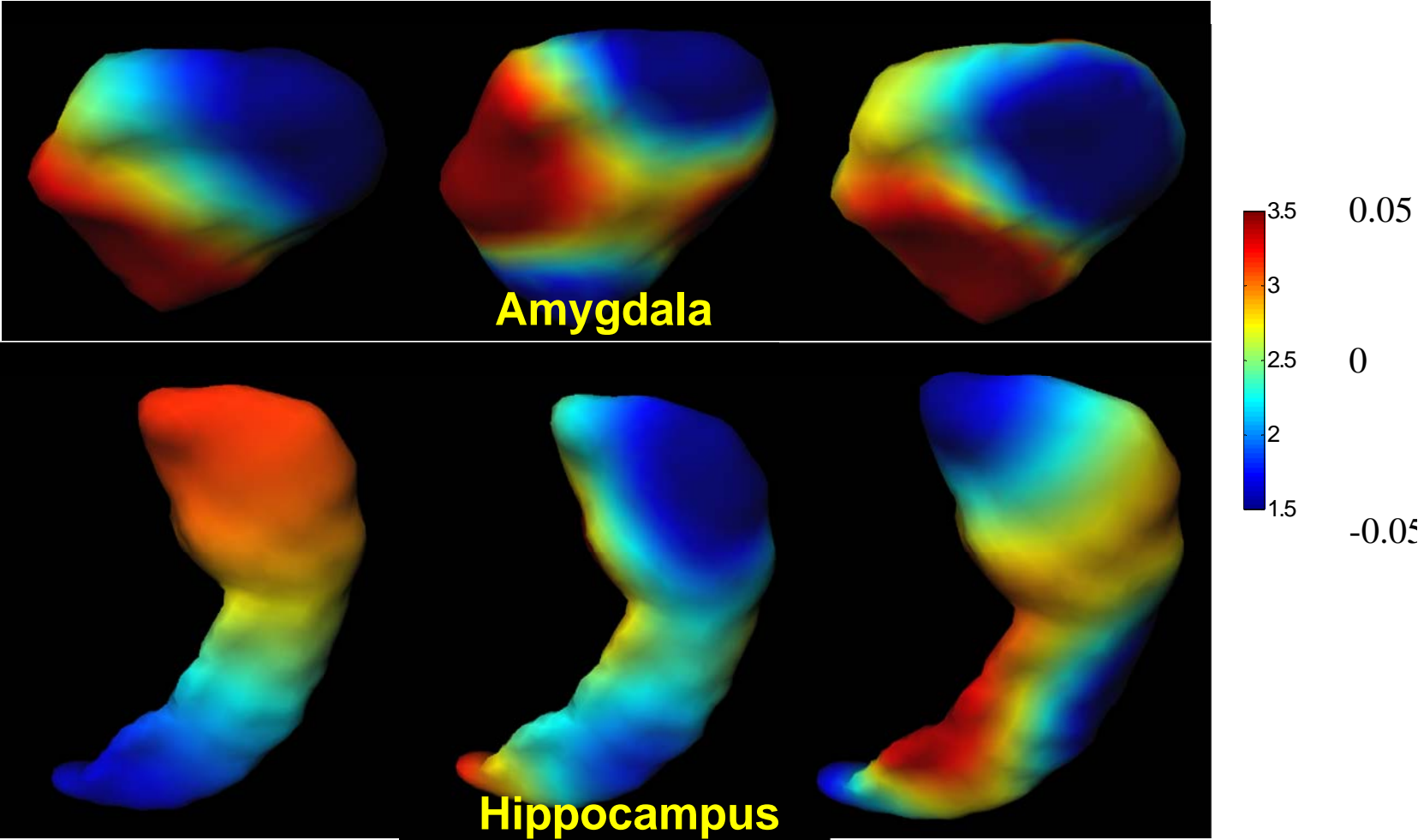
LB Basis 1　　　**LB Basis 2**　　　**LB Basis 3**

Template Injection into Populations

ventricle

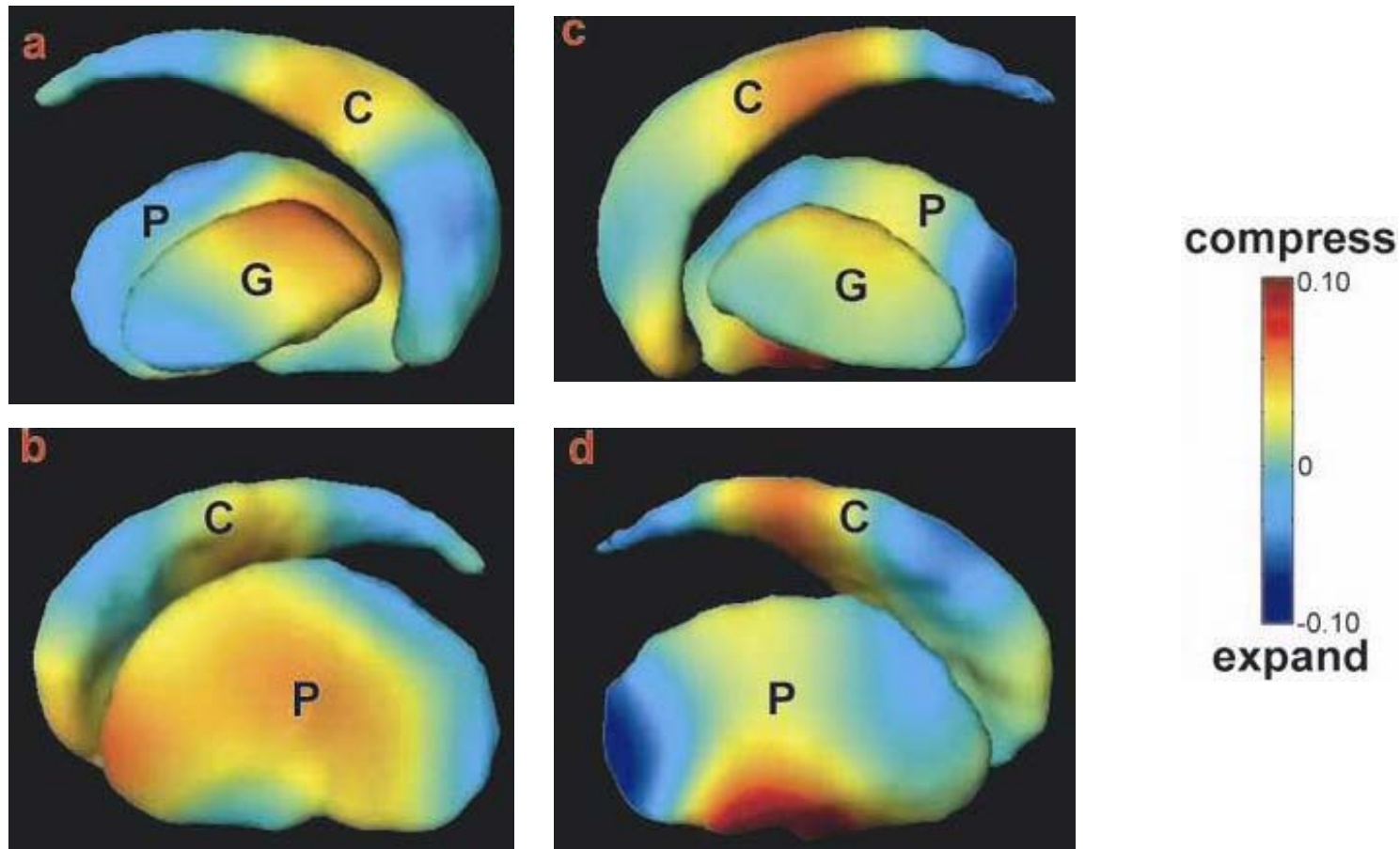hippocampus

caudate

hippocampus

Qiu, Miller "Multi-Structure Network Shape Analysis via Normal Momentum Maps", NeuroImage, 2008.

Left and right templates of the basal ganglia in the medial view. The caudate (C), putamen (P), and globus pallidus (G) are respectively represented in blue, yellow, and green
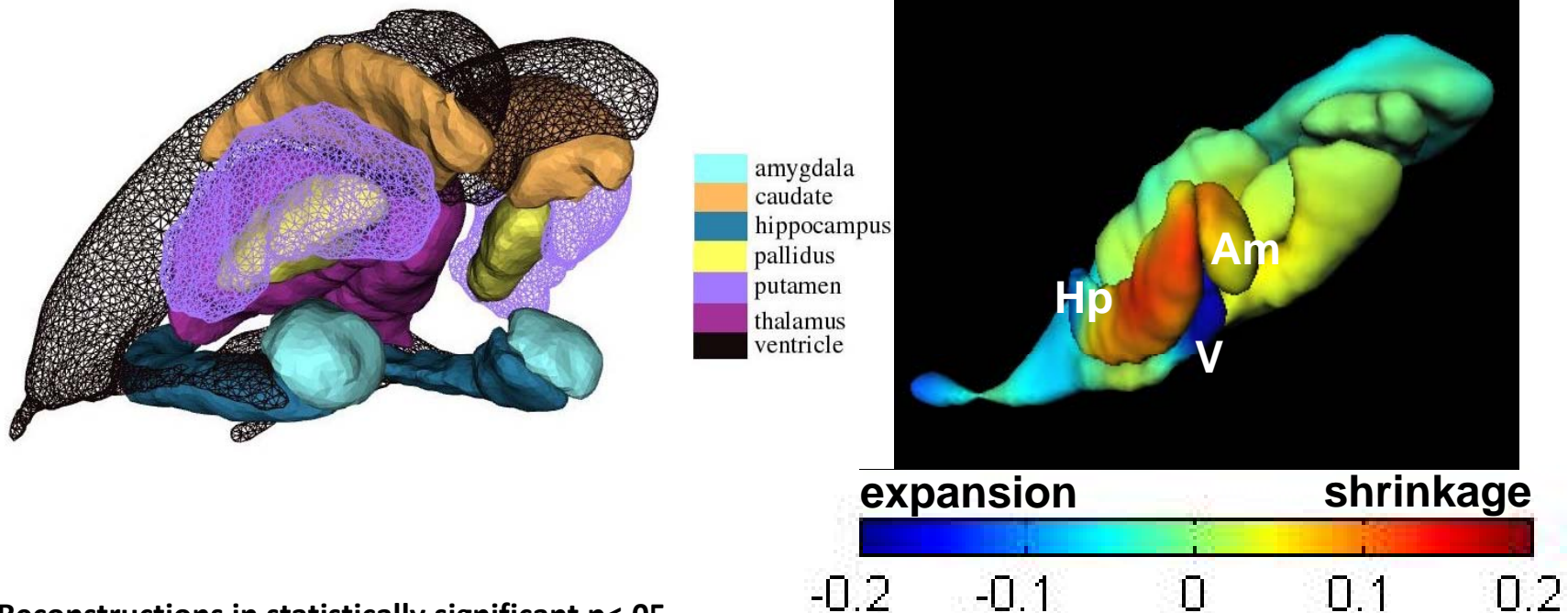
Diagnostic effects within boys

Qui A, Crocetti D, Adler M, Mahone EM, Denckla M, Miller MI, Mostofsky SH
(2009) Basal Ganglia Volume and Shape in Children With Attention Deficit
Hyperactivity Disorder. Am. J. Psychiatry. 166: 74-82.
http://dx.doi.org/10.1176/appi.ajp.2008.08030426

Subcortical Shape Analysis in Dementia

Groups	N	gender		age (mean±SD)
		male	female	
control	133	71	62	75.8±4.90
MCI	170	119	51	74.6±7.39
AD	80	49	31	75.2±7.62

CON vs. AD

amygdala
caudate
hippocampus
pallidus
putamen
thalamus
ventricle

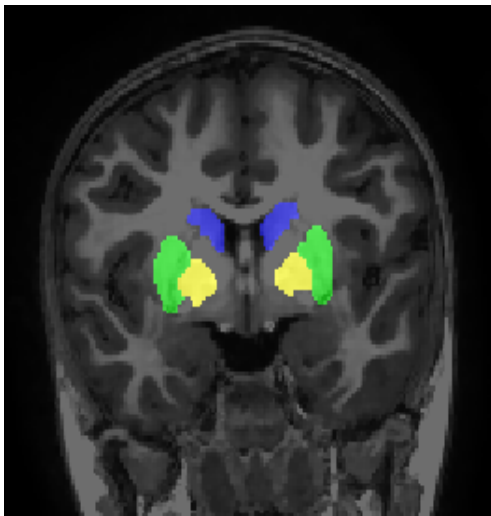expansion   shrinkage

-0.2   -0.1   0   0.1   0.2

Reconstructions in statistically significant p<.05

Anqi Qiu Christine Fennema Notestine, Anders M. Dale, Michael I. Miller, and the Alzheimer's Disease Neuroimaging Initiative, "Regional Subcortical Shape Abnormalities in Mild Cognitive Impairment and Alzheimer's Disease ", NeuroImage,45:656-661, 2009
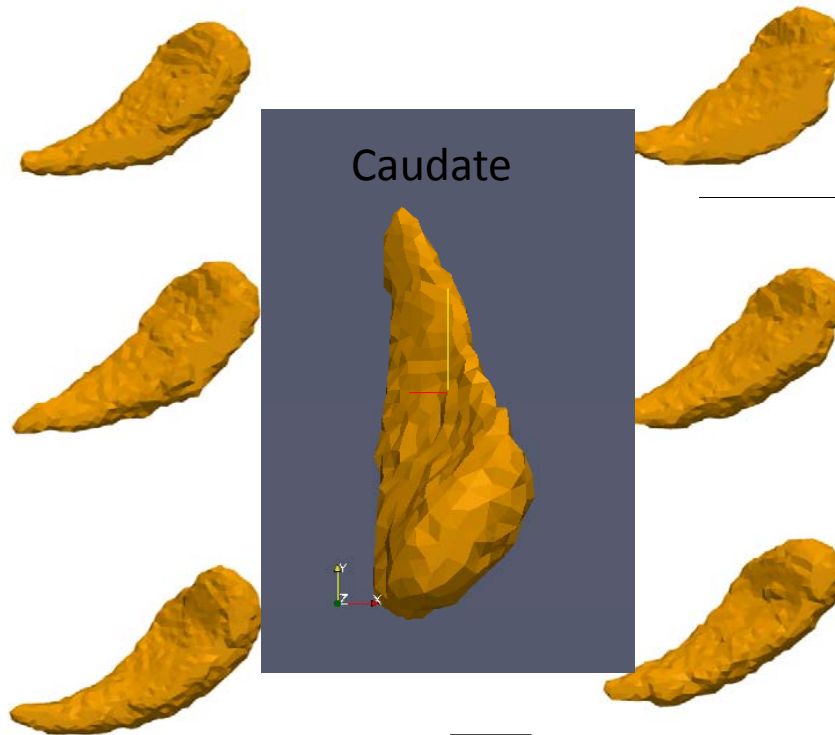
The ROI Statistical Paradigm

Caudate Template Injected into Targets

Shape Encoded on Template Surface Structures via Random Field Models

MRI Target

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Caudate

$$F = \sum_k F_k \quad \phi_k$$

structure-function
response-variables

Laplace-Beltrami or
PCA Basis