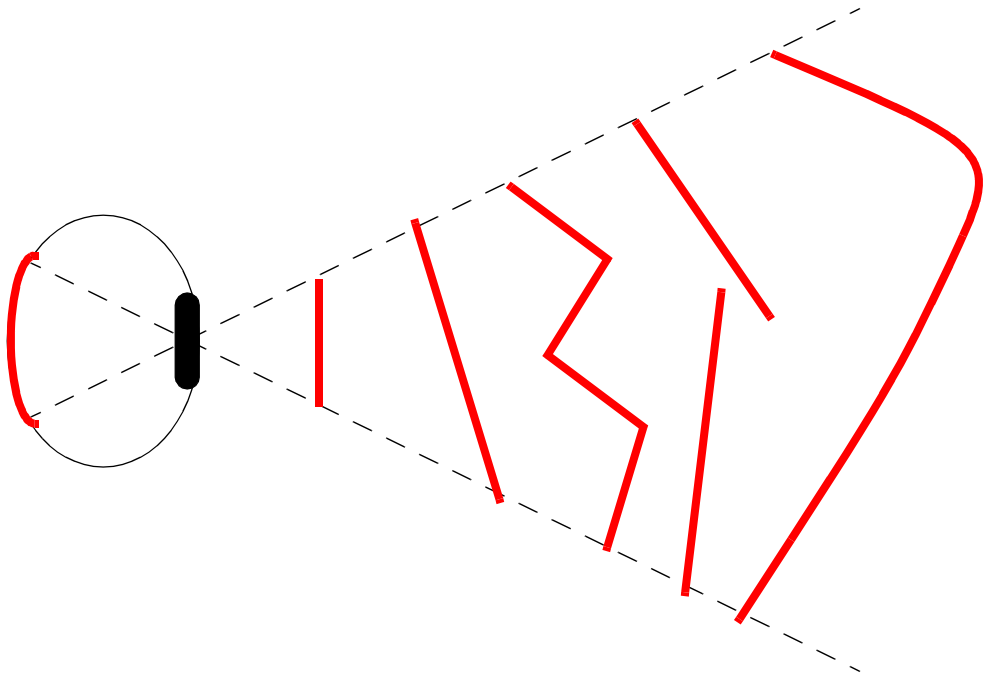
Perception and Consciousness

Ambiguity of Perception

One-to-many mapping of retinal image to objects in the world



Same issue with 2D retina and 3D images, e.g., Necker cube

Ambiguity of Perception

Perception as unconscious inductive inference (Helmholtz)

recover the most likely objects in the world based on the ambiguous evidence

Percept is a hypothesis about what the brain thinks is out there in the world.

Constructivist view

Ambiguity of Perception

Additional knowledge required to perceive

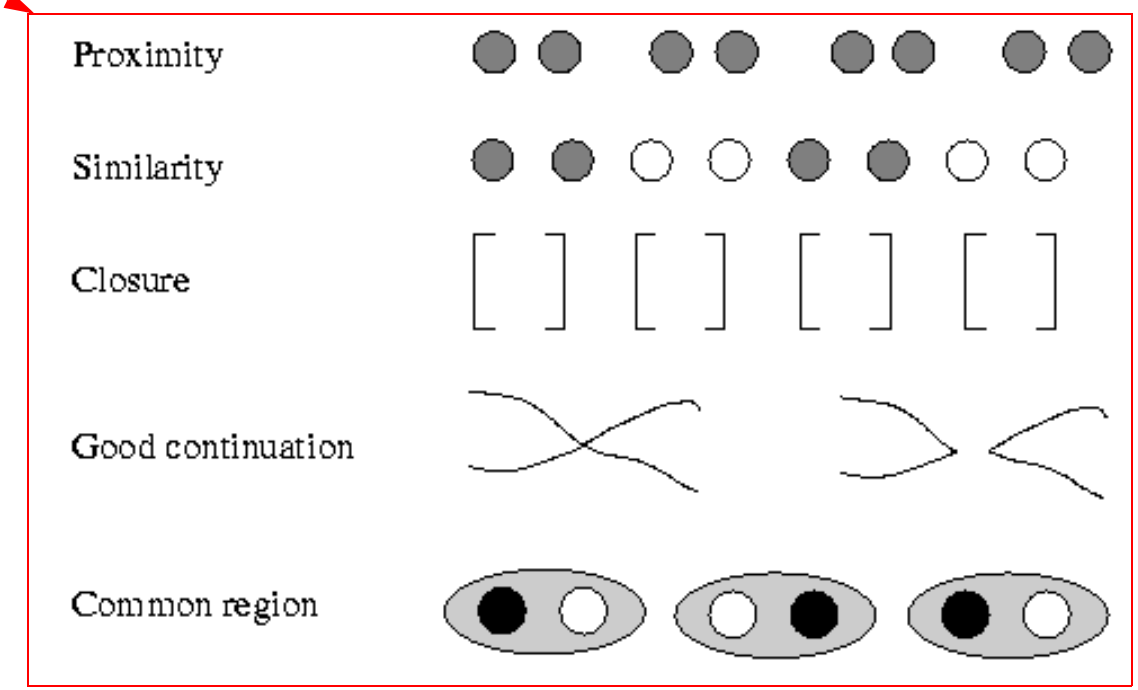
General knowledge

e.g., smooth shapes are more common than jagged shapes
e.g., any point in the image has only one interpretation
possibly innate

Acquired knowledge

based on specific experience/learning

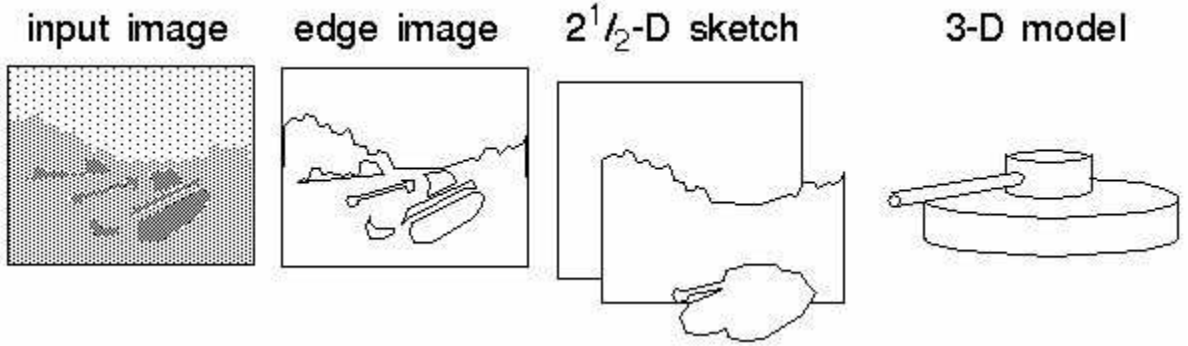
Gestalt grouping principles



Two Views of Perception

1. Traditional

Bottom-up process that constructs a veridical 3D reconstruction of the visual world (Marr)



2. Modern

Interactive (bottom-up and top-down) process that constructs an interpretation of what's out there, relevant to current tasks and goals

Implications of modern view

- allows for an understanding of visual illusions
- allows for an understanding of visual imagery
- perception is about *interpretation* (and awareness requires intepretation)

Perception as Constraint-Satisfaction Search

Necker cube

bottom-up input: visual features of the environment

top-down knowledge: knowledge used to constrain interpretations

e.g., interpretation of neighboring vertices should be consistent

Illusions

Most of the time, top-down knowledge helps produce the correct interpretation of the perceptual data.

Illusions are the rare cases where knowledge misleads.

E.g., Hollow face illusion

`http://www.michaelbach.de/ot/fcs_hollow-face/`

constraints: light source, shading cues, knowledge of faces

Rees Outline

1. To what extent does the brain process stimuli that are not consciously perceived?

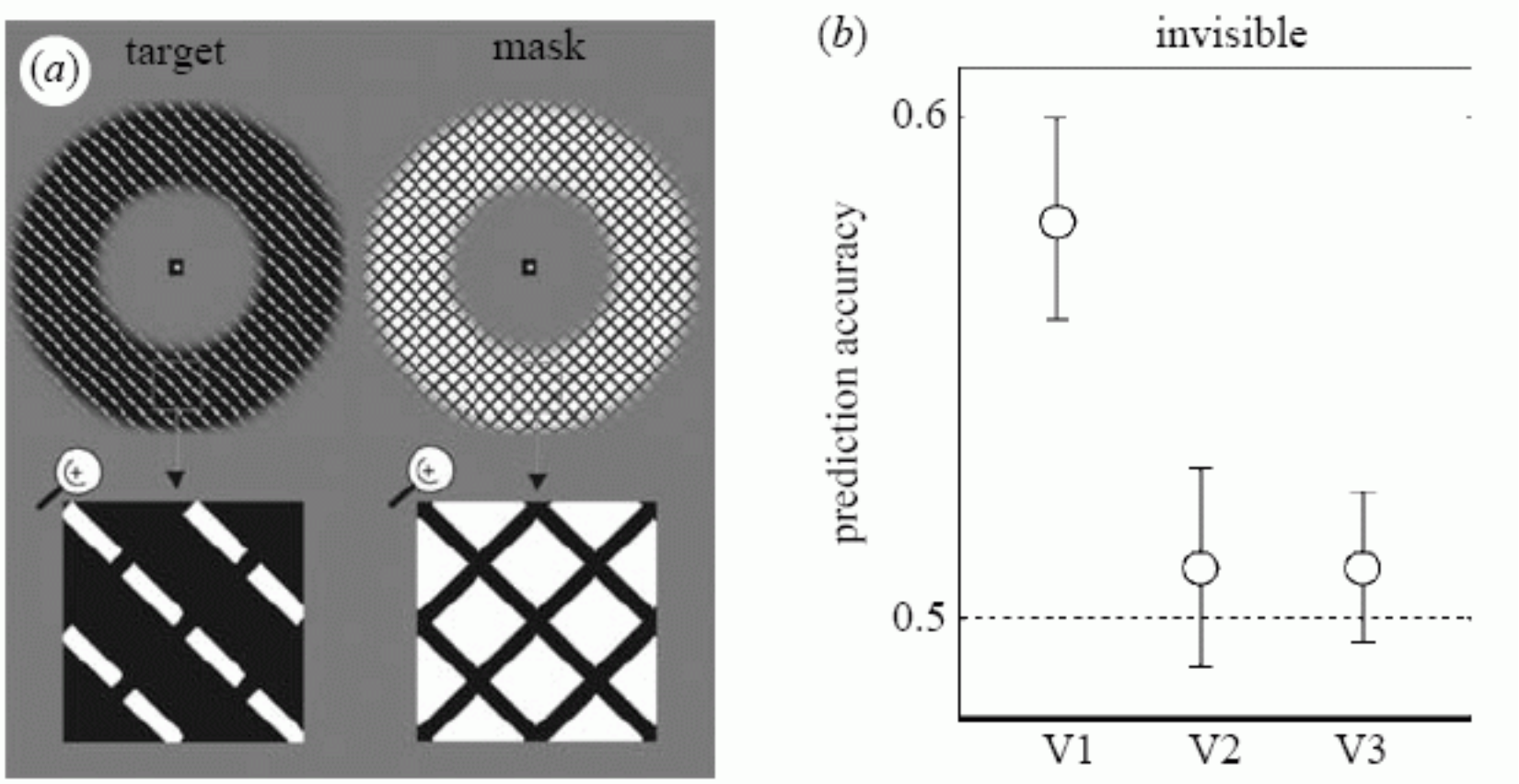
Neural Activation for Unconscious Stimuli

All visually responsive cortical areas appear to show responses to stimuli that do not reach awareness.

‘modest’ activity: generally less activity for unconscious than conscious stimuli

Neural Activation for Unconscious Stimuli

e.g., V1 activity reflects feature-selective processing, even without awareness.



e.g., binocular fusion study (following slides)

Binocular Fusion (Moutoussis & Zeki, 2002)

Images from two eyes are ordinarily fused.

Complementary images will be perceived as homogeneous color

Requires isoluminance

Requires short viewing to avoid rivalry

brief flashes (50 ms) with intervals of nonstimulation (150 ms) for 1.5 sec

Experimental Design

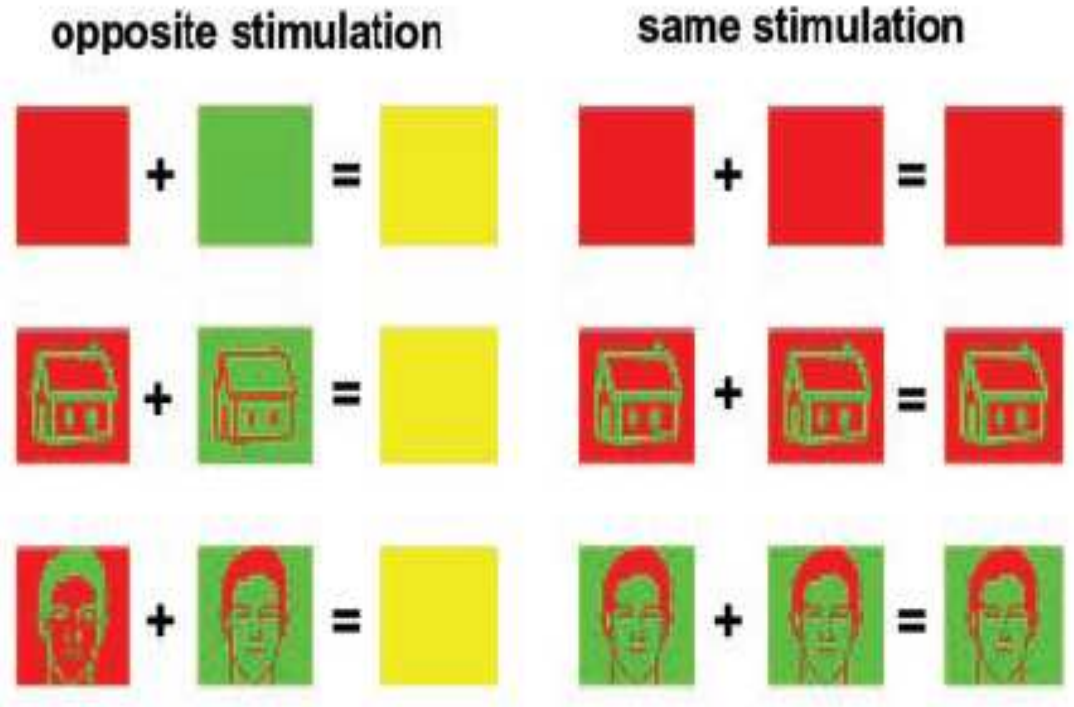
Stimuli: faces, houses, and control

Three conditions

OPPOSITE color contrast in the two eyes, brief presentations, leading to binocular fusion

SAME color contrast in the two eyes, leading to conscious perception

UNIFORM fields with opposite color contrast



Response

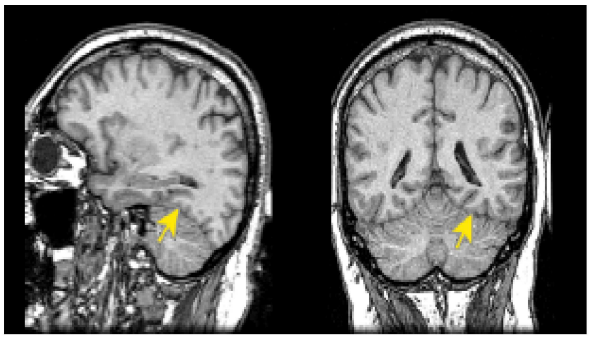
Subjects report “face”, “house”, “nothing”

Fusiform Face Area and Parahipp. Place Area

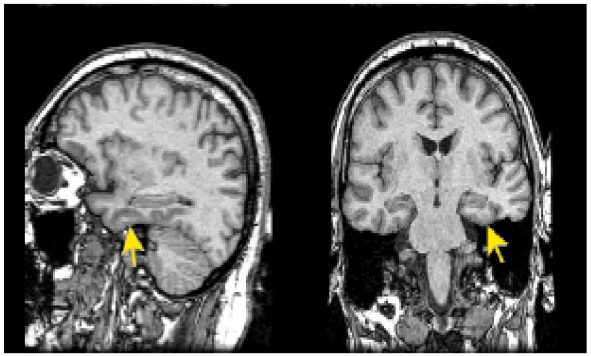
Both in medial temporal lobe

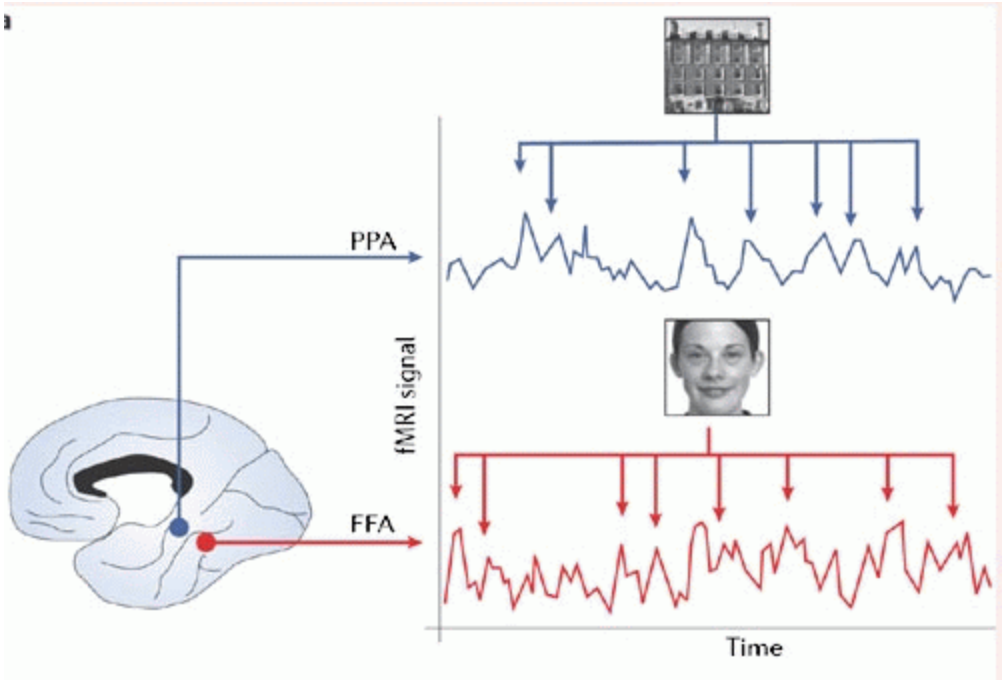
PPA anterior to FFA

Fusiform gyrus:



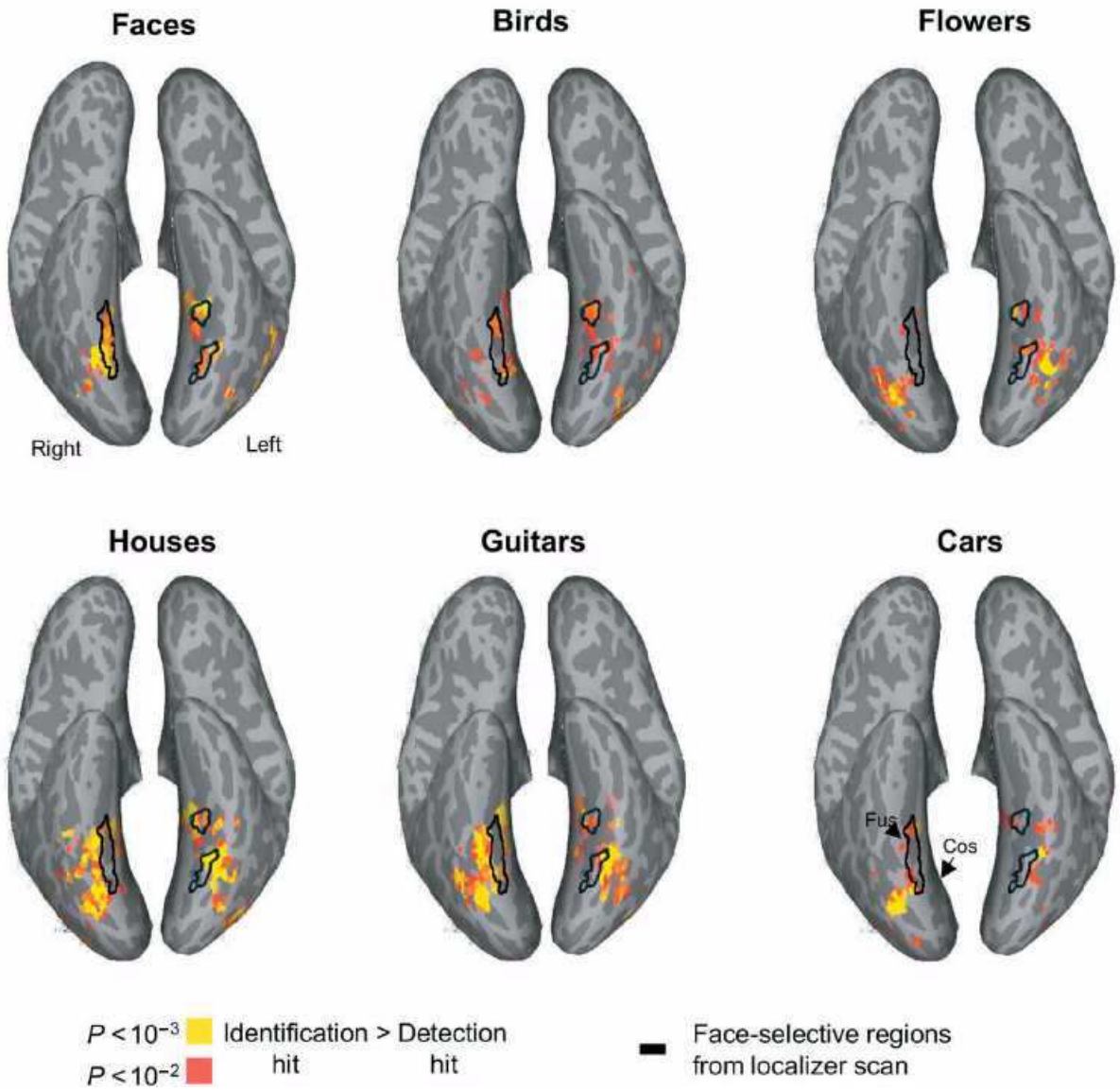
Parahippocampus:





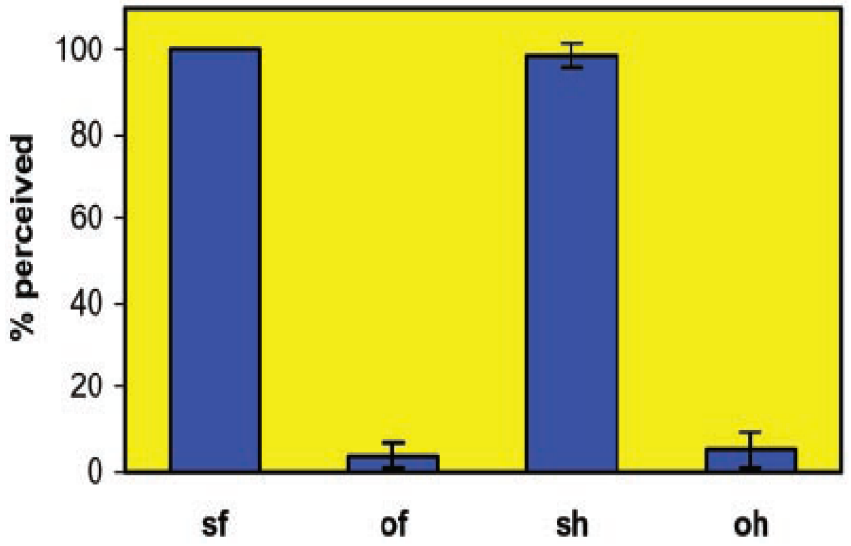
FFA Activation

Grill-Spector et al. (2004)



Behavioral Results

presence or absense of face/house during scanning



2 alternative forced choice (between different instances) before scanning

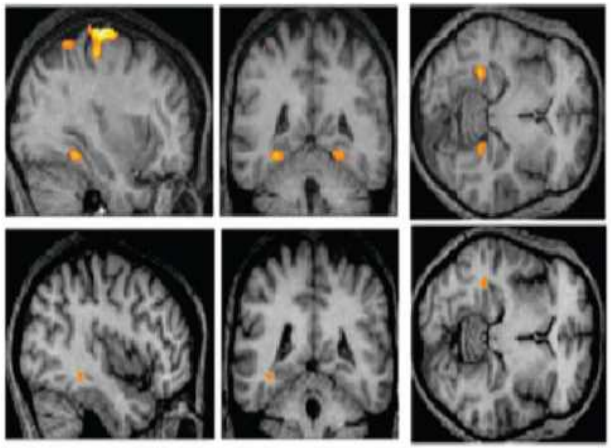
52.7% in opposite condition, 98.2% in same condition

fMRI Results

Stimulus-specific activation in parahippocampal gyrus for houses

same houses –
same faces

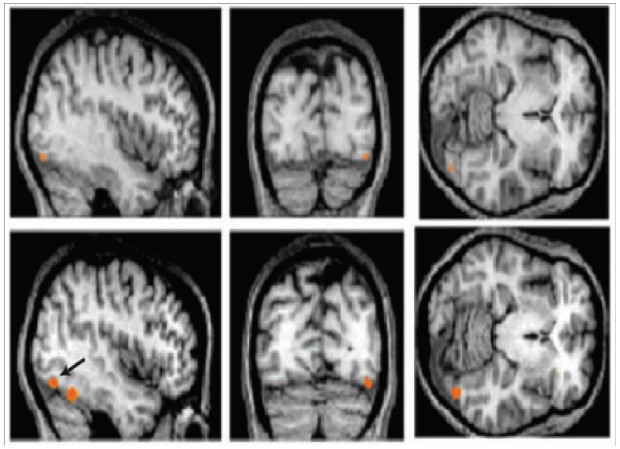
opposite houses –
opposite faces



Stimulus-specific activation in fusiform gyrus for faces

opposite faces –
opposite houses

same faces –
same houses



Summary of Moutousis and Zeki Experiment

Unconscious stimuli activated much the same areas as conscious stimuli, but less activation overall

Evidence for stimulus specific processing for nonperceived stimuli

- face-specific activity found in fusiform face area (FFA)
- house-specific activity found in parahippocampal place area (PPA)

Rees Outline

1. To what extent does the brain process stimuli that are not consciously perceived?

2. What neural activity is associated with conscious perception?

a) fixed stimulus, comparing aware vs. unaware trials

Neural Activation Linked to Awareness

Activity in V1 and beyond reflects conscious perception.

E.g., apparent motion

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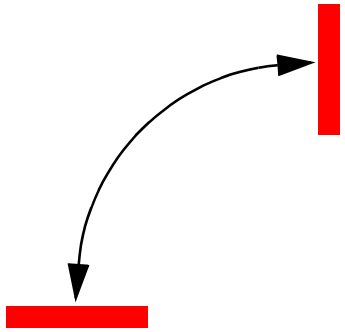


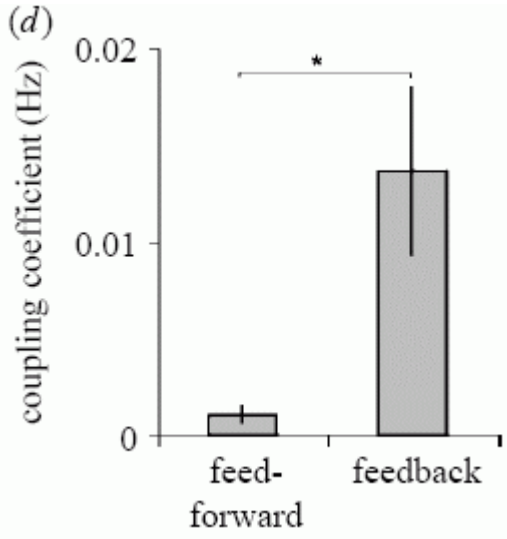
Neural Activation Linked to Awareness

Activity in V1 and beyond reflects conscious perception.

E.g., apparent motion

Neural activity in V1 along (imaginary) path of apparent motion

Activity seems to be associated with feedback connections from area MT/V5 to V1



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b) ambiguous stimulus, comparing one interpretation vs. the other

Neural Activation Linked to Awareness II: Bistable Perception

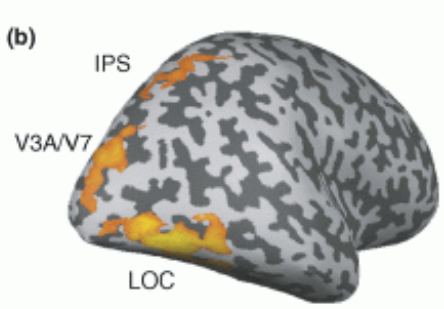
Rivalrous images

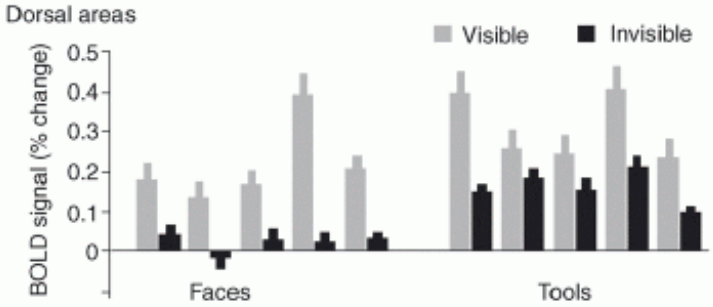
Participants indicate which one they are currently perceiving.

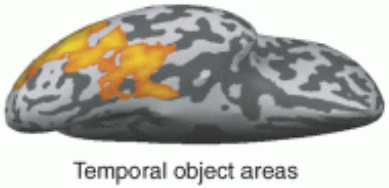
Compare fMRI activation when a stimulus is 'visible' or 'invisible'

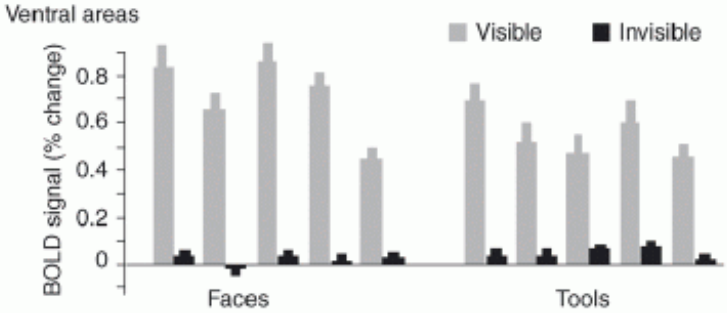
LGN, V1, and higher brain areas all show changes in activity correlated with contents of consciousness.

see Tong, Meng, & Blake (2006) for details









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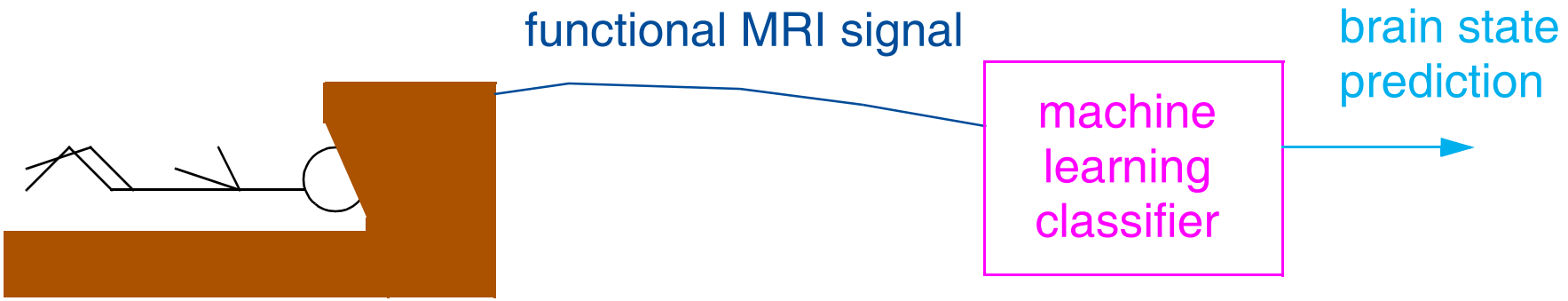
3. Methodology for determining the contents of brain activity

Decoding the Brain



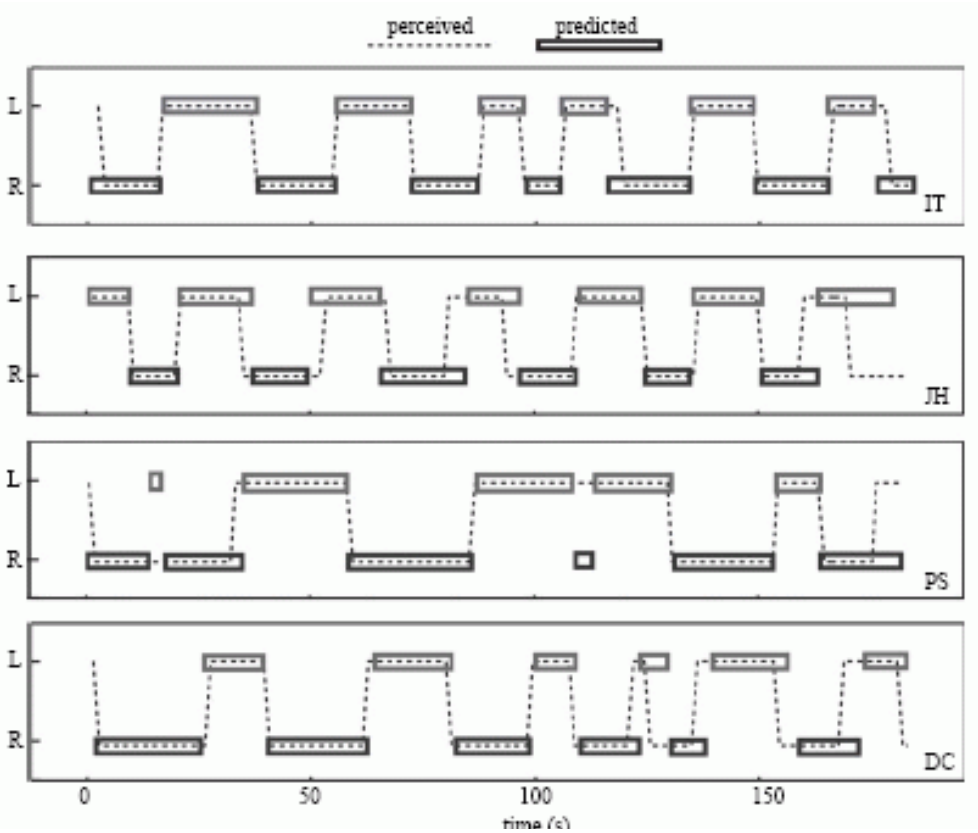
Classifier can predict what individual is currently perceiving.

e.g., orientation and direction of motion and object identity

e.g., ambiguous stimuli

binocular rivalry

reading monocular activity in V1



Conclusions

Higher visual areas convey information about the stimulus, even when it is not perceived.

e.g., binocular fusion study

Higher visual areas convey information about the conscious state, even when the stimulus is held constant.

e.g., binocular rivalry studies

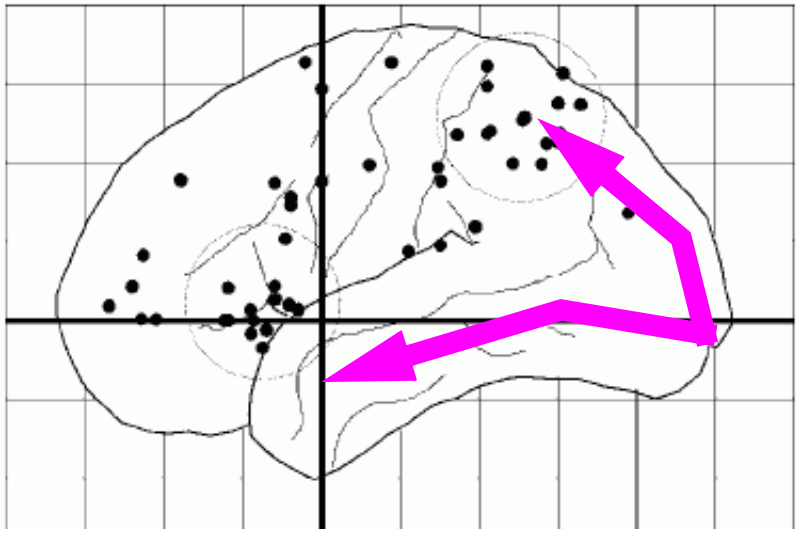
How do we reconcile these findings?

Less activity for unconscious stimuli

One possible account (hinted at by Rees)

Consciousness arises from highly consistent, mutually reinforcing activation from multiple brain systems

An Account of the Neural Basis of Consciousness



Feedforward visual processing leads to temporal and parietal activity

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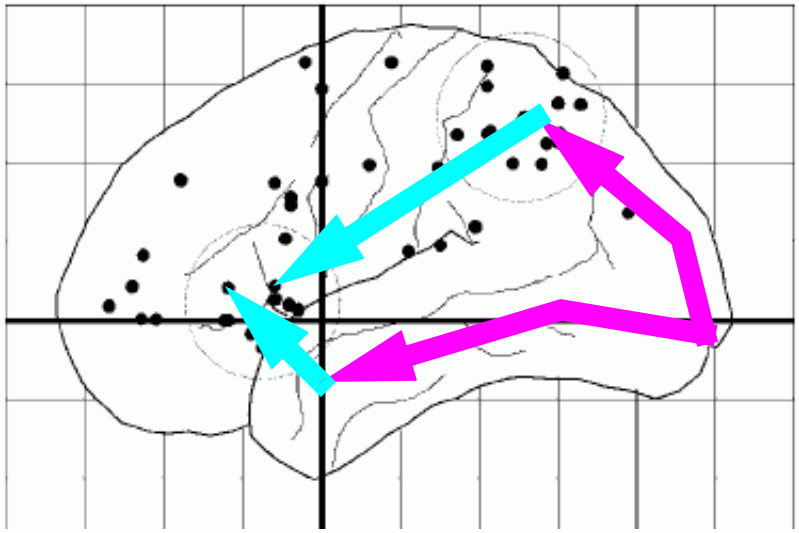

Feedforward visual processing leads to temporal and parietal activity

Frontal areas also become activated

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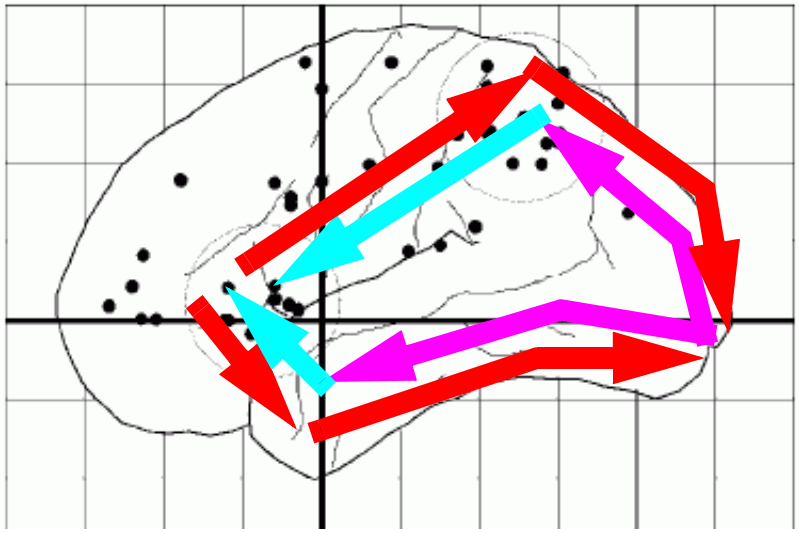
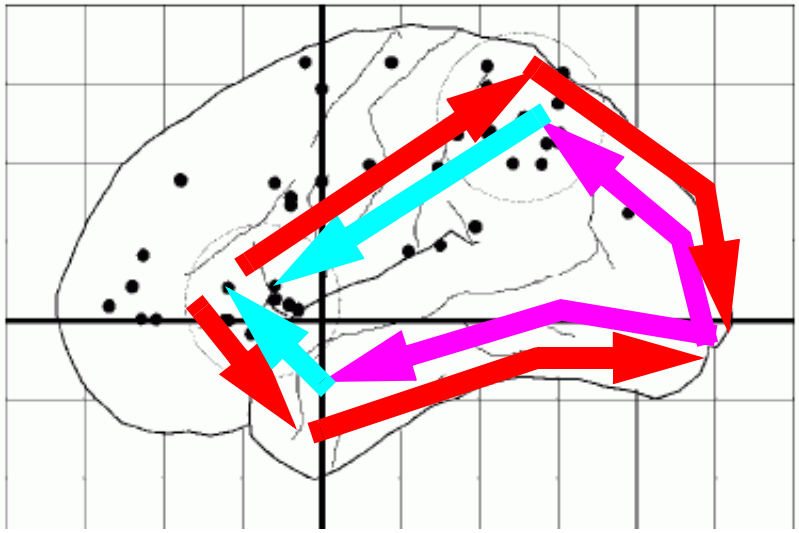


Feedforward visual processing leads to temporal and parietal activity

Frontal areas also become activated

Feedback from frontal areas reinforces lower brain activity

An Account of the Neural Basis of Consciousness



Neural correlate of awareness

Significant, mutually consistent activity in multiple brain areas

Explains many aspects of the data

Conscious perception depends on V1, and intact parietal cortex.

Conscious perception is more likely if initial V1 activation is large.

Conscious perception depends on feedback signals.