Statistical Power Computation Under Multiple Comparisons in Hippocampus and Amygdala

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69 middle-age and elderly normal adults between 38-79 years. 23 males 46 females

MIDUS
MRI data

Advancing Knowledge of Factors That Promote Positive Health and Resilience

MID-LIFE IN THE UNITED STATES
A National Study of Health and Well-Being

Age/brain volume distribution

Not significant, p=0.25

Slope=-98.2; intercept=930

Brain volume (cm$^3$)

Brain volume (cm$^3$)

age (yr)

male
female

not significant, p=0.25

Slope=-98.2; intercept=930
Manual segmentation

The surface template obtained by averaging the warped binary segmentation and thresholding it.

Diffeomorphic registration: ANTS

Template
Kim et al. 2011, Lecture Notes in Computer Science 7087:36-47

New hypothesis: possibly signal is localized within regions!
ROI volumetric study by Peschke et al. 2010
ROI volumetric study by Peschke et al. 2010

Left hippocampus head

Right hippocampus head

Left hippocampus body

Right hippocampus body
Possible ROI partition artifacts?

- Left hippocampus head
- Right hippocampus head
- Left hippocampus body
- Right hippocampus body

Figure 38: Linear correlation with age.
Deformation-based surface morphometry (DBSM)

deformation from the template to subject 73M

Analysis pipeline established in Chung et al. 2003 *NeuroImage*
Sparse Shape model via Laplace-Bertram eigenfunctions

Measurement

\[ Y(p) = \sum_{j=0}^{k} \beta_j \psi_j(p) + \epsilon(p) \]

\[ Y = \psi \beta \]

Least square estimation

\[ \hat{\beta} = (\psi'\psi)^{-1}\psi'Y \]

Sparse shape model

\[ \min_{\beta} \|Y - \psi \beta\|_2^2 + \lambda \|\beta\|_1 \]
$T$-stat. maps after accounting for age and brain size

Age effect

Rejection region
Direction of aging

Group I: $39 < \text{age} < 50$
Group II: $50 < \text{age} < 65$
Group III: $65 < \text{age} < 79$

Group II-I

Group III-II
Statistical power = the probability of detecting signal assuming there is true signal

Traditionally a function of effect and sample sizes

Not useful for complex study design

Under multiple comparisons on brain surface

Effect size 0.2
Power computation under multiple comparisons

Multiple comparison corrected p-value:

\[ P\left( \sup_{p \in \mathcal{M}} T(p) > h \right) = 0.05 \]

\[ \downarrow \]

Statistical power:

\[ P\left( \sup_{p \in \mathcal{M}_1} T(p) > h \right) \]

\( \mathcal{M}_1 = \text{cluster where signal is detected} \)
Power curve: hippocampus

9% increase of power = 5 samples less
Thank you! What next?

Establishing Anatomical Twin study

5 Dizygotic (DZ) pairs
5 Monozygotic (MZ) pairs
20 twins vs. 39 NC

Classical: Heritability index
Modern: Variance component model

If we don’t detect any signal, at least we can establish a pipeline for future twin/sibling studies.
Gender effect

a) Age Effect

R

\( p=0.05 \)

\( t\)-statistics

-5 younger > older 0 younger < older 5

b) Gender Effect

R

\( p=0.05 \)

\( t\)-statistics

-5 female > male 0 female < male 5