Introduction into fMRI analysis.
PsyMsc4 (Goethe 2022).

Inference II.
Session-4

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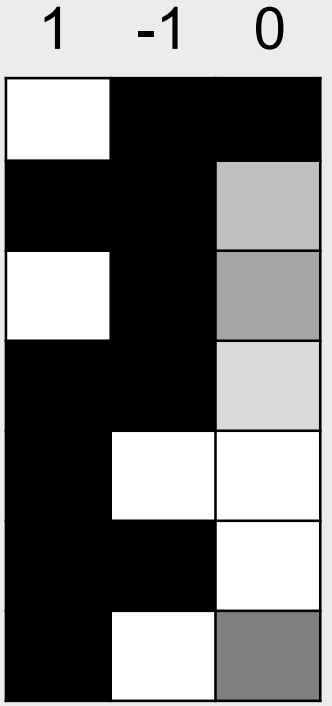
Recap of last week

General recap.

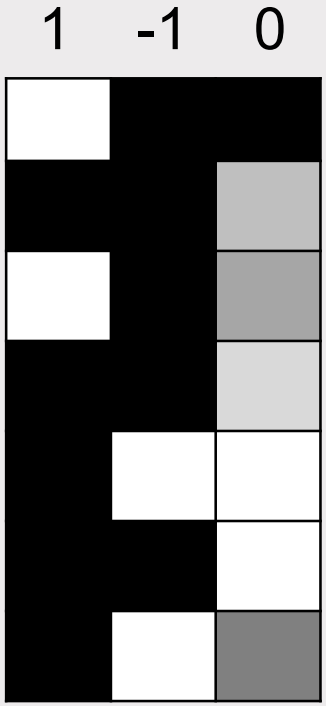
- Beta estimates cannot be interpreted directly.
- T and F contrasts can be used to compare conditions.
- Beware of contrasts against implicit baseline.
- Contrast vectors are widely used and powerful when we have complex comparsions.
- When designing an experiment, always chose an appropriate baseline.



Functional MRI. Group-level analysis.

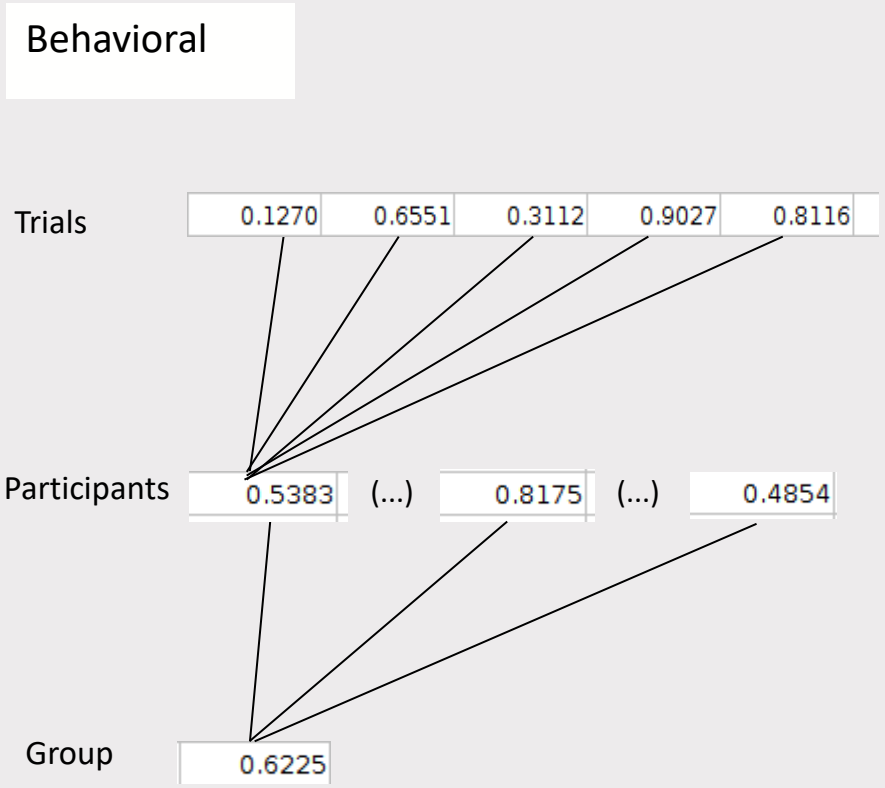
We have obtained contrast maps for each participant in our study. These contrast maps contain the values for each participant that correspond to our contrast vectors. Namely, the differences between conditions (in the directions specified by the vectors).

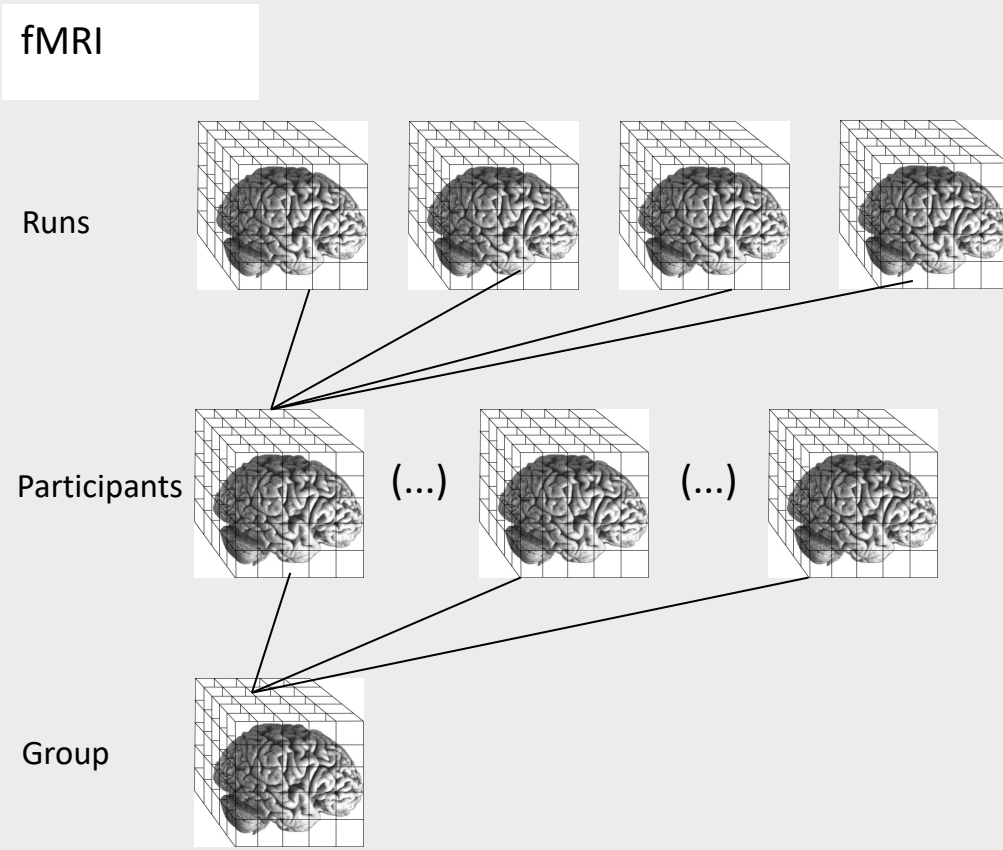
Similar as for a behavioral study, now we would want to see how consistent are those differences across the entire sample.



Functional MRI. Group-level analysis.

What are group-level analysis?
Comparison with a (rather) equivalent process to understand the rationale of the steps that we have done.





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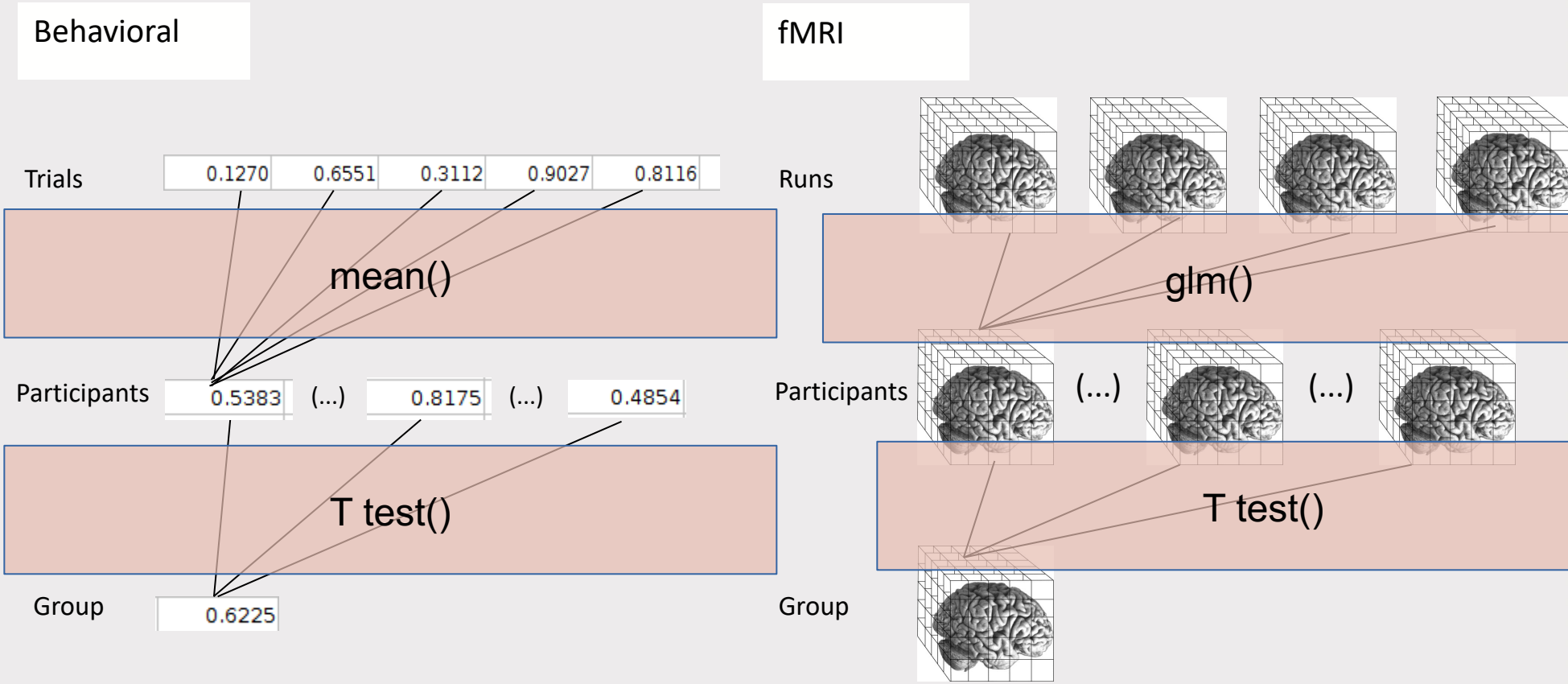

Functional MRI. Group-level analysis.

Quick note: Different names for the same (conceptual) steps on different packages.

	FSL	SPM
Subjects	1st level	1st level
Runs	2nd level	
Group	3rd level	2nd level

Functional MRI. Group-level analysis.

So how do we do this? Back to RTs...

Participants / Conditions	Congruent (ms)	Incongruent (ms)	Congruity effect (ms)
1	750	889	139
2	322	569	247
3	477	789	312
4	566	865	299
(...)	(...)	(...)	(...)

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We can take these values and run T test against zero.

We will get a T value.

QUESTION:
What will this test tell us?

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Functional MRI. Group-level analysis.

What if we do this in one voxel?

Participants / Conditions	Congruent	Incongruent	Congruity effect
1	1750	889	-861
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Functional MRI. Group-level analysis.

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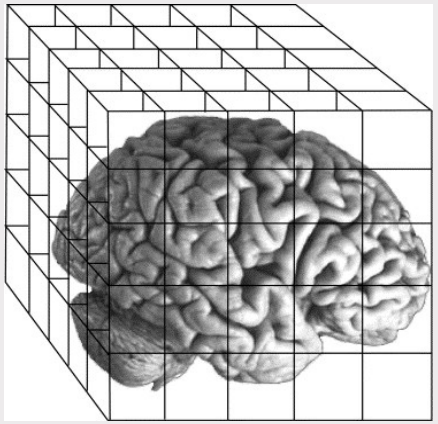

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Functional MRI. Group-level analysis.

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4	
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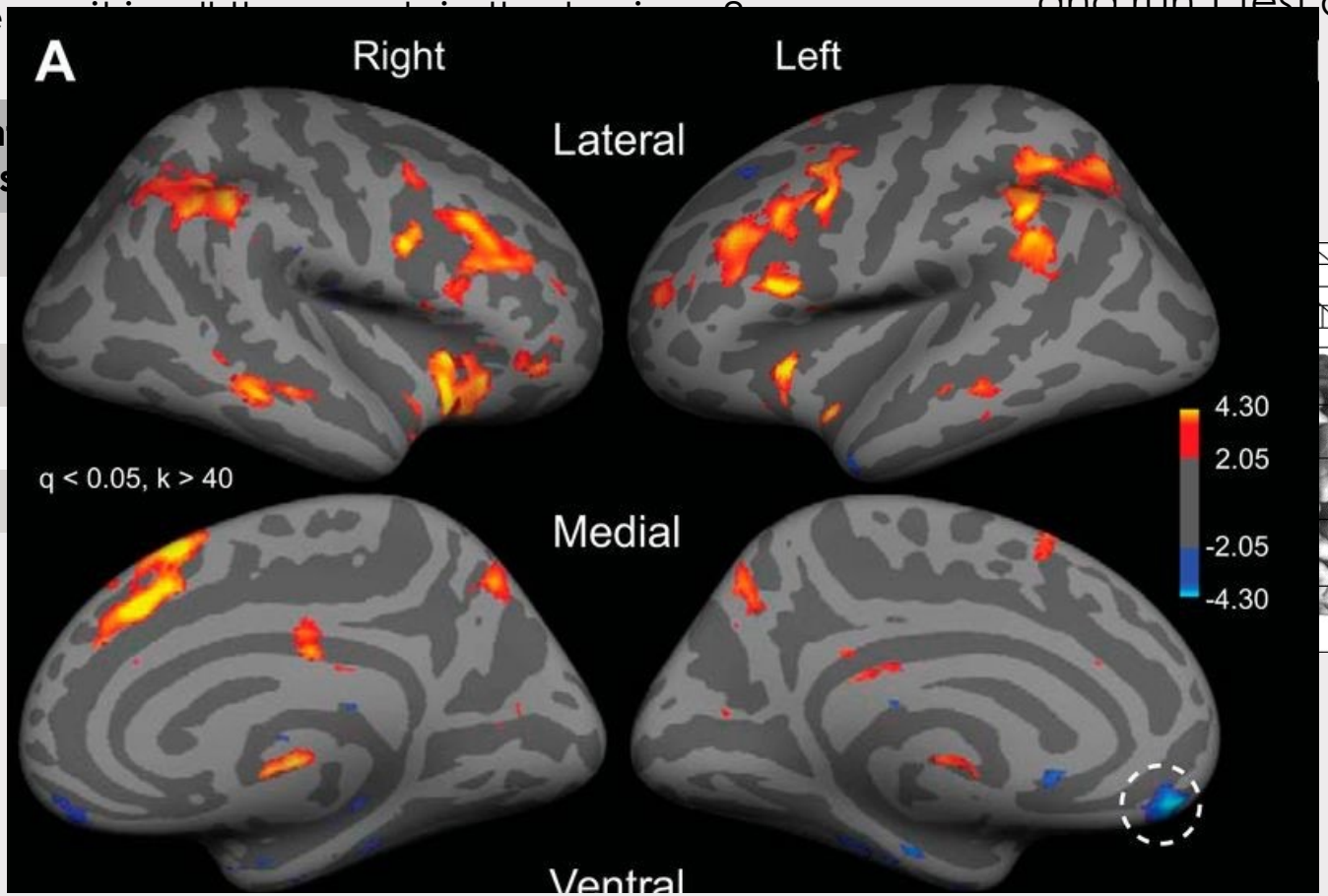
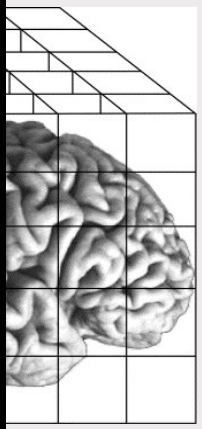


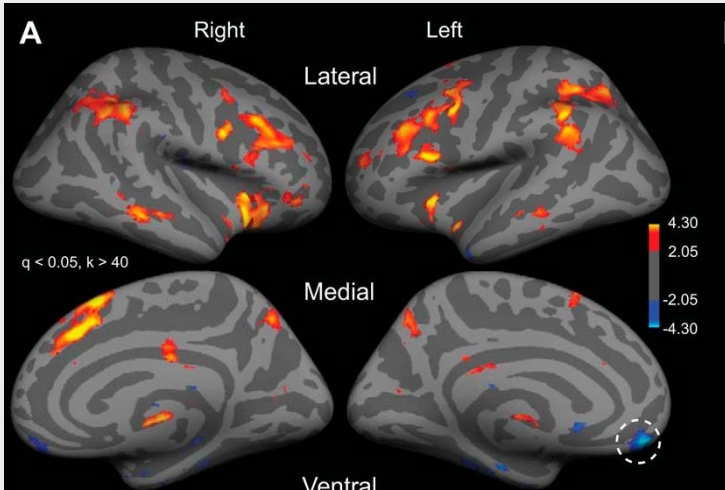


So… activation maps are **not activity maps** per se: they are **Statistical Parametric Maps (SPM) -**T values in this case-.

Inference II.

Interim recap.

- First level analysis take in raw BOLD signals and produce beta maps.
- In a univariate contrast analysis, we subtract beta maps for each of our conditions from one another to obtain contrast maps.
- Contrast maps are brought to a Second level (Third level in FSL) to aggregate across subjects.
- Activation maps are actually statistical parametric maps.



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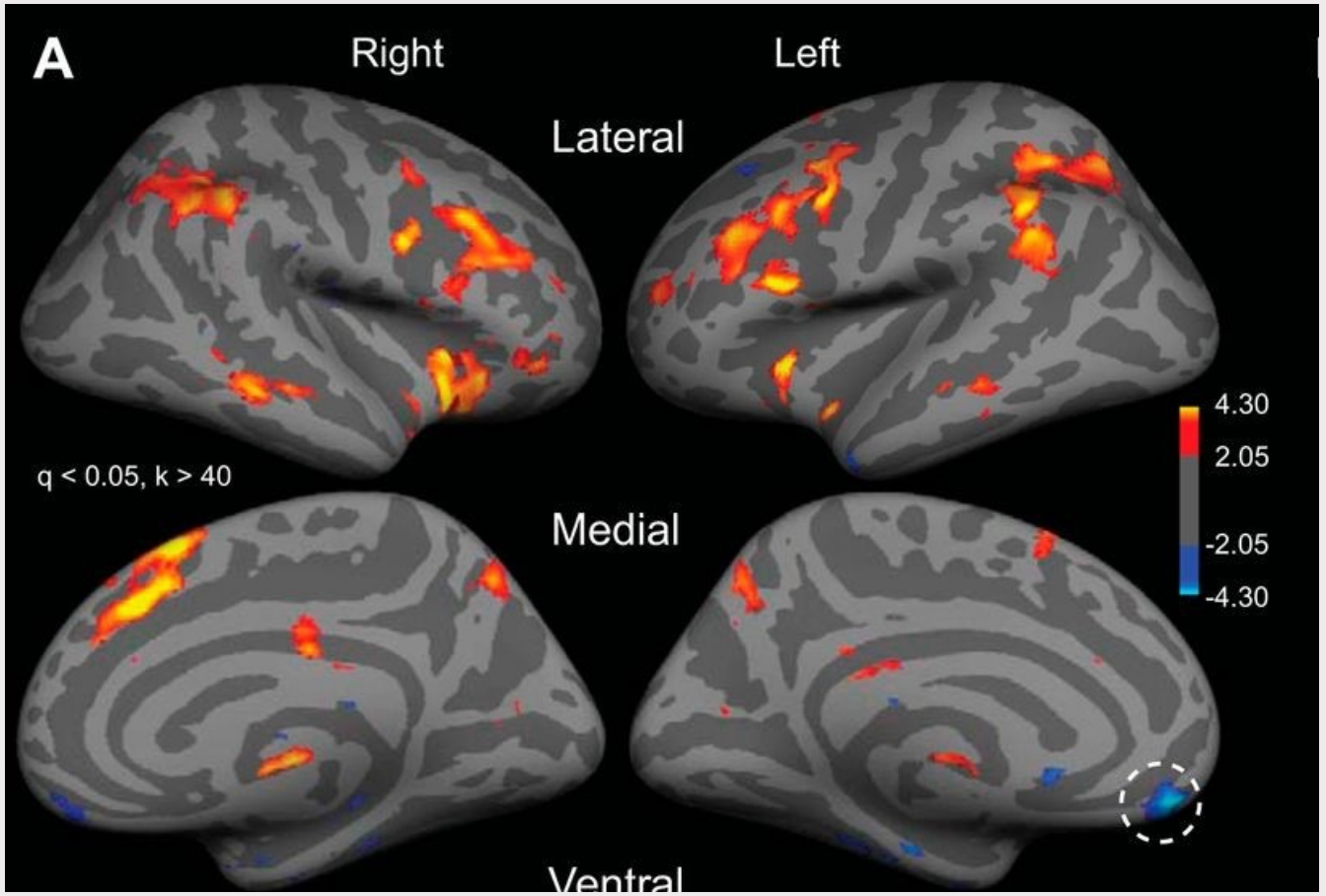
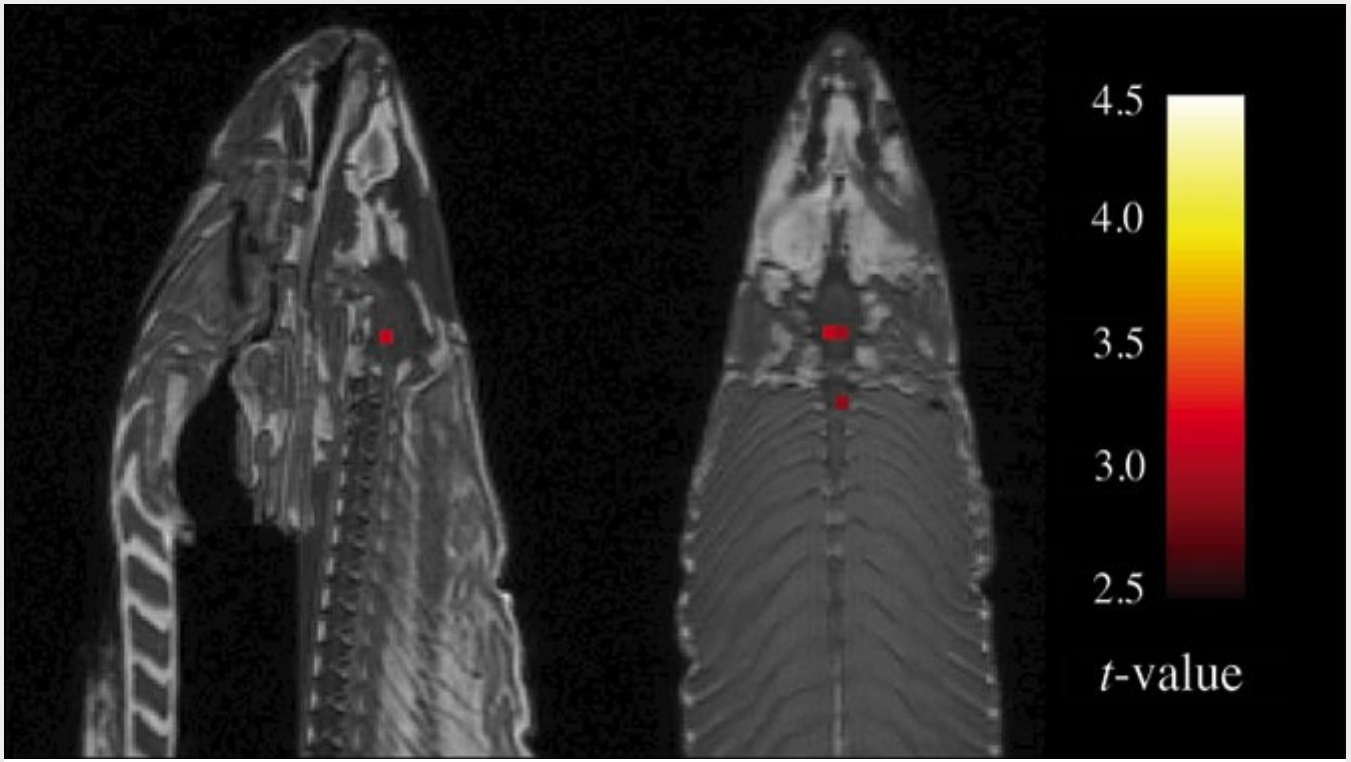


QUESTION:
Why is not the entire brain colored?

} Hint

Functional MRI. Group-level analysis.

Enter: The dead salmon and MCC.



Neural correlates of interspecies perspective taking in the post-mortem Atlantic Salmon: An argument for multiple comparisons correction

Craig M. Bennett[1], Abigail A. Baird[2], Michael B. Miller[1], and George L. Wolford[3]

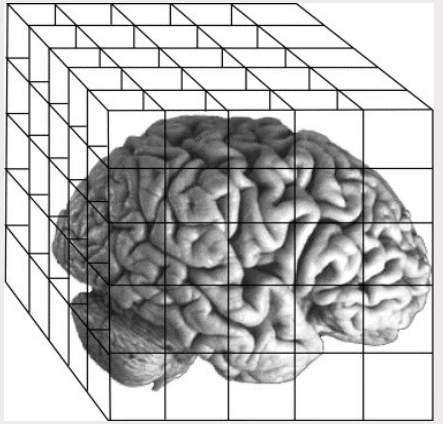
Functional MRI. Group-level analysis.

Multiple comparison problem:

A standard MNI brain has over 260,000 voxels.

Running a T test on every voxels implies running over 260,000 tests.

QUESTION:
What is the implication of this huge number of tests for our statistical inferences?



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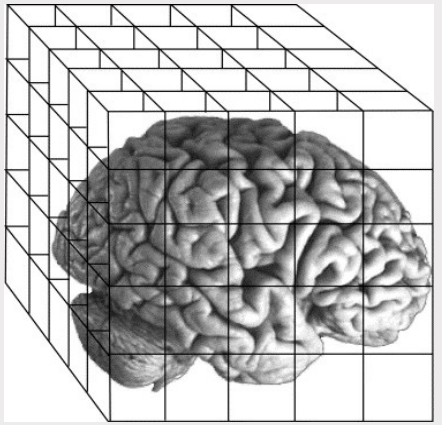
Functional MRI. Group-level analysis.

Multiple comparison correction:

- Bonferroni.
- False Discovery Rate (peak level. For a nice visualization of the procedure see https://andysbrainbook.readthedocs.io/en/latest/fMRI_Short_Course/fMRI_Appendices/Appendix_A_ClusterCorrection.html#appendix-a-clustercorrection)
- False Discovery Rate (cluster level).



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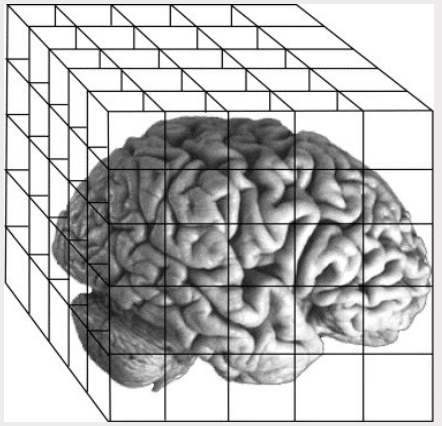
Functional MRI. Group-level analysis.

Bonferroni correction.

Corrected alpha = alpha / number of tests.

QUESTION:
Do you spot any problems with this type of correction?



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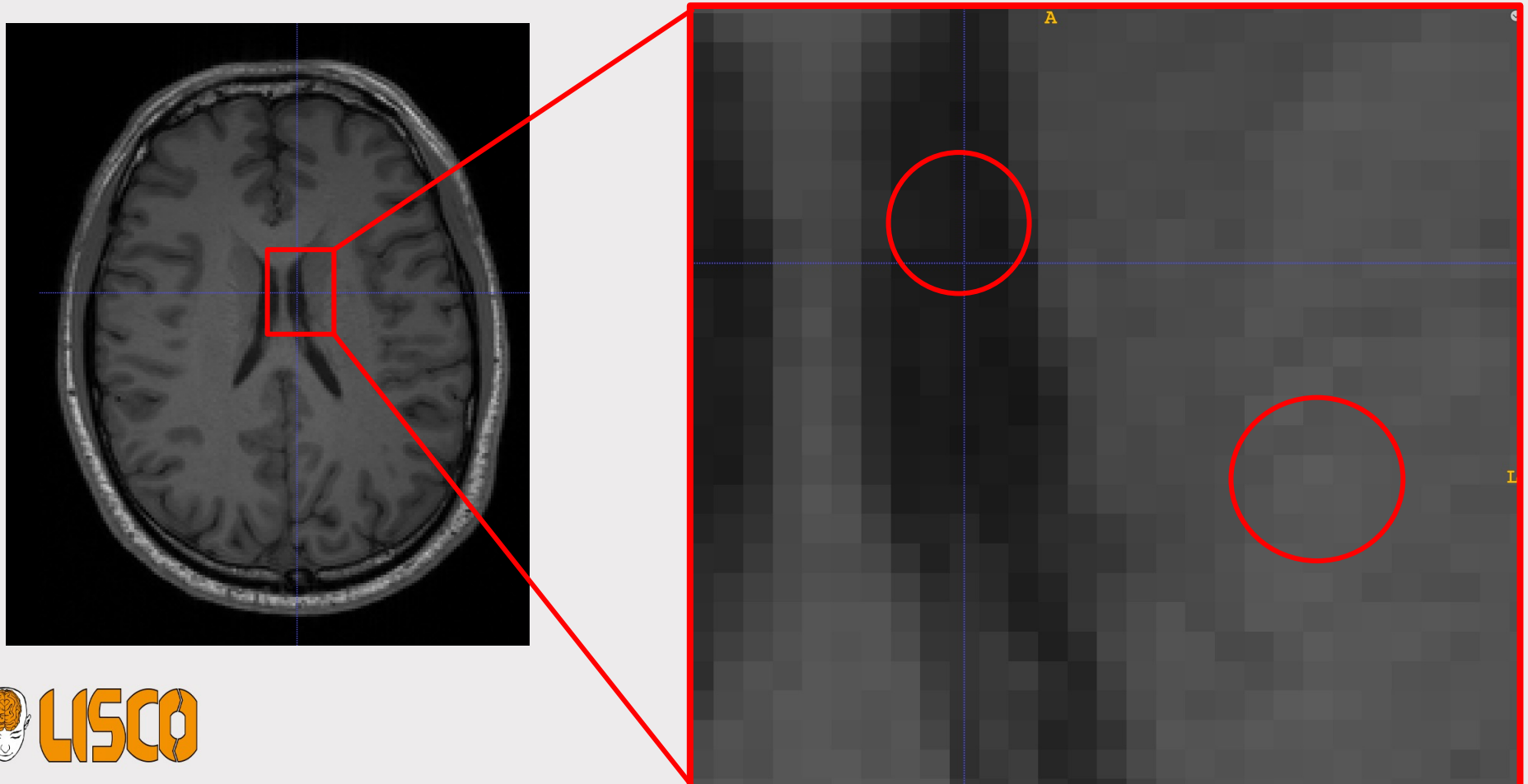

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- FDR (cluster level). What is the minimum cluster size that we are going to consider relevant?

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- FDR (cluster level). What is the minimum cluster size that we are going to consider relevant?
- Random Field Theory (RFT). *Not covered here.*

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- Contrast maps are brought to a Second level (Third level in FSL) to aggregate across subjects.
- Activation maps are actually **thresholded** statistical parametric maps.
- Thresholding is done to account for the multiple comparison problem.
- Bonferroni is usually too-strict and fails to take into account spatial correlation of BOLD signal.
- FDR can help us obtain a good balance between specificity and sensitivity.