Lab session 12:

Final exam review of lab material

(Lab material is cumulative with emphasis on second half)

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04/13/16

Session no.	Date (all Wednesday)	Topic/activity	Topic of quiz that day	Topic of lab write-up (assignment) due that day
1	13-Jan	Lab overview		
2	20-Jan	Brain anatomy		
3	27-Jan	Data preprocessing	Brain anatomy (no. 1)	
4	3-Feb	Set up GLM model	Functional brain anatomy (no. 2)	
5	10-Feb	Single-subject SPM contrasts	Data preprocessing and GLM model (no. 3)	Brain anatomy (no. 1)
6	17-Feb	Within-subject MVPA		Single-subject SPM contrasts (no. 2)
7	24-Feb	SIBR tour and review for mid-term exam		Within-subject MVPA (no. 3)
No lab	2-Mar	No lab (mid-term exam)		
No lab	9-Mar	No lab (spring break)		
8	16-Mar	Group-level SPM contrasts		
9	23-Mar	Between-subjects MVPA		Group-level SPM contrasts (no. 4)
10	30-Mar	Voxel-wise modeling		Between-subjects MVPA (no. 5)
11	6-Apr	Functional connectivity analysis (*no assignment*)		
12	13-Apr	Review for final exam		Voxel-wise modeling (no. 6)
No lab	20-Apr	No lab		
No lab	27-Apr	No lab (final exam)		

“Bird’s eye view” of major data analyses

	GLM	**MVPA (*DISCRIMINATIVE* CLASSIFICATION)**
Target of analysis:	Increased or decreased neural processing	Information encoded within neural activity
Measurement (more specifically):	Differences in BOLD univariate responses recorded for conditions	Differences in the distributed multi-voxel activity patterns recorded for different conditions

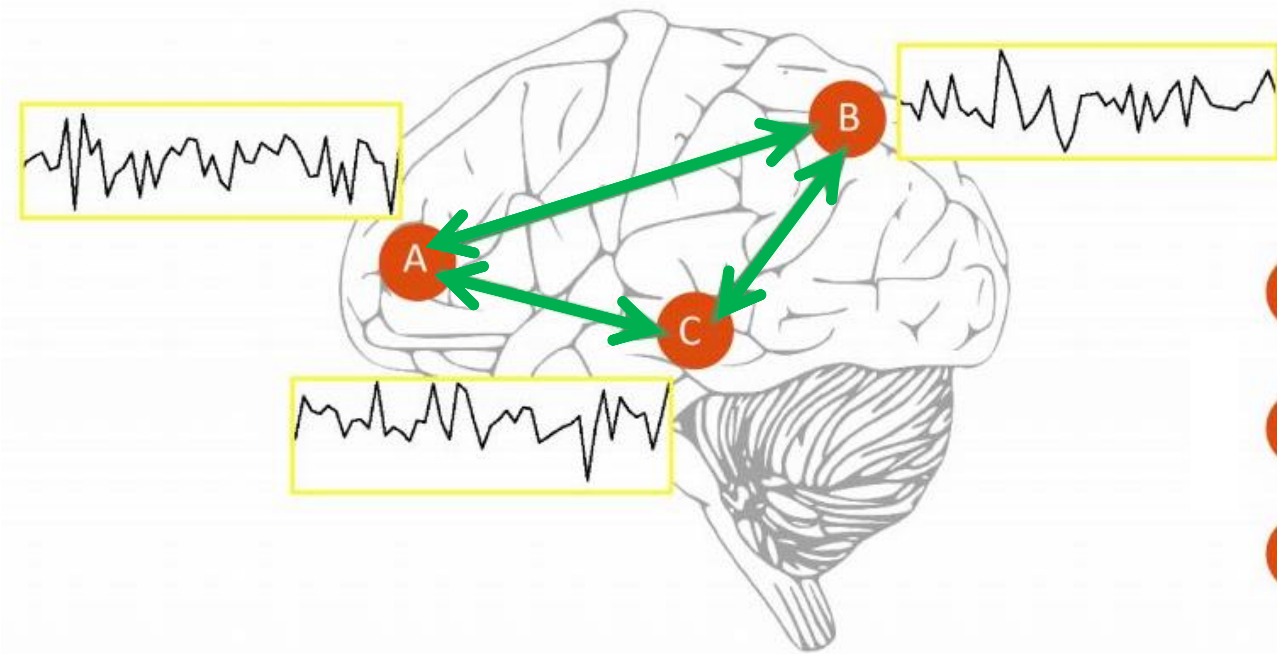
	(BASIC) FUNCTIONAL CONNECTIVITY ANALYSIS	**VOXEL-WISE MODELING (*GENERATIVE* CLASSIFICATION)**
Target of analysis:	Shared increases or decreases in neural processing across regions	Information encoded within neural activity and *identifying* what that information is (i.e. feature decomposition of a concept)
Measurement (more specifically):	Synchronized changes in levels of univariate activation over a timecourse	Ability of a model to correctly match a predicted multi-voxel pattern with the actual/observed pattern

(Image adapted from Coutanche & Thompson-Schill, 2013)

Sample exam question about **functional connectivity analysis (FCA)**

- What is the purpose of FCA—that is, what does it seek to demonstrate?

Basic correlational FCA:
Pairwise correlations between nodes



	A	B	C
A	1	0.8	0.7
B	0.8	1	0.5
C	0.7	0.5	1

- Define network *nodes* (spatial coordinates or regions of interest)
- Identify a timeseries associated with each node
- Estimate the *edge strengths*, or connections between the nodes
  - For example, correlate each timeseries with every other timeseries

(Image adapted from Smith et al., 2013)

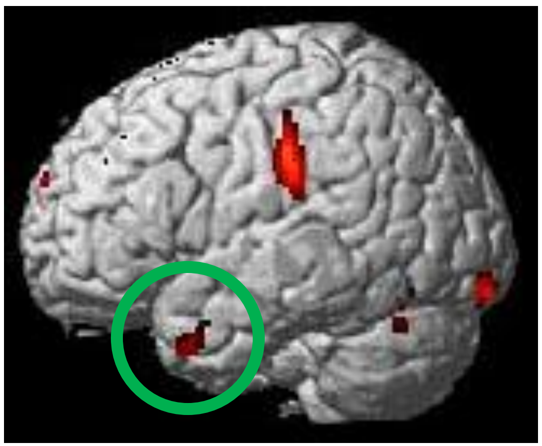
Sample exam question about **group-level GLM analysis**

- Describe how *group-level* GLM results generally differ from *single-subject* GLM results

What are group-level results generally like?

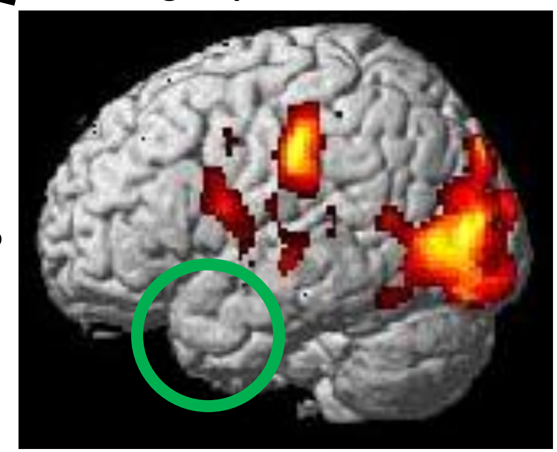
- Stronger activation, which often means:
  - Greater number of statistically significant voxels (using the same *p*-value threshold when comparing a single-subject to a group-level contrast)

A single-subject contrast



p = 0.005

The group-level contrast



- Also, group-level results contain *common* clusters of activation
  - **Disappearance of clusters that correspond to only one or a couple subjects**
  - The less common a cluster, the less likely it will be statistically significant in the group-level analysis

Multiple comparisons problem
(Applies to *both* single-subject and group-level analysis)

- Say we set p = 0.05 threshold for each voxel in a contrast
  - This means we are willing to tolerate a 5% chance that a voxel is statistically significant purely due to chance
  - If 200,000 voxels tested in an analysis, then there could be 200,000 * 0.05 = **10,000 falsely significant voxels**

- Ways to combat this problem:
  - Lower the *p*-value threshold to make a statistically significant voxel less likely due to chance
  - Set a cluster size threshold (e.g. 10, 20, 30 voxels)
    - A big cluster of significant voxels is less likely to be due to chance

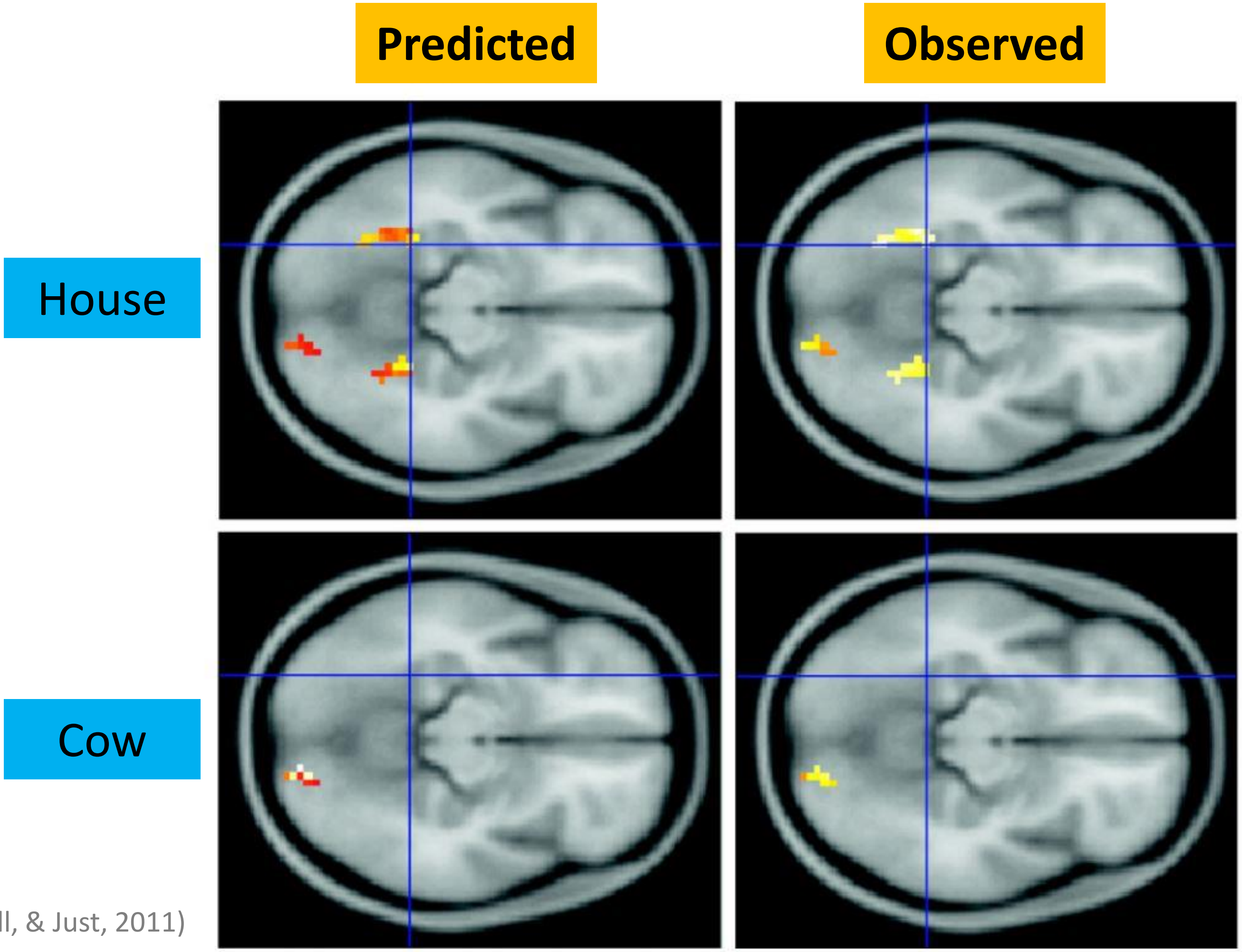
Sample exam question about **voxel-wise modeling**

- Explain what “modeling” refers to in *voxel-wise modeling*

Predictive voxel-wise modeling

- Predict the multi-voxel activation pattern of a concept…

  based on a model of how different voxels encode the concept's features
  - E.g. **house**: is used for shelter, is made of wood or brick, etc.



(Chang, Mitchell, & Just, 2011)

How & why do voxel-wise modeling?

- We first estimate a model of how each voxel responds to a set of features that define object concepts
  - E.g. one particular voxel activates to thinking about motion (one possible feature), but not about color (another feature)
- We can then predict the brain activation pattern of a concept based on:
  - The feature decomposition of that concept
  - The estimated model of how each voxel responds to these features
- This analysis determines:
  - *What* types of information (features) of concepts are represented in the brain
  - *Where* these features are represented in the brain

Step 1: Break down a concept into constituent features (e.g. recruit subjects to)

HOUSE

Used for shelter

Is warm

Is large

Rectangular shaped

Made of wood

Step 2: Categorize the features

HOUSE

Used for shelter	***Function***
Is warm	***Tactile***
Is large	***Visual surface***
Rectangular shaped	***Visual surface***
Made of wood	***Visual surface***

Step 3: Weight each feature category
(based on proportion its features)

HOUSE

Function	**1/5**
Tactile	**1/5**
Visual surface	**3/5**

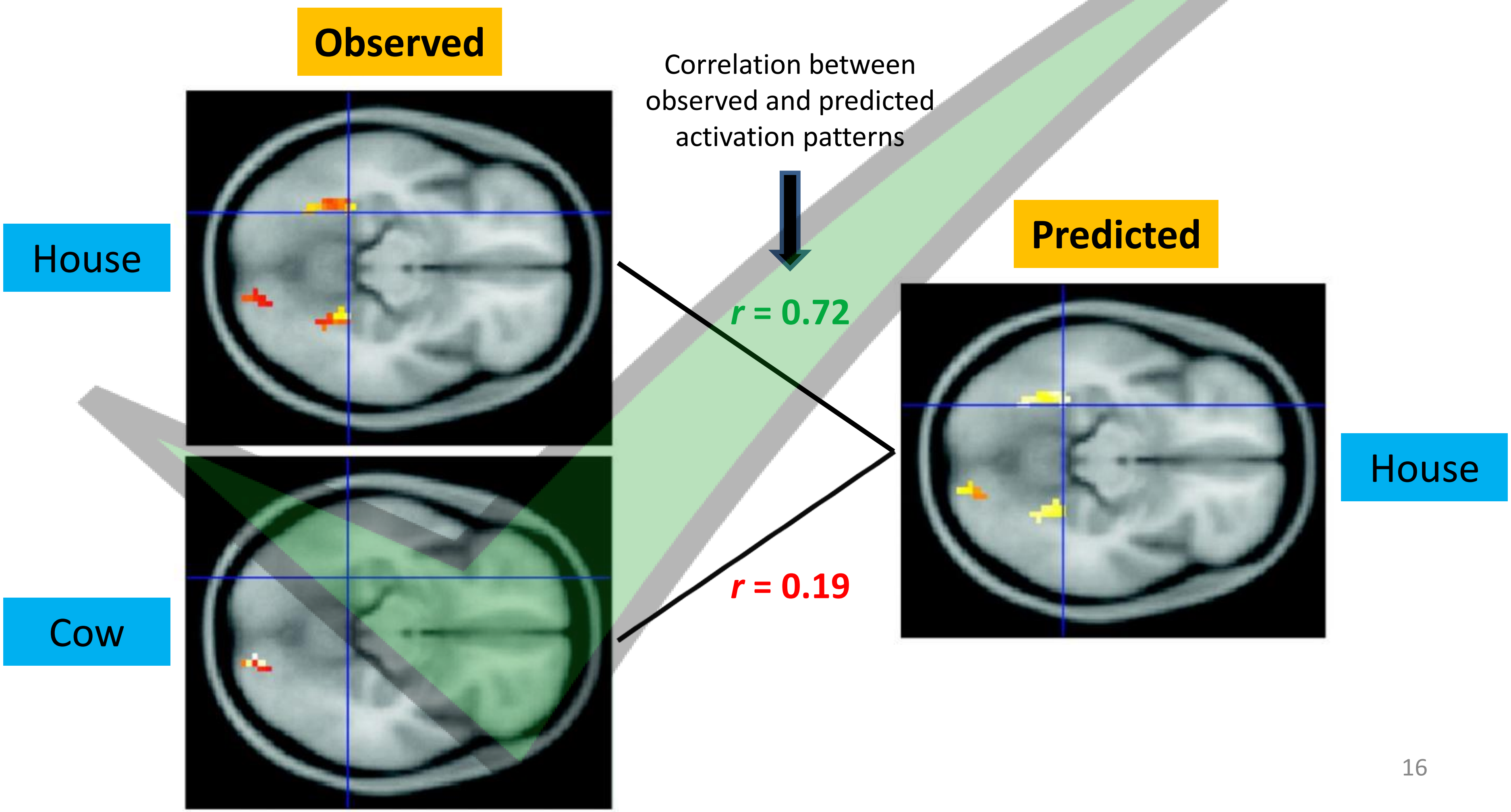
After defining concepts by constituent features…

Step 4: Run subjects in the scanner, asking them to think about the concepts

Steps 5&6: After estimating how each of *n* feature categories affects a voxel's activation, predict the activation pattern of each concept, then evaluate predictions

Mean proportion correct using BR encoding scheme

Model	All	Frontal	Temporal	Parietal	Occipital	Fusiform	Hippocampus
(d) Ability to distinguish between the activation of two previously unseen words (accuracy)							
BR	0.65	0.60	0.57	0.66	0.62	0.69	0.49



Another sample exam question about **voxel-wise modeling**

- What is another name for voxel-wise modeling? (*“________ classifier.”*) Why is it called this?

Voxel-wise modeling is often called *generative* (vs. *discriminative*) *classification*

- It can generate/predict the activation pattern for *any* unseen concept, as long as the concept can be decomposed into the model's feature categories

***Generative* classifier**

TRAIN on:		TEST on:
Car	TRAINING stimuli	House
Hammer	can be ≠	Cow
Apple	TEST stimuli	Tree

***Discriminative* classifier (MVPA)**

TRAIN on:		TEST on:
Car	TRAINING stimuli	Car
Hammer	must be =	Hammer
Apple	TEST stimuli	Apple

Generative vs. *discriminative classification* approaches to studying multi-voxel activation patterns

- *Discriminative*
  - Does *not* model feature encodings of concepts
  - Still useful in determining *where* in the brain there are multi-voxel neural representations of concepts

- *Generative (i.e. predictive voxel-wise modeling)*
  - *Does* model feature encodings of concepts
    - Generally truer results (lower classification accuracy, but less overfitting)
  - This analysis determines:
    - *What* types of information (features) of concepts are represented in the brain
    - *Where* these features are represented in the brain

“Closing ceremony”
Delete the lab folder

1. Find the lab folder in: *C:/Users/Public*
2. Then permanently delete the whole folder: *lab_85_429_2016*

- NOTE: Shift+Delete will permanently remove the folder
  - Or you can delete the folder normally and then manually delete it from Recycle Bin