Qdec:

A group-analysis tool for Freesurfer

Nick Schmansky
nicks@nmr.mgh.harvard.edu
Martinos Center for Biomedical Imaging
Massachusetts General Hospital

What is Qdec?

- An application included in the FreeSurfer software package used to conduct a group analysis of morphometric and other types of data
- Graphical User Interface (GUI)
- Powered by a GLM-fitter
- Optimized for display of results on the cortical surface

What problem does it solve?

- There is an ever-growing collection of subjects processable by Freesurfer's 'recon-all' stream: eg. 400+ OASIS subjects, 300+ ADNI subjects, 1000+ FHS subjects

- Researchers need a GUI tool to allow easy exploration of the morphometric data found in this and other subject groups

Explore data correlations

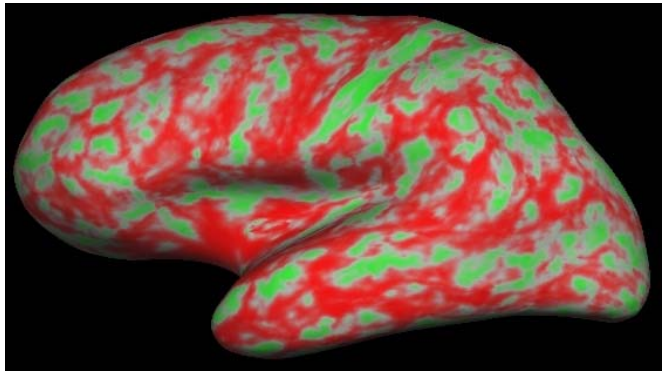
- Does subject age correlate with cortical thickness?
- Does hippocampal volume correlate with cortical thickness in a particular region?
- Is there a gender-diagnosis interaction in the thickness-age correlation?

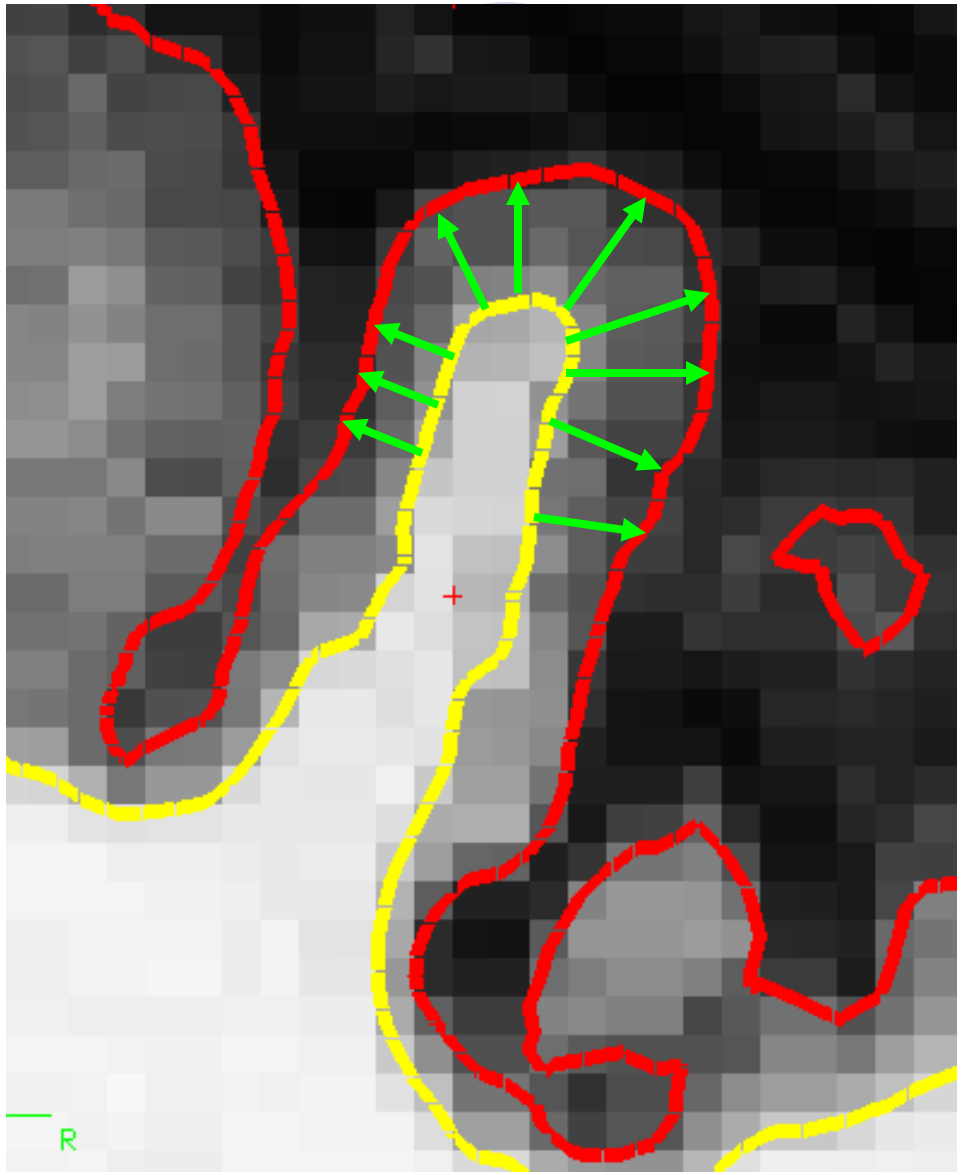
What is FreeSurfer?

- Cortical reconstruction and subcortical segmentation of T1 MRI images (single subject)
- Morphometric data: cortical thickness, subcortical structure volume
- Surface-based registration: alignment to another subject’s cortical folds

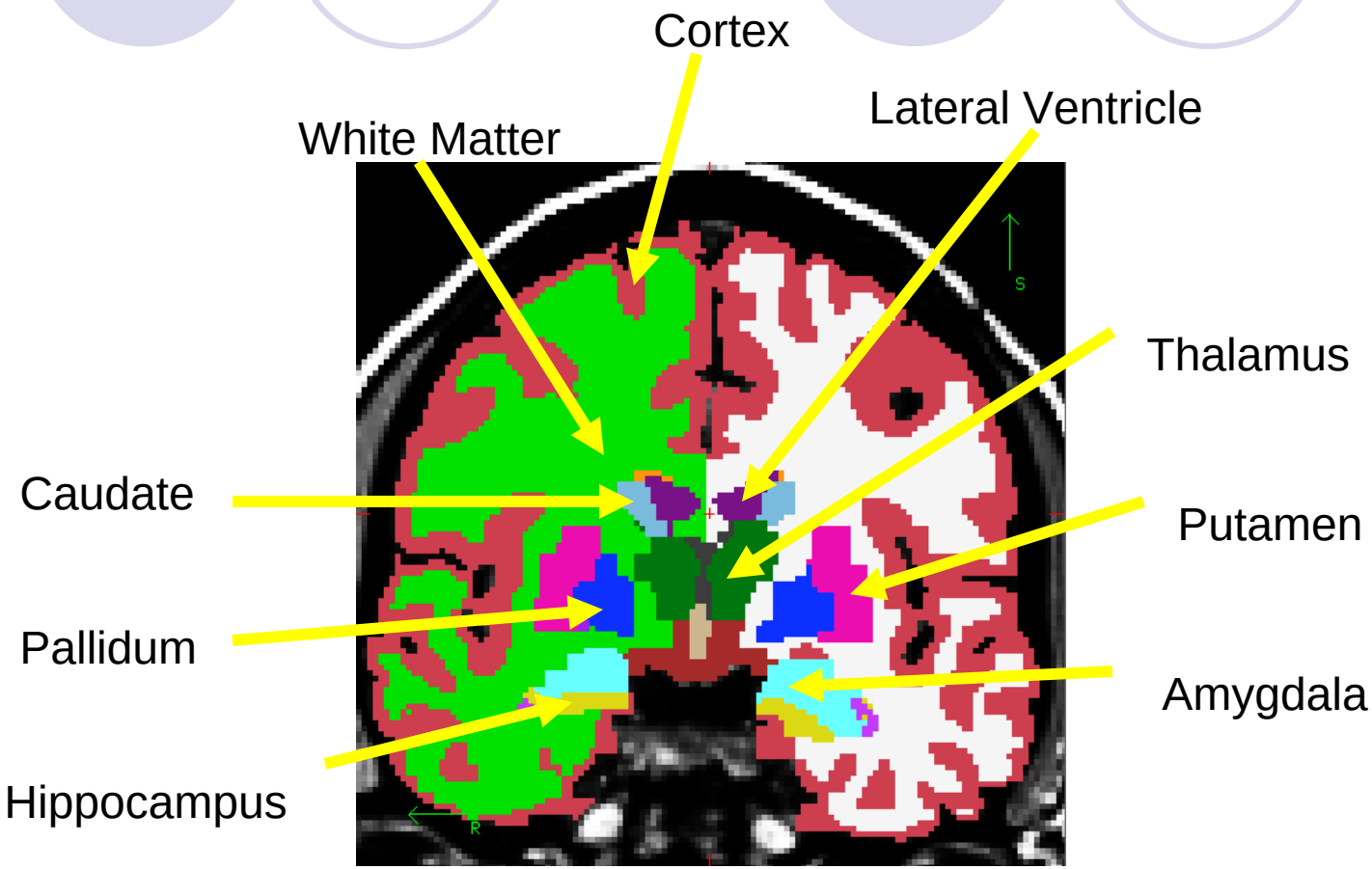
Cortical thickness

- Distance between white and pial surfaces
- One value per vertex

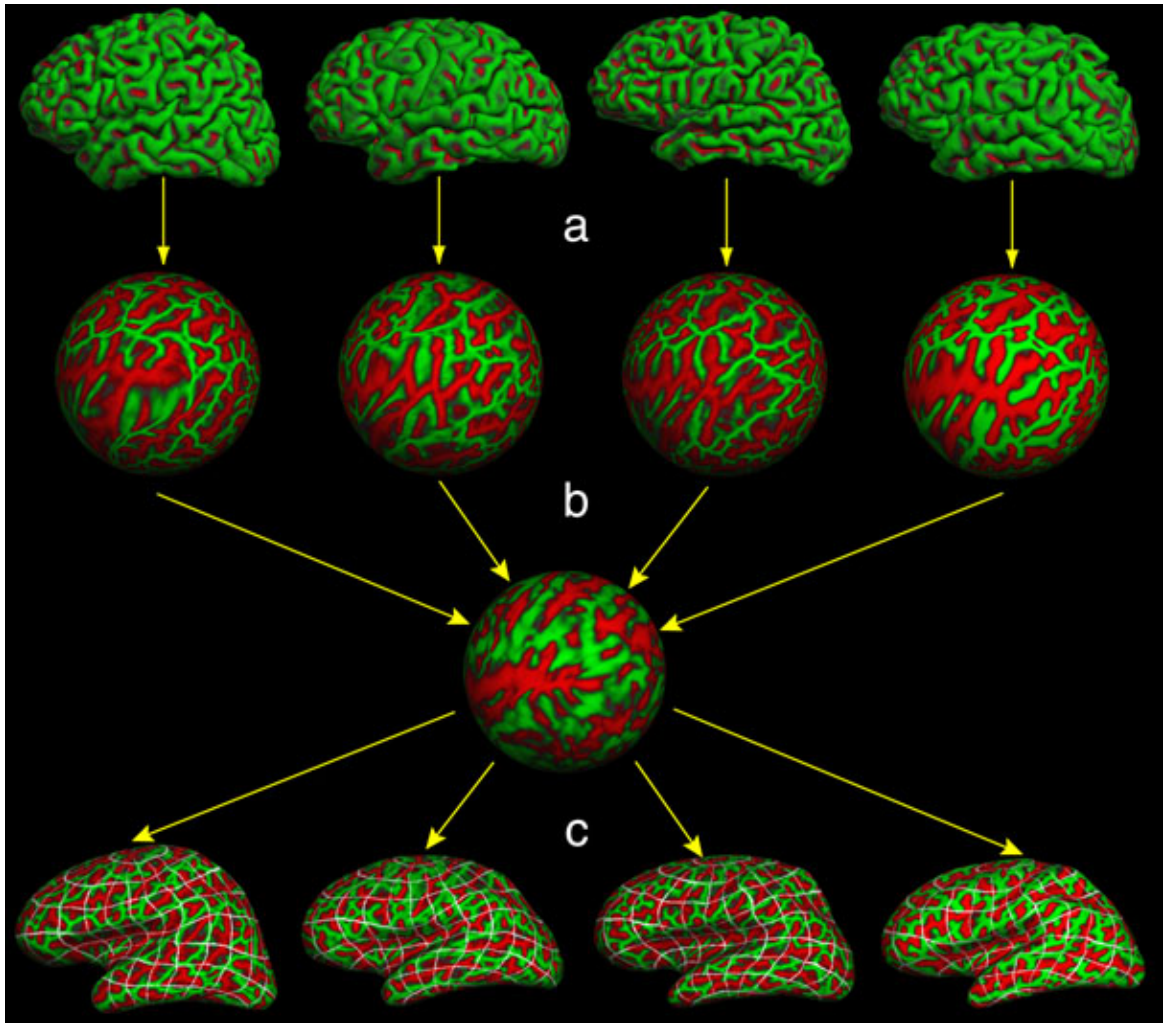




Subcortical structures



Surface-based registration

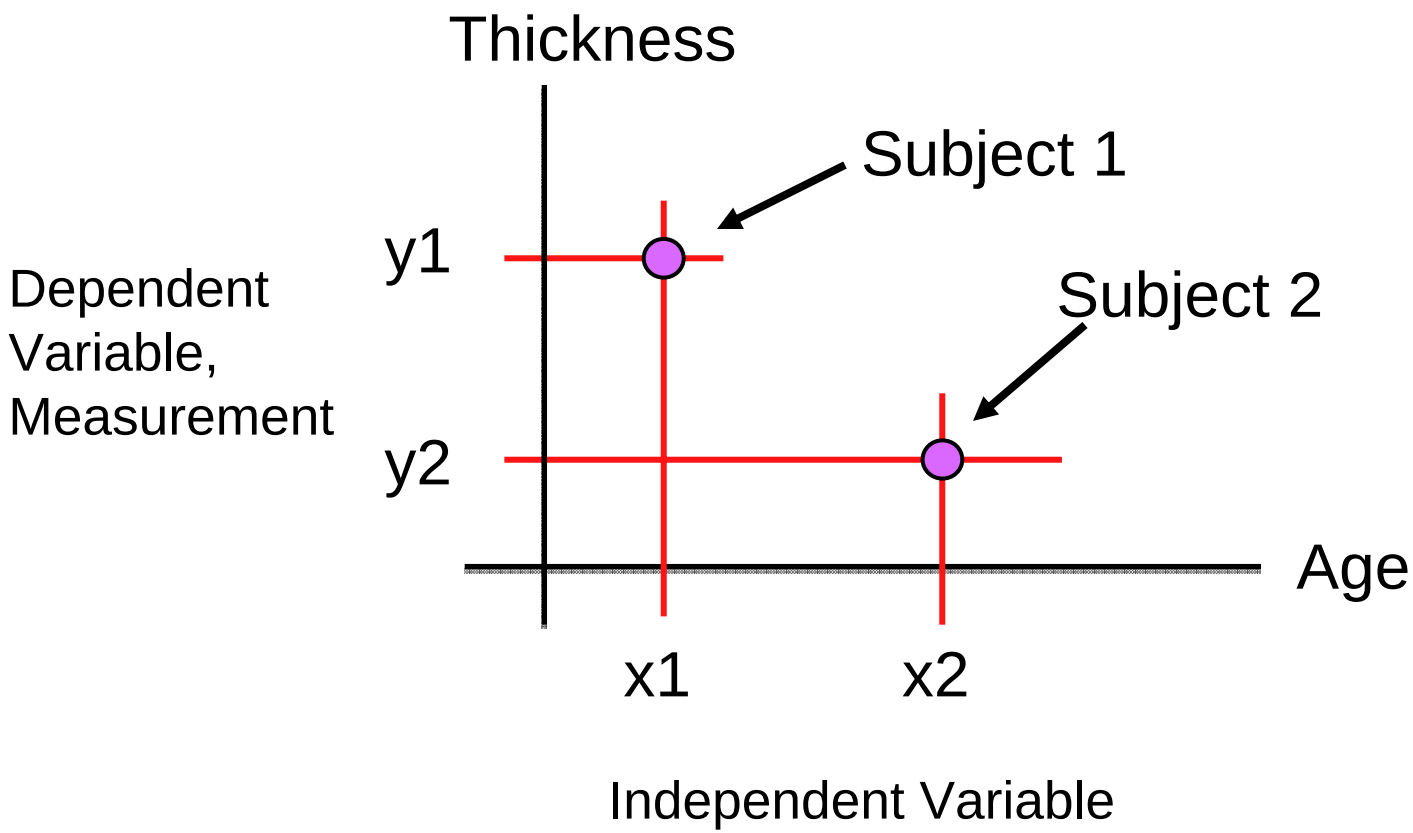


So what is QDEC???

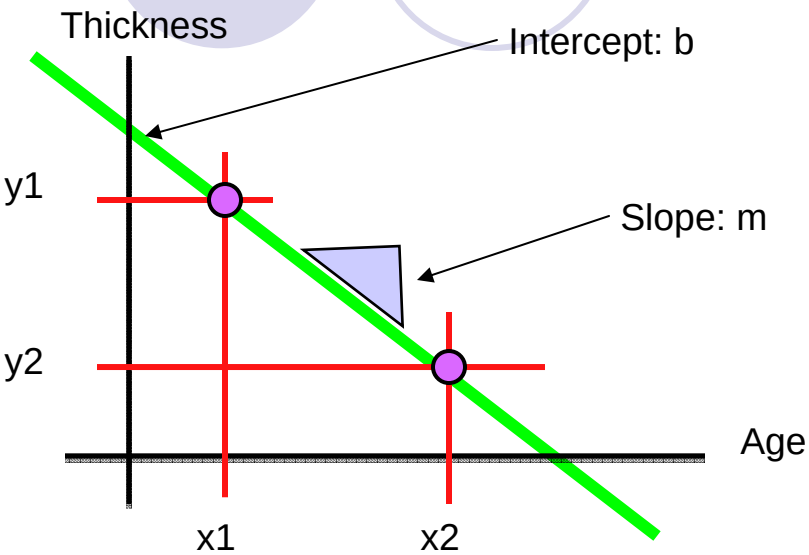
- Query (a subject database)
- Design (matrix, of data points, for GLM)
- Estimate (regression coefficients, GLM)
- Contrast (matrix, hypothesis)

GLM theory

Is Thickness correlated with Age?



Linear model



Intercept = Offset

X = Design Matrix
β = Regression Coefficients
= Parameter estimates
= “betas”
= Intercepts and Slopes
= beta.mgh (mri_glmfit)

System of Linear Equations

y1 = 1*b + x1*m
y2 = 1*b + x2*m

Matrix Formulation

$$\begin{bmatrix} y1 \\ y2 \end{bmatrix} = \begin{bmatrix} 1 & x1 \\ 1 & x2 \end{bmatrix} * \begin{bmatrix} b \\ m \end{bmatrix}$$

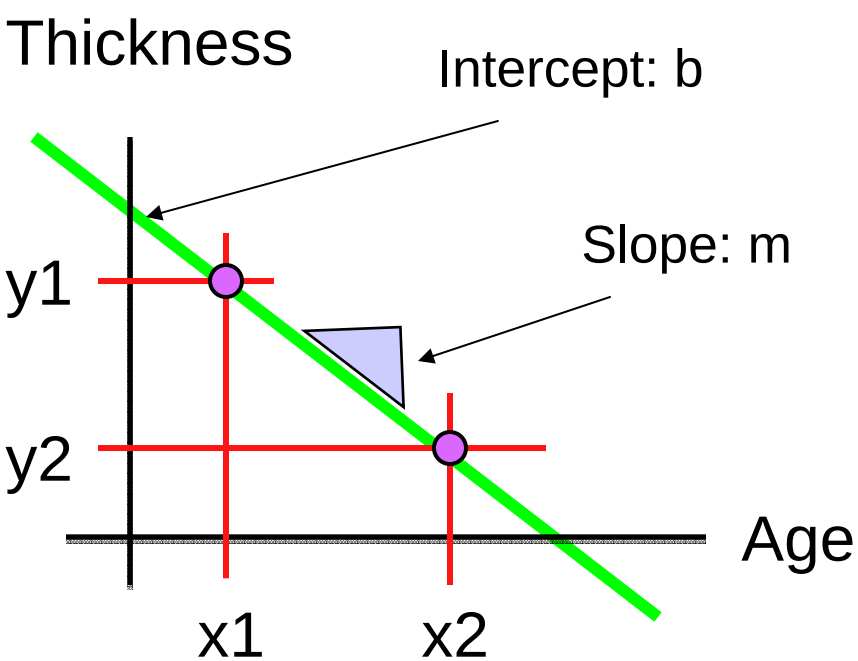
$$\boxed{Y = X*\beta} \qquad \beta = \begin{bmatrix} b \\ m \end{bmatrix}$$

Hypotheses and contrasts

$$\begin{bmatrix} y1 \\ y2 \end{bmatrix} = \begin{bmatrix} 1 & x1 \\ 1 & x2 \end{bmatrix} * \begin{bmatrix} b \\ m \end{bmatrix}$$

Is Thickness correlated with Age?
Does m = 0?
Null Hypothesis: H0: m=0

$$m = [0\ 1] * \begin{bmatrix} b \\ m \end{bmatrix}$$



$$\beta = \begin{bmatrix} b \\ m \end{bmatrix}$$

$$\boxed{\gamma = C * \beta \stackrel{?}{=} 0}$$

C=[0 1]: Contrast Matrix

Two groups

Do groups differ in Intercept?
Does b1=b2?
Does b1-b2 = 0?
C = [+1 -1 0 0], $\gamma = C*\beta$

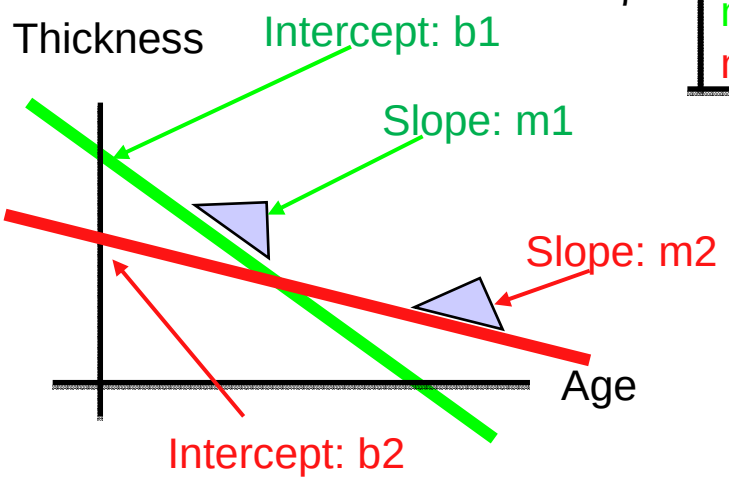
$$\begin{bmatrix} y11 \\ y12 \\ y21 \\ y22 \end{bmatrix} = \begin{bmatrix} 1 & 0 & x11 & 0 \\ 1 & 0 & x12 & 0 \\ 0 & 1 & 0 & x21 \\ 0 & 1 & 0 & x22 \end{bmatrix} * \begin{bmatrix} b1 \\ b2 \\ m1 \\ m2 \end{bmatrix}$$

Do groups differ in Slope?
Does m1=m2?
Does m1-m2=0?
C = [0 0 +1 -1], $\gamma = C*\beta$

$Y = X*\beta$

$$\beta = \begin{bmatrix} b1 \\ b2 \\ m1 \\ m2 \end{bmatrix}$$

Is average slope different than 0?
Does (m1+m2)/2 = 0?
C = [0 0 0.5 0.5], $\gamma = C*\beta$



t-test and p-values

$Y = X*\beta$

$\gamma = C*\beta$

$$t = \frac{C*\beta}{\sqrt{\sigma^2 C*(X^T X)^{-1} C^T}}$$

<u>p-value/significance</u>

- value between 0 and 1
- closer to 0 means more significant

<u>FreeSurfer stores p-values as –log10(p):</u>

- $0.1=10^{-1} \rightarrow$ sig=1, $0.01=10^{-2} \rightarrow$ sig=2
- sig.mgh files
- Signed by sign of γ
- p-value is for an unsigned test

More GLM stuff…

- For a more thorough treatment of the GLM, and FreeSurfer's implementation of it in the 'mri_glmfit' utility, see these resources:
  - Group analysis PowerPoint slides
  - Group analysis mri_glmfit tutorial

Qdec demo

- Flash movie on next slide…
- Also see:
  - http://surfer.nmr.mgh.harvard.edu/fswiki/FsTutorial/QdecGroupAnalysis

Future features

- Greater number of factors
- Contrast selection
- Subcortical structure volumes, and volumetric maps
- fMRI, PET, EEG/MEG surface data

Acknowledgments

- Overall concept - Bruce Fischl
  fischl@nmr.mgh.harvard.edu
- GLM fit development - Doug Greve
  greve@nmr.mgh.harvard.edu
- VTK/KWWidget development - Kevin Teich
  kteich@nmr.mgh.harvard.edu