Outline

- Statistical Analysis
- Results Viewing

Statistical Analysis

One-Sample T-Test

Wang, Yan et al., 2011, Hum Brain Mapp
Two-Sample T-Test

Wang, Yan et al., 2011, Hum Brain Mapp.

Two-Sample T-Test

T Statistic Matrix: positive corresponds to the mean of Group 1 is greater than the mean of Group 2

Two-Sample T-Test with covariates: e.g. other matrix
Please make sure the correspondence of the group matrices and the covariate matrices: e.g. head motion (mean FD), age, sex etc.

Paired T-Test

 две-мерной матрицы спектров двух групп.

Paired T-Test

Condition 1 – Condition 2
Please make sure the correspondence

ANOVA or ANCOVA

Wang, Yan et al., 2011, Hum Brain Mapp.
ANOVA or ANCOVA

Post-hoc procedures: the corrected p-values under a given control procedure for comparing group means of any pairs were calculated (e.g., through Studentized Range statistic for Tukey-Kramer correction) with the same route as MATLAB command multcompare. The p maps were then converted to Z maps according to the Normal inverse cumulative distribution function (norminv), with the sign of group mean differences applied.

Correlation Analysis

The imaging measure: FC matrices
Traits: e.g. MMSE.txt

Mixed Effect Analysis

fALFF of MPFC Cingulate
Group x Age Interaction

Yan et al., 2016. Translational Psychiatry
Mixed Effect Analysis

The imaging measure should be:
- Group1Condition1
- Group1Condition2
- Group2Condition1
- Group2Condition2

Mixed Effect Analysis

- "_ConditionEffect_T.mat" - the T values of condition differences (corresponding to the first condition minus the second condition) (WithinSubjectFactor)
- "_Interaction_F.mat" - the F values of interaction (BetweenSubjectFactor by WithinSubjectFactor)
- "_Group_TwoT.mat" - the T values of group differences (corresponding to the first group minus the second group).
  Of note: the two conditions will be averaged first for each subject. (BetweenSubjectFactor)

Statistical Analysis

Statistical Analysis

{DPABI_Dir}/StatisticalAnalysis/y_GroupAnalysis_Image.m

Get p: Parametric vs. non-parametric

Non-parametric: permutation

- We can permute the data itself to create a distribution that we can use to test our statistic.
- Makes very few assumptions about the data
- Works for any test statistic

Winkler et al., 2016. NeuroImage; Converted from FSL course

Non-parametric: permutation

- We can permute the data itself to create a distribution that we can use to test our statistic.
- Makes very few assumptions about the data
- Works for any test statistic

Converted from FSL course
Non-parametric: permutation

- We can permute the data itself to create a distribution that we can use to test our statistic.
- Suitable if the data is not normally distributed.
- Makes very few assumptions about the data.
- Works for any test statistic.

Of the 5000 re-labelings, only 90 had a t-value > 2.27 (the original labelling was the 5000th). The chance of getting a t-value > 2.27 is 1.8%.

I.e. there is only a ~1.8% (90/5000) chance of obtaining a value > 2.27 if there is no difference between the groups.

C.f. p(>2.27) = 1.7% for t₁₀₀₀₀₀

5000 re-labelings, Phew!

Related labels:

Get p: Parametric vs. non-parametric

<table>
<thead>
<tr>
<th>Assumed distribution</th>
<th>Parametric</th>
<th>Non-parametric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assumed variance</td>
<td>Normal</td>
<td>Homogeneous and Heterogeneous</td>
</tr>
<tr>
<td>Typical data</td>
<td>Ratio or Interval</td>
<td>Ordinal or Nominal</td>
</tr>
<tr>
<td>Data set relationships</td>
<td>Independent</td>
<td>Any</td>
</tr>
<tr>
<td>Usual central measure</td>
<td>Mean</td>
<td>Median</td>
</tr>
<tr>
<td>Benefits</td>
<td>Can draw more conclusions</td>
<td>Simplicity; Less affected by outliers</td>
</tr>
</tbody>
</table>

Non-Parametric: For NBS Correction!

Parametric, can be used for FDR

converted from FSL course
Non-Parametric, Permutation-based, can be used for FDR

Non-Parametric, Permutation-based, Already FWE Corrected! Very Strict, rarely use!

Non-Parametric, Permutation-based, For NBS!

Statistical Analysis

Multiple Comparison Correction

... I estimate about 15,000 papers use cluster size inference with correction for multiple testing; of these, around 3,500 use a CDT of P=0.01... So, are we saying 3,500 papers are "wrong"? It depends.....

-- Thomas Nichols
July 08, 2016
Multiple Comparison Correction

Bonferroni correction: $p = 0.05/5 = 0.01$

- Bonferroni correction: $0.05/N$
- False Discovery Rates (FDR) correction
- Network-Based Statistic (NBS)
  (only for permutation test)

FDR Theory

<table>
<thead>
<tr>
<th>Number of errors committed when testing $m$ null hypotheses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>True null hypotheses</td>
</tr>
<tr>
<td>Non-true null hypotheses</td>
</tr>
<tr>
<td>$m - R$</td>
</tr>
</tbody>
</table>

* False discovery rate $Q_e = \frac{E(V)}{E(V+S)} = \frac{E(V)}{R}$

Benjamini and Hochberg, 1995, Journal of the Royal Statistical Society
**FDR Theory**

- Let $H_1, \ldots, H_m$ be the null hypotheses and $P_1, \ldots, P_m$ their corresponding p-values. Order these values in increasing order and denote them by $P_{(1)}, \ldots, P_{(m)}$. For a given $q$, find the largest $k$ such that $P_{(k)} \leq kq/m$.

- Then reject (i.e. declare positive) all $H_i$ for $i = 1, \ldots, k$.

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**Get p: Parametric vs. non-parametric**

![Parametric vs. Non-Parametric](image)

**Parametric**
- Can be used for FDR

**Non-Parametric**
- Permutation-based, can be used for FDR

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**Multiple Comparison Correction**

- Bonferroni correction: $0.05/N$
- False Discovery Rates (FDR) correction
- Network-Based Statistic (NBS)
  (only for permutation test)
Multiple Comparison Correction

Gaussian Random Field Theory Correction
Monte Carlo simulations (AlphaSim)

Network-Based Statistic (NBS)

Outline

• Statistical Analysis
• Results Viewing
Li, et al., 2021. *Hum Brain Mapp*.

Between-group differences in whole-brain functional connectivity (NBS)
Further Help

The R-fMRI Course V3.0

http://rfmri.org/wiki

The R-fMRI Journal Club

http://rfmri.org/Course

Official Account: RFMRILab

DPABI/DPABISurf/DPARSF特训营

第九届DPABI/DPABISurf/DPARSF
脑影像基础特训营（云端）通知
2021.3.27～3.29

第一届DPABISurf/DPABINet
脑网络进阶特训营（北京现场）通知
2021.4.24～4.26

定期举办，请关注http://rfmri.org

Acknowledgments

• National Natural Science Foundation of China
• National Key R&D Program of China
• Chinese Academy of Sciences

Funding

Thanks for your attention!