# Module 20:
# FDR Correction

# Issues with FWER

- Methods that control the FWER (Bonferroni, RFT, Permutation Tests) provide a strong control over the number of false positives.

- While this is appealing the resulting thresholds often lead to tests that suffer from low power.

- Power is critical in fMRI applications because the most interesting effects are usually at the edge of detection.

# False Discovery Rate

- The false discovery rate (FDR) is a recent development in multiple comparison problems due to Benjamini and Hochberg (1995).

- While the FWER controls the probability of any false positives, the FDR controls the proportion of false positives among all rejected tests.

# Notation

Suppose we perform tests on m voxels.

| | **Declared Inactive** | **Declared Active** | |
|---|---|---|---|
| **Truly inactive** | U | V | $m_0$ |
| **Truly active** | T | S | $m-m_0$ |
| | m-R | R | m |

U, V, T and S are unobservable random variables.

R is an observable random variable.

# Definitions

- In this notation:

$$FWER = P(V \geq 1)$$

- False discovery rate:

$$FDR = E\left(\frac{V}{R}\right)$$

- The FDR is defined to be 0 if R=0.

# Properties

- A procedure controlling the FDR ensures that on average the FDR is no bigger than a pre-specified rate q which lies between 0 and 1.

- However, for any given data set the FDR need not be below the bound.

- An FDR-controlling technique guarantee controls of the FDR in the sense that FDR ≤ q.

# BH Procedure

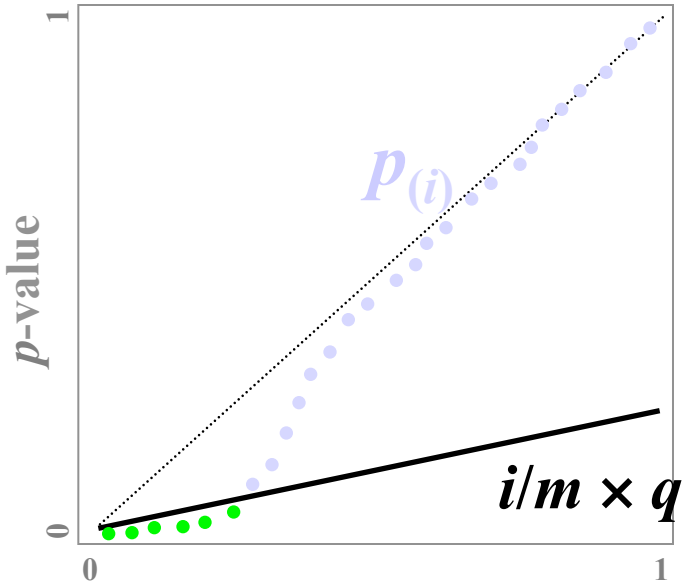
1. Select desired limit $q$ on FDR (e.g., 0.05)

2. Rank p-values, $p_{(1)} \le p_{(2)} \le \ \ldots \le p_{(m)}$

3. Let $r$ be largest $i$ such that

$$p_{(i)} \le \ i/m \times q$$

4. Reject all hypotheses corresponding to $p_{(1)}, \ldots, p_{(r)}$.



# Comments

- If all null hypothesis are true, the FDR is equivalent to the FWER.
- Any procedure that controls the FWER also controls the FDR. A procedure that controls the FDR only can be less stringent and lead to a gain in power.
- Since FDR controlling procedures work only on the p-values and not on the actual test statistics, it can be applied to any valid statistical test.

# End of Module

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