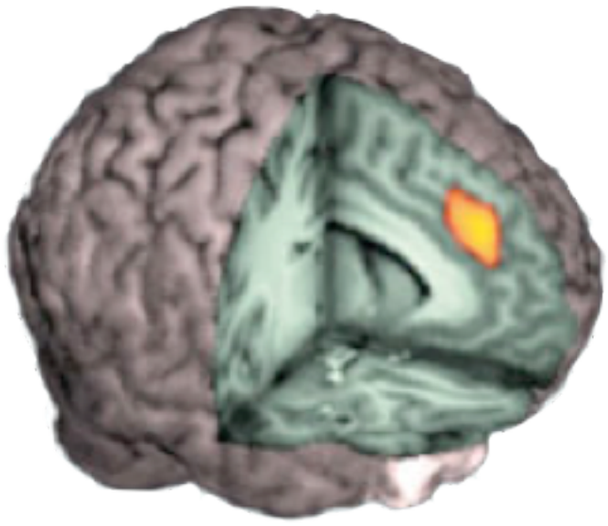
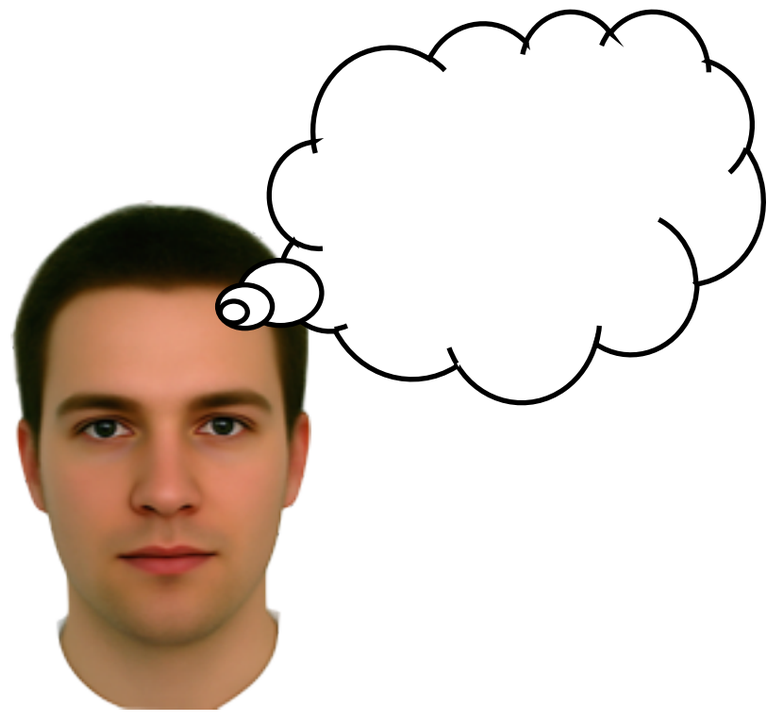
fMRI 101, Part 3

Geoffrey K Aguirre, MD, PhD

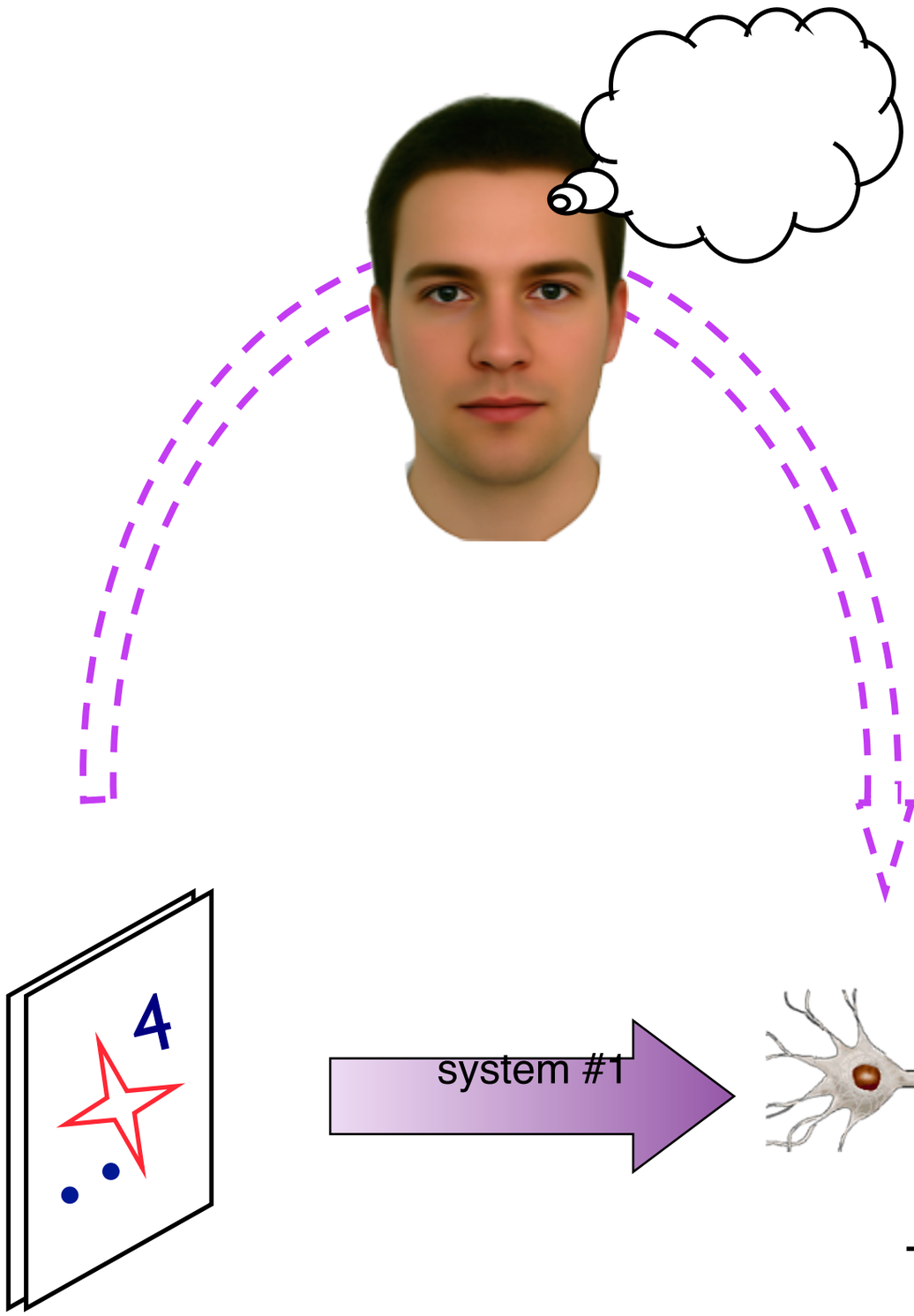
CENTER FOR
COGNITIVE
NEUROSCIENCE

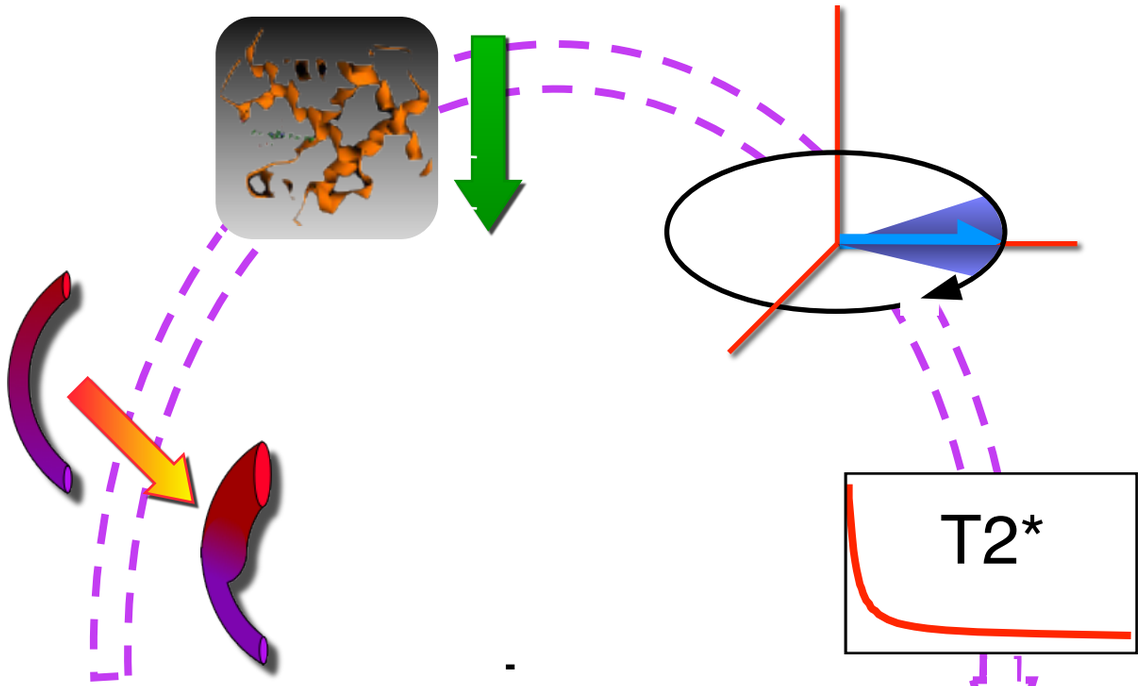




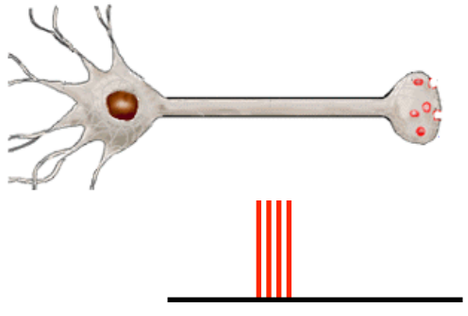
cognition / consciousness

physics / physiology

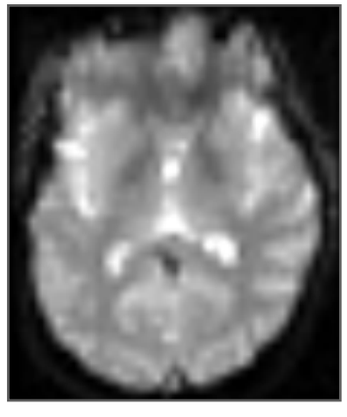




system #1

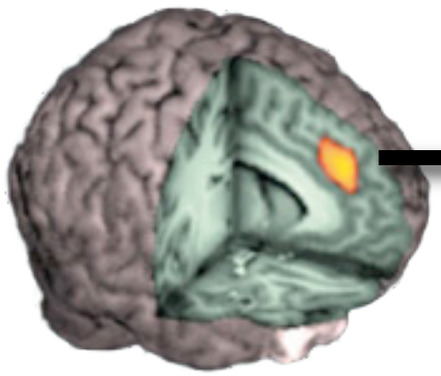


system #2



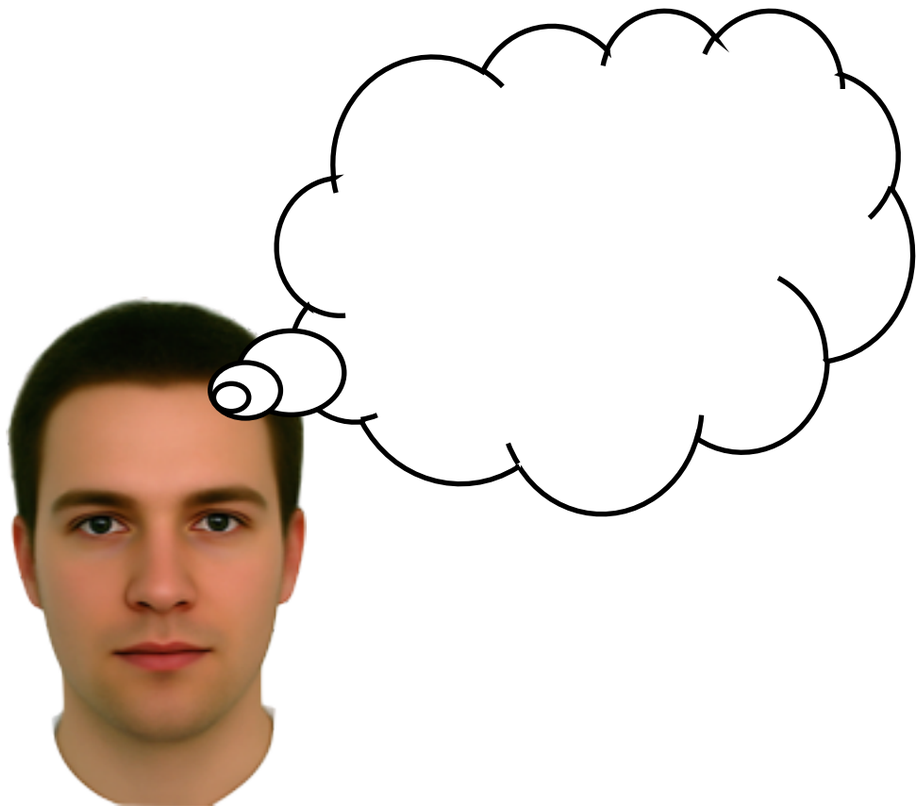
Two basic types of neuroimaging studies (and a third that combines the two)

The key question to ask for each



The brain area for “Love”?

Forward inference



which brain areas correspond to
an isolated behavior?

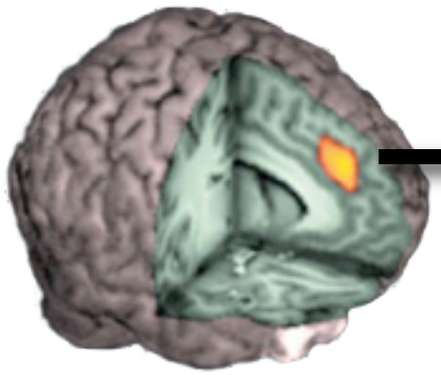
TIME

- Why we love
- What your brain looks like on faith
- What makes us moral
- When worry hijacks the brain
- How w
- Marke

A menopausal hot flash increases activity within the insula

New

- 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]



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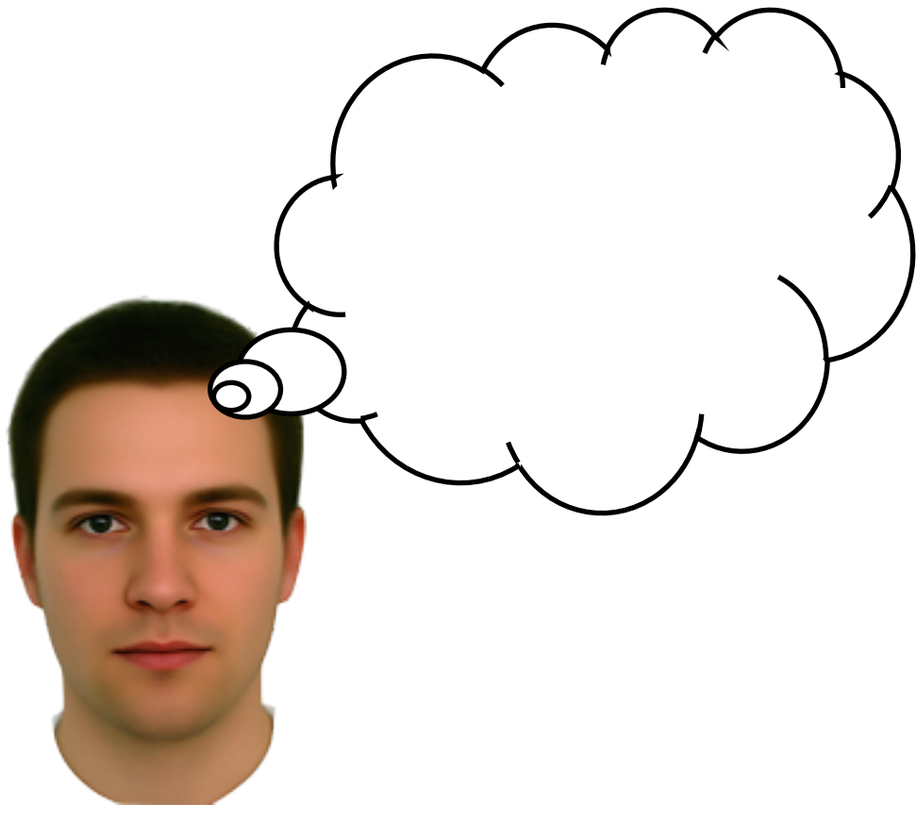
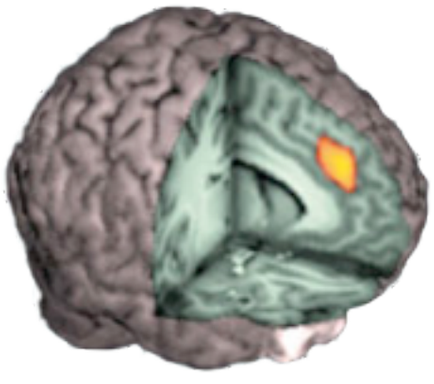
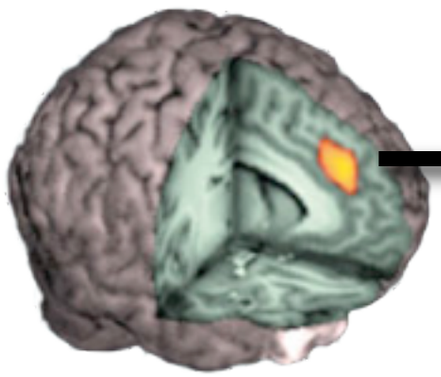


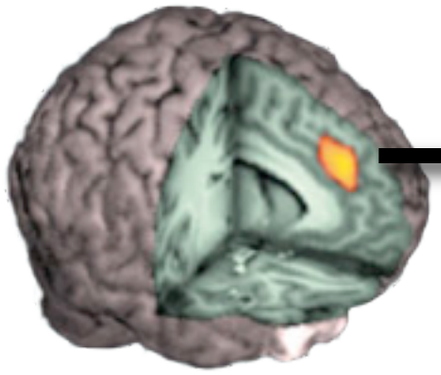


isolate behavior by subtracting conditions



The brain area for “Love”?

Spouse vs. Friend over time



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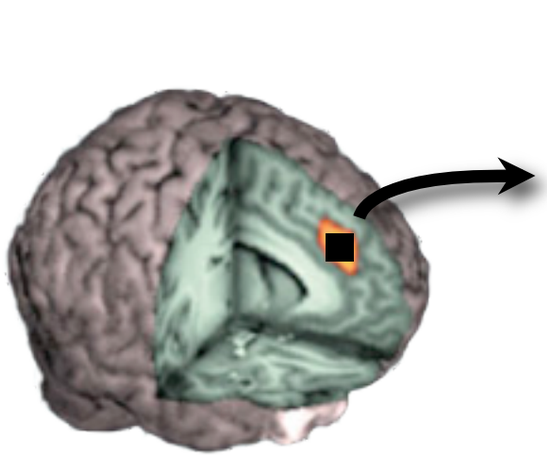

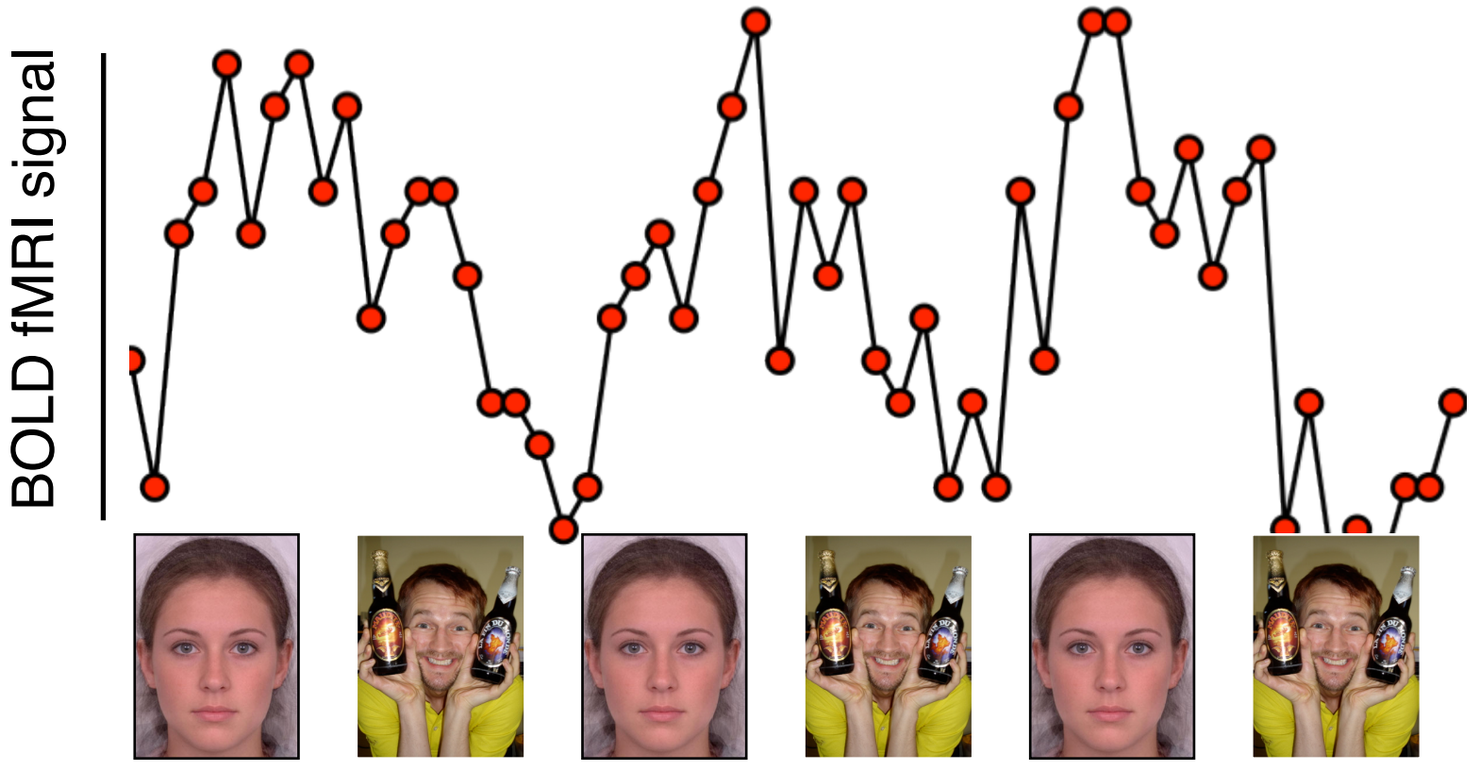

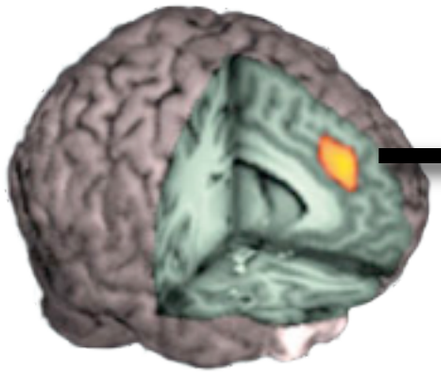

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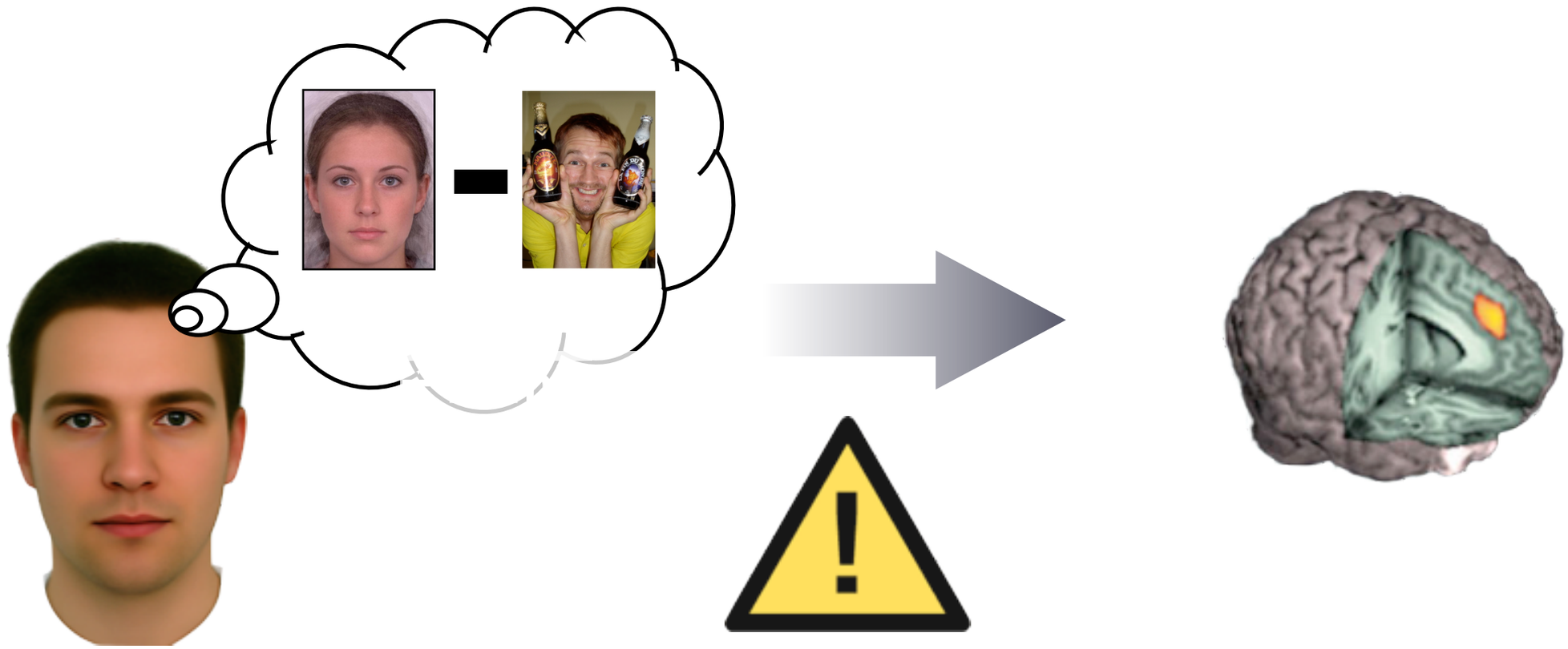
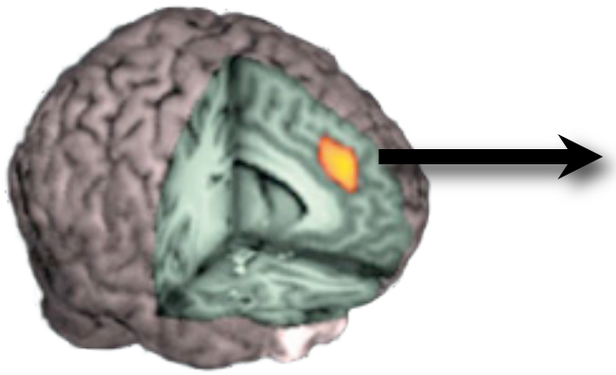
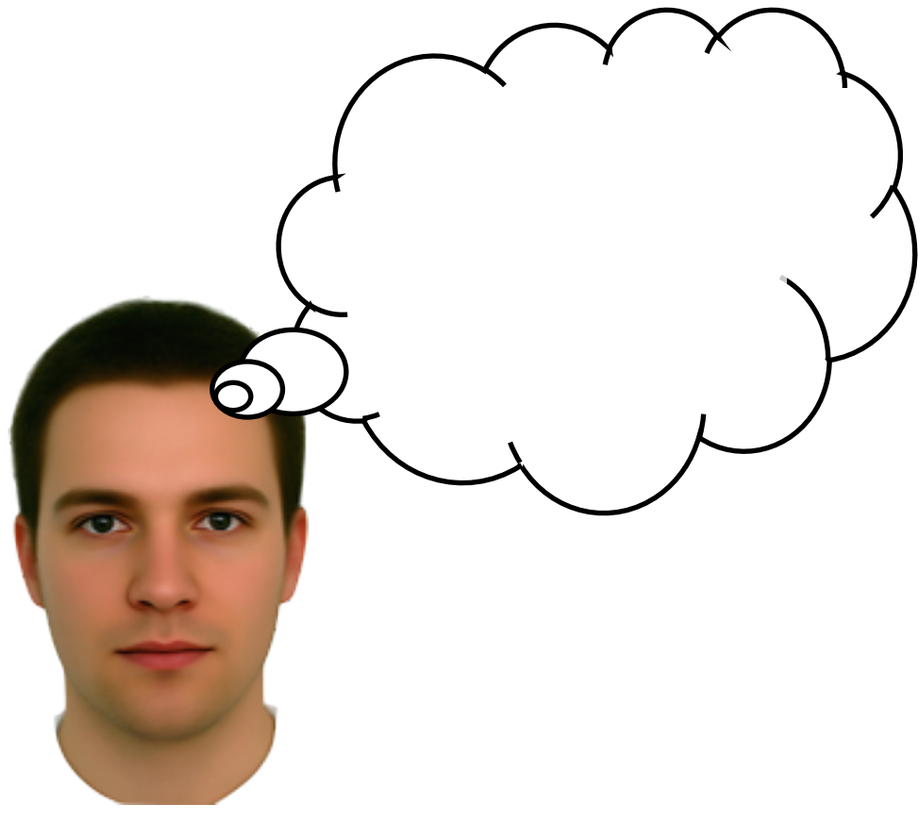


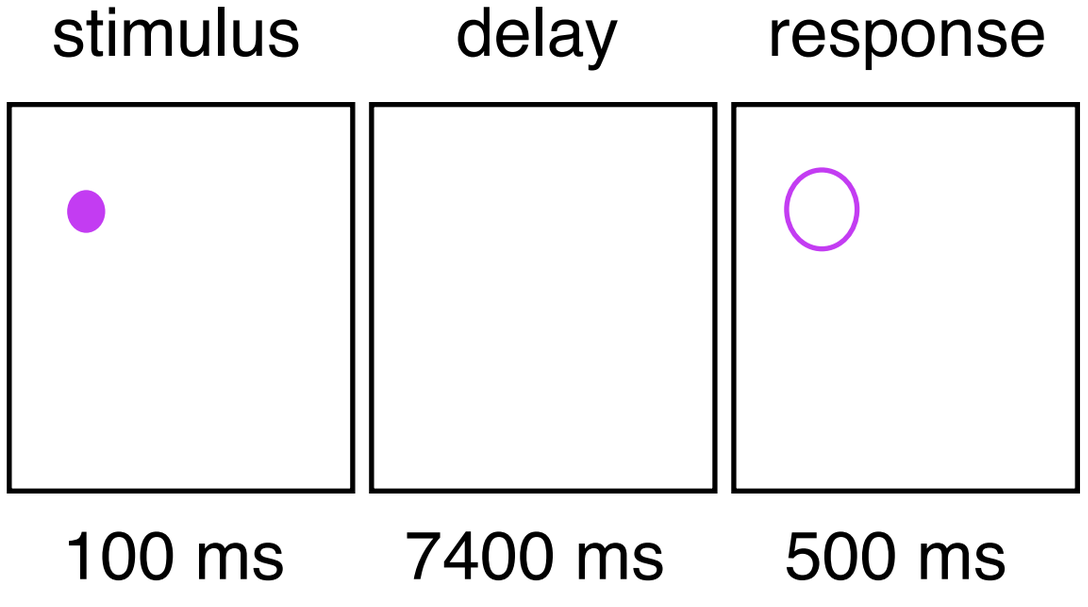
what if the “subtraction”
includes other mental states?



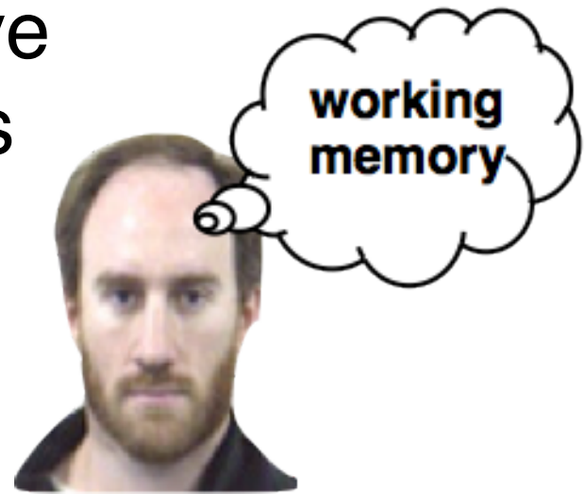
The brain area for
“working memory”?

Manipulating mental operations



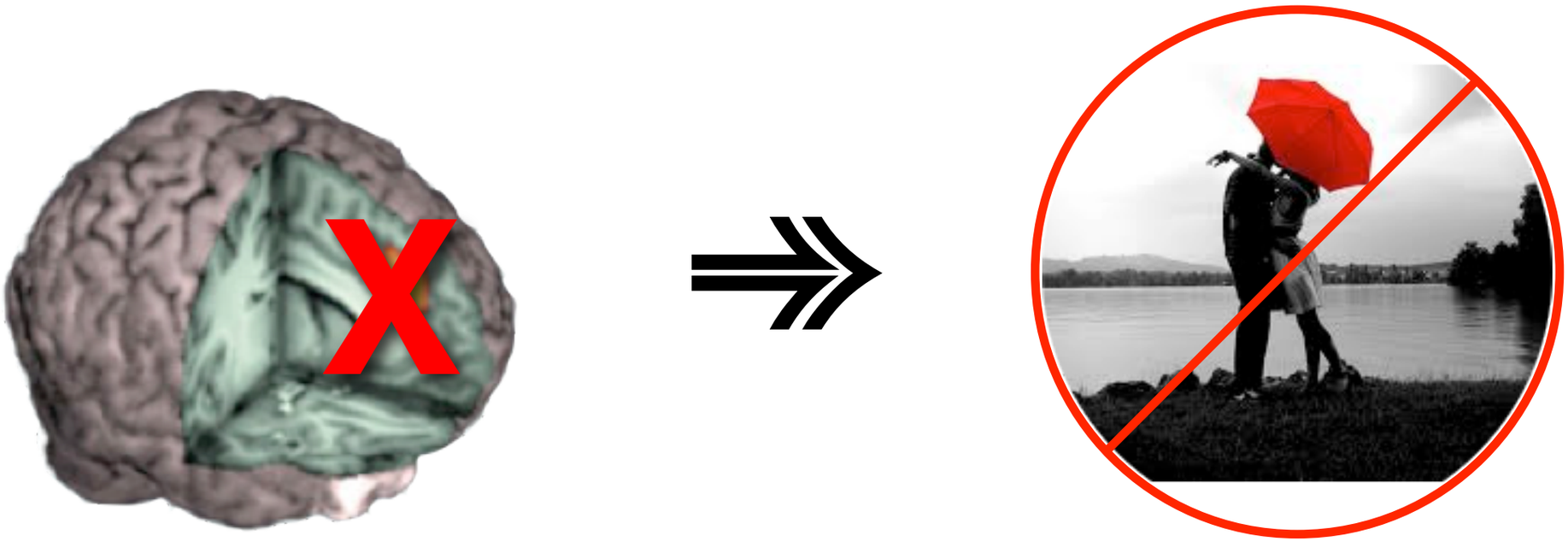


Task versus cognitive process

task	cognitive process
	
delayed vs. immediate match to sample	working memory
matching rotated vs. non-rotated figures	mental rotation
pictures of spouse vs. pictures of friends	romantic love

Imaging versus lesion inference

This brain area is necessary for
the perception of love



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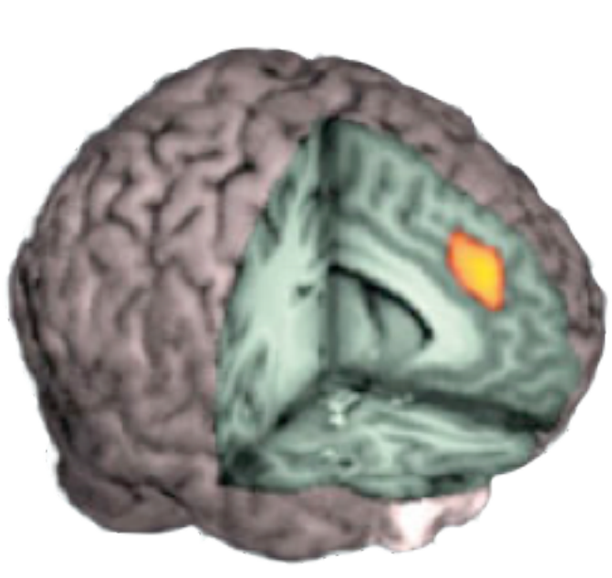

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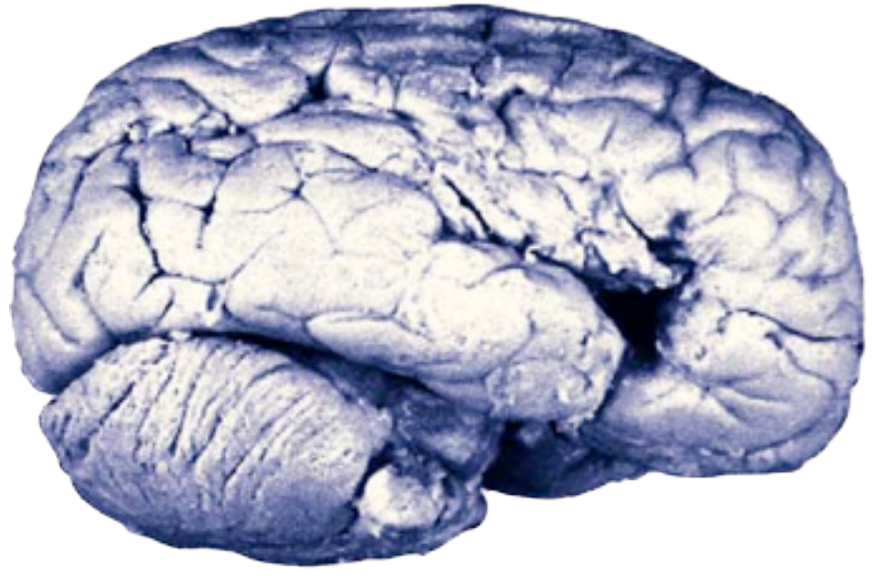
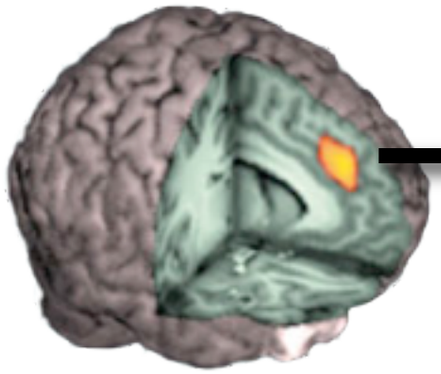


Imaging and lesion inferences are largely independent



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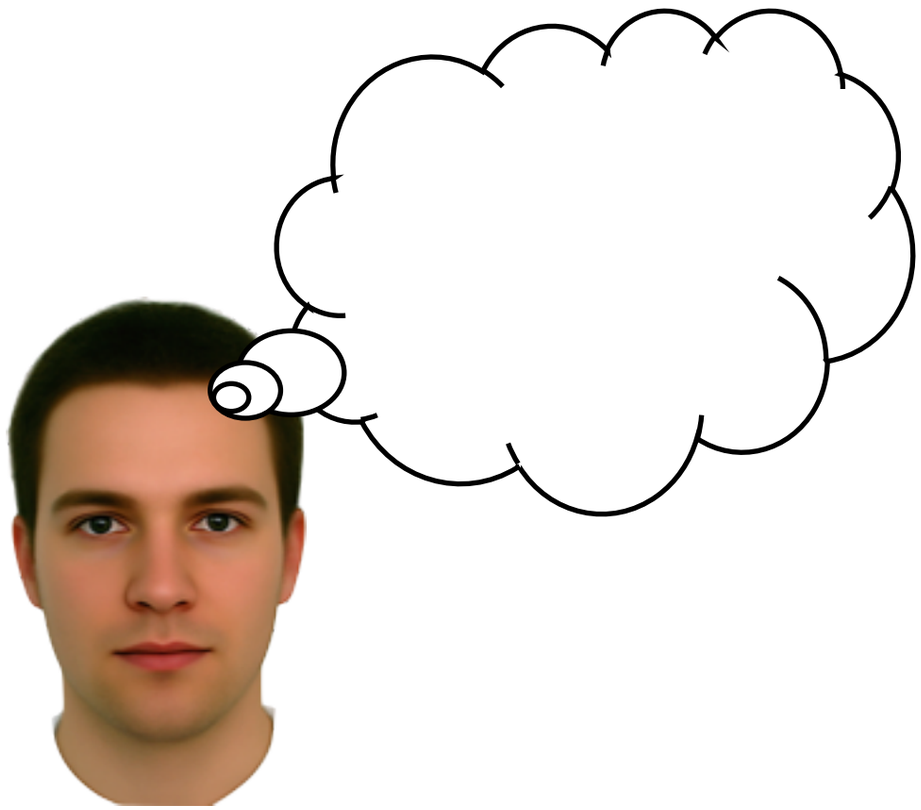
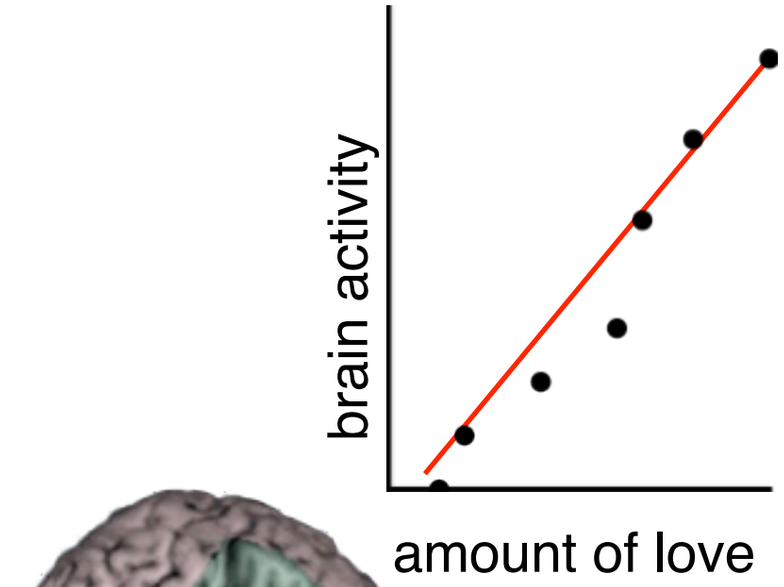
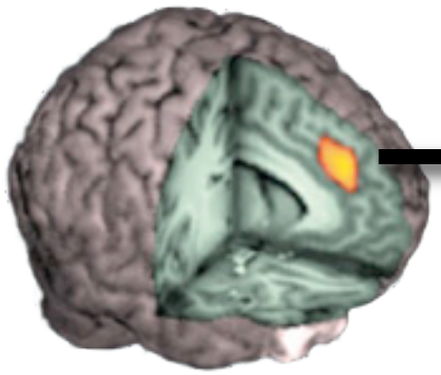




relate variations in the behavior
to variations in neural response



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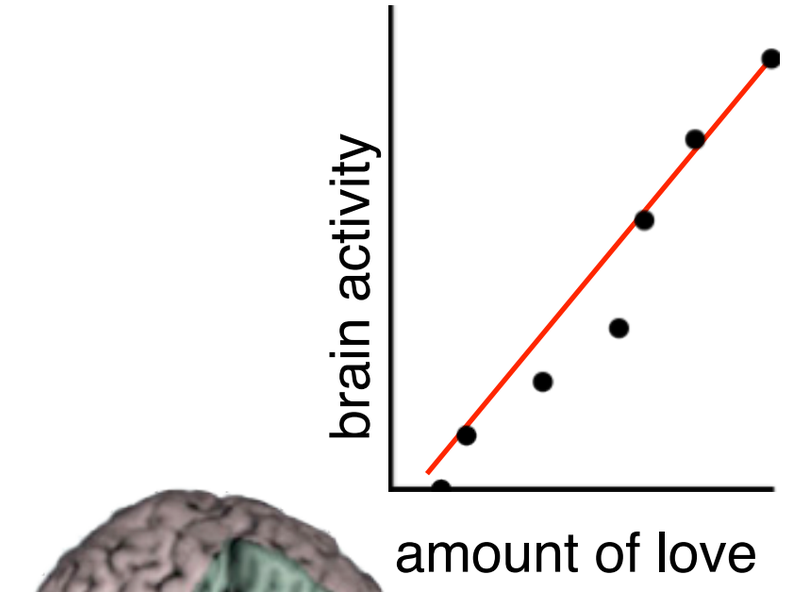
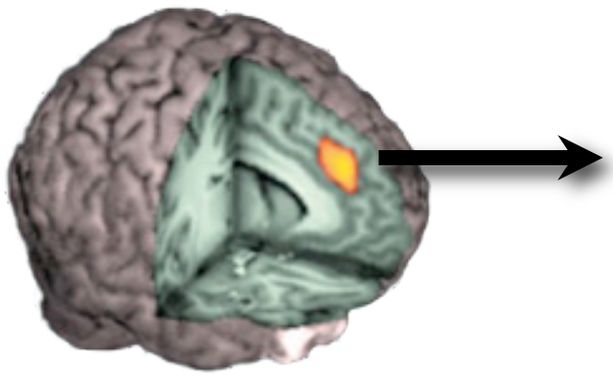


relate individual differences in behavior to brain differences

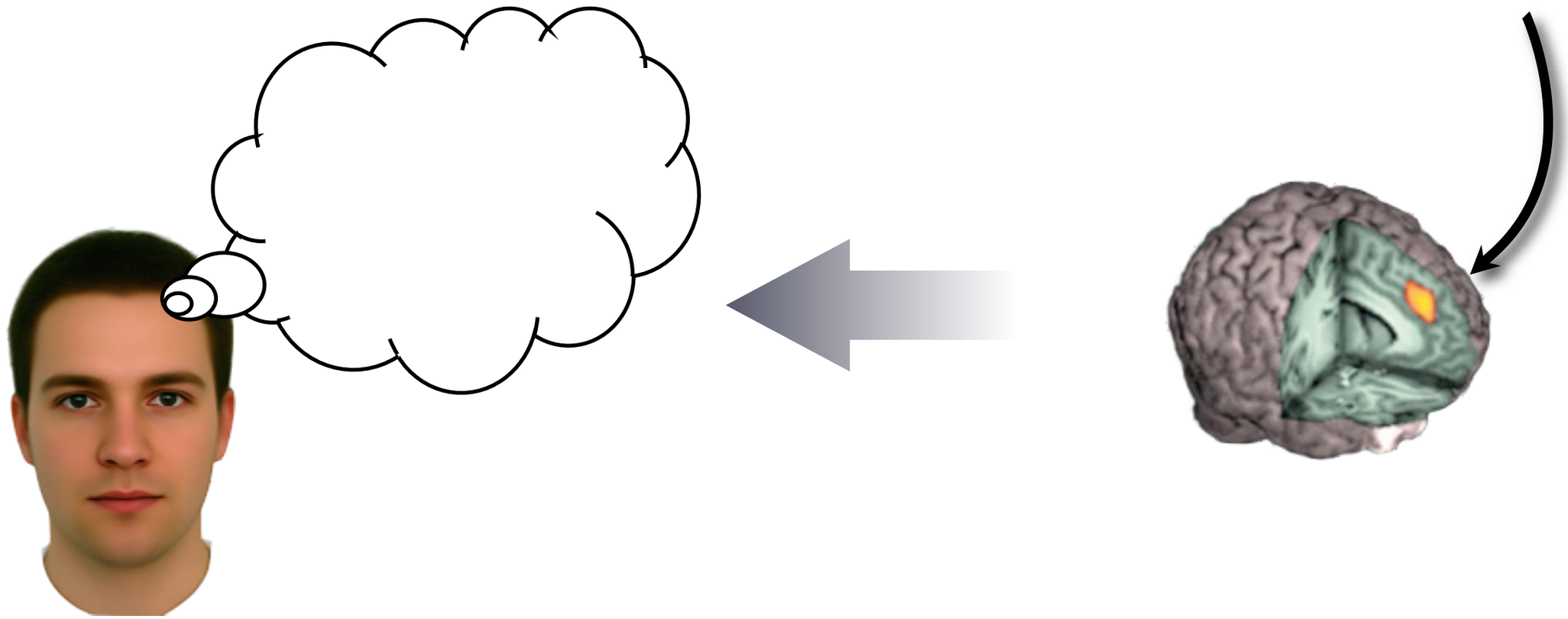
Forward inference

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

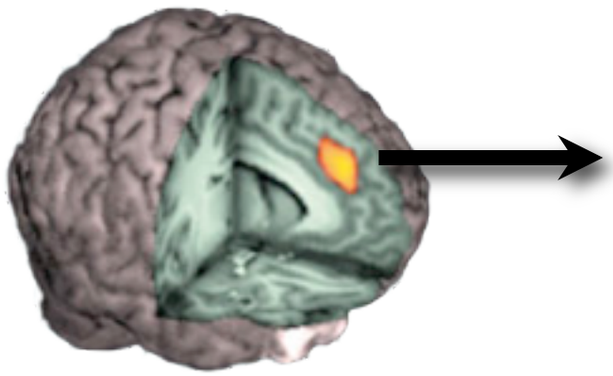
TIME

- Why we love
- What your brain looks like on faith
- What makes us moral
- When worry hijacks the brain
- How w
- Marke

Scratching evokes a sense of pleasure because it decreases memory of pain

New

- 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]



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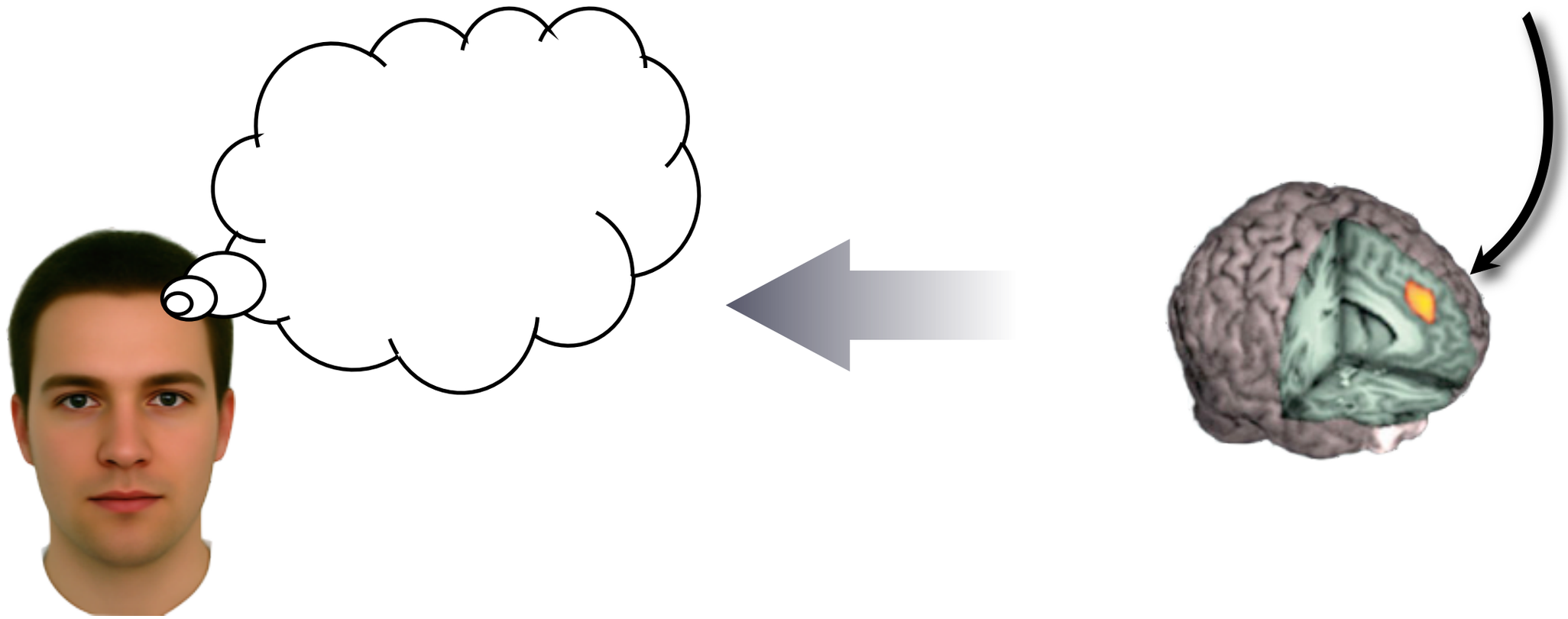

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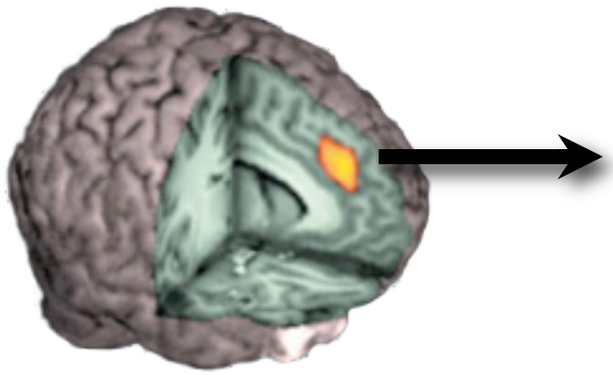
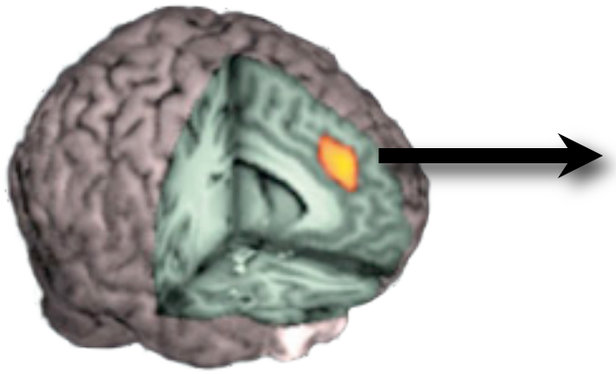


Does hearing a bad joke induce physical pain?

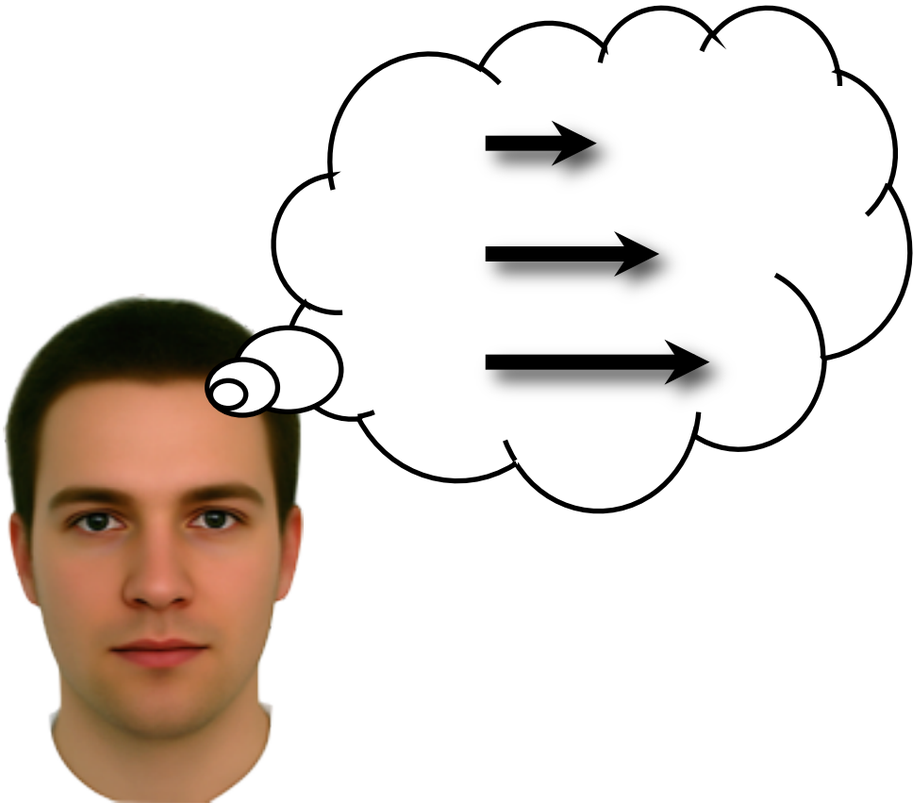
Focal reverse inference

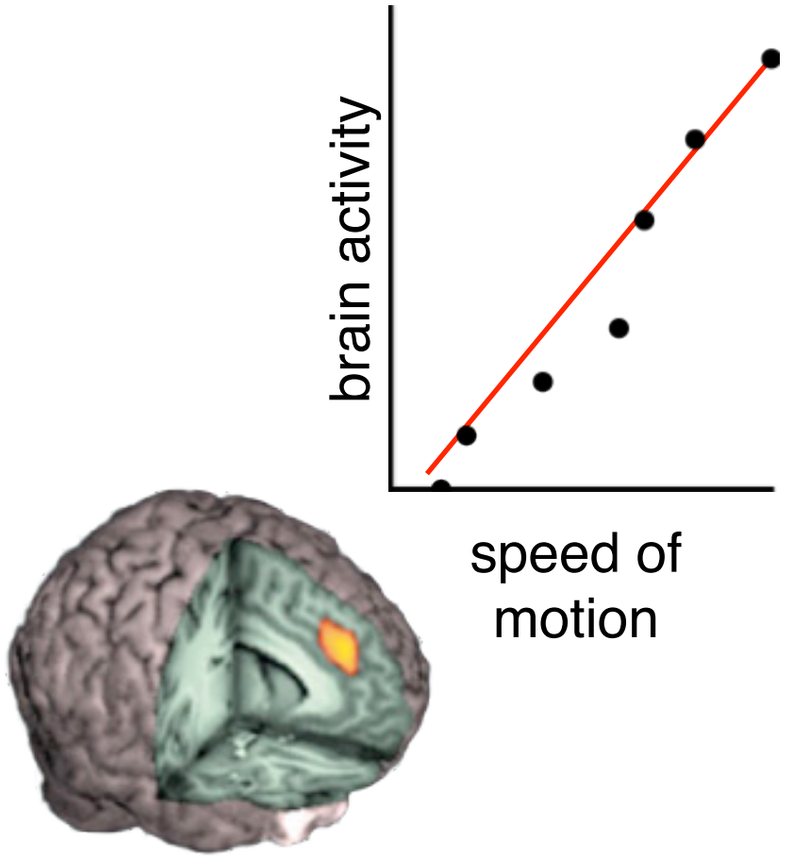
what if more than one state can activate a brain region?



“Boring neuroscience”

Implementation

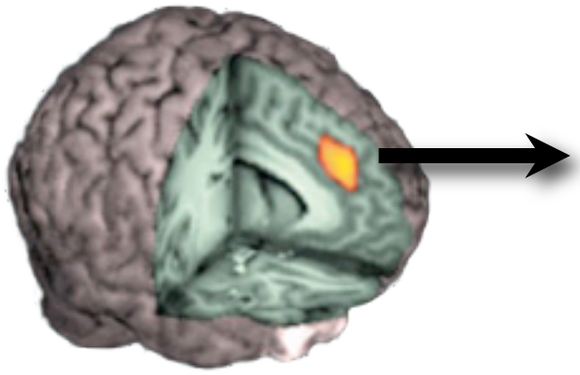




relate variations in stimulus properties or information processing to response

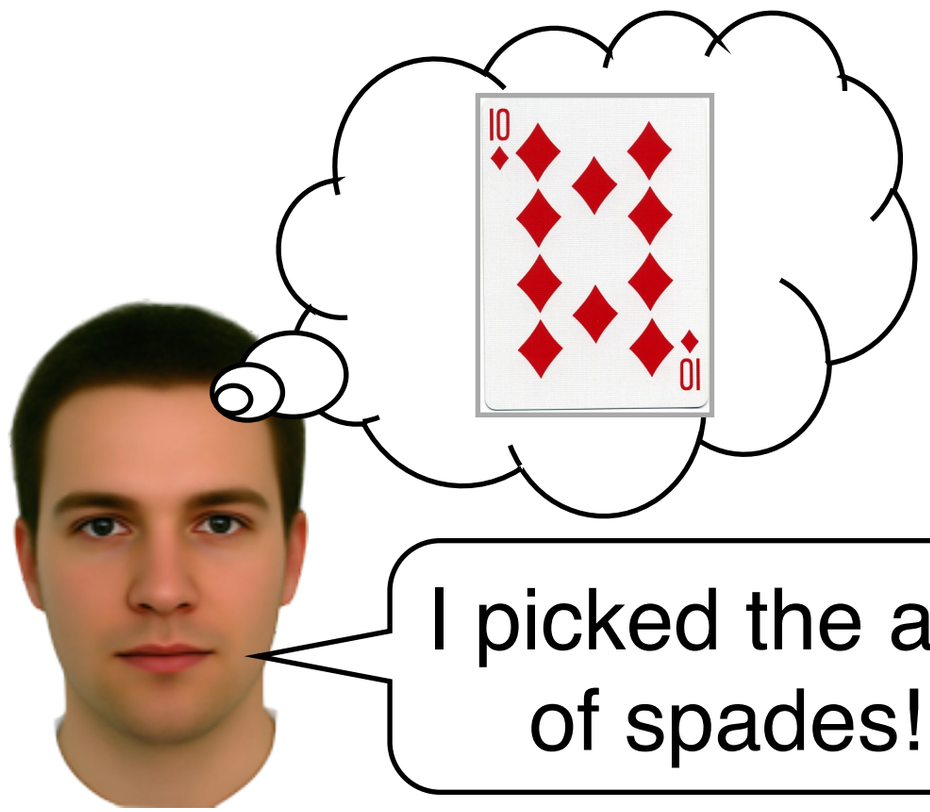
Focal reverse inference

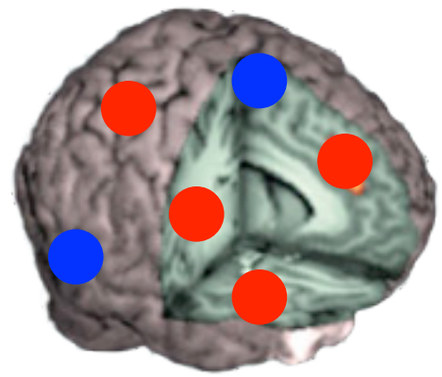
how strong is the association between local brain activity and the assumed evoked behavior?



Are you lying?

Goal: brain pattern detects lies





LIAR

TIME

- Why we love
- What your brain looks like on faith
- What makes us moral
- When worry hijacks the brain
- How w
- Marke

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

New

- Inside the grieving brain
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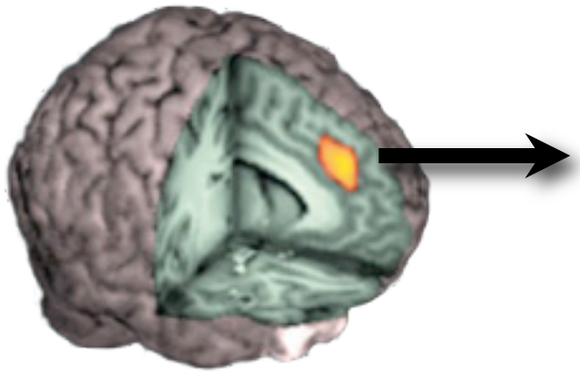
- Hot flashes [fMRI of menopause]



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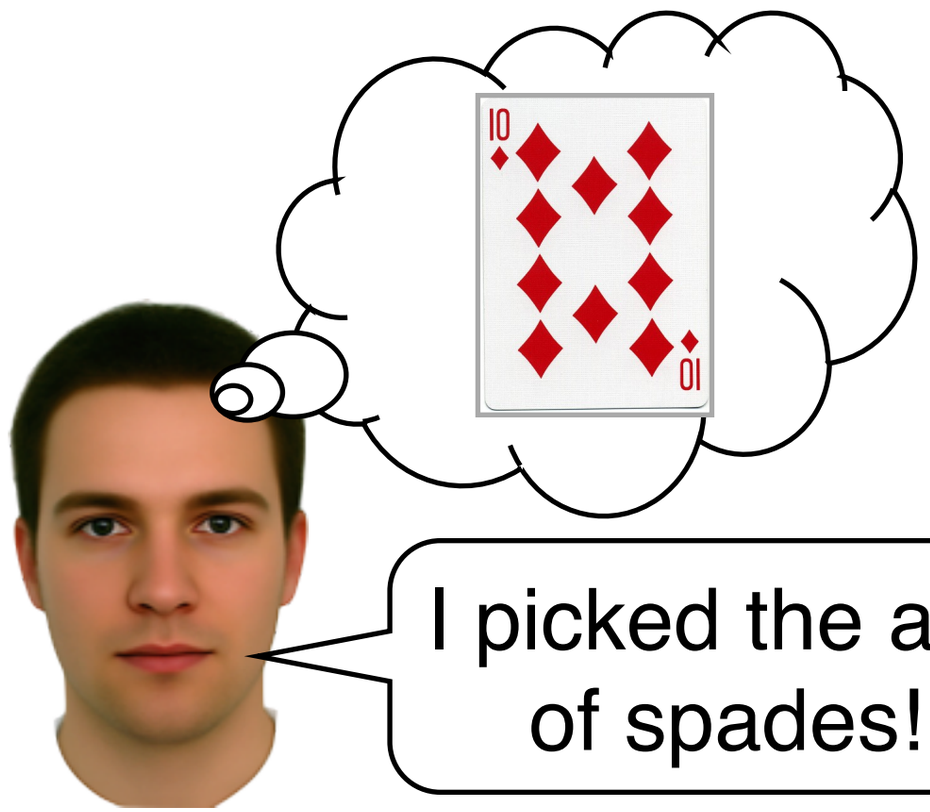
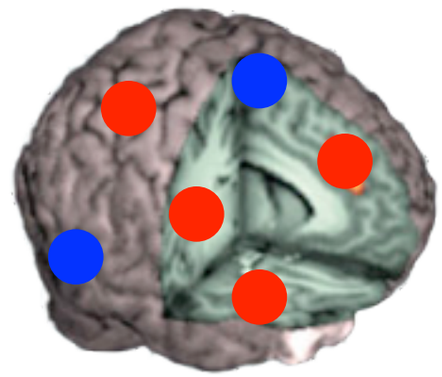
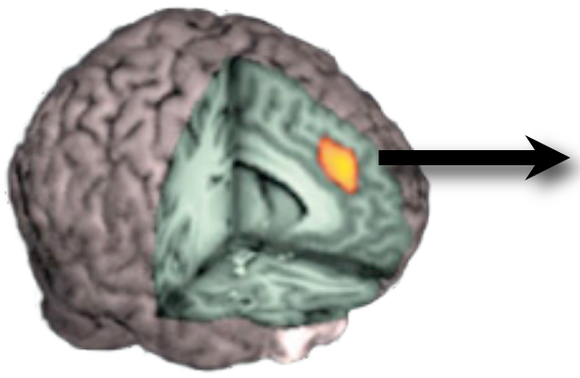


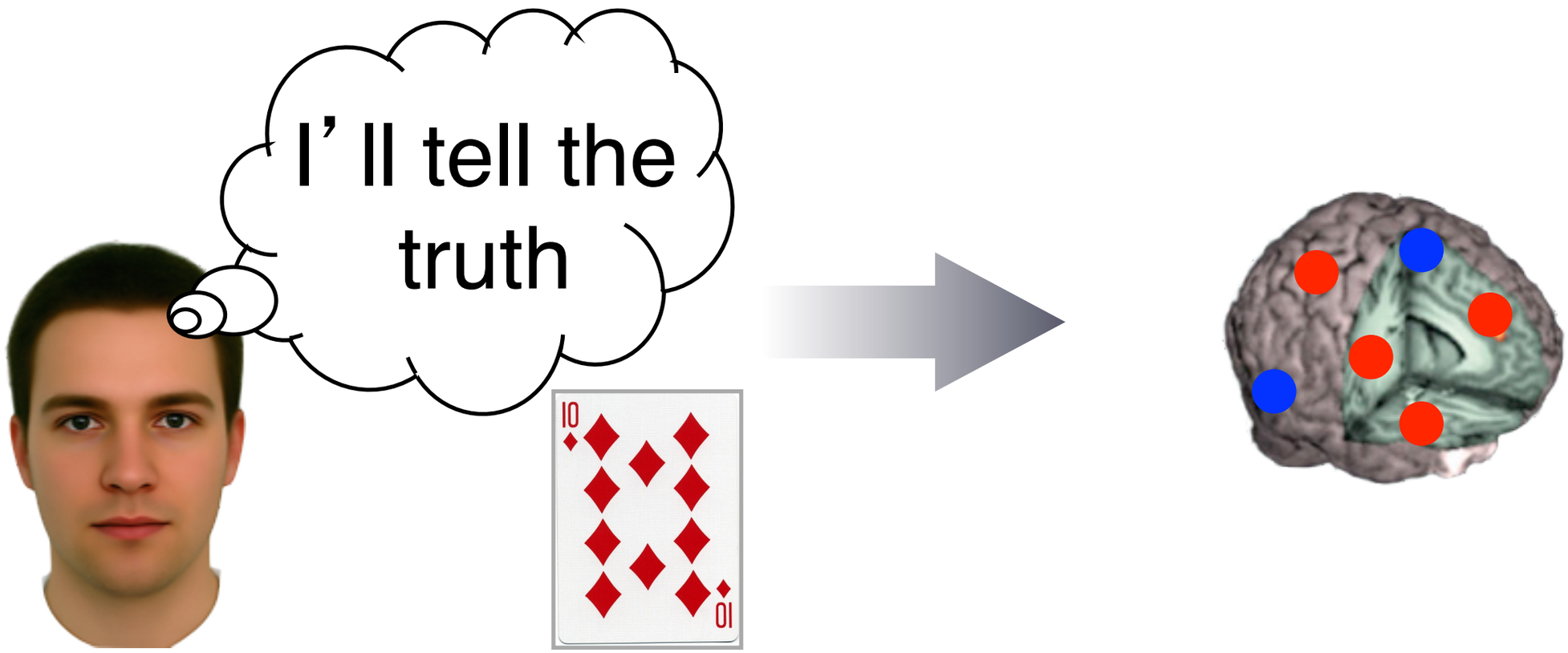


LIAR

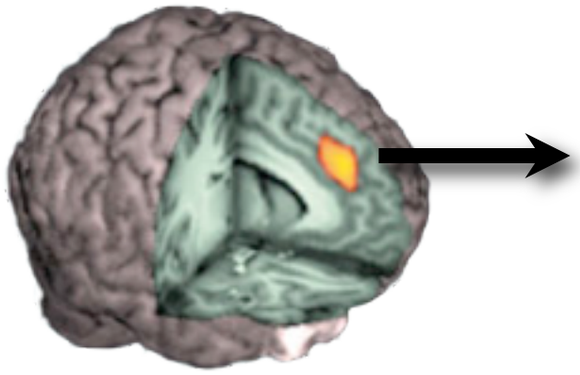


Are you lying?

Step 1: forward inference



train a computer to learn the pattern of activity evoked by telling truth



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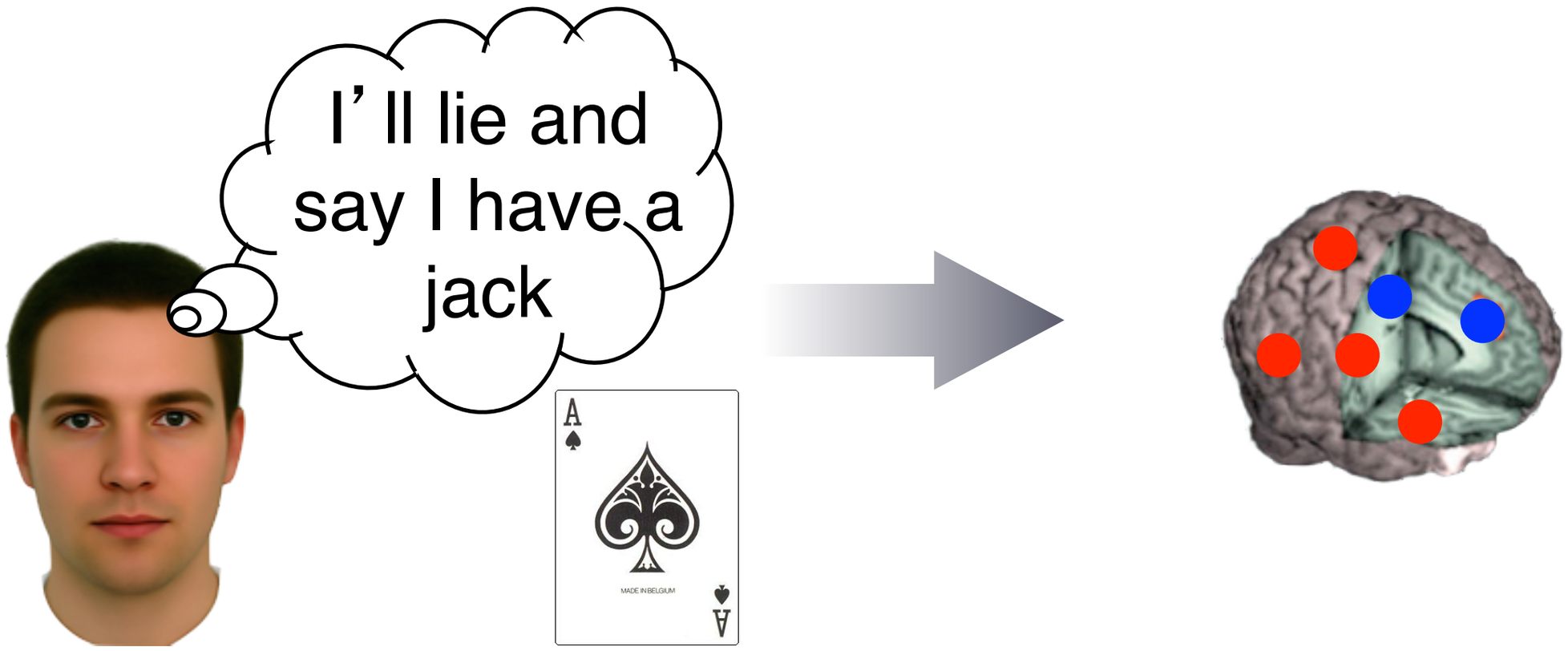

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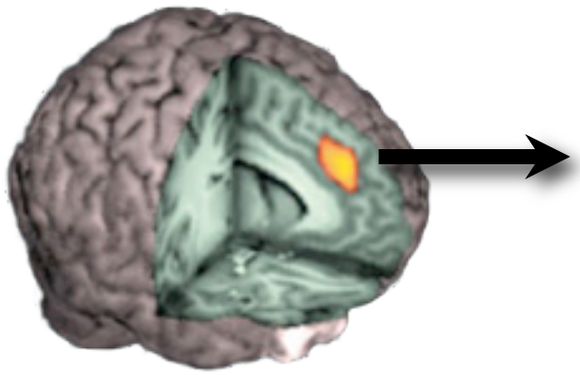
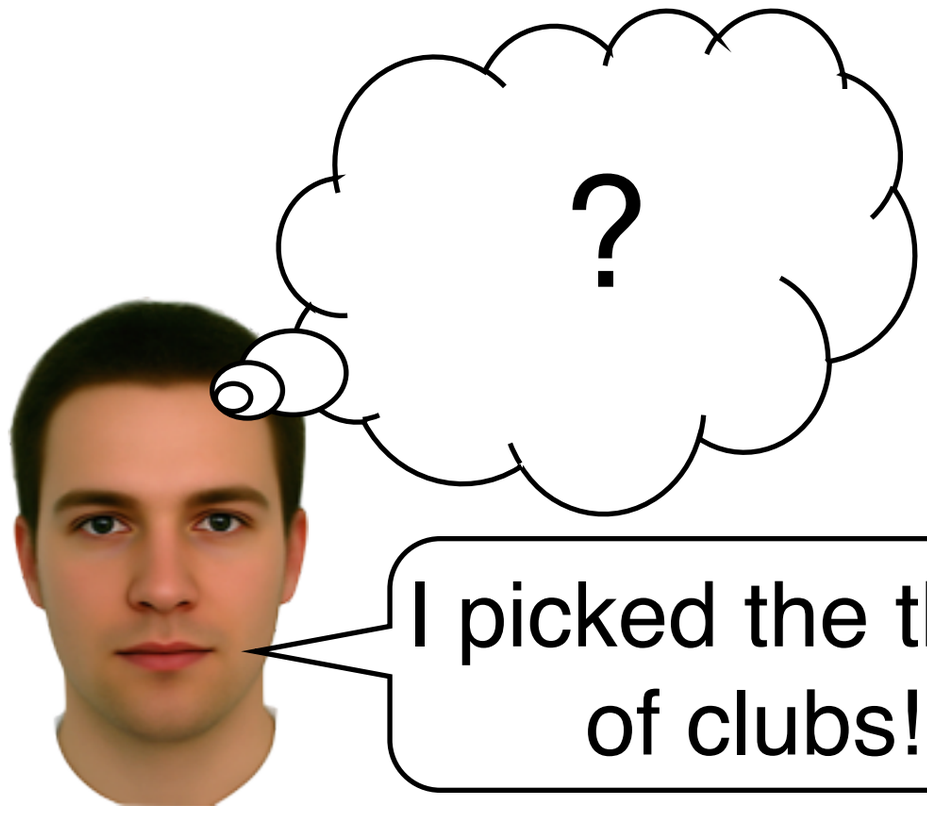
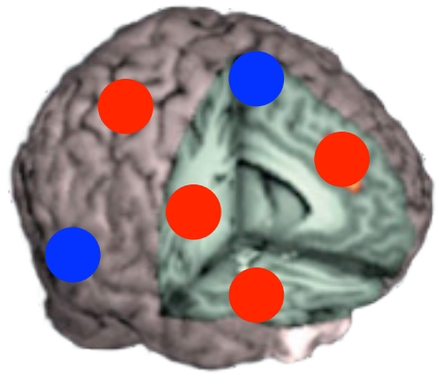


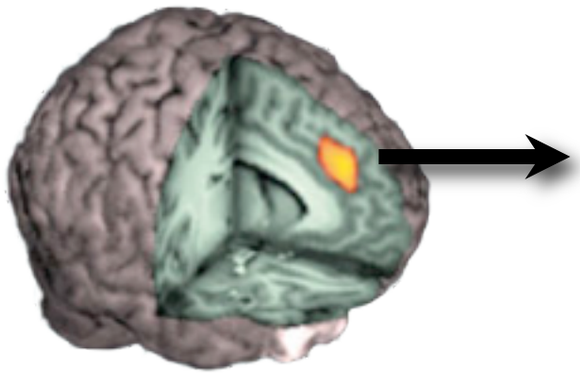
Are you lying?

Step 2: reverse inference



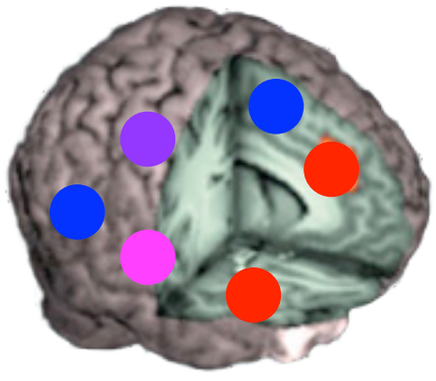


Measure brain activity to discover if a new statement is a truth or lie



Are you lying?

The limitation



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? It's 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?