Data-analytical Stability in Second-Level fMRI inference

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problem

- fMRI plays an important role to localize brain regions
- 2-level mass-univariate GLM-based approach still popular for multi-subject analysis
- in voxel-based analysis: 1) continued use of different models to pool information over subjects; 2) various multiple testing procedures to control false positives and 3) distinct inference procedures
- choices in each of three phases impact reproducibility
- today no golden standard for a voxel-based approach
- data-analytical stability has the ability to further inform these choices, while it is also a proxy for reproducibility and intrinsically allows for an evaluation on real data

goals

- comparison of combinations of methods for analysis of multi-subject fMRI
- to achieve a golden standard for analysis
- illustrate how to evaluate based on both simulation and real data

methods

- simulation 2 clusters in $45 \times 45 \times 45$ volume; no first-level noise; smoothing applied to comply RFT assumptions; 2 SNR settings
- real data: 15 subjects from HCP data
- criteria
  - type I/II error rates
  - stability
- procedures FSL-based, in-house R-based

real data

- stability

  - re-selection rates for parametrical inference

  - FDR: more variable + has lower re-selection rates
  - WLS is found to be less variable

simulation study

- balance FP and TP

  - WLS outperforms OLS
  - BCL outperforms FDR and FWE
  - permutation no diff. between OLS and WLS
  - for higher SNR, smaller differences

- stability

  - FDR is always more variable
  - BCL comparable with FWE
  - permutation $\approx$ parametrical inference
  - high SNR, FDR + permutation: very instable

discussion and conclusions

- model WLS is slightly more stable than OLS, in ROC WLS outperforms OLS
- multiple testing correction FWE and BCL are almost always more stable than FDR; in ROC BCL outperforms FDR/FWE
- inference both for FP/TP balance and stability we find no large differences between permutation-based and parametrical inference
  - with respect to FP/TP balance, BCL offers a good alternative, but lacks statistical justification
  - with respect to stability, FDR is outperformed by the other procedures

references

[5] Lieberman et al. (2009). Type I and Type II error concerns in fMRI research: ... SCAN

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http://tinyurl.com/j9qaajjd