Summarising distance information: exemplar discriminability and models tests

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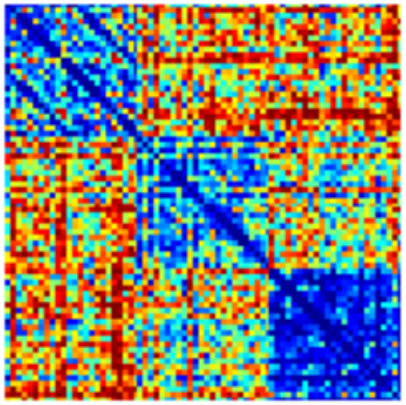
RSA workshop, February 16-17, 2015

MRC | Cognition and Brain Sciences Unit

Distance information

Testing …

- exemplar information
- representational geometries



How can we test if within-category exemplars are distinctly represented?

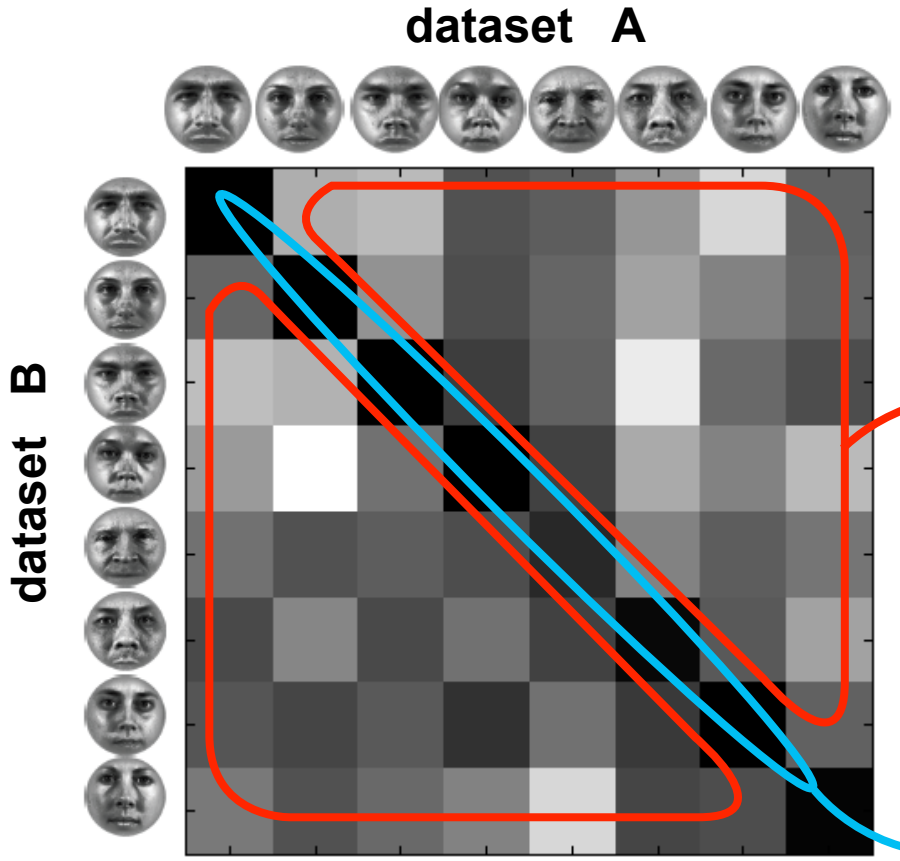
Testing exemplar information

Nili et al.
(in preparation)

Testing exemplar information

Nili et al.
(in preparation)

Summary statistics for condition-rich designs



between-exemplar dissimilarity

exemplar discriminability index (EDI)
= mean(off-diagonal) – mean(diagonal)

exemplar replicability

Nili et al.
(in preparation)

Exemplar information

- General idea:

  Within exemplar dissimilarity < between exemplar dissimilarity
  - EDI > 0
  - Expected value of EDI under $H_0 = 0$

- **Conventional way of testing EDI at the group level:**
  - One-sided t-test (average EDI>0), use correlation distance
  - Not applicable for testing EDIs at the single subject level or fixed effects analysis for group of subjects

Nili et al.
(in preparation)

List of possible tests and test statistics

Test statistics

- EDI based on correlation distance, Euclidean, or Mahalanobis distance
- Average LD-*t* for all pairwise comparisons

Tests

Subject as random effect

- One-sided *t* test
- One-sided Wilcoxon signed-rank test

Single-subject or subject as fixed effect

- RDM-level condition-label randomisation test
- Pattern-level condition-label randomisation test

Nili et al.
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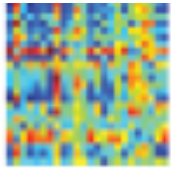
Nili et al.
(in preparation)

RDM-level condition-label randomisation test

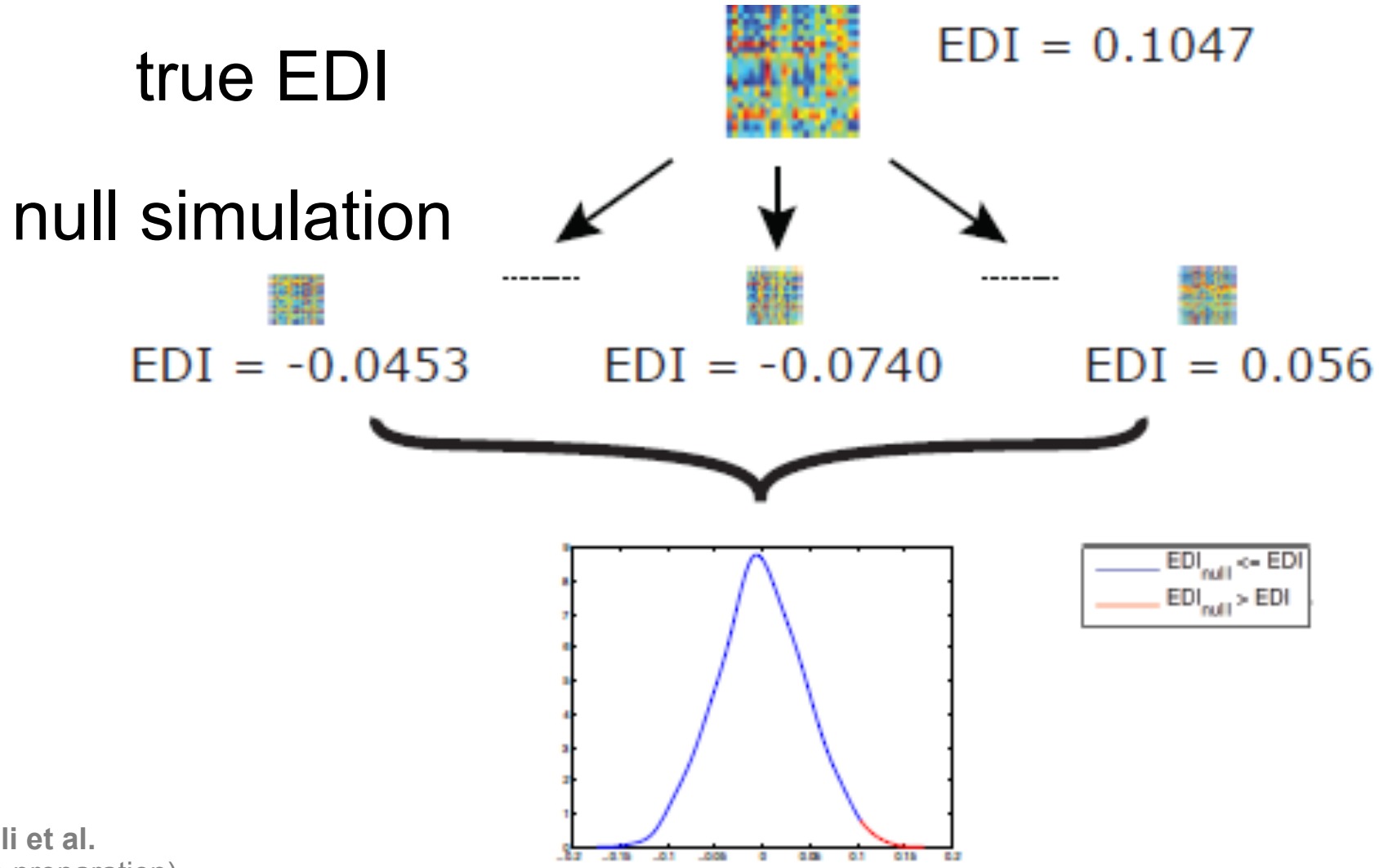
true EDI



EDI = 0.1047

Nili et al.
(in preparation)

RDM-level condition-label randomisation test



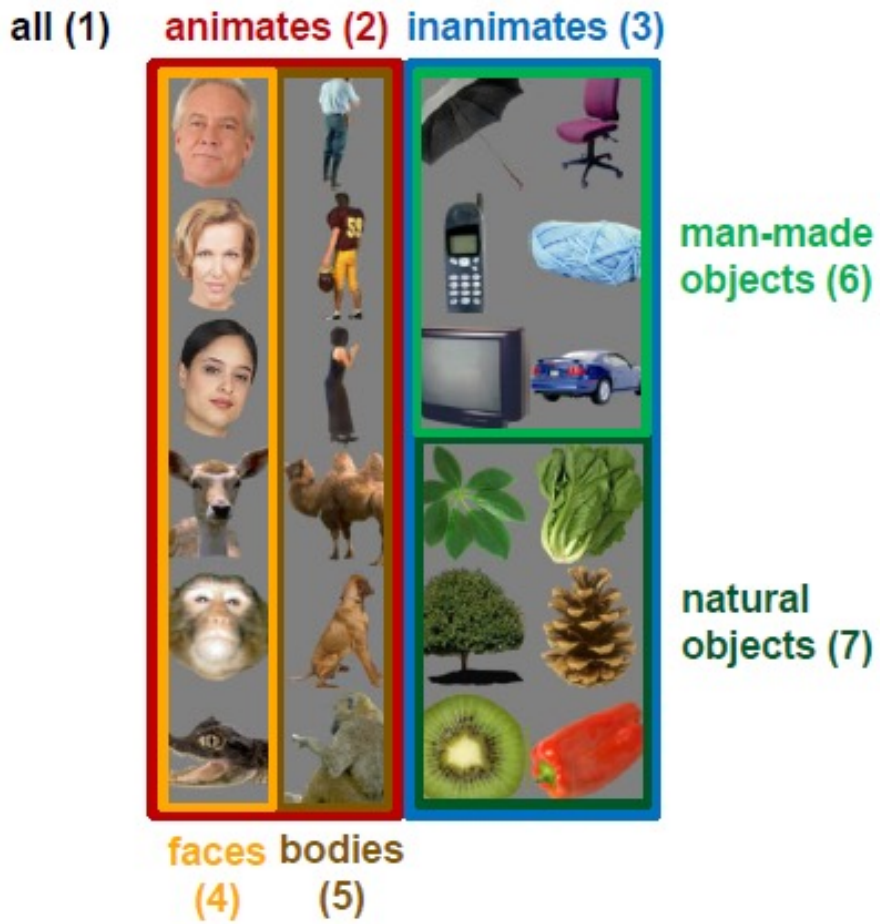
Nili et al.
(in preparation)

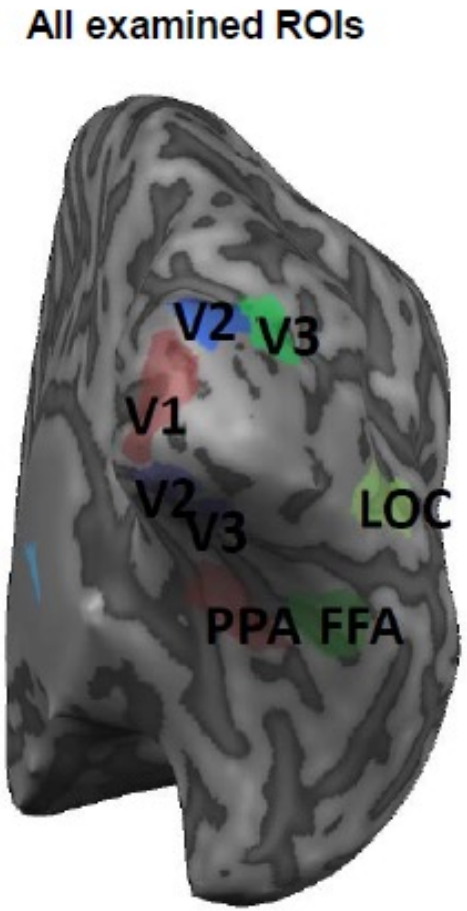
Which tests are best?

- We need to show that the statistical tests are both sensitive and specific.
- **Specificity (→ valid test)**
- **Sensitivity (= power)**

Nili et al.
(in preparation)

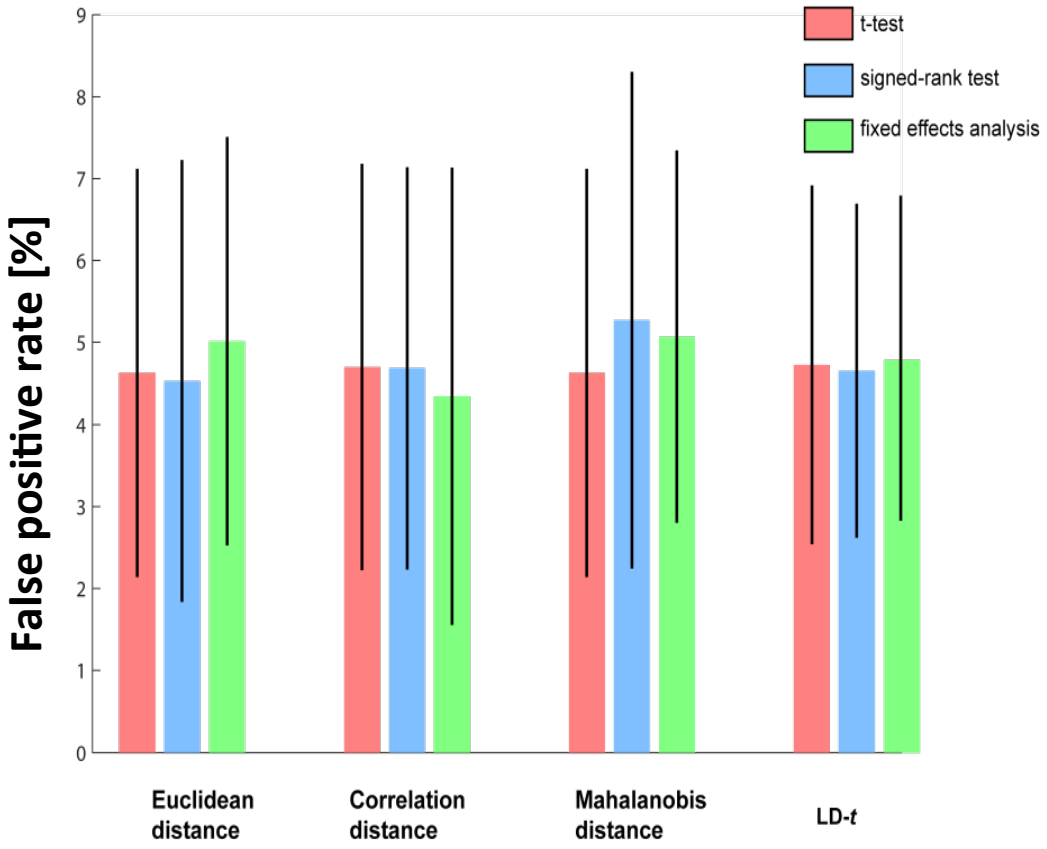
Different exemplar sets and ROIs





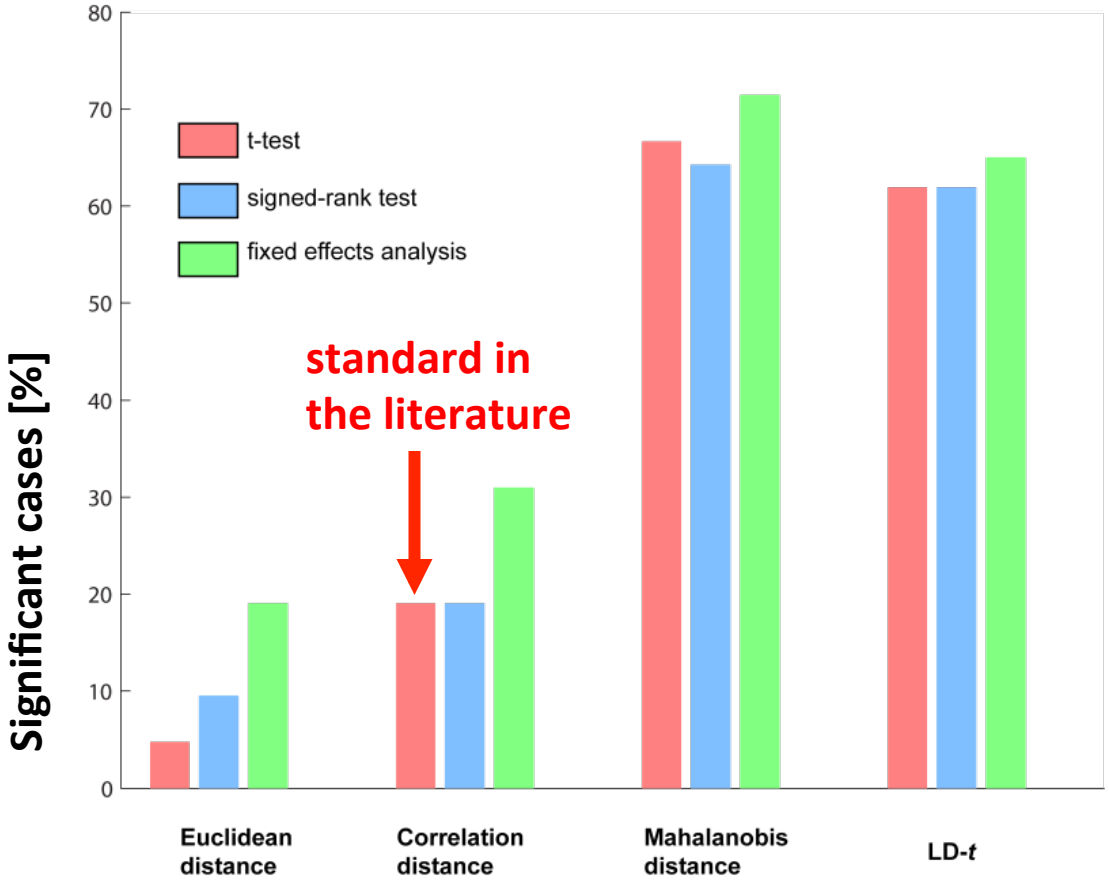
Nili et al.
(in preparation)

Are the tests valid?



Nili et al.
(in preparation)

How sensitive are the tests?



Nili et al.
(in preparation)

Conclusions

- **Multivariate noise normalisation** allows sensitive detection of exemplar information

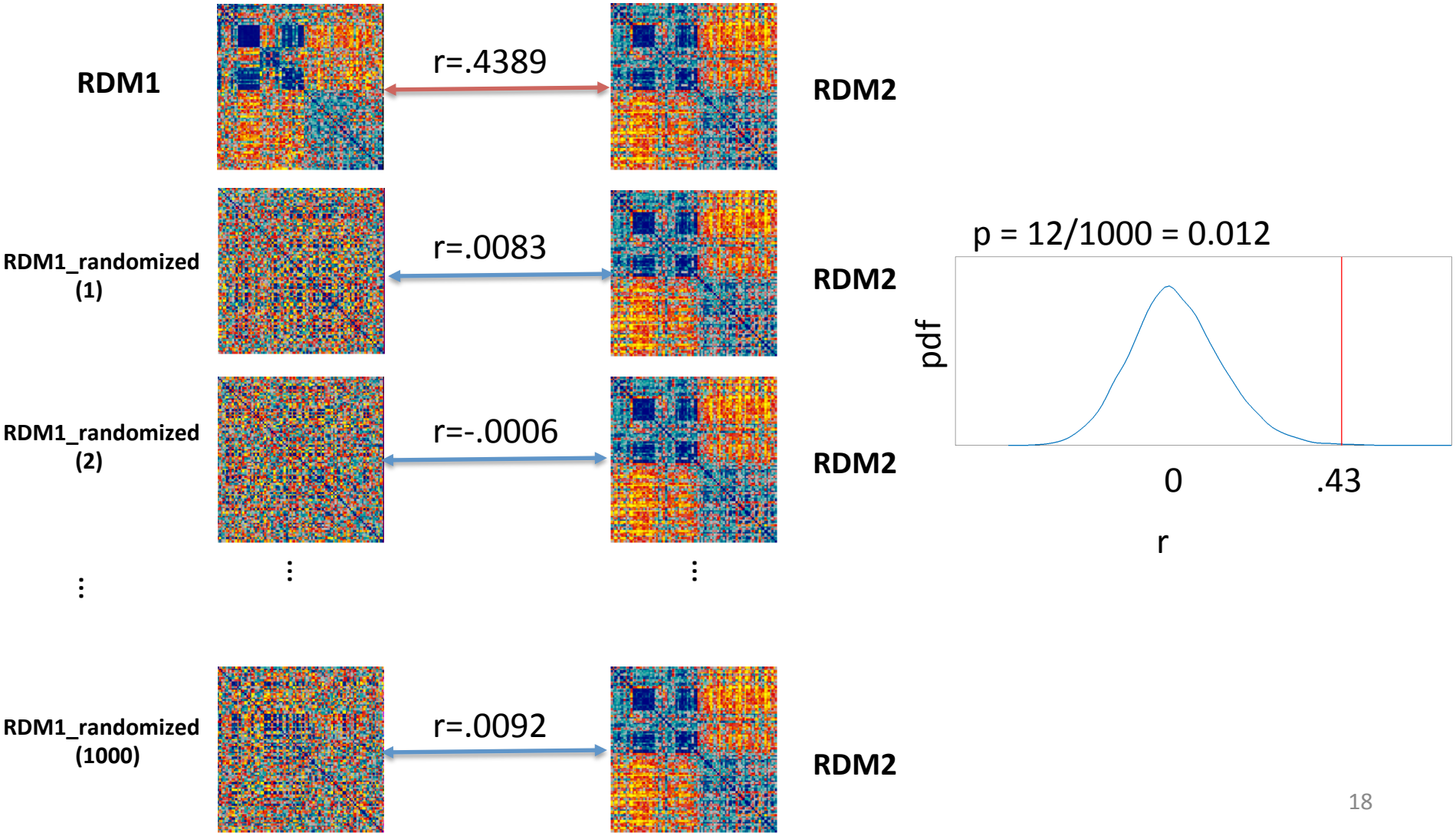
- **Recommendation:** multivariate noise normalization of the response patterns.

How can we test if two representational geometries are related?

- similarity of two RDMs: dissimilarity correlation
- Testing RDM correlations

Kriegeskorte et al. (2008)

Condition-label randomisation test



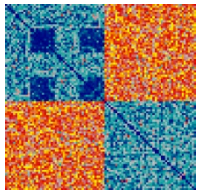
How can we test if one model's prediction of the representational geometry is better than another model's ?

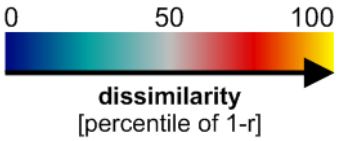
How can we tell if a model fully explains the representational geometry data from a brain region?

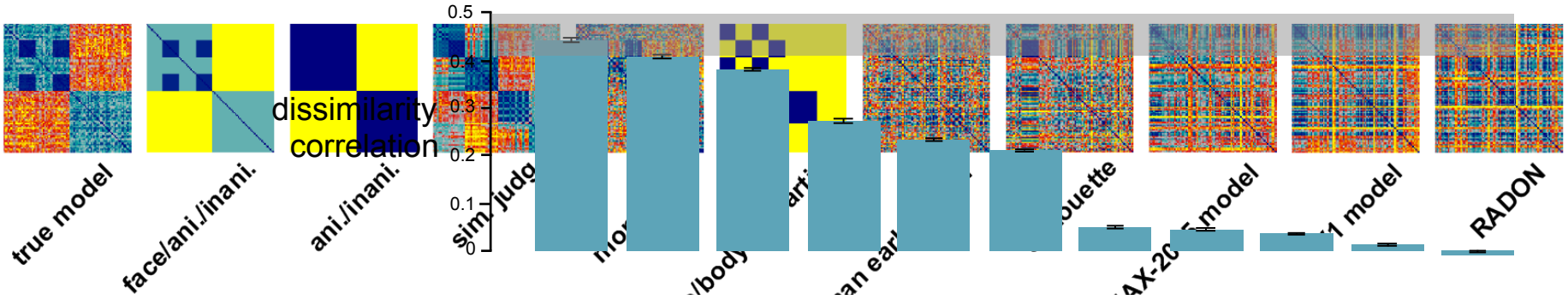
Nili et al.
(PLoS Comp Biol, 2014)

Statistical inference

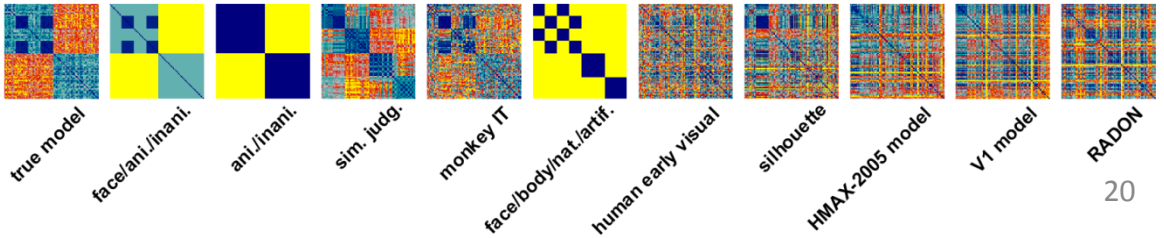
brain representation (human IT)





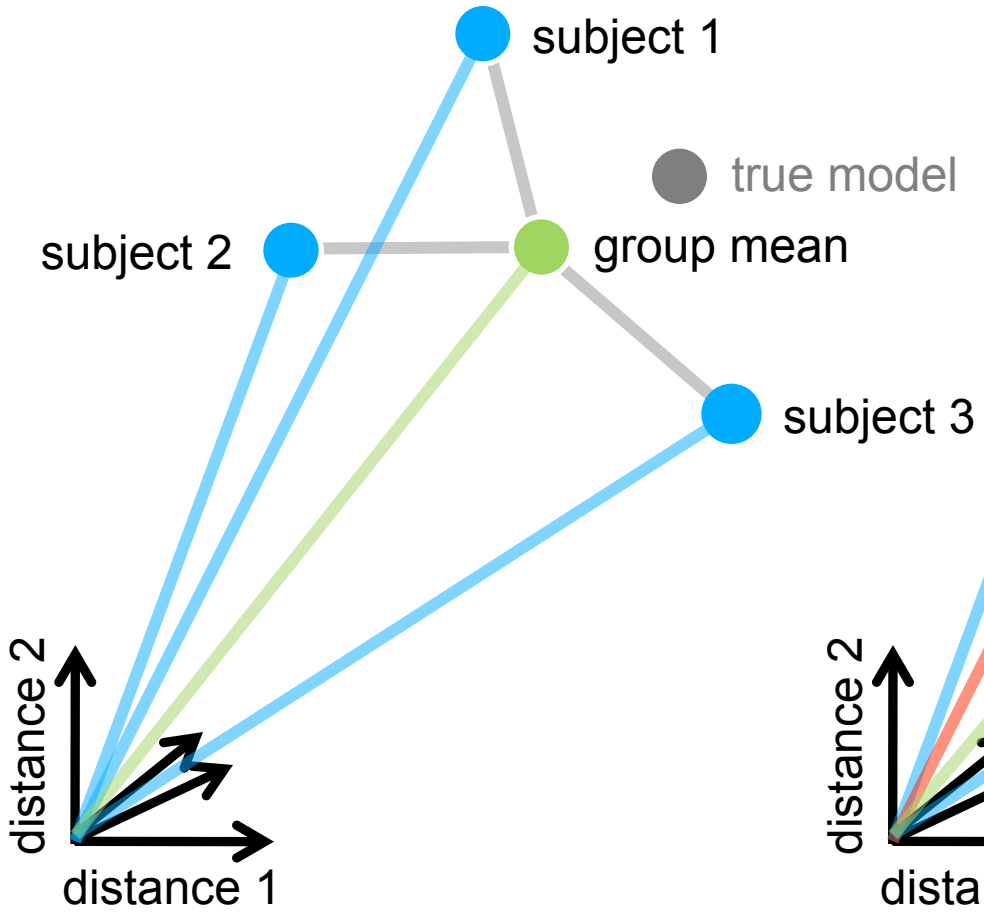


model representations

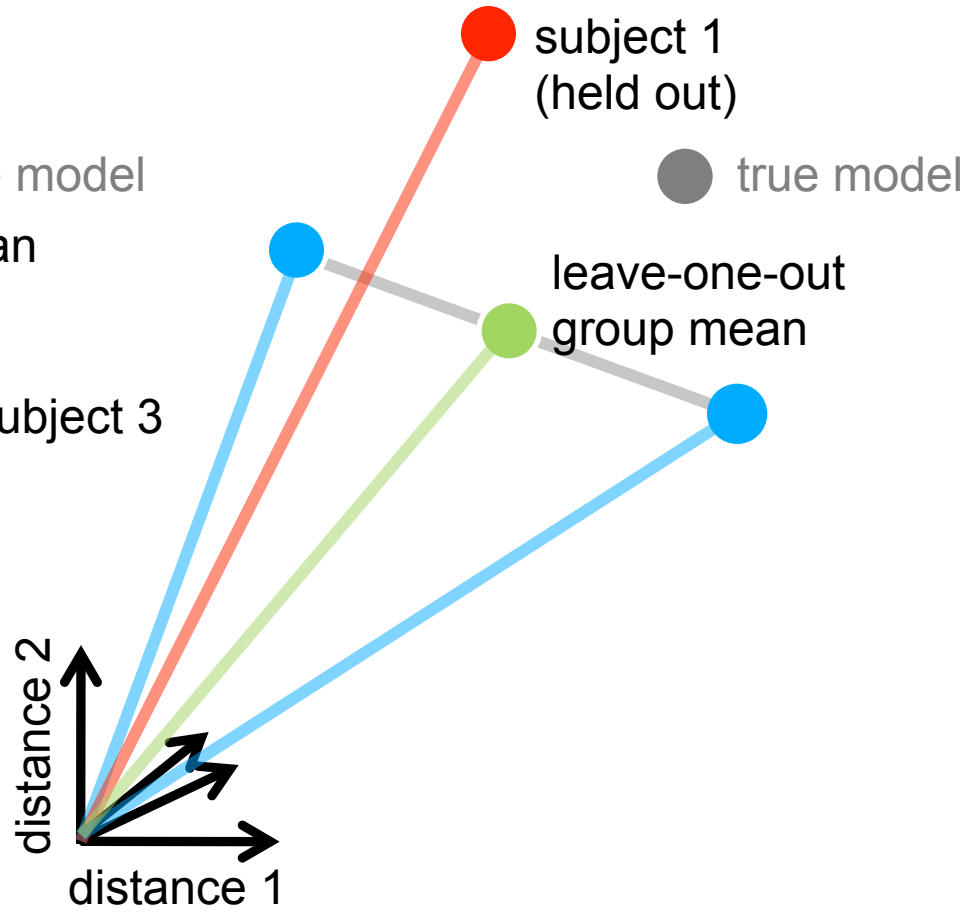


Nili et al.
(PLoS Comp Biol, 2014)

Estimating the noise ceiling on the brain-model RDM correlation



upper bound

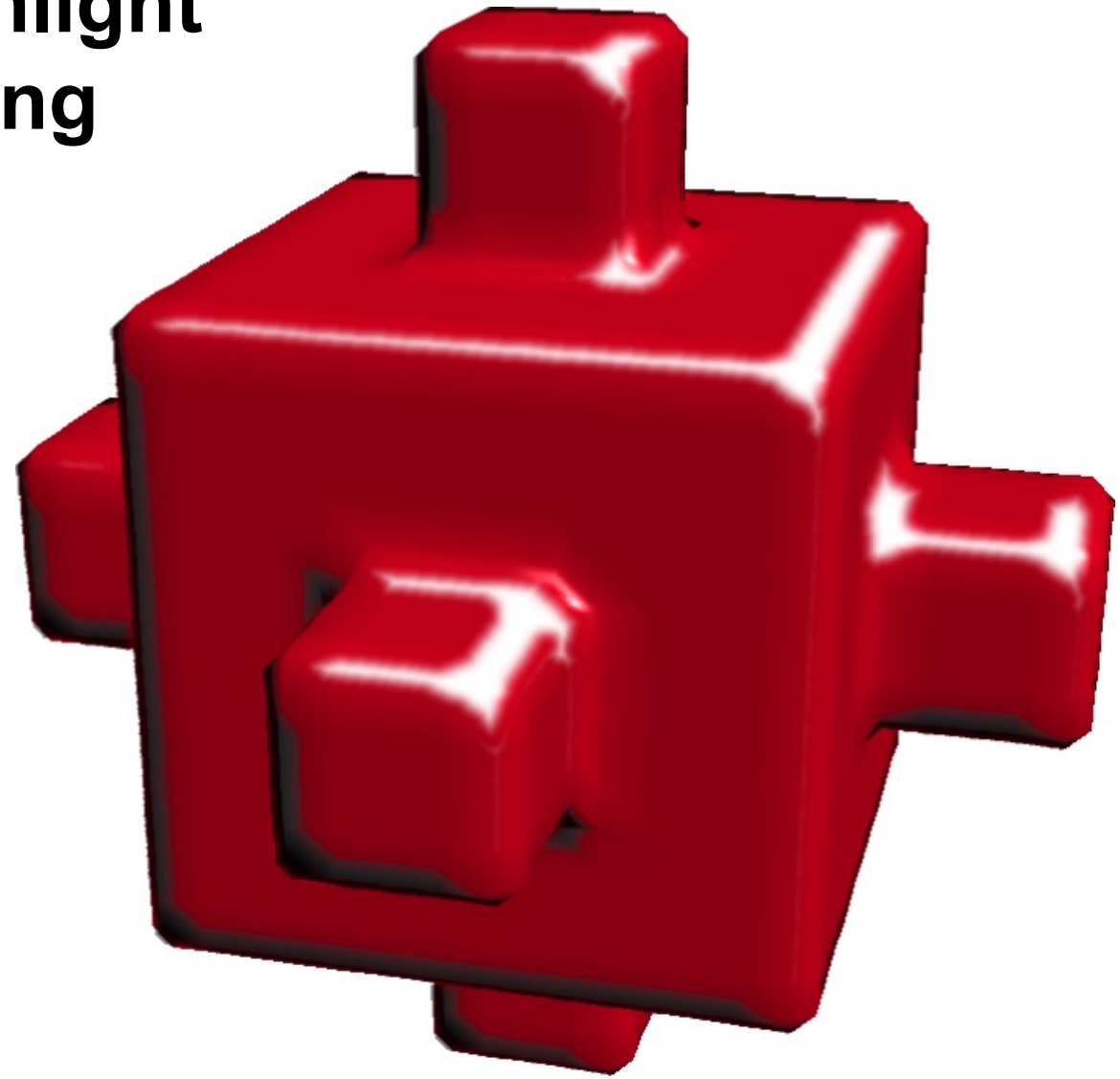


lower bound

Nili et al. 2014 (RSA Toolbox)

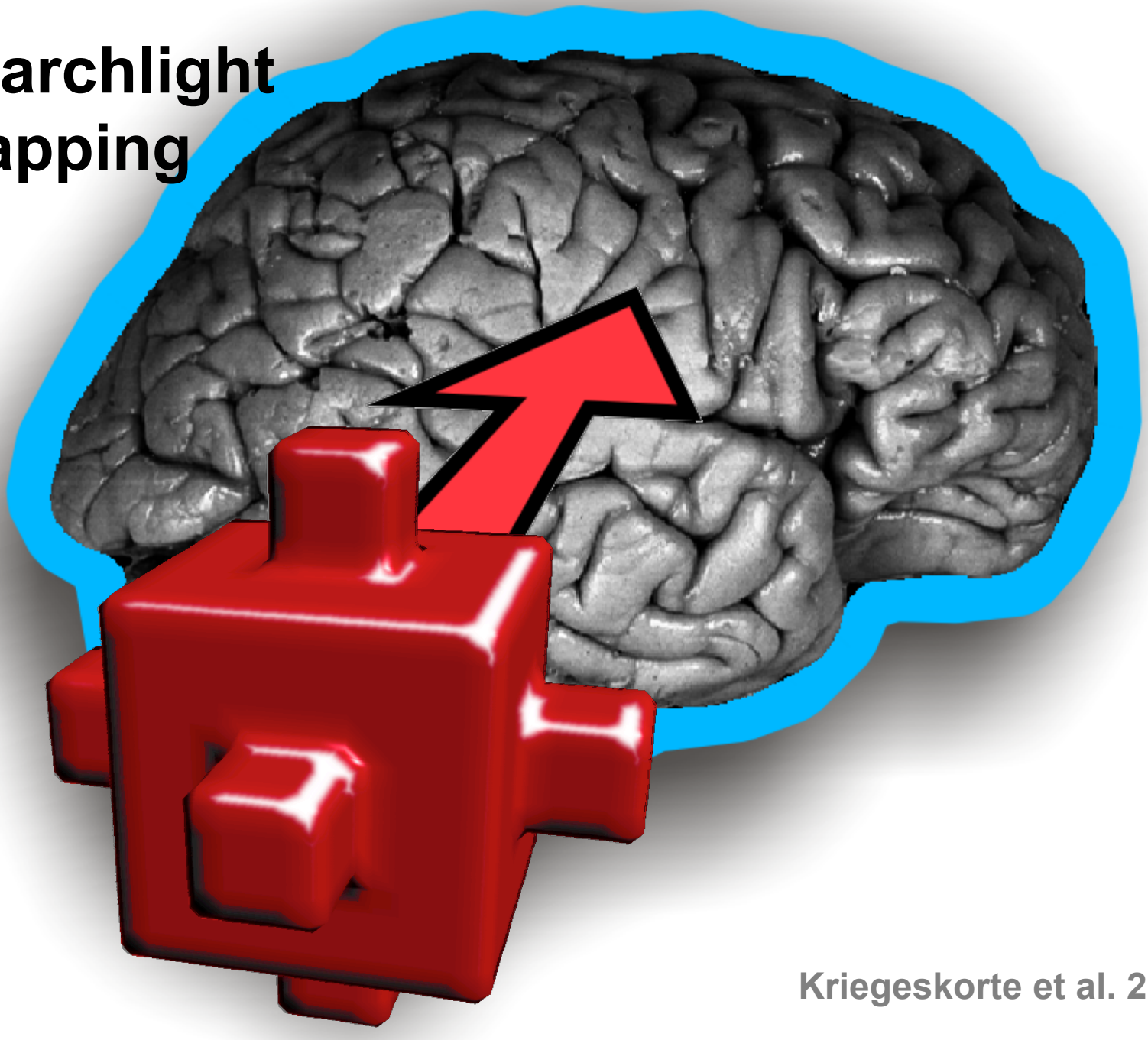
How can we find brain regions exhibiting a particular representational geometry?

Searchlight mapping



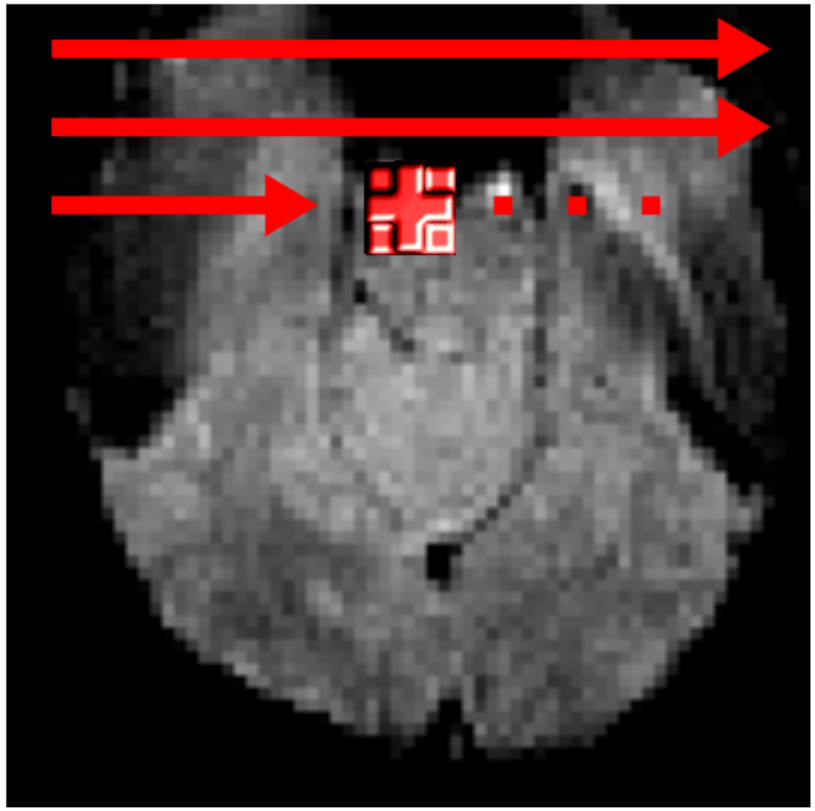
Kriegeskorte et al. 2006

Searchlight mapping



Kriegeskorte et al. 2006

Spherical multivariate searchlight

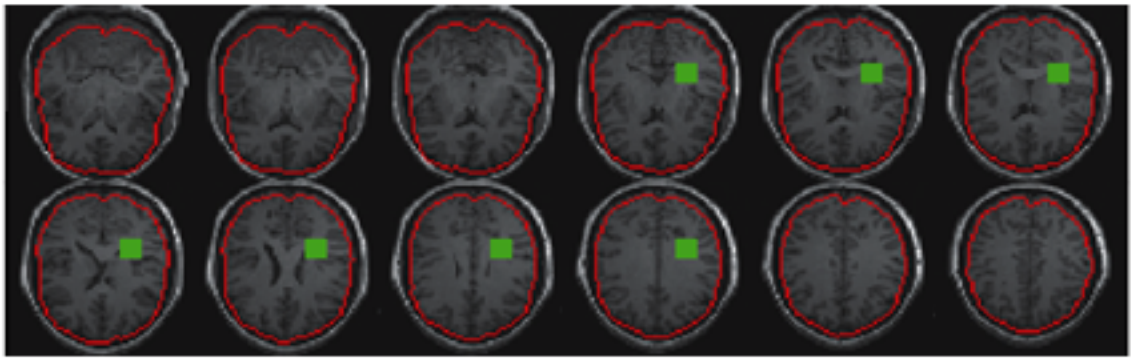


Kriegeskorte et al. 2006

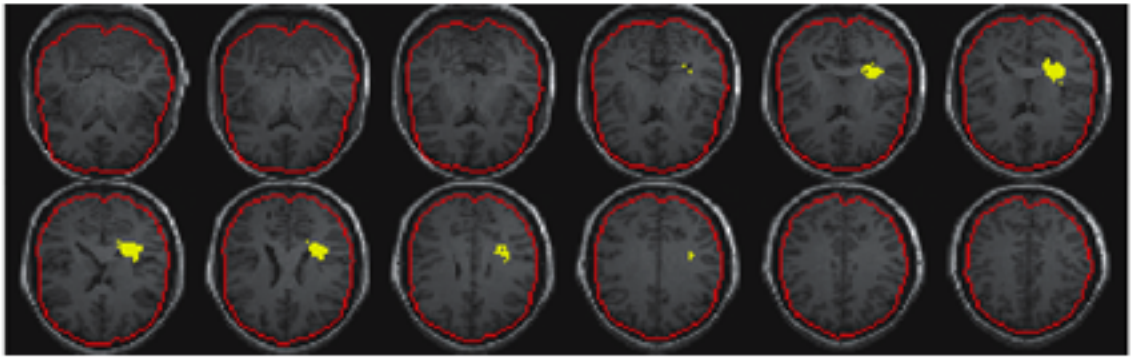
Searchlight RSA

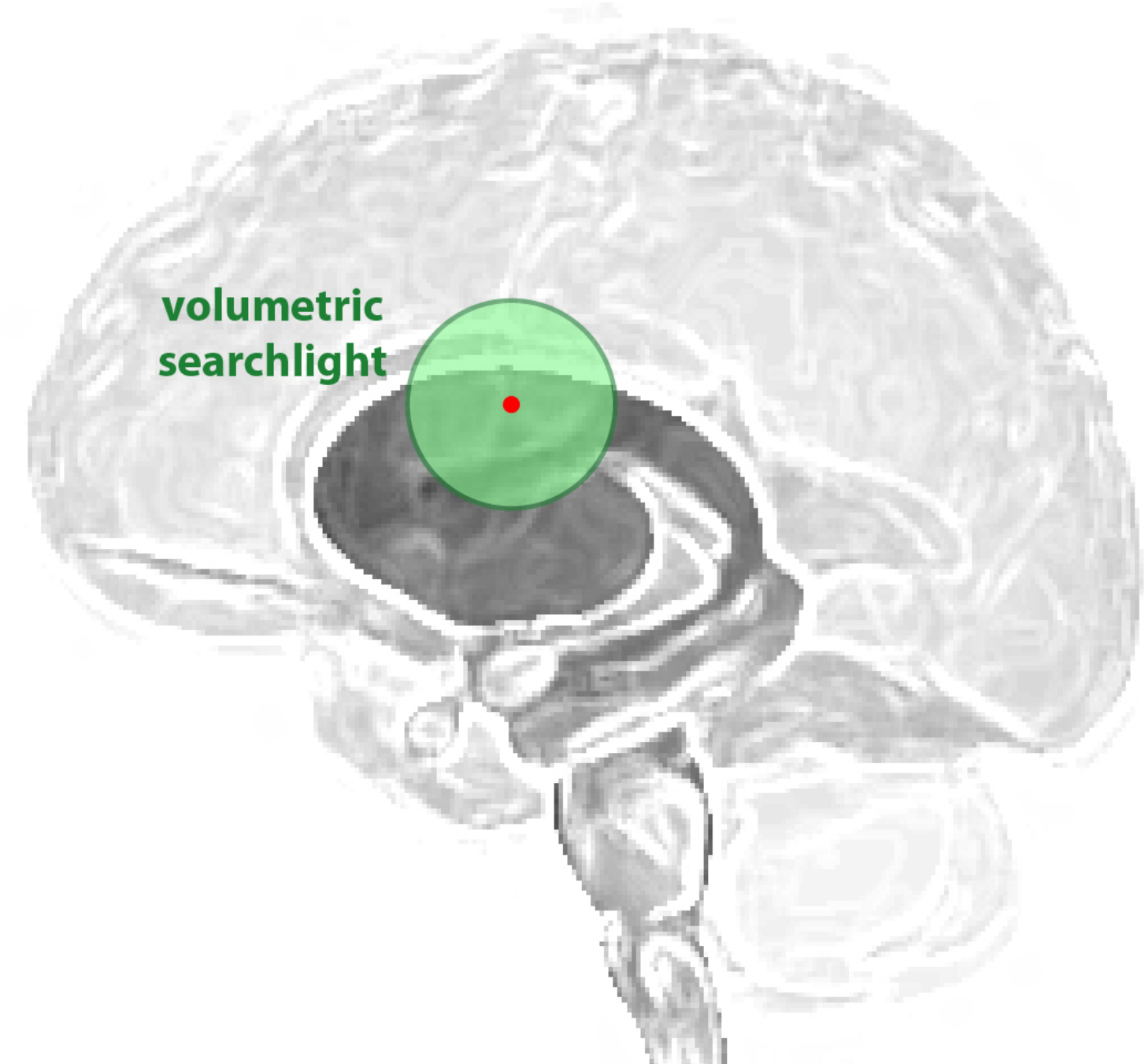
simulated effect

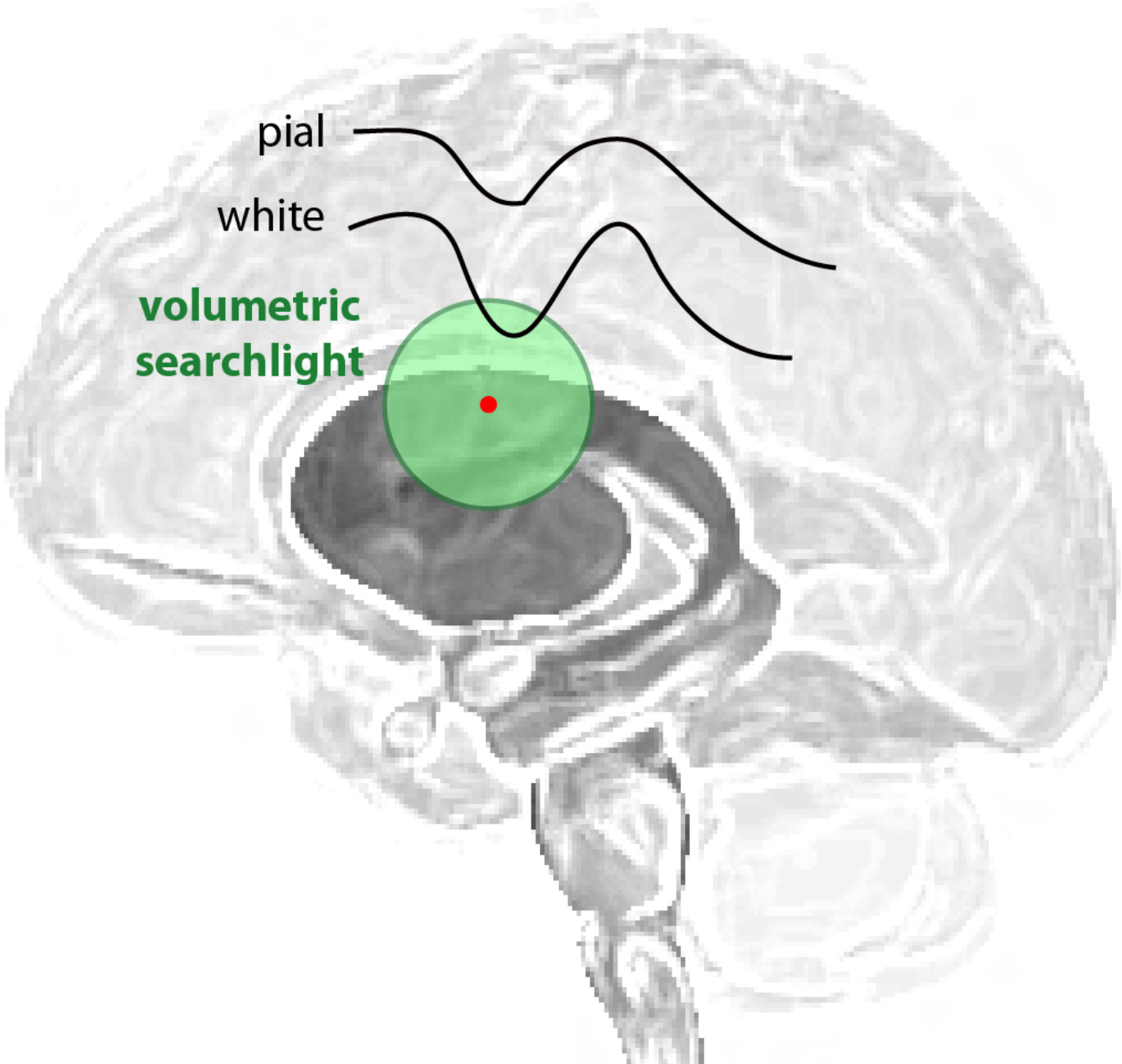
$p < 0.05$, FDR

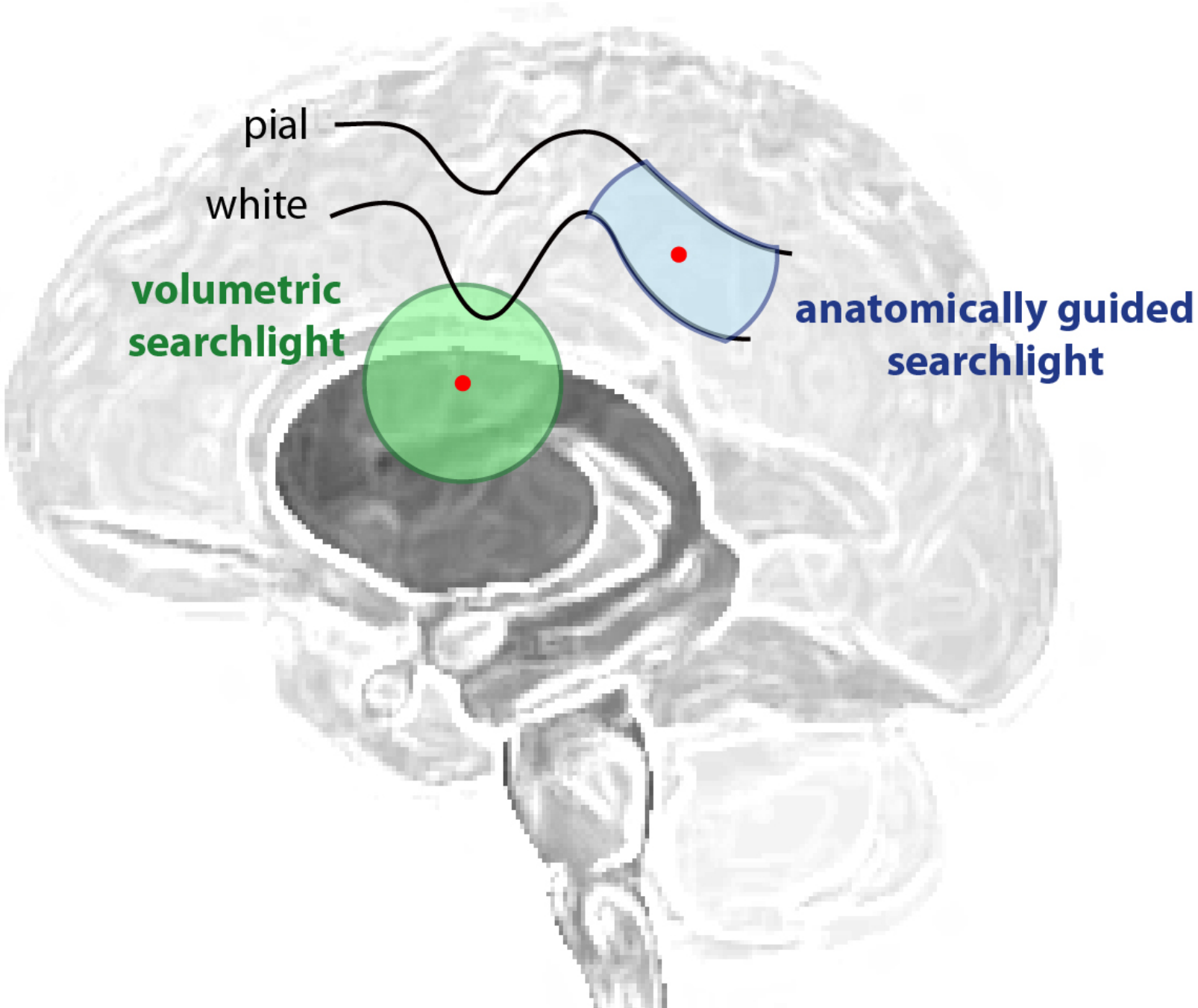


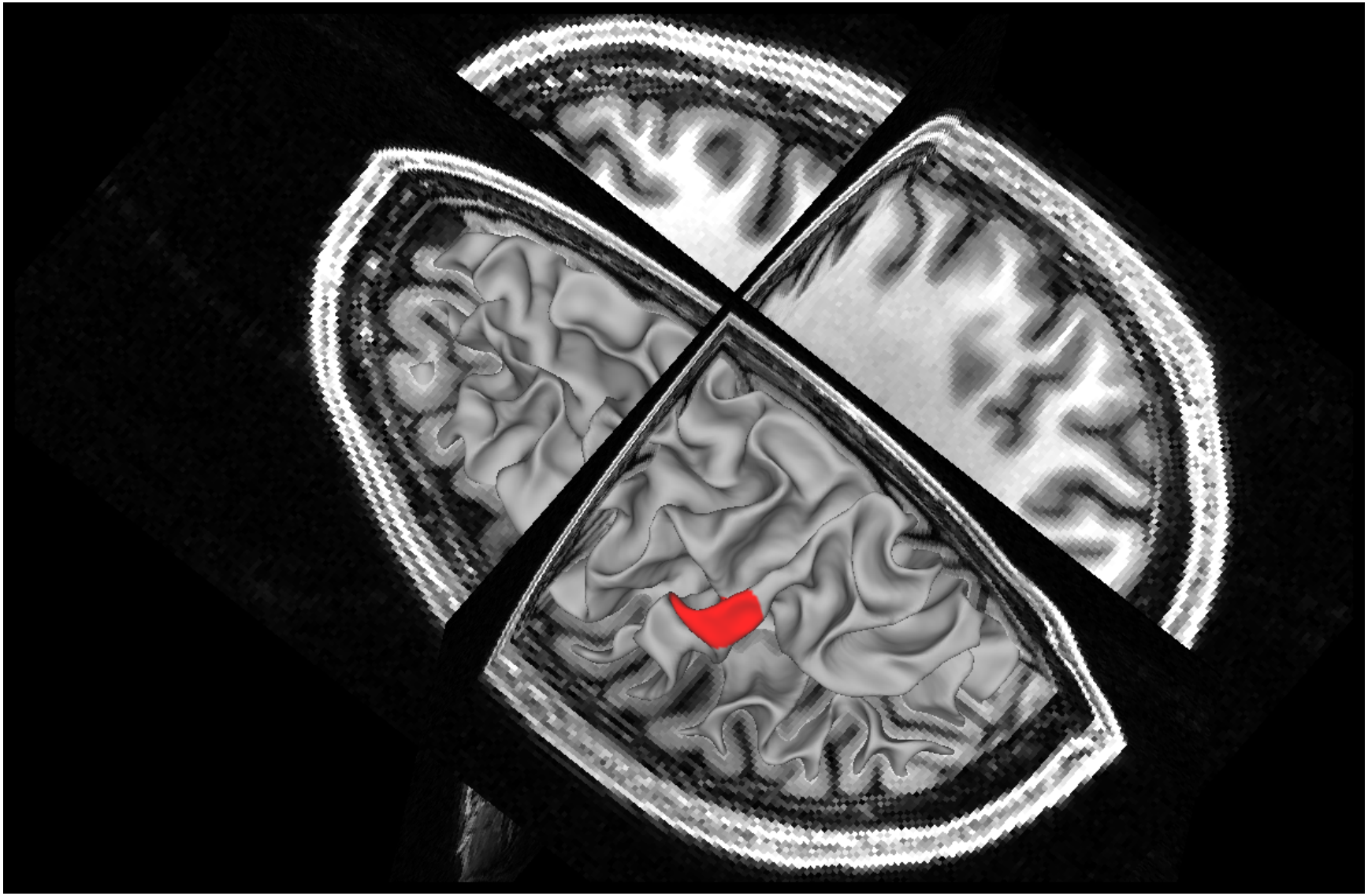
group level RFX




volumetric
searchlight


pial
white
volumetric
searchlight


pial
white
volumetric
searchlight
anatomically guided
searchlight



Key insights

C1 We can combine effects across many pairwise comparisons to gain power in condition-rich designs.

C2 The most powerful tests of exemplar discriminability use multivariate noise normalisation with fixed-effects or random-effects inference.

C3 We can test if two RDMs are related by simulating the null hypothesis using RDM randomisation.

C4 We can test if one model explains a brain RDM better than another model by using a random-effects signed-rank test or a condition-bootstrap test.

C5 We can assess if a model fully explains a brain RDM by comparing its RDM correlation with the brain RDM to the noise ceiling.

C6 We can find brain regions exhibiting a particular representational geometry using volume- or cortical-surface-based searchlight RSA.

SUPPLEMENTARY SLIDES

Comparing Spearman and Kendall's tau-a