fMRI 101, Part 3

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cognition / consciousness

physics / physiology

system #1

system #2

T2*
Two basic types of neuroimaging studies (and a third that combines the two)

The key question to ask for each
The brain area for “Love”? 

Forward inference

which brain areas correspond to an isolated behavior?
• Why we love
• What your brain looks like on faith
• What makes us moral
• When worry hijacks the brain
• How we get addicted
• Marketing to your mind
• Inside the grieving brain
• It feels good and everybody does it [scratching]
• Mind reading is now possible
• This is your brain on optimism
• Hot flashes [fMRI of menopause]

A menopausal hot flash increases activity within the insula
The brain area for “Love”?

Forward inference

isolate behavior by subtracting conditions
The brain area for “Love”? 

Spouse vs. Friend over time
The brain area for “Love”? 

Spouse vs. Friend over time 

BOLD fMRI signal
what if the “subtraction” includes other mental states?

The brain area for “Love”?
The brain area for “working memory”?

Manipulating mental operations

- Stimulus: 100 ms
- Delay: 7400 ms
- Response: 500 ms
Task versus cognitive process

- **Task**
  - delayed vs. immediate match to sample
  - matching rotated vs. non-rotated figures
  - pictures of spouse vs. pictures of friends

- **Cognitive process**
  - working memory
  - mental rotation
  - romantic love
Imaging versus lesion inference

This brain area is necessary for the perception of love
Imaging versus lesion inference

This brain area is necessary for the perception of love

Imaging and lesion inferences are largely independent
The brain area for “Love”? 

Forward inference

relate variations in the behavior to variations in neural response
relate individual differences in behavior to brain differences

The brain area for “Love”?
Forward inference

how was the behavior isolated?
Does hearing a bad joke induce physical pain?

Focal reverse inference

use local brain activity to identify mental states or emotions a situation evokes
• Why we love
• What your brain looks like on faith
• What makes us moral
• When worry hijacks the brain
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Scratching evokes a sense of pleasure because it decreases memory of pain
Does hearing a bad joke induce physical pain?

Focal reverse inference

use local brain activity to identify mental states or emotions a situation evokes
Does hearing a bad joke induce physical pain?

Focal reverse inference

what if more than one state can activate a brain region?
relate variations in stimulus properties or information processing to response
Focal reverse inference

how strong is the association between local brain activity and the assumed evoked behavior?
Are you lying?

Goal: brain pattern detects lies

I picked the ace of spades!

LIAR
• Why we love
• What your brain looks like on faith
• What makes us moral
• When worry hijacks the brain
• How we get addicted
• Marketing to your mind
• Inside the grieving brain
• It feels good and everybody does it [scratching]
• Mind reading is now possible
• This is your brain on optimism
• Hot flashes [fMRI of menopause]

The scanner can determine if you are lying or telling the truth
Are you lying?

Goal: brain pattern detects lies

I picked the ace of spades!

LIAR
Are you lying?

Step 1: forward inference

I’ll tell the truth

train a computer to learn the pattern of activity evoked by telling truth
Are you lying?

Step 1: forward inference

I’ll lie and say I have a jack

train a computer to learn the pattern of activity evoked by telling lies
Are you lying?

Step 2: reverse inference

I picked the three of clubs!

Measure brain activity to discover if a new statement is a truth or lie
Are you lying?

The limitation

I never shot a man in Reno just to watch him die!

Can the classification generalize beyond the training set?
Multi-voxel classification

can the classification be generalized beyond the training context?
Forward inference
determine which brain region is associated with an isolated behavior

Focal reverse inference
use localized brain activity to determine which mental states are evoked by a complex behavior

Multi-voxel classification
use distributed patterns of brain activity to predict which mental state is being experienced
Forward inference

how was the behavior isolated?

Focal reverse inference

how strong is the association between local brain activity and the assumed evoked behavior?

Multi-voxel classification

can the classification be generalized beyond the training context?
Inferences in neuroimaging

State question in terms of neural activity:
• Can my design produce bulk changes in neural activity detectable with fMRI?

Make the inferential framework clear:
• What is the cognitive process and what is the task?
• Am I looking for the neural location of a cognitive process? Its computational implementation? Or am I studying the task itself?

Be cautious of inference across populations:
• Are my subjects impaired at the very cognitive process I seek to study?
• Could the populations differ in hemodynamic instead of neural physiology?