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9.71 Functional MRI of High-Level Vision
Fall 2007

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9.71 Fall 2007

**Lecture 7: The Neural basis of Perceptual Awareness
or
Perceptual Representation vs. Perceptual Awareness:
What's the Difference?**

Outline of Class today:

- I. Reminder: Term Paper outlines due in class next week!
- II. Lecture: Perceptual Awareness
(break in the middle somewhere)
- III. Presentation: Nune, on Pasley et al (2004)

Term Papers

Option I: Write a Review Article

Choose a relatively focused *question* about visual cognition that has been investigated extensively with fMRI, and write a term paper reviewing the relevant literature on this question. Conclude with a discussion of how the question has been answered by the relevant literature, and what aspects of the question have not been answered. Finally, discuss any important questions for future fMRI research that arise from the literature you have reviewed.

A topic question and article outline (including REFERENCES TO at least ten of the main articles you will review) is due at the beginning of class October 25

Option II: Propose a Novel Experiment

Here you will propose a novel experiment testing a theoretically-motivated hypothesis that has not been resolved in the prior literature. This assignment requires more independent thought and creativity than Option I, but may also emerge naturally from Option I. If you elect Option II you should email Nancy or Talia a very short synopsis of your idea (one paragraph) as early as possible. Your choice of topics is subject to my approval of the outline you hand in on October 25. The requirements for the three phases of the project are described below.

Carefully read “Experiment Proposal Outline Guidelines” from handout for what is due Oct 25..

Conscious *States* versus Conscious *Percepts*

A distinction:

- Conscious *states*: normal waking / sleep/ meditation/ anesthesia/ PVS/ coma

Image removed due to copyright restrictions.
fMRI images of supplementary motor area in two imagery scenarios: playing tennis and walking around the house.
See Figure 1 in Owen, A. M., et al.
"Detecting awareness in the vegetative state." *Science* 313 (2006): 1402.

- Consciousness *of something* (= perceptual awareness).

this is what we'll try to grapple with today

What is to be explained?

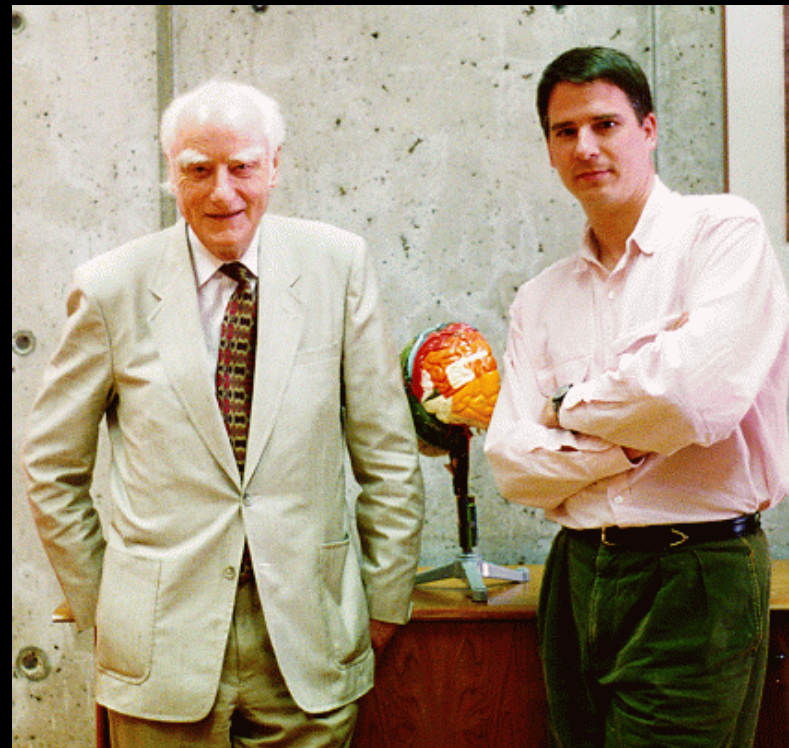
Consider two cases:

- a stimulus lands on your retina, and you become aware of it
- the same stimulus lands on your retina, and you fail to become aware of it

A complete understanding of perceptual awareness would have to specify:

- • *What* happens differently in the mind and brain in the two cases?
brain: the “neural correlates of consciousness” (NCC)
- *Why* does it happen differently?
i.e., what are the causal mechanisms that lead to one outcome vs. another?
- *What are the consequences* of this difference?

Considerable hoopla (from Crick, Koch, others) about the “neural correlates of consciousness” (NCC)



Courtesy of Christopher Koch. Used with permission.

Let's instead use NCA since it is awareness that we are focusing on

Do they involve some special class of neurons?

Do they all live in some “theater of awareness” localized somewhere in the brain?

Beware Assuming a “Cartesian Theater”

Where the contents of consciousness are presented.

Photo of Prof. [Daniel C. Dennett](#) removed due to copyright restrictions.

“So a function of consciousness is to present the results of underlying computations- but to whom? The Queen? This kind of hypothesizing merely begs the question: “And then what happens?” and avoids the hard questions of how to explain “the tricky path from (presumed) consciousness to behavior, including, especially, introspective reports.”

Dan Dennett

Uncoupling Mental/Neural Representation and Awareness

Same stimulus > different awareness

- • Identical stimuli that are either perceived or not (on diff trials)
- Also: attention (same stim, diff experience)
- Rivalry

Let's consider some data from fMRI that speak to this.

We can use the FFA and PPA as “markers” for representations of faces and houses respectively.

And we can ask what happens in e.g. the FFA when a face is presented and the subject is versus is not conscious of the stimulus.

I.e. conscious of different things: it's presence, it's category, it's specific identity

Correlating fMRI signals with behavioral outcomes

Overall Strategy:

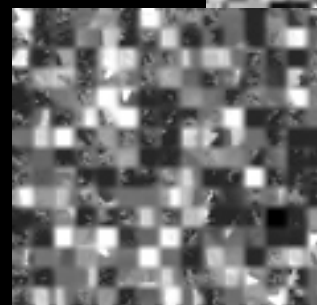
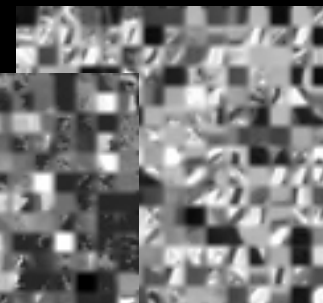
- Have Ss perform perceptual task in scanner;
 - Make task difficult so subjects make some mistakes;
- bin fMRI data by behavioral response;
- Look for correlations btwn behavioral responses and BOLD response in FFA (identified individually in each subject in a prior “localizer” scan).

Kalanit Grill-Spector

Grill-Spector, Knouf, & Kanwisher (2004), *Nature Neuroscience*.

Task: is this

- i) Harrison Ford**
- ii) some other guy**
- iii) nothing**



0

image exposure
33ms or 50ms:
Near threshold

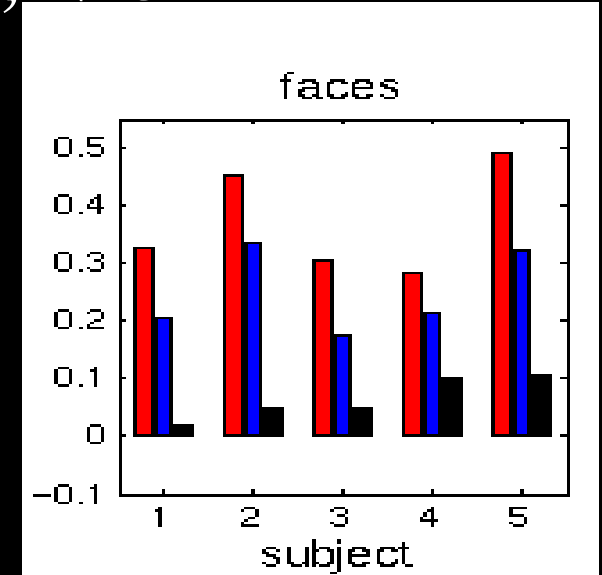
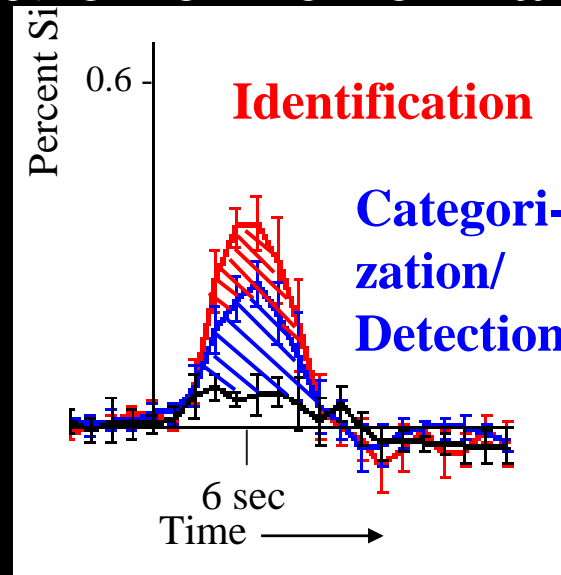
2000 ms

4000ms

Stimulus images not repeated

Grill-Spector, Knouf, & Kanwisher (2004), *Nature Neuroscience*.

Right FFA Response to Target Faces (e.g., Harrison) As a Function of Performance, N=5



**FFA Involved in:
Detec & Ident of faces**

**What about other
kinds of objects?**

Task: is this

i) electric guitar

ii) other guitar

iii) nothing

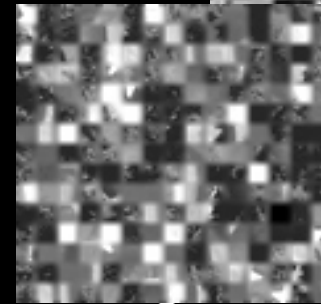


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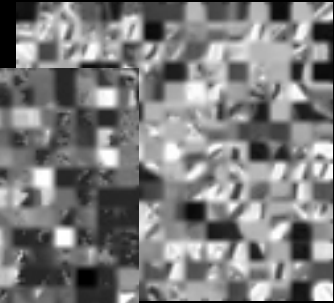
image exposure
33ms or 50ms



2000 ms



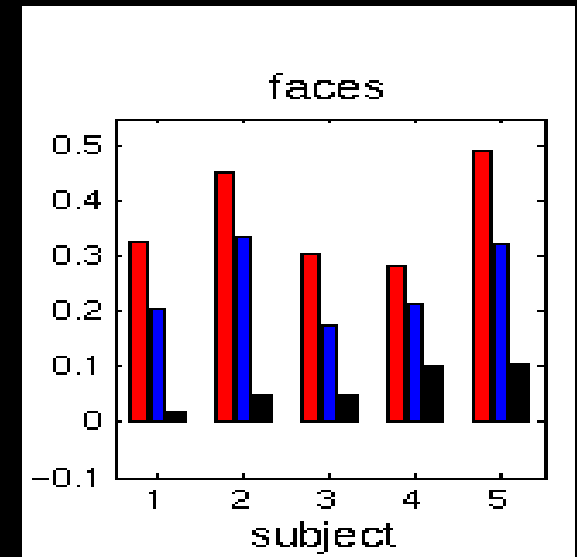
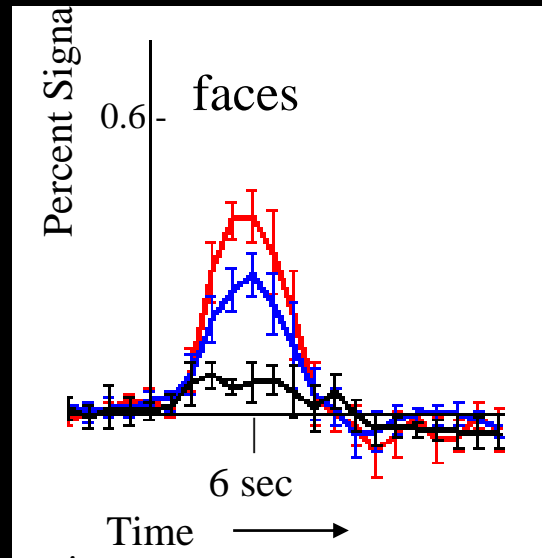
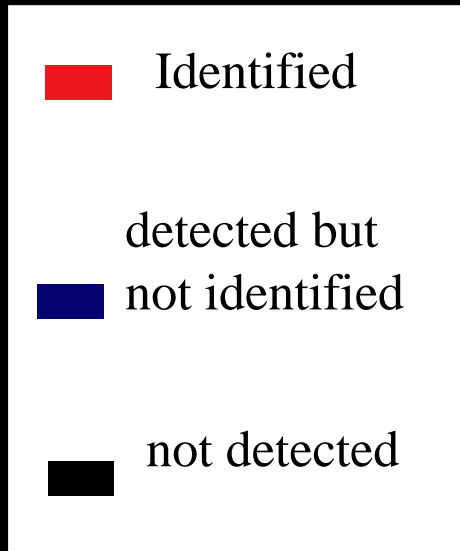
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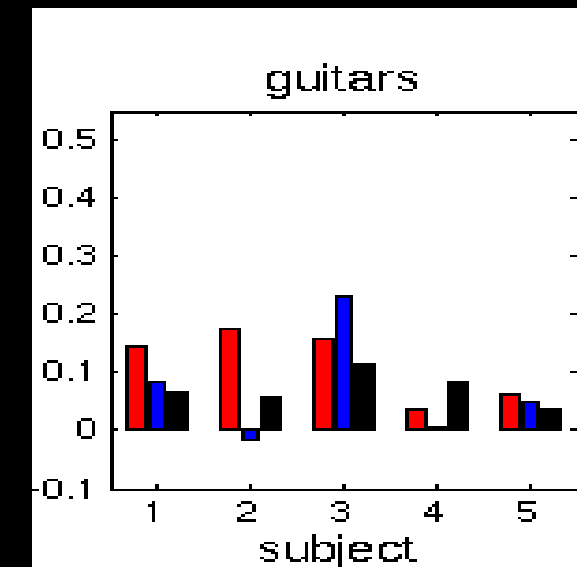
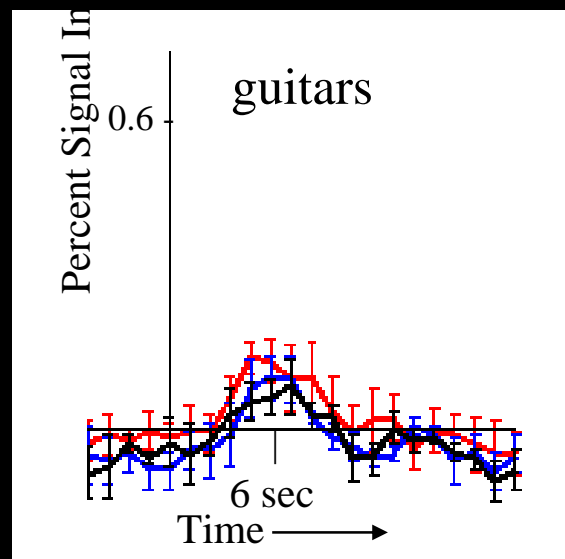
Stimulus images not repeated

Grill-Spector, Knouf, & Kanwisher (2004), *Nature Neuroscience*.

Right FFA Response to Target Faces or Guitars As a Function of Performance, N=5



**FFA involved in:
Detect & Ident of faces
Neither detect nor ident
of guitars.**



Uncoupling Mental/Neural Representation and Awareness

Same stimulus > different awareness

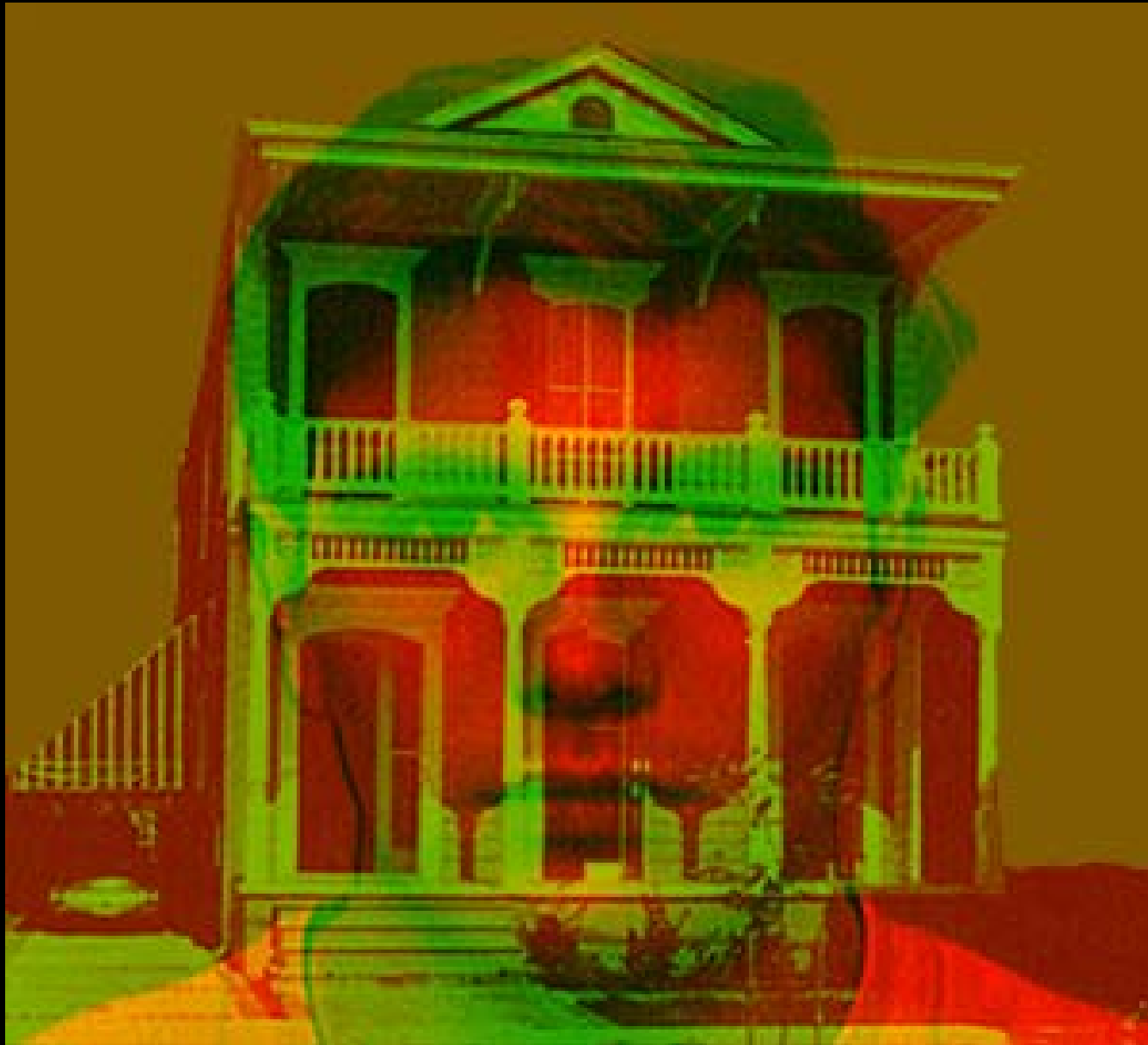
- Identical stimuli that are either perceived or not (on diff trials)
- Also: attention (same stim, diff experience)
- • Rivalry

Question 1: What happens in e.g. the FFA when a face is presented and the subject is versus is not conscious of the stimulus (or its category/identity).

Answer 1: Activity in the FFA is higher when the S is aware of the presence/category of stimulus, higher yet for specific identity.

BUT: retinal stimulation not identical...

Question 2: What happens in the FFA and the PPA when awareness switches between face and house, even though the retinal stimulus has not changed?



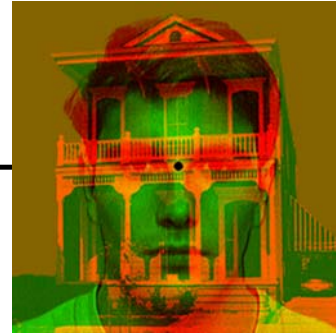
Courtesy Elsevier, Inc., <http://www.sciencedirect.com>. Used with permission.

Binocular Rivalry and Visual Awareness

Tong, Nakayama, Vaughan & Kanwisher (1998)

Rivalry

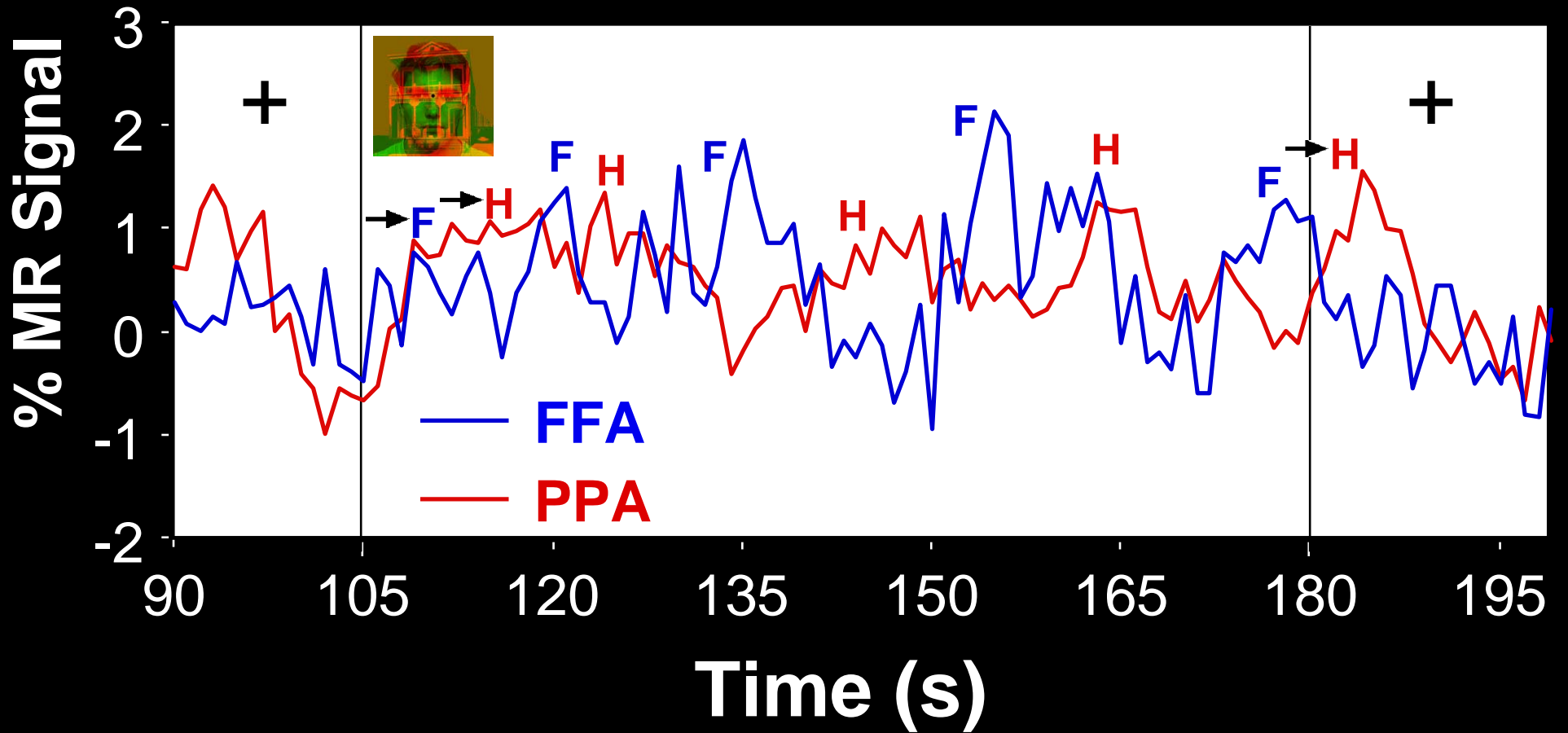
Stimulus



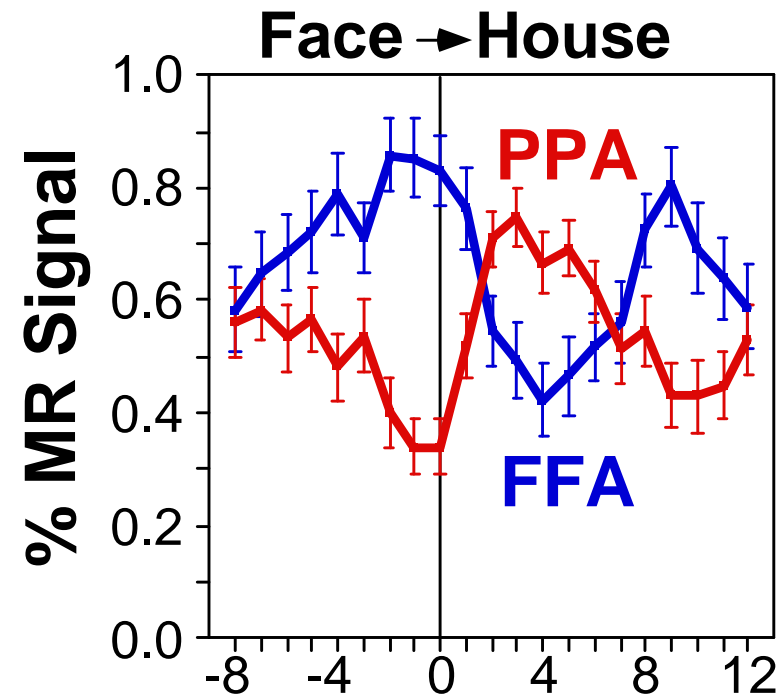
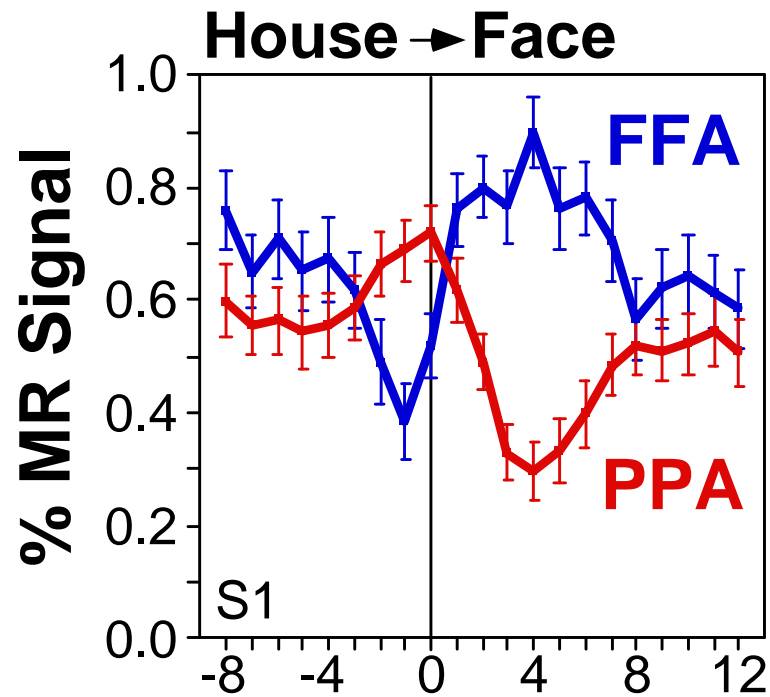
Percept



Tong et al 1998



Rivalry



Time from reported *perceptual* switch (s)

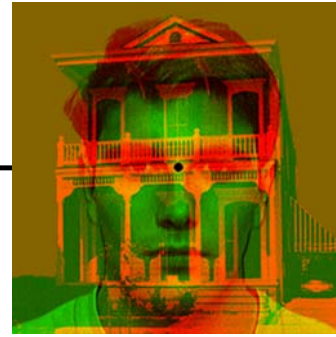
Tong, Nakayama, Vaughan, & Kanwisher, 1998

Binocular Rivalry and Visual Awareness

Tong, Nakayama, Vaughan & Kanwisher (1998)

Rivalry

Stimulus



Percept



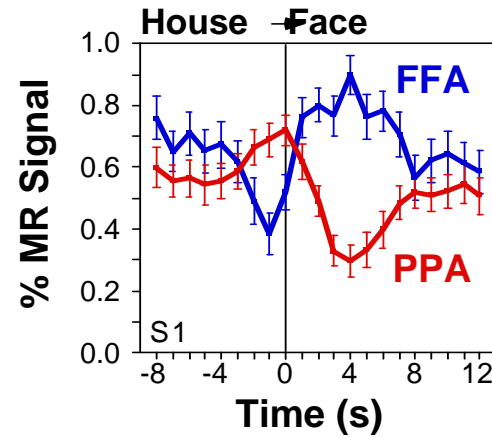
Nonrivalry

Yoked
Stimulus

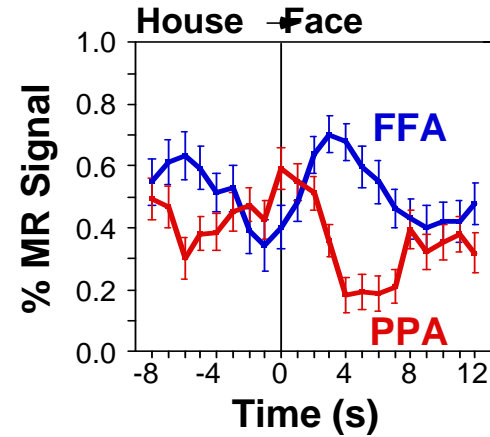


Time (s)

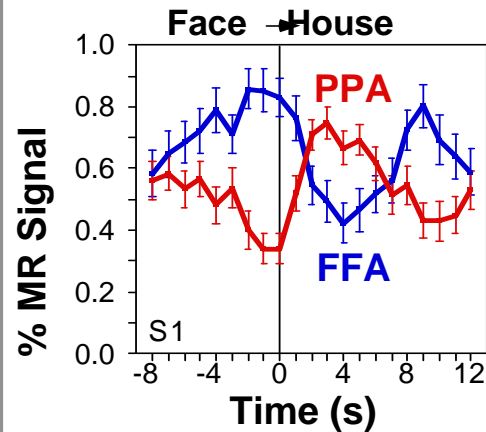
Rivalry



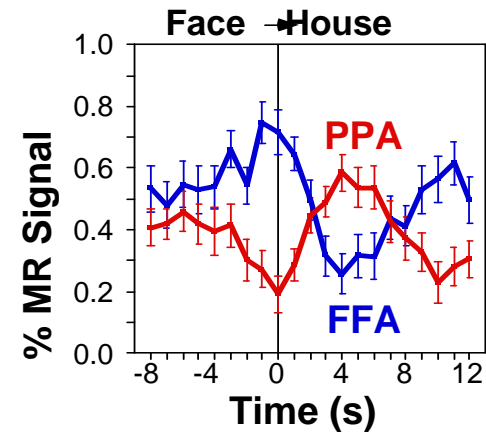
Non-Rivalry

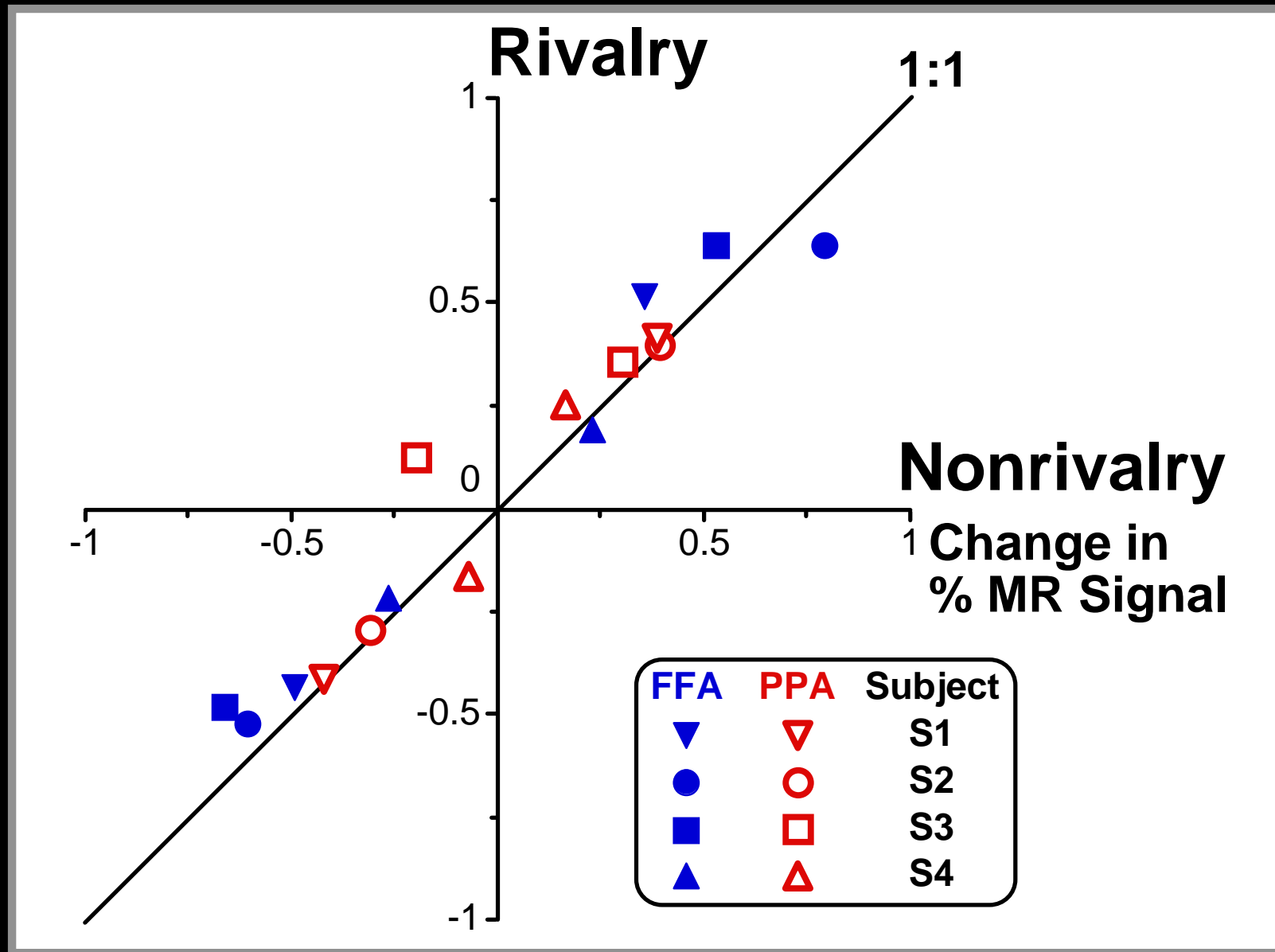


Rivalry



Non-Rivalry





Uncoupling Mental/Neural Representation and Awareness

Same stimulus > different awareness

- Identical stimuli that are either perceived or not (on diff trials)
- Also: attention (same stim, diff experience)
- • Rivalry

Question 1: What happens in e.g. the FFA when a face is presented and the subject is versus is not conscious of the stimulus (or its category/identity).

Answer 1: Activity in the FFA is correlated with subject's awareness.

Question 2: What happens in the FFA and the PPA when awareness switches between face and house, even though the retinal stimulus has not changed?

Answer 2: Activity in the FFA and PPA is 100% driven by what the subject is aware of, completely unconfounded from the stimulus!

Uncoupling Mental/Neural Representation and Awareness

Same stimulus > different awareness

- Identical stimuli that are either perceived or not (on diff trials)
- Also: attention (same stim, diff experience)
- Rivalry

What happens differently in the brain when you are vs. are not aware of the stimulus?

>>> Can find “NCC”, unconfounded from the stimulus. Lots of these .
They aren't all in the same single “awareness area” in the brain, instead:
The neural correlates of awareness of a given stimulus attribute are found in the neural structure that analyzes that stimulus attribute.

What are we to do with these NCCs now that we have them?

Really we want to understand not just *correlation*, but *causal connection*

Uncoupling Perception and Awareness

NCCs: correlations

Stronger tests of
causal connection:

Are these NCCs
necessary for awareness?
Look for cases here.

	Perceptual Awareness -	Perceptual Awareness +
Neural Activity -	√	Potential Evidence Against Necessity
Neural Activity +	Potential Evidence Against Sufficiency	√

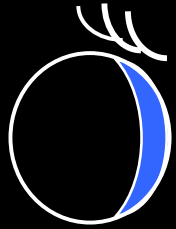
Kanwisher, N. "Neural events and perceptual awareness." *Cognition* 79, no. 1-2 (April 2001): 89-113.
Courtesy Elsevier, Inc., <http://www.sciencedirect.com>.
Used with permission.

Are they *sufficient*? Look for cases here.

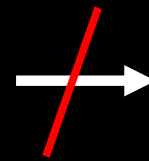
cases of representation/neural activity without awareness?
a topic in American psychology since James, Sidis (1898)
what does this mean?....

Uncoupling Representation and Awareness

Representation without awareness



Mental/neural representations extracted from a stimulus (whether reportable or not).



Awareness:
The ability to explicitly report about the presence or properties of the stimulus.

How do you measure these?



Indirect Tests:

Behavioral evidence, e.g.:

priming

psychophys. adaptation

Neural evidence, e.g.:

differential responses

fMRI adapt'n; classific'n



Explicit tests:

Forced choice (2AFC)

detection of stimulus.

- this stimulus not detected

- overall at chance

Discrimination (e.g., 2AFC)

Some examples.....

Representation without Awareness: Example 1

1. He & MacLeod (2001): found orientation-selective tilt after-effect from “invisible” gratings.
 - adapt to gratings so high in spatial frequency they are perceptually indistinguishable from a uniform field,
 - observers nonetheless experience tilt aftereffect from these gratings

Representation without Awareness: Example 1

1. He & MacLeod (2001): found tilt after-effect from “invisible” gratings.

Representation without Awareness: Example 1

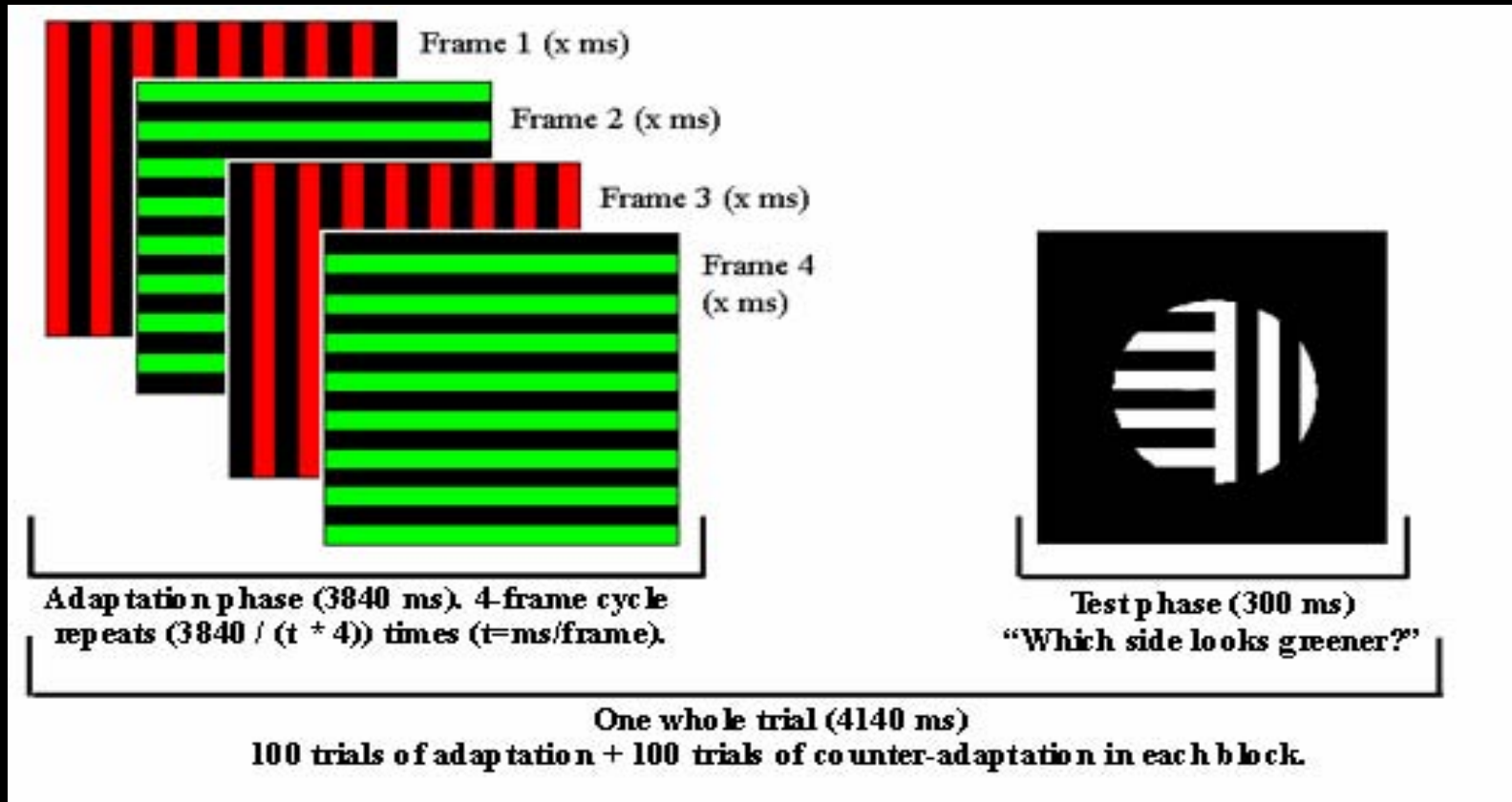
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 - adapt to gratings so high in spatial frequency they are perceptually indistinguishable from a uniform field,
 - observers nonetheless experience tilt aftereffect from these gratings

Conclusion:

“Because these after-effects are due to changes in orientation-sensitive mechanisms in visual cortex, our observations imply that extremely fine details, even those too fine to be seen, can penetrate the visual system as far as the cortex, where they are represented neurally without conscious awareness.”

Representation without Awareness: Example 2

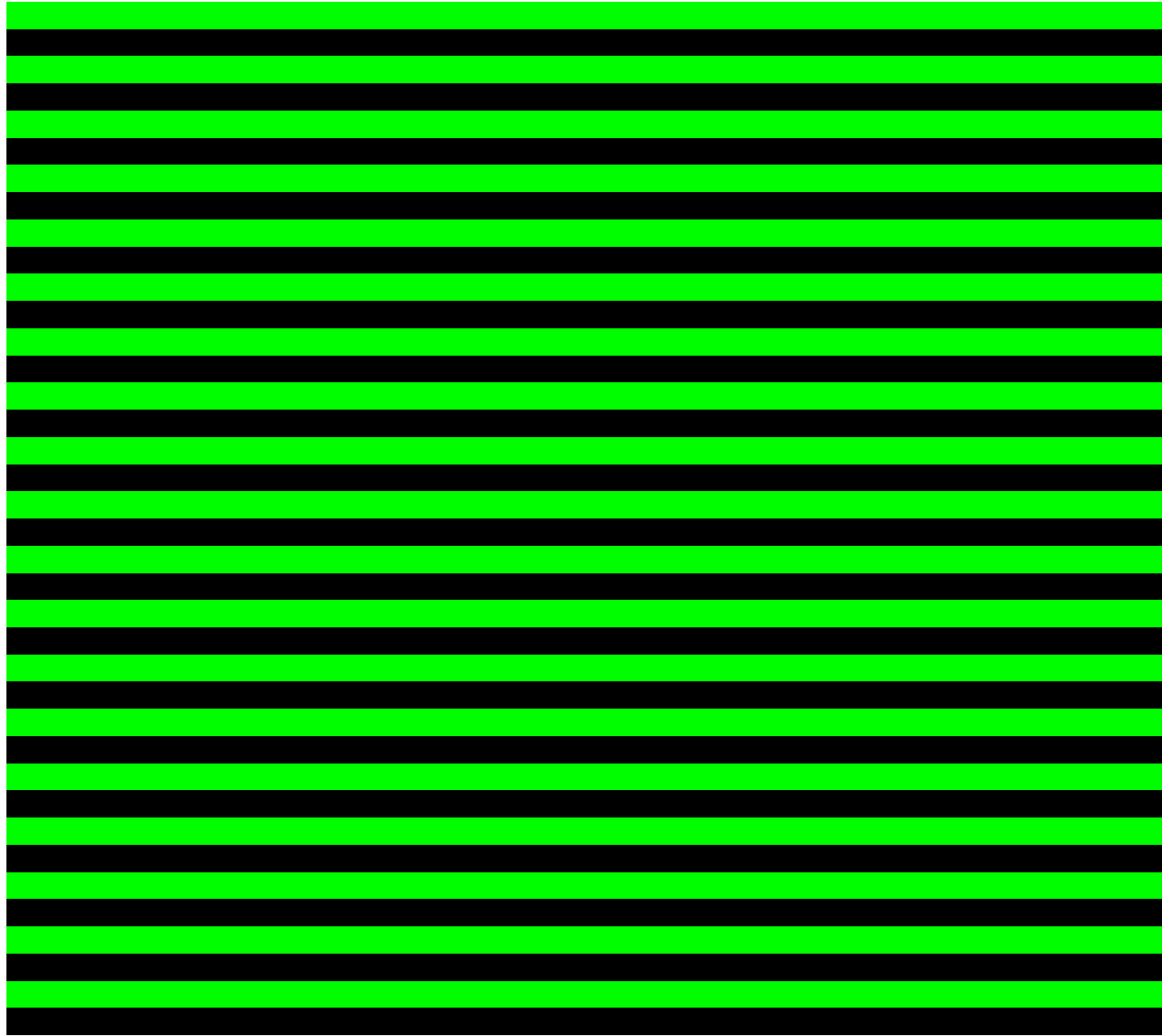
But that is just orientations.
What about conjunctions of orientation & color?
Test with the McCoullough Effect:



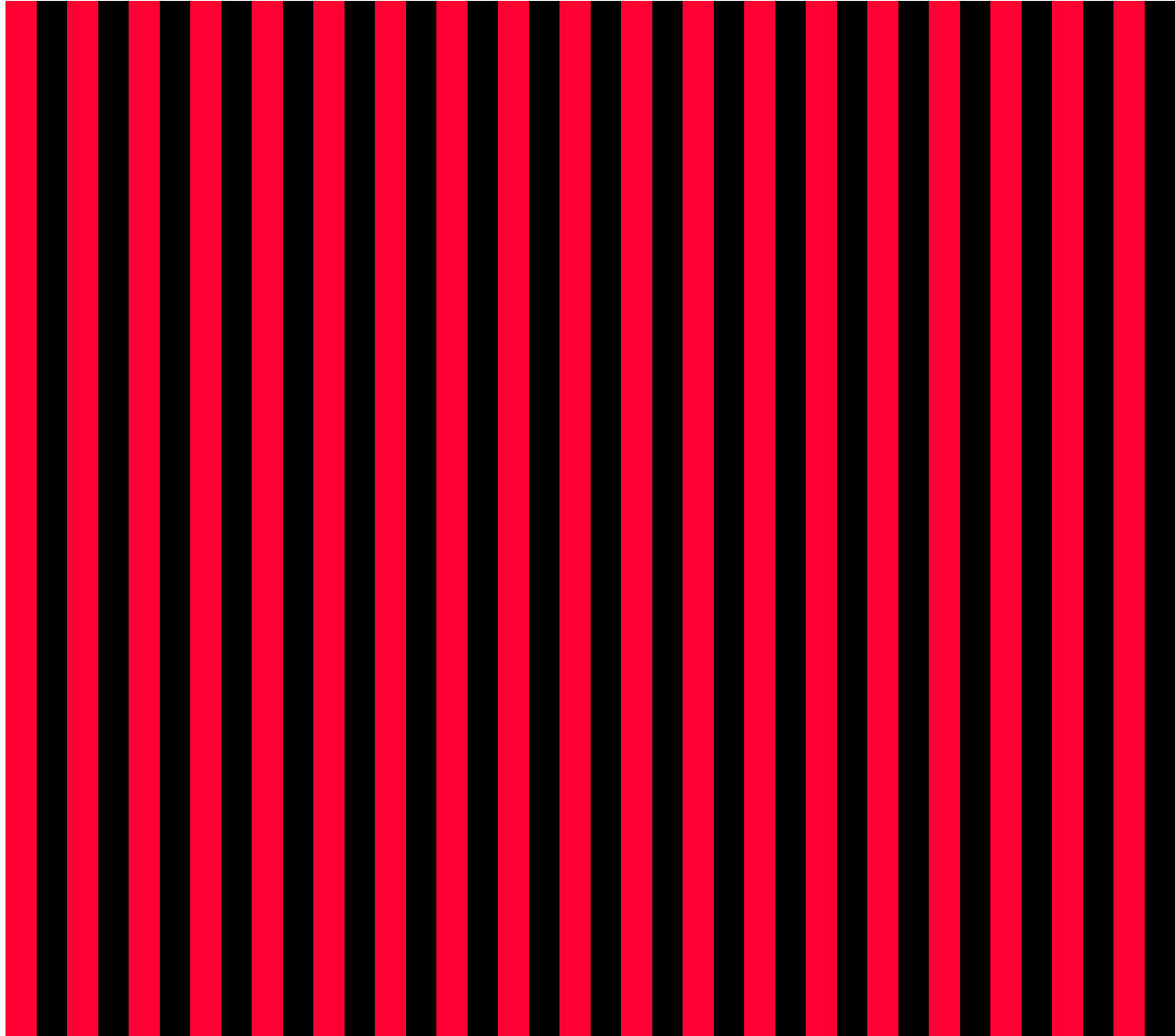
Ed Vul and David MacLeod, Nat Neurosci 9:7 (2006): 873.

demo.....

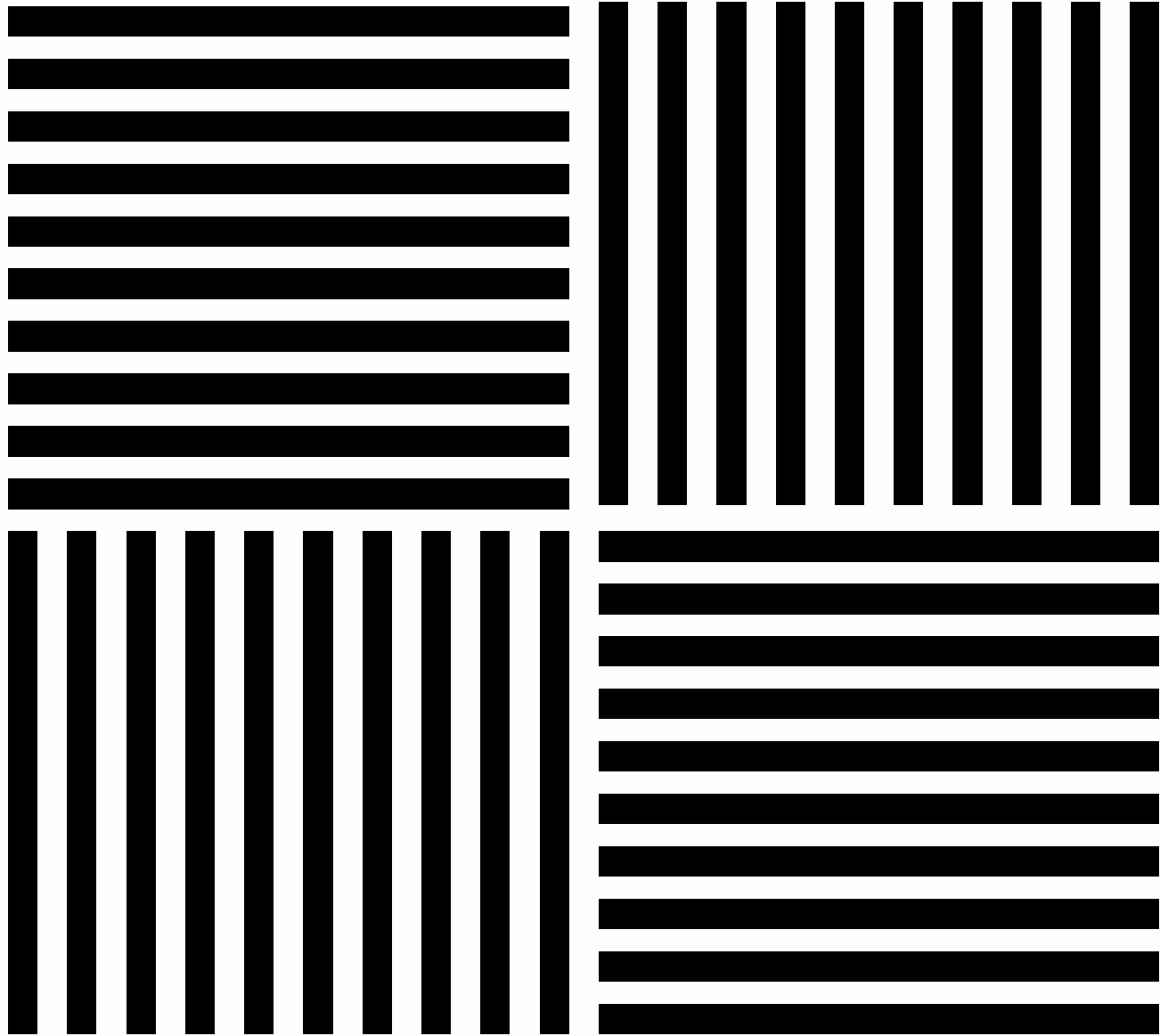
Courtesy Edward Vul. Used with permission.



Courtesy Edward Vul. Used with permission.



Courtesy Edward Vul. Used with permission.



Courtesy Edward Vul. Used with permission.

Representation without Awareness

Example 1: He & MacLeod (2001): found orientation-selective tilt after-effect from “invisible” gratings.

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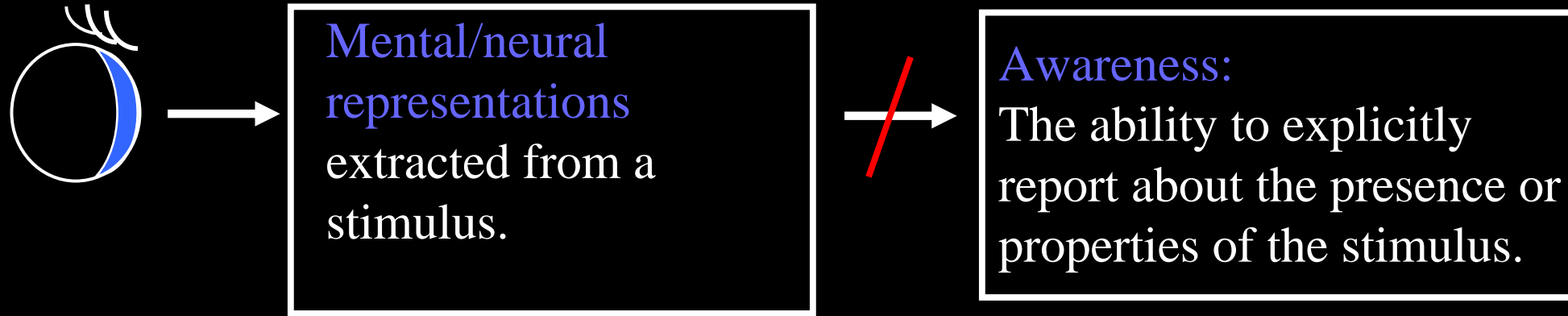
“Because these after-effects are due to changes in orientation-sensitive mechanisms in visual cortex, our observations imply that extremely fine details, even those too fine to be seen, can penetrate the visual system as far as the cortex, where they are represented neurally without conscious awareness.”

Example 2: Vul & MacLeod (2006): found color-contingent aftereffects from gratings that were “invisible” because they were flickering so fast.

So: not just orientations, but *combinations* of color & orientation, can be coded outside of awareness.

Uncoupling Perception and Awareness

So: we can have Representation without Awareness:



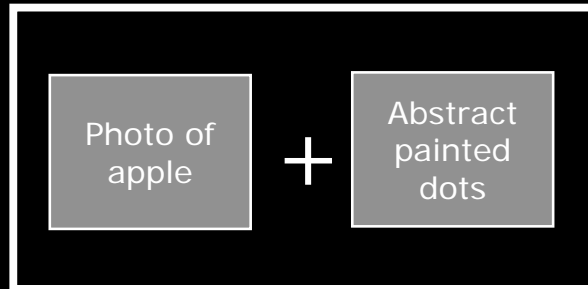
What determines which perceptual information reaches awareness??

- Kind of information (only low-level stuff? Or semantic/Motor?).
- Special brain regions (e.g., cortex)?
- “Activation strength hypothesis”?
- Kind of neural event? (Feedback to V1? Synchrony?)
- Information access hypothesis: *awareness of a particular element of stimulus information entails not just a strong neural representation, but also access to that information by most of the rest of the mind/brain...*

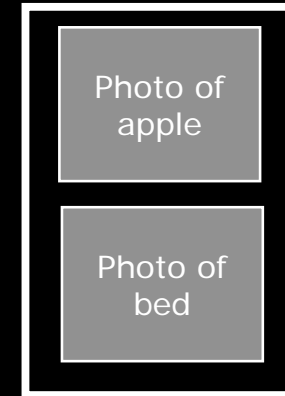
Representation without Awareness: Example 2

McGlinchey-Berroth et al (1993) semantic priming from unseen stimuli, neglect

A. Neglect
Ss at chance
at this task:

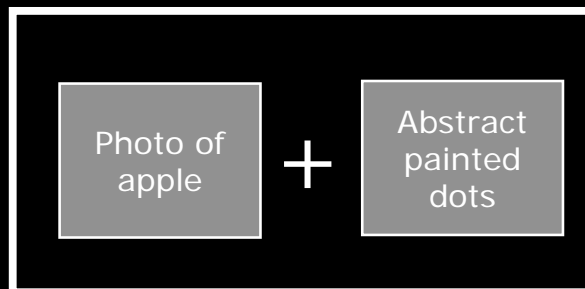


Images removed due to copyright restrictions.



Which
was
seen
before?

B. But show
semantic
priming here:



Images removed due to copyright restrictions.

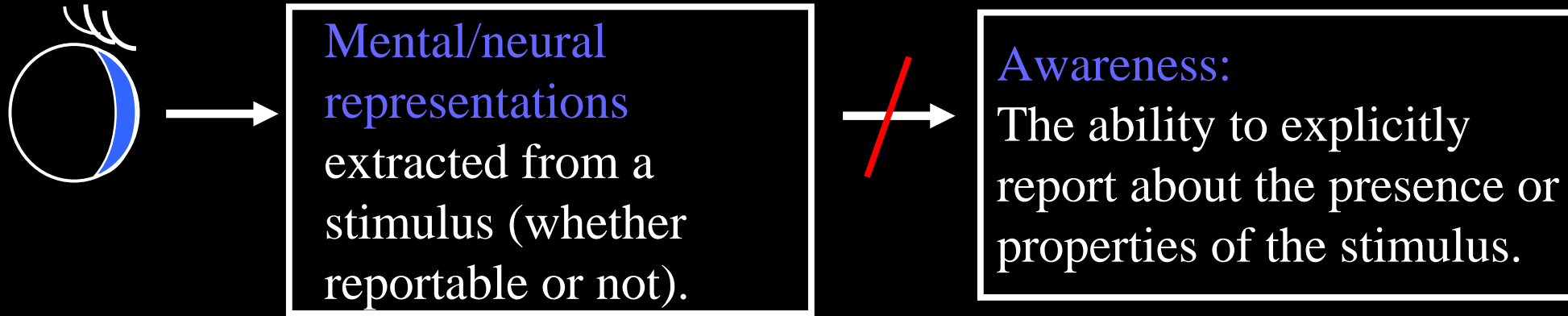


Word
or not?

So even meanings can be represented outside of awareness.

Uncoupling Perception and Awareness

1. If we can have Representation without Awareness:

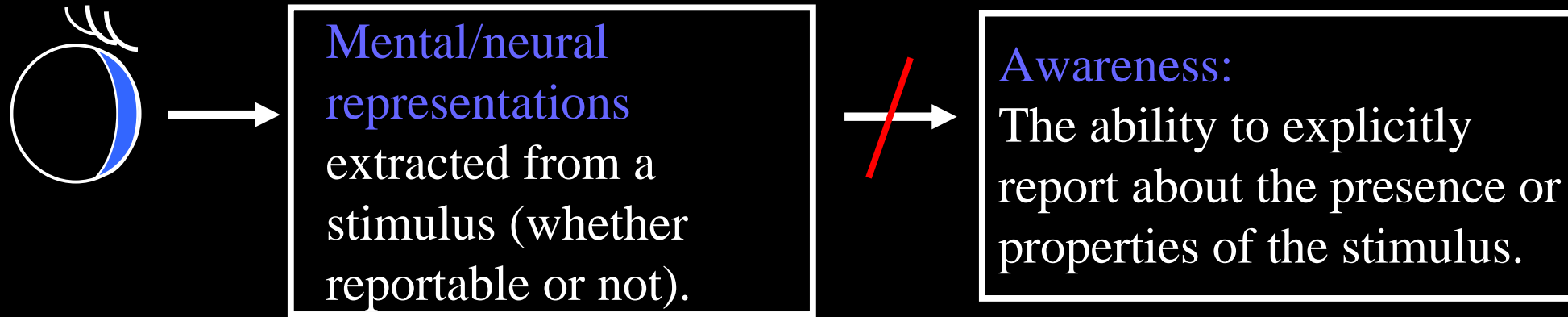


What determines which perceptual information reaches awareness??

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Uncoupling Perception and Awareness

1. If we can have Representation without Awareness:



What determines which perceptual information reaches awareness??

- Kind of information (~~only low-level stuff?~~ Or semantic/Motor?).

→ • Special brain regions (e.g., cortex)?

He & MacLeod; Vul & MacLeod: info in V1 w/out awareness

Pasley et al: info in amygdala but not VVP w/out awareness

What about the dorsal visual pathway?

Two visual pathways

The two visual processing streams for different visual percepts:
“What” (ventral/occipitotemporal stream)- object recognition

“Where” (dorsal/occipitoparietal stream) - spatial perception

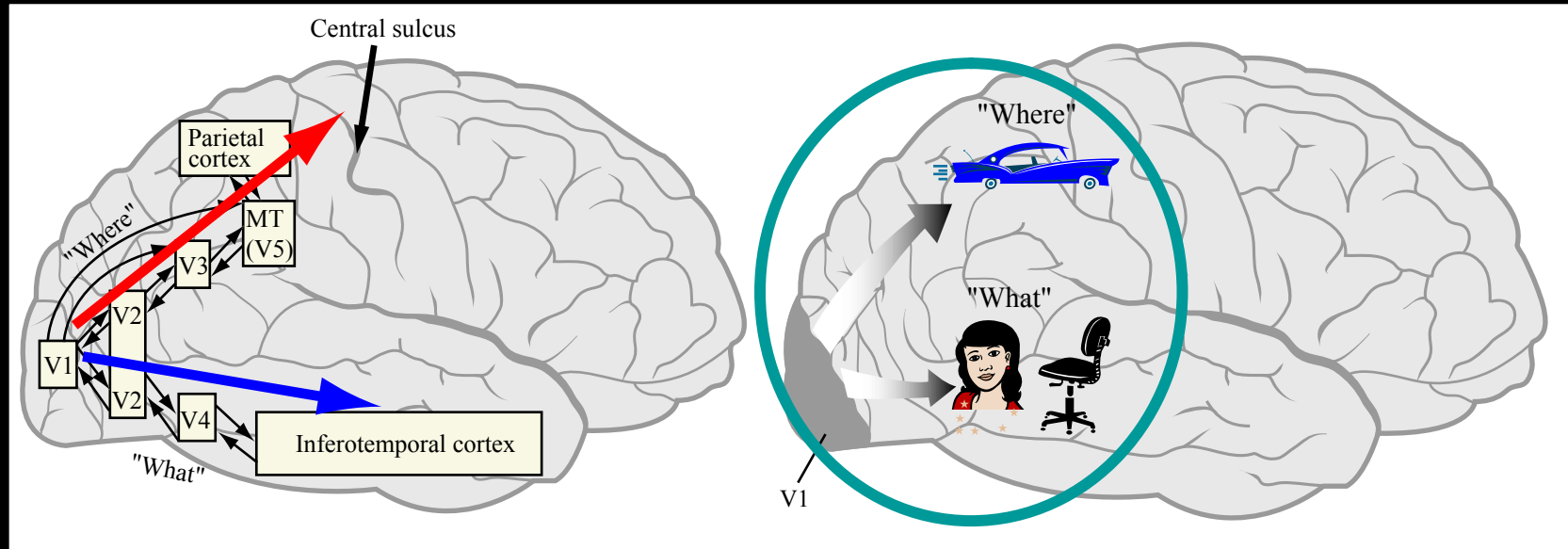


Figure by MIT OpenCourseWare.

Based on Mishkin & Ungerleider experiments, 1982

Courtesy of Jody Culham. Used with permission.

“What” vs. “How”

Goodale and Milner, 1991

- dichotomy should be “what” (ventral stream) vs. “how” (dorsal stream)
- dorsal system has strong input to motor systems and is essential for using visual information to guide actions
- Information in dorsal system is not consciously accessible (think of EMs)
- Evidence for this view?

Patient DF: no visual form perception

Images removed due to copyright restrictions.

See Figure 10.3 (p.320) in Goodale, M. A., and G. K. Humphrey, "Separate Visual Systems for Action and Perception." *Blackwell Handbook of Perception*. Edited by E. Bruce Goldstein. New York, NY: Wiley-Blackwell, 2001. [[Preview](#) this content in Google Books.]

Patient DF has a “ventral stream” lesion

Object agnosia

- Cannot identify line drawings of common objects
- Cannot copy line drawings
- Can draw from memory as long as she doesn't lift hand from paper

Patient DF: acting without perceiving

DF Control Posting task

Images removed due to copyright restrictions.

See Figure 10.4 (p.321) in Goodale, M. A., and G. K. Humphrey, "Separate Visual Systems for Action and Perception." *Blackwell Handbook of Perception*. Edited by E. Bruce Goldstein. New York, NY: Wiley-Blackwell, 2001. [[Preview](#) this content in Google Books.]

Perceptual matching task: performs very badly. But:

Posting task: performs well, begins to rotate card in the correct direction when movement begins.

So dorsal pathway sufficient for action but not awareness?

Let's look at more data....

Fang & He (2005)

Questions:

Can object-selective responses in the **ventral** pathway register without awareness?

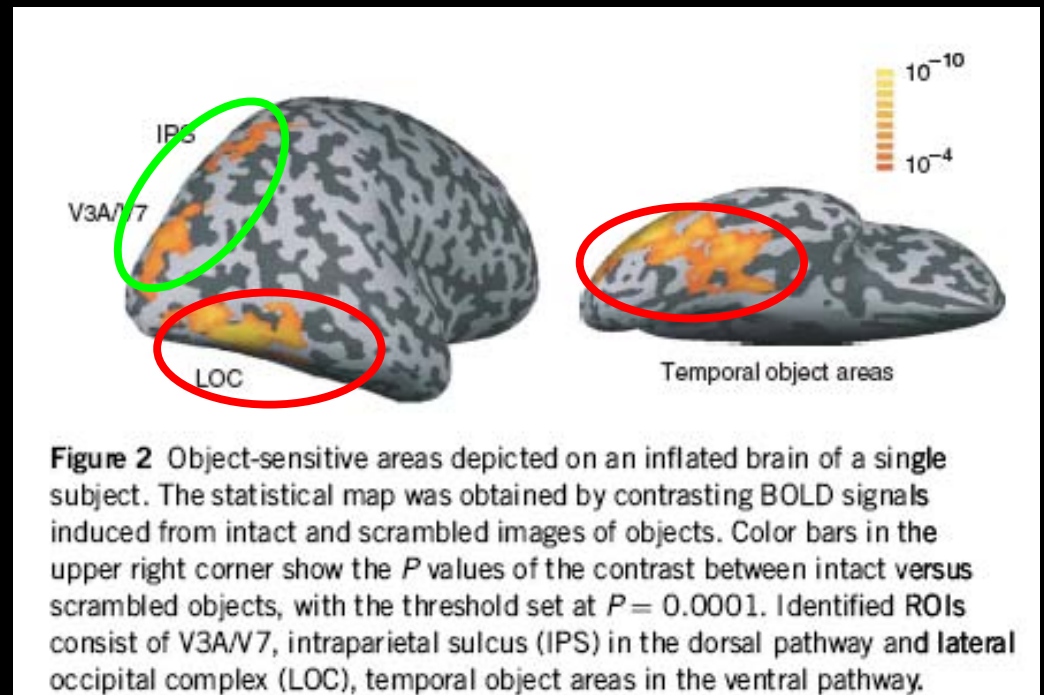
Can object-selective responses in the dorsal pathway register without awareness?

Localisers:

Intact > scrambled objects

Dorsal

Ventral



Courtesy of Sheng He. Used with permission.

Fang & He (2005) Experiment 1

Invisible stimuli

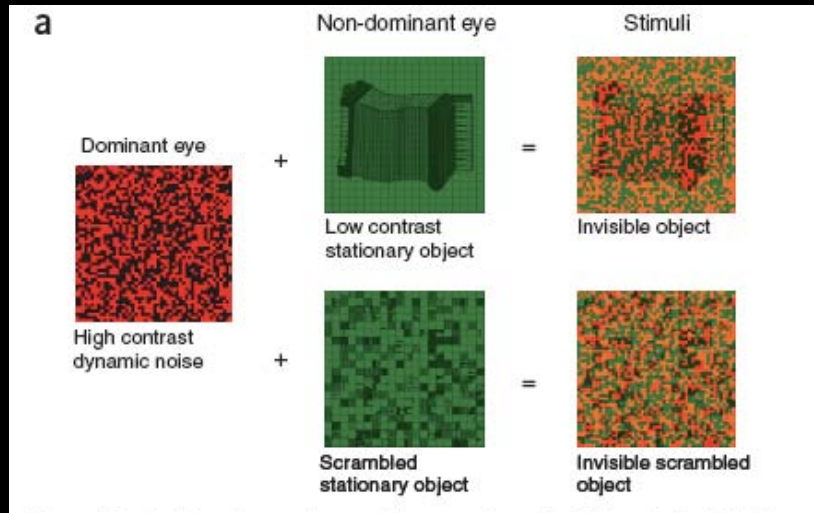


Figure 1 Stimuli and procedure used in experiment 1. (a) In the 'invisible' condition, awareness of stationary and low-contrast intact or scrambled objects presented to the non-dominant eye can be completely suppressed by dynamic, high-contrast, random textures presented to the dominant eye. Although the

Visible stimuli

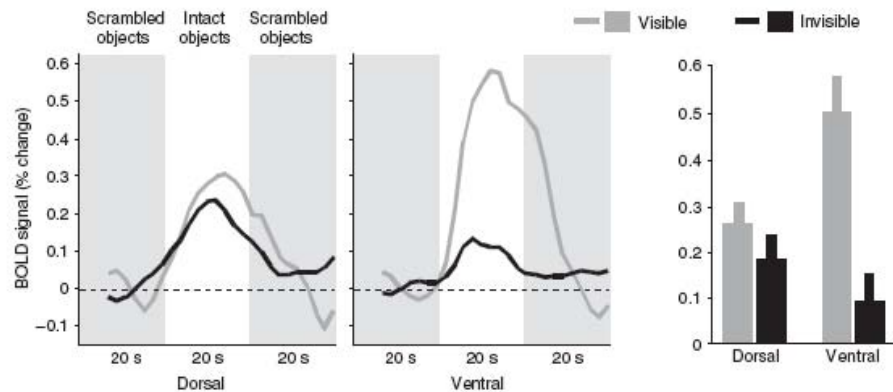
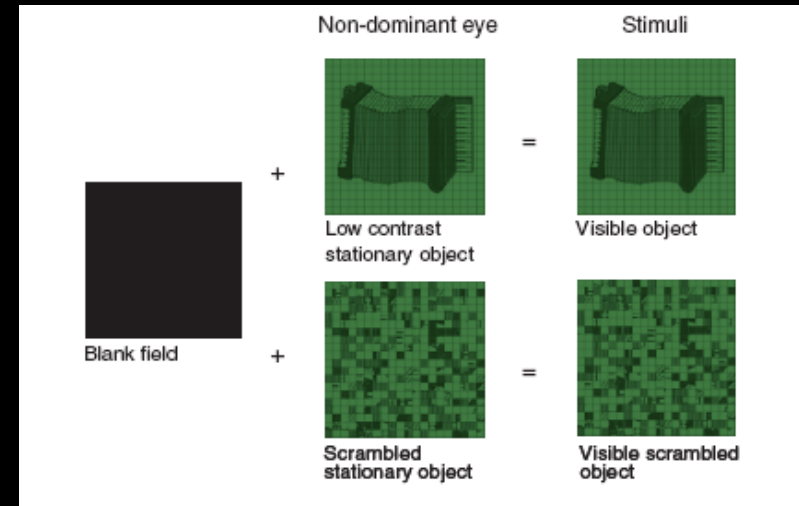


Figure 3 Results from the first experiment showing time courses and the average BOLD signals (percentage change) from dorsal and ventral object sensitive areas in 'visible' (gray curves and bars) and 'invisible' (black curves and bars) conditions. Data (mean \pm s.e.m.) were averaged across eight subjects.

So: dorsal pathway “sees” the invisible stimulus, ventral does not!

How much does dorsal pathway “know” about the stimulus?

Courtesy of Sheng He. Used with permission.

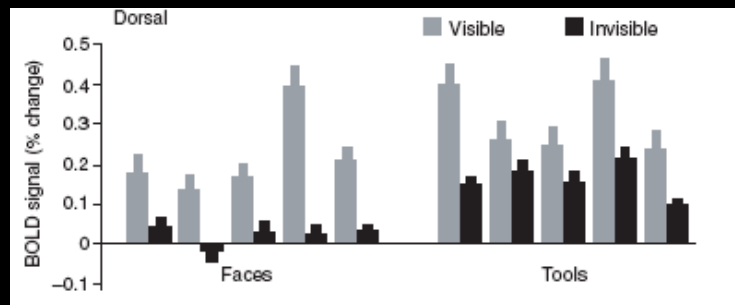
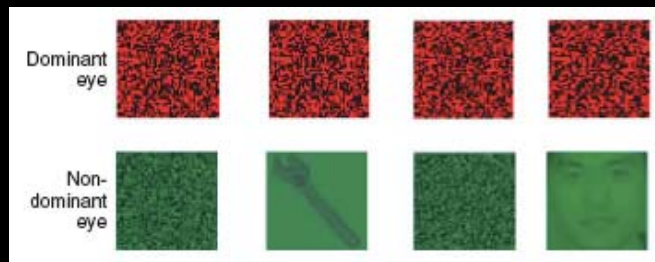
Fang & He (2005) Experiment 2

Does the dorsal pathway have info about specific unseen objects?

e.g. tools versus faces

Yes!

But ventral pathway does not.



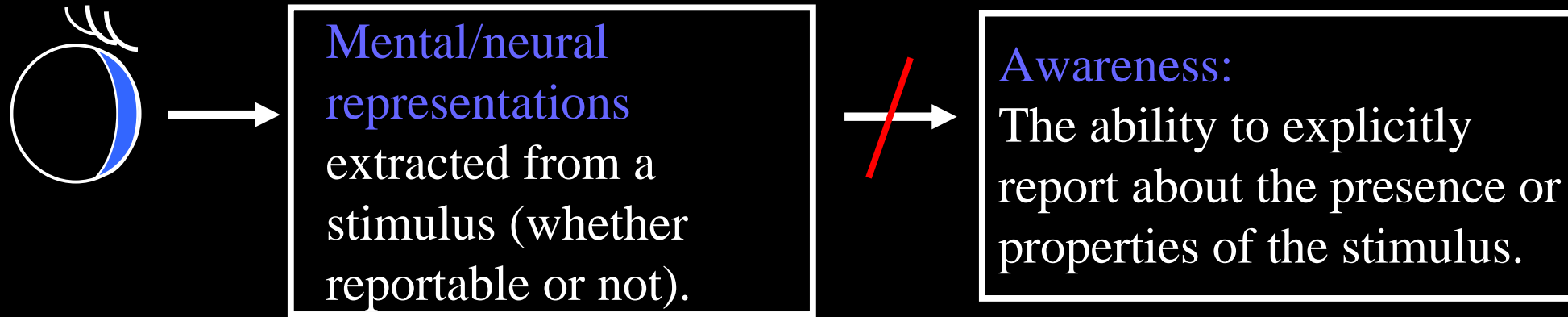
Courtesy of Sheng He. Used with permission.

Mystery:

So why then have others apparently showed selective activation of the FFA for unseen faces in neglect patients ?

Uncoupling Perception and Awareness

1. If we can have Representation without Awareness:



What determines which perceptual information reaches awareness??

- Kind of information (~~only low-level stuff?~~ Or semantic/Motor?).

→ • Special brain regions (e.g., cortex)?

So: no evidence for brain regions where specific activation is sufficient for awareness.

He & MacLeod; Vul & MacLeod: info in V1 w/out awareness

Pasley et al: info in amygdala but not VVP w/out awareness

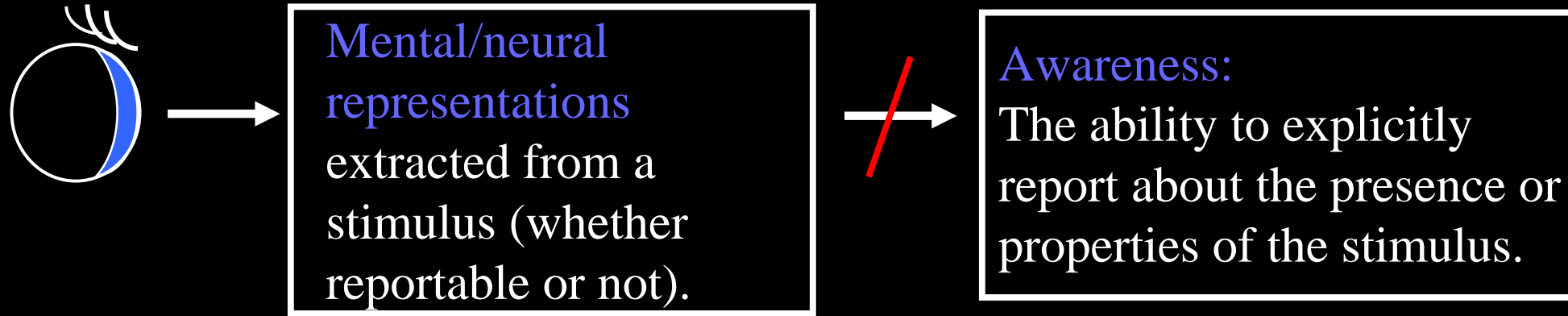
Fang & He: dorsal pathway registers w/out awareness

but ventral pathway does not

But see Vuilleumier et al (2001) on unconscious FFA activation

Uncoupling Perception and Awareness

1. If we can have Representation without Awareness:

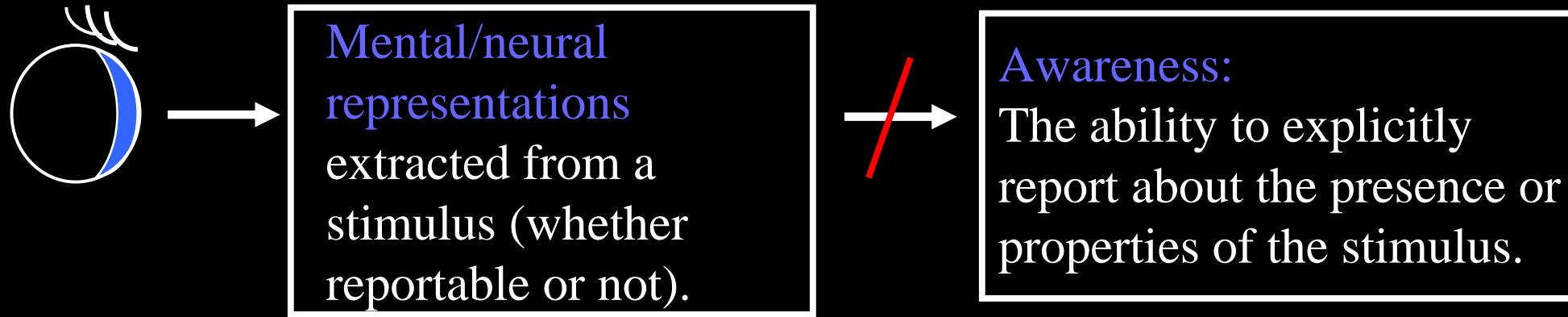


What determines which perceptual information reaches awareness??

- Kind of information (~~only low-level stuff?~~ Or semantic/Motor?).
- Special brain regions (e.g., cortex)? **No evidence yet....**
- “Activation strength hypothesis”?
- Kind of neural event? (Feedback to V1? Synchrony?)
- Information access hypothesis: *awareness of a particular element of stimulus information entails not just a strong neural representation, but also access to that information by most of the rest of the mind/brain...*

Uncoupling Perception and Awareness

1. If we can have Representation without Awareness:



What determines which perceptual information reaches awareness??

- Kind of information (~~only low-level stuff?~~ Or semantic/Motor?).
- Special brain regions (e.g., cortex)? **maybe**
- • “Activation strength hypothesis”?
- Kind of neural event? (Feedback to V1? Synchrony?)
- Information access hypothesis: *awareness of a particular element of stimulus information entails not just a strong neural representation, but also access to that information by most of the rest of the mind/brain...*

Marois et al (2004) Attentional Blink

Demo:

A very rapid sequence of digits will flash on. Two letters will be included in the sequence. Your task is to report the two letters.....

Marois et al (2004) Attentional Blink

That was X then H
Ready for the next one?

Marois et al (2004) Attentional Blink

1. That was X then H

long lag, 4 intervening letters

2. That was A then P

short lag, one intervening letter

People detect the second target more often at long than short lags: the “attentional blink”

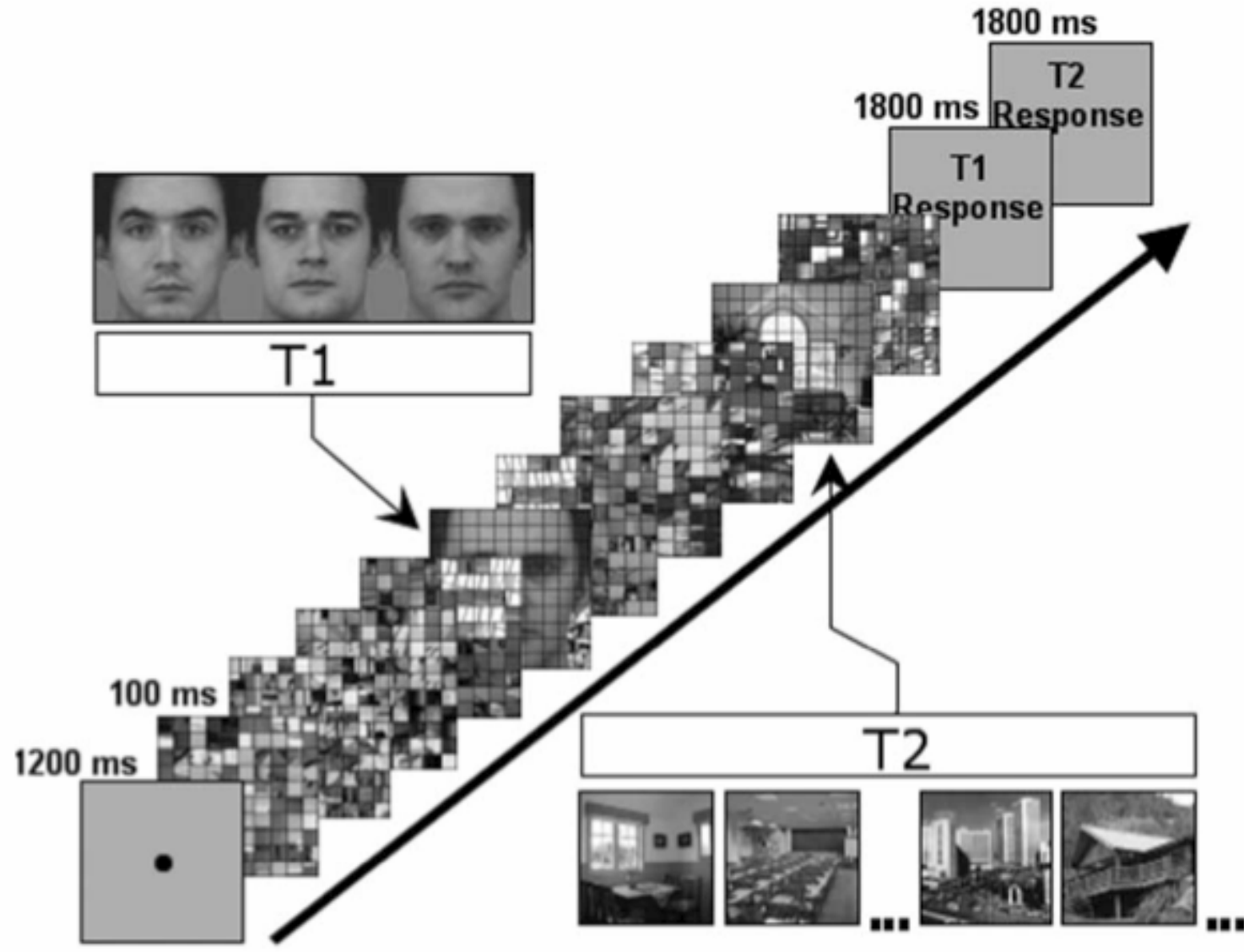
Critical question: when you fail to see the second letter, what happens to it?

Marois et al (2004) Attentional Blink

Task:
detect face (T1), then
scene (T2)

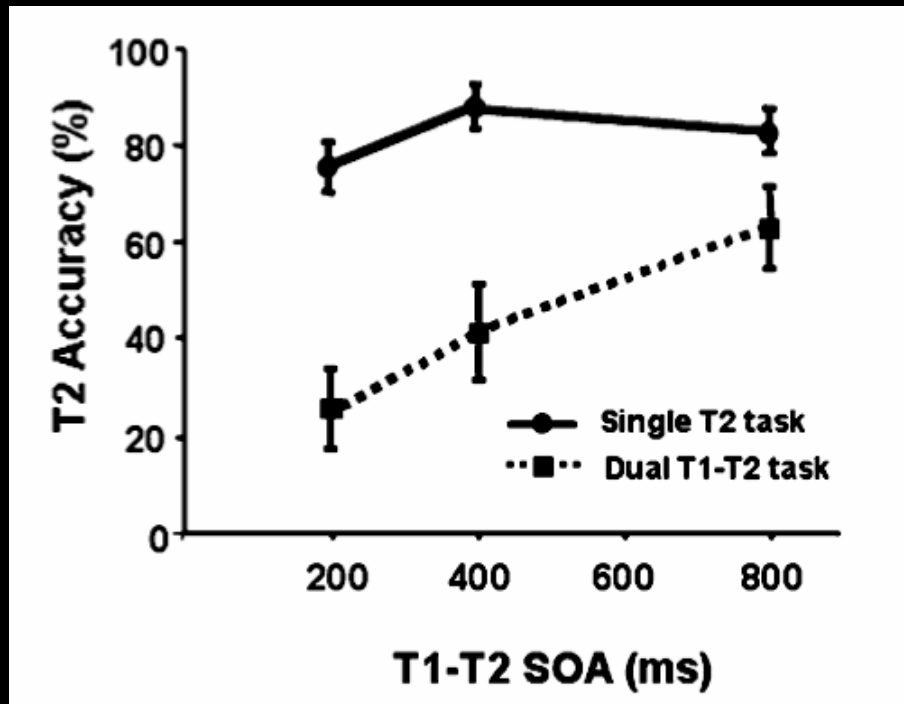
Figure 1. Experimental Design

In the dual-task experiment, subjects searched for a face target (T1) and a scene target (T2) presented in an RSVP of scrambled distractor scenes. The SOA between T1 and T2 was varied. The single-task experiment was identical except that subjects searched only for the target scene. Insets show the three face targets and examples of both indoor and outdoor scene targets.

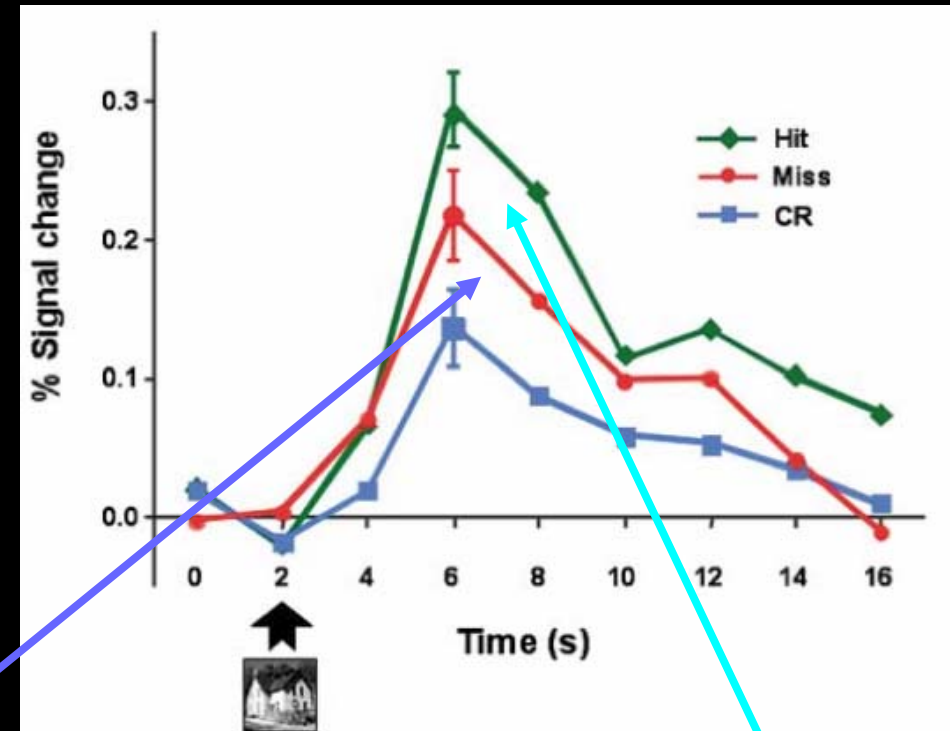


Marois et al (2004) Results

Behavioral Data:



fMRI Data - Response of PPA:

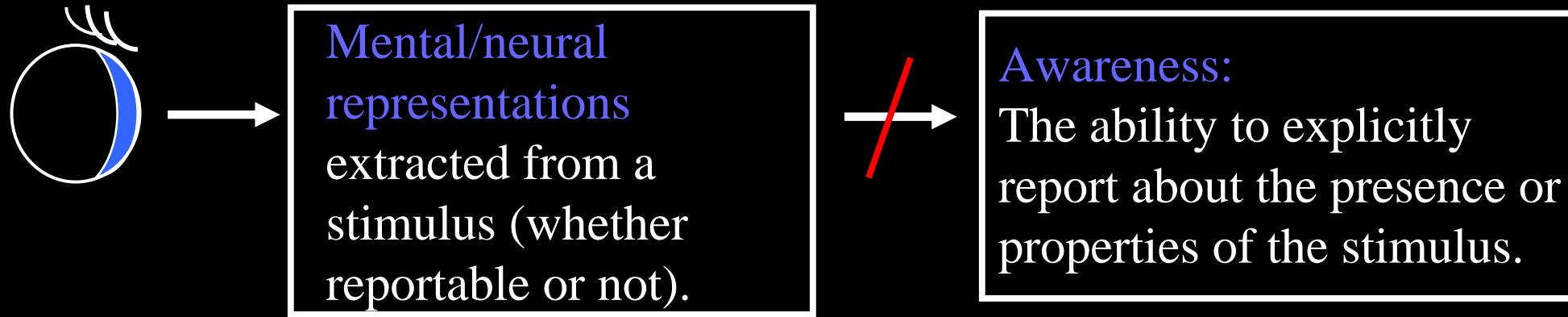


Representation without awareness

Activation Strength hypothesis

Uncoupling Perception and Awareness

1. If we can have Representation without Awareness:



What determines which perceptual information reaches awareness??

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- Special brain regions (e.g., cortex)? **maybe**
- “Activation strength hypothesis”? **maybe**
- Kind of neural event? (Feedback to V1? Synchrony?) **maybe**

→ • Information access hypothesis: *awareness of a particular element of stimulus information entails not just a strong neural representation, but also access to that information by most of the rest of the mind/brain...*

**Dehaene et al
(2001)**

Unmasked Words

Masked Words

Wider activation throughout the brain for unmasked words (perceived consciously) than masked words (not perceived consciously).

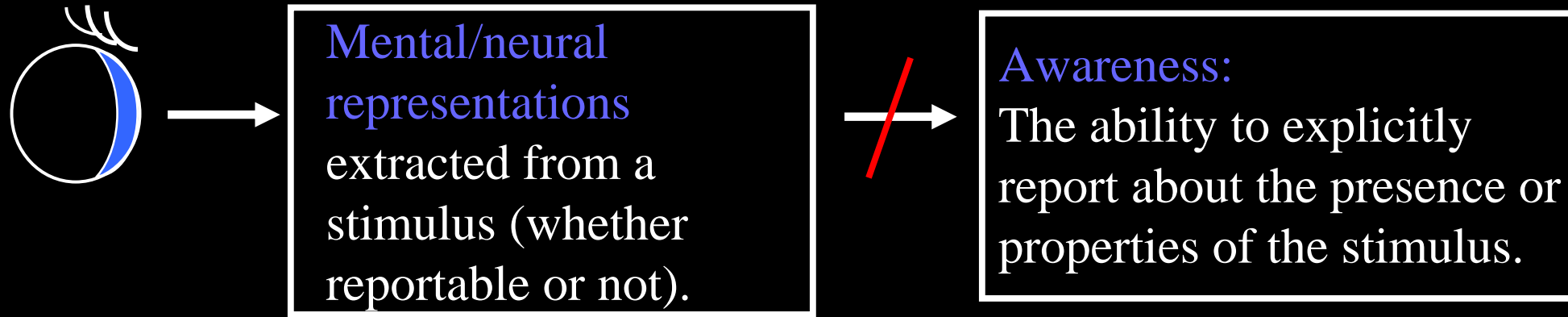
Are you convinced that widespread access to the information is the crux of awareness?

Image removed due to copyright restrictions.

Figure 2 in Dehaene, S., et al. "Cerebral mechanisms of word masking and unconscious repetition priming." *Nature Neuroscience* 4 (2001): 752-758. doi:10.1038/89551 .

Uncoupling Perception and Awareness

1. If we can have Representation without Awareness:



What determines which perceptual information reaches awareness??

- Kind of information (~~only low-level stuff?~~ Or semantic/Motor?).
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- Kind of neural event? (Feedback to V1? Synchrony?) **maybe**
- Information access hypothesis: *awareness of a particular element of stimulus information entails not just a strong neural representation, but also access to that information by most of the rest of the mind/brain...* **maybe**

Uncoupling Perception and Awareness

Other questions:

1. Is awareness/access all or none? (Dehaene PNAS)
2. Is awareness necessarily tied to space & time?
3. Is awareness composed of discrete time points (Koch/Crick)?
4. Is there (or what is the nature of the) limit on the capacity/bandwidth of awareness?

What determines which perceptual information reaches awareness??

- Kind of information (~~only low-level stuff?~~ Or semantic/Motor?).
- Special brain regions (e.g., cortex)? **maybe**
- “Activation strength hypothesis”? **maybe**
- Kind of neural event? (Feedback to V1? Synchrony?) **maybe**
- Information access hypothesis: *awareness of a particular element of stimulus information entails not just a strong neural representation, but also access to that information by most of the rest of the mind/brain...* **maybe**

**Coda: Mark Williams' work on
readout of distributed cortical
patterns.**

Which Spatial Patterns of fMRI Response are accessible to awareness?

Haxby argues that the whole spatial profile of response across centimeters of ventral visual pathway constitutes the representation of an object. And indeed there is some object info spread across here.

But:

Just because some information is *present* in the SPfR in a given ROI does not mean that that SPfR is *accessible to awareness* and hence used in task performance.

What we need to know:

Which pattern information is accessible to awareness?

How could we tell?

First, a reminder about pattern analysis....

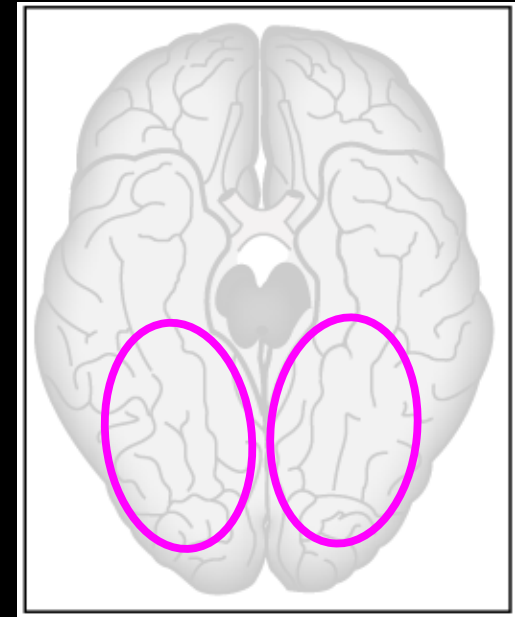
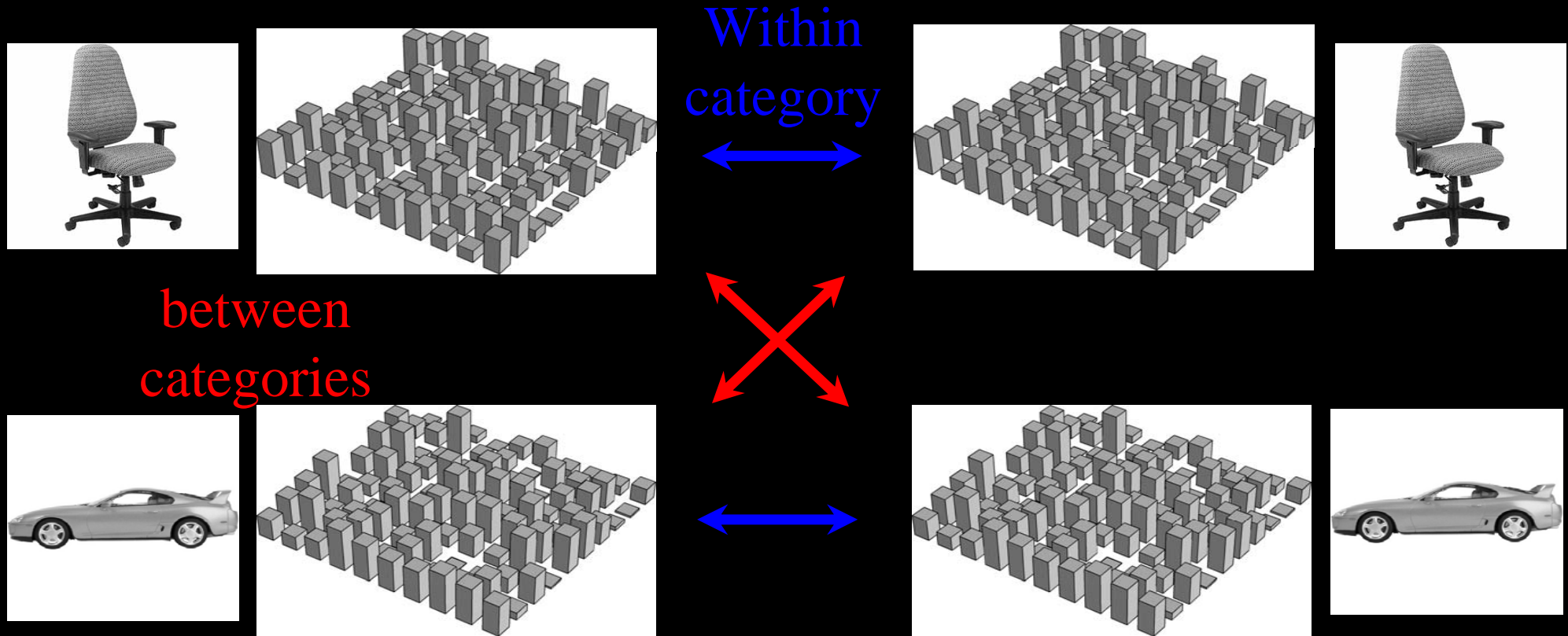


Figure by MIT OpenCourseWare. After Allison, 1994.

Correlation-based Classification Analysis (Haxby et al., 2001)

1. Scan each subject while they view multiple stimulus categories.
2. Split the data in 1/2; generate activation maps for each category.
3. Compute correlation across activation maps.



between
categories

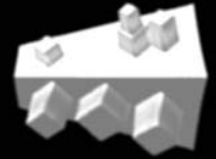
Within
category

If $r(\text{Within}) > r(\text{Between})$

the region contains category information

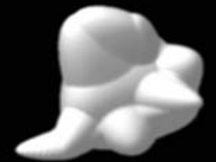
Williams et al (2007)

Overall Logic



The Question:

Which pattern information is accessible to awareness?



Design: Brief masked stimuli, shape categorization task

some errors, but above chance

bin fMRI data by behavioral performance



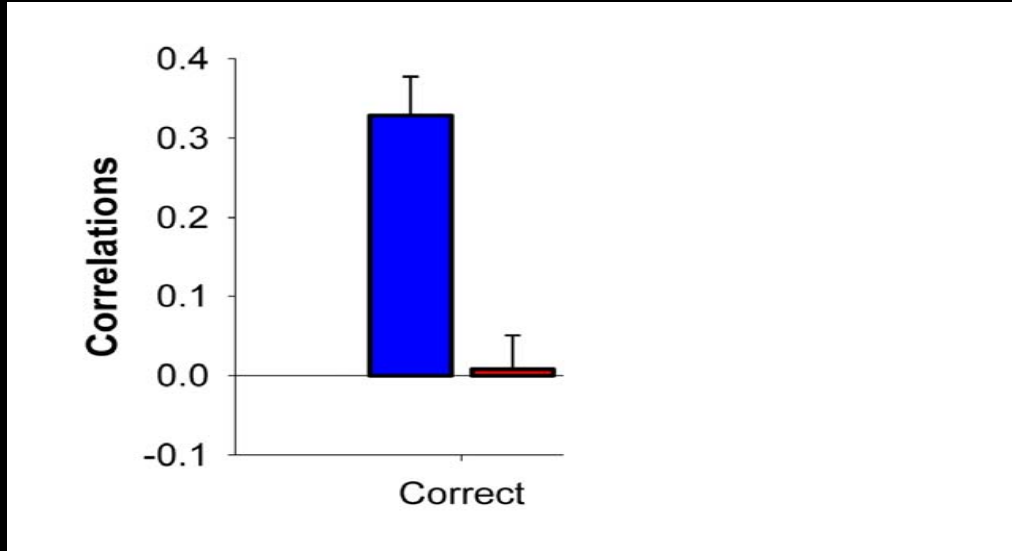
Key prediction:

Any pattern information that is accessible to awareness should be stronger on correct than incorrect trials, i.e.:

$[r(\text{w/in}) - r(\text{betwn})]$ on correct trials $>$ $[r(\text{w/in}) - r(\text{betwn})]$ on incorrect trials

Williams et al, Results

Retinotopic Cortex



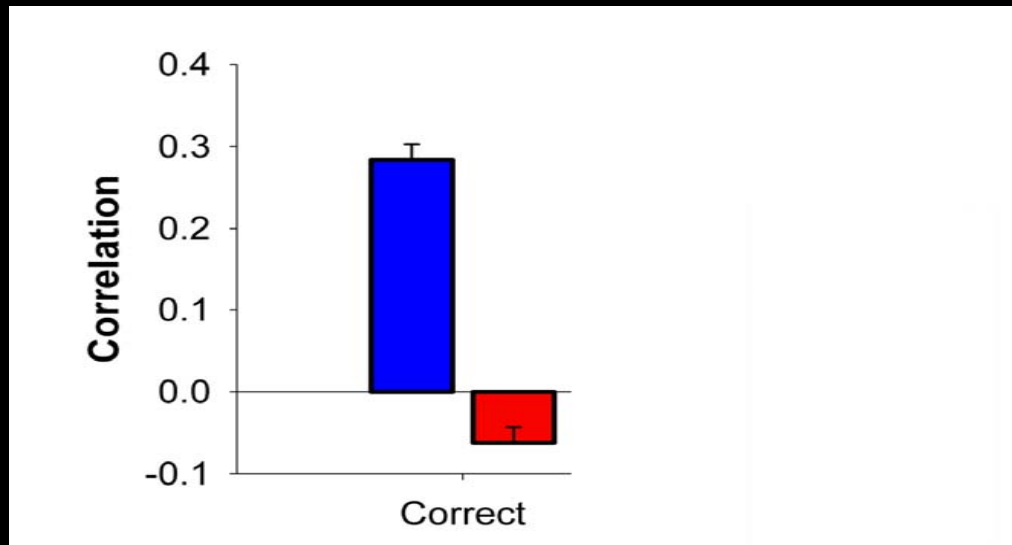
Within-category



Between-category

Information is present in retinotopic cortex, but not accessible to awareness!

Lateral Occipital Complex (LOC)



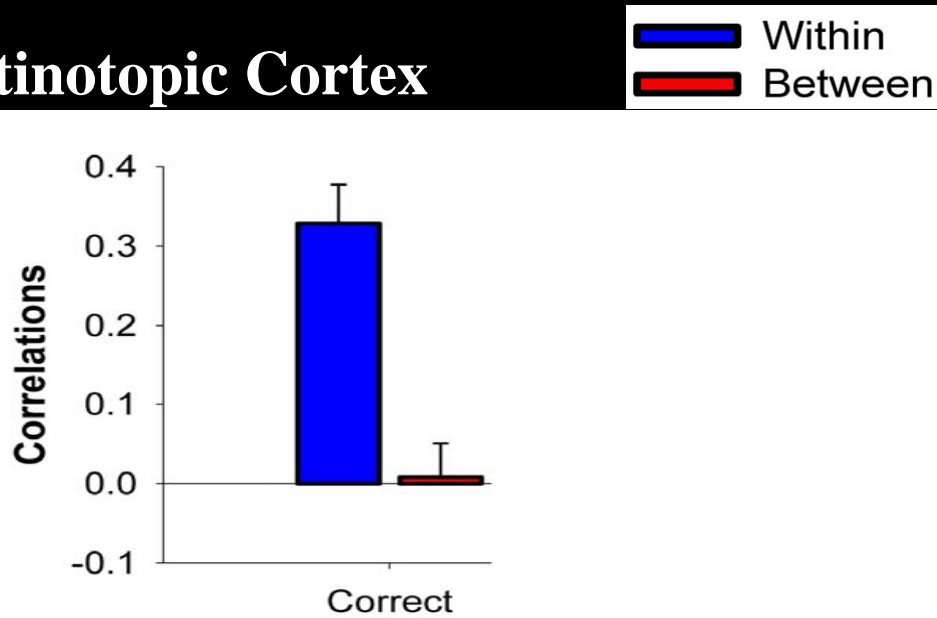
Information is present in LOC on correct trials, not on incorrect trials>>>>

This information is accessible to awareness.

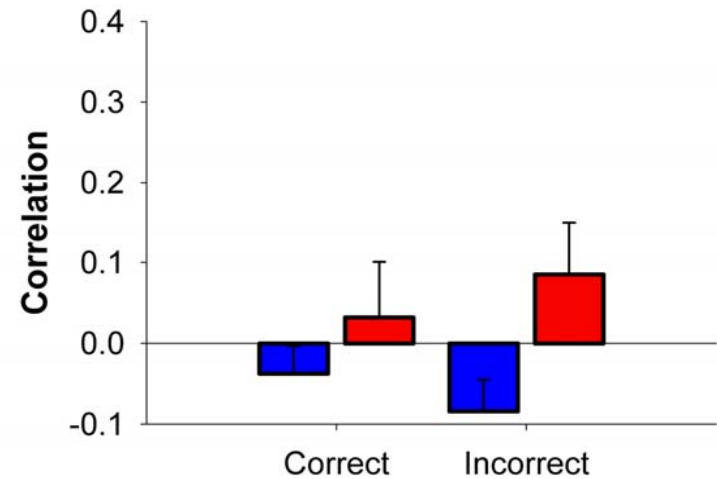
Other areas?

Williams et al, Results

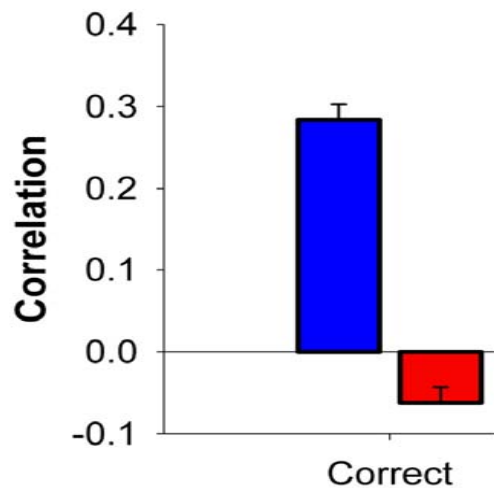
Retinotopic Cortex



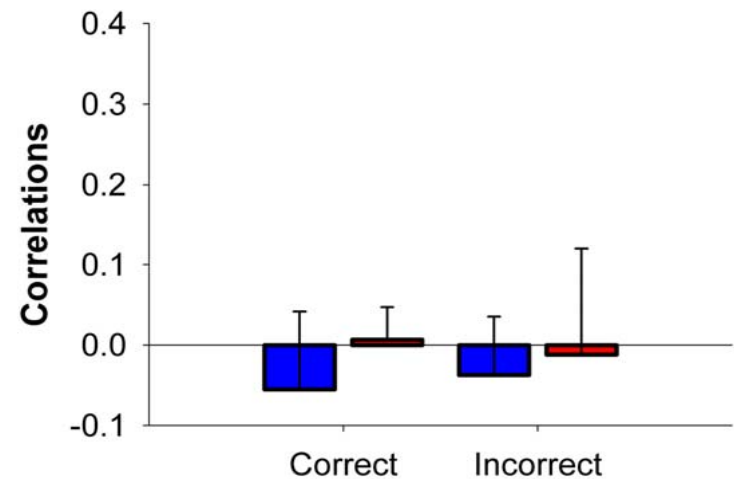
Posterior Fusiform



Lateral Occipital Complex (LOC)

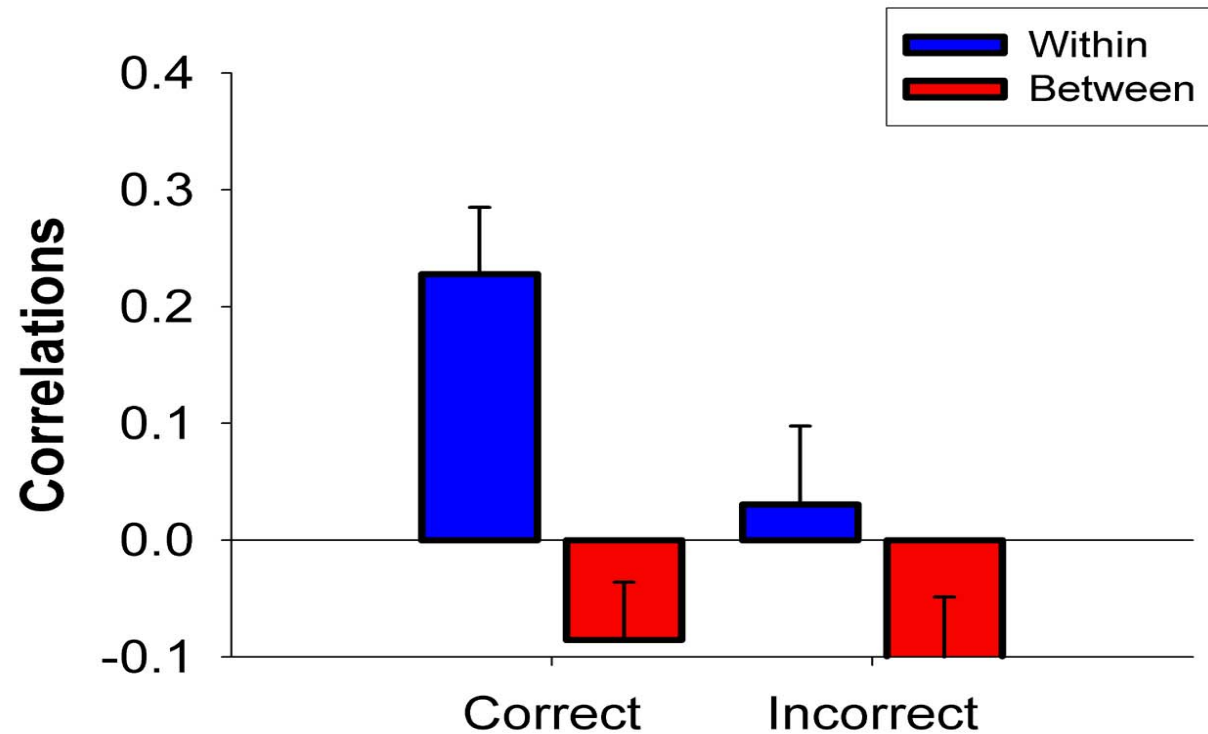


FFA



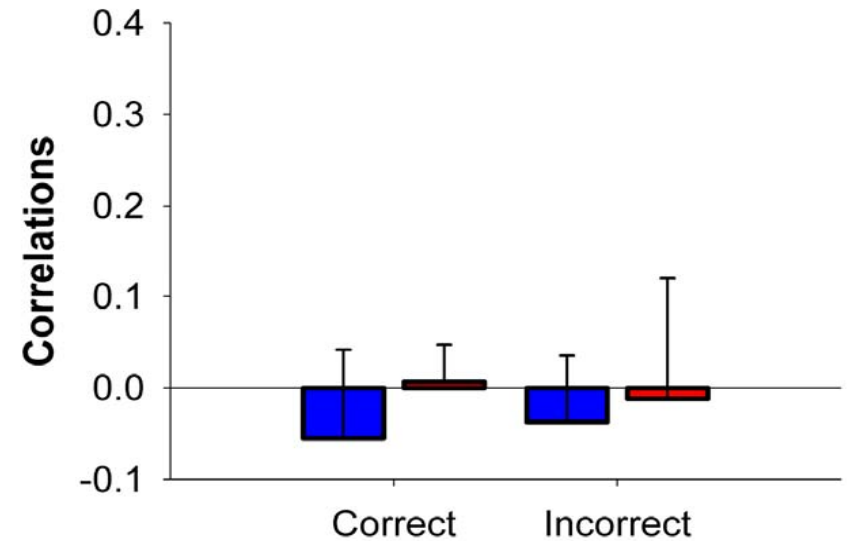
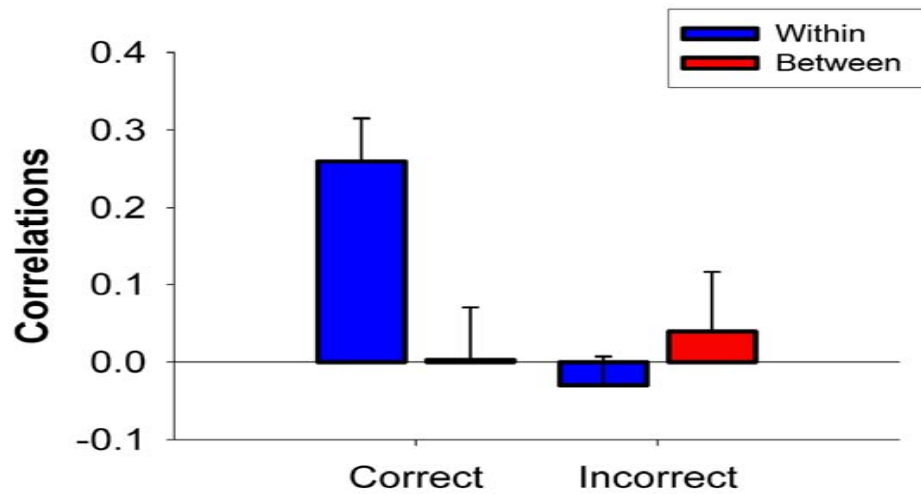
Could weaker category information in incorrect trials be due to the smaller number of trials? **No**

Equalised trial numbers



Is the greater category information in LO than FFA due to a larger number of voxels? **No**

Equalised voxel numbers.



Which Spatial Patterns of fMRI Response are accessible to awareness?

Haxby argues that the whole spatial profile of response across centimeters of ventral visual pathway constitutes the representation of an object. And indeed there is some object info spread across here.

But:

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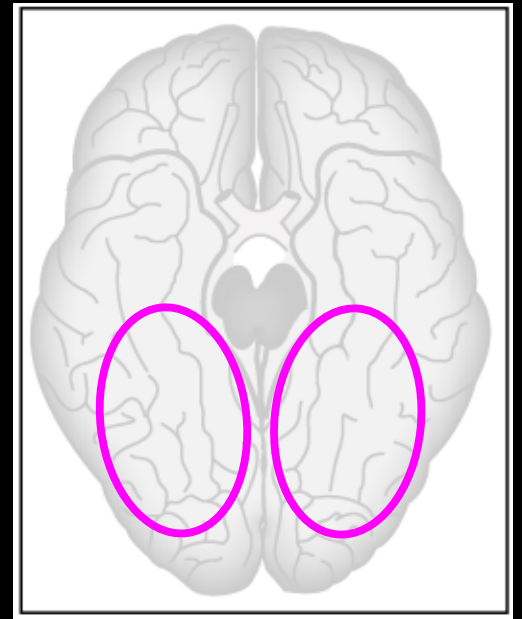


Figure by MIT OpenCourseWare. After Allison, 1994.

Pattern information in LOC is accessible to awareness, but information in retinotopic cortex is not!

Extra slides

A Sampler of Historical Perspectives on Consciousness

Leibniz, 1704:

"there are hundreds of indications leading us to conclude that at every moment there is in us an infinity of perceptions, unaccompanied by awareness or reflection; that is, of alterations in the soul itself, of which we are unaware because the impressions are either too minute or too numerous, or else too unvarying, so that they are not sufficiently distinctive on their own. "

Helmholtz, 1866:

"These inductive conclusions leading to the formation of our sense-perceptions certainly do lack the purifying and scrutinizing work of conscious thinking. nevertheless, in my opinion, by their peculiar nature they may be classified as conclusions, inductive conclusions unconsciously formed."

Nietzsche, about 1882

"The absurd overvaluation of consciousness ...consciousness only touches the surface...The basic activity is unconscious...The real continuous process takes place below our consciousness; the series and sequence of feelings, thoughts, and so on, are symptoms of this underlying process."

A Sampler of Historical Perspectives on Consciousness (continued)

James, 1890

"however numerous the things [we may attend to], they can only be known in a single pulse of consciousness for which they form one complex 'object', so that properly speaking there is before the mind at no time a plurality of *ideas*, properly so called."

Sidis, 1898:

Concluded that his experiments demonstrated "the presence within us of a secondary subwaking self that perceives things which the primary waking self is unable to get at."

Watson, 1930

"Behaviorism claims that consciousness is neither a definite nor a usable concept. The Behaviorist, who has been trained always as an experimentalist, holds further that belief in the existence of consciousness goes back to the ancient days of superstition and magic."

Crick & Koch, 1992

"the time is now ripe for an attack on the neural basis of consciousness."

Julesz, 1994

"Psychology without consciousness is like math without infinity" - possible but not very interesting.

A Cool Result Reported in *Science* this week

Owen et al (2006), *Science*, 313, p. 1402.

Tennis > rest

And

Navigation > rest

**Are these patterns of
activation different
from each other?**

*These statistics don't
tell us!*

*(What would we have
to do?)*

Image removed due to copyright restrictions.
fMRI images of supplementary motor area in
two imagery scenarios: playing tennis and
walking around the house.

See Figure 1 in Owen, A. M., et al.
"Detecting awareness in the vegetative
state." *Science* 313 (2006): 1402.

Some of the ways that people have thought about consciousness throughout history:

as a fact that poses fundamental questions about the nature of reality,

as the natural focus for scientific psychology,

as a topic psychology must avoid at any cost,

as a nonexistent or "epiphenomenal" by-product of brain functioning, and

as an important unsolved problem for psychology and neuroscience.

(from "A Cognitive Theory of Consciousness", by Bernie Baars)

A Cool Result Reported in *Science* this week

Owen et al (2006), *Science*, 313, p. 1402.

23-year old woman

Traffic accident >

Vegetative state.

Preserved sleep-wake

cycles, but

unresponsive.

*Might she be “in there”
cognitively despite her
inability to respond?*

But.....

Image removed due to copyright restrictions.
fMRI images of supplementary motor area in
two imagery scenarios: playing tennis and
walking around the house.

See Figure 1 in Owen, A. M., et al.
“Detecting awareness in the vegetative
state.” *Science* 313 (2006): 1402.

Consider these Events

- 1957 New Jersey company inserted subliminal messages (“drink coke”/”eat popcorn”) into movies and claimed to increase sales
- self-help audio tapes claim to raise self-esteem or improve memory by presentation of subliminal messages
- 2 teenagers commit suicide, and their families try to sue a rock band for having placed subliminal messages in their music.

Are these things possible?

- Swets & Bjork, 1990 showed that students don't learn a thing when they are asleep
- A careful study of self-help audio tapes done in 1991 showed no improvement after months of use.
- The judge in the suicide case ruled that there isn't "credible scientific evidence" that a subliminal message can influence behavior.

What can science tell us?

Uncoupling Mental/Neural Representation and Awareness

1. Same stimulus > different awareness

- Identical stimuli that are either perceived or not (on diff trials)
- Also: attention (same stim, diff experience)
- Rivalry

>>> Can find “NCC”, or NCA, unconfounded from the stimulus

Lots of these how now been reported.

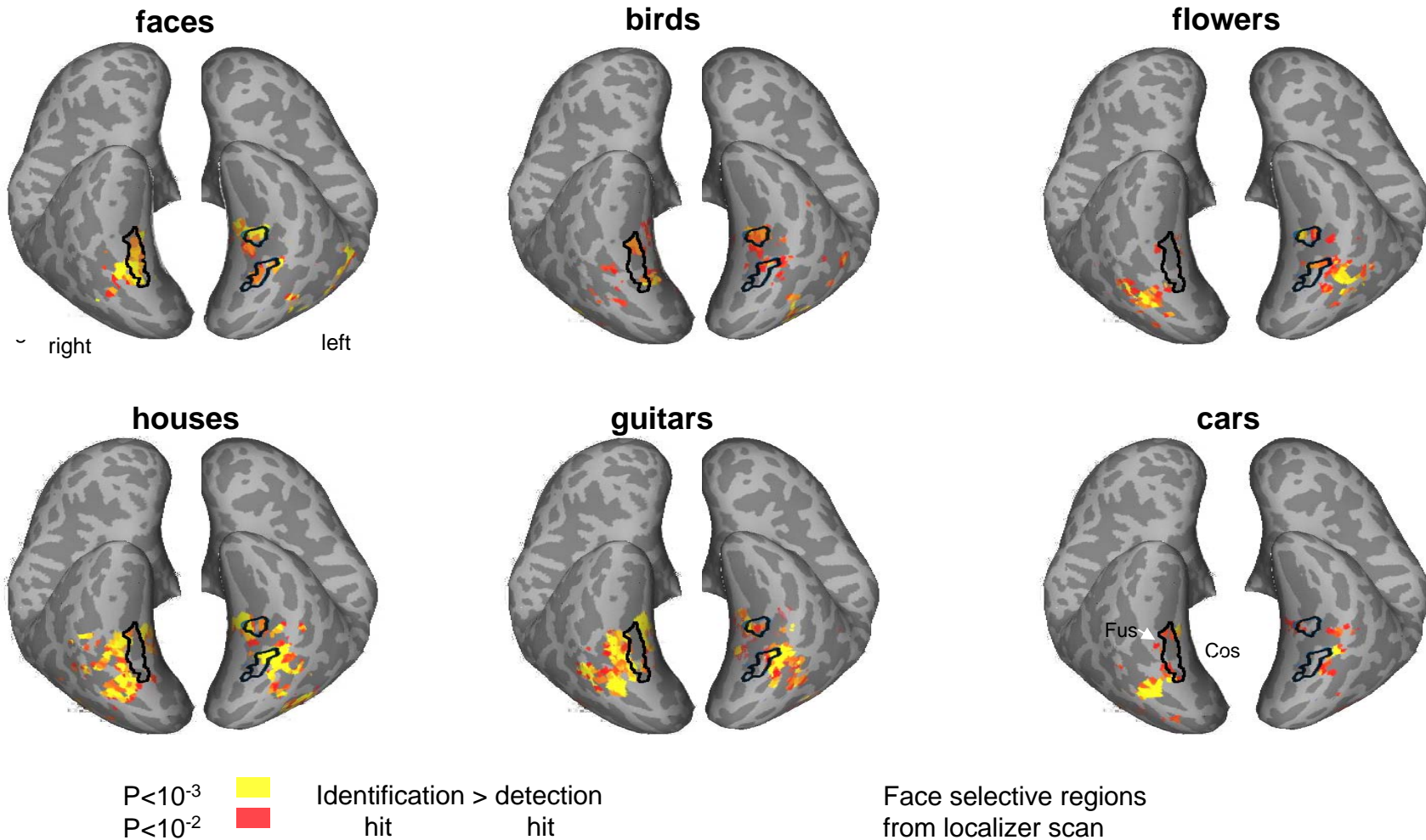
They aren't all in the same single “awareness area” in the brain, but rather it seems like:

The neural correlates of awareness of a given stimulus attribute are found in the neural structure that analyzes that stimulus attribute.

What are we to do with these NCAs now that we have them?

Really we want to understand not just *correlation*, but *causal connection*

Are Other Regions Correlated with Face Identification? Object Identification?

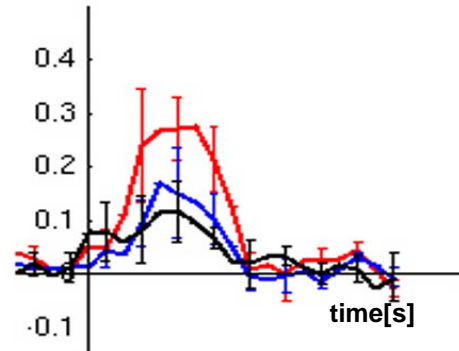


- Face Identification Primarily Involves the FFA
- Identification of other Categories primarily Involves Other Regions
- What about experts?

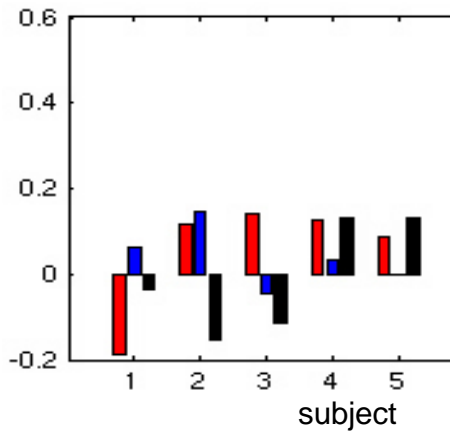
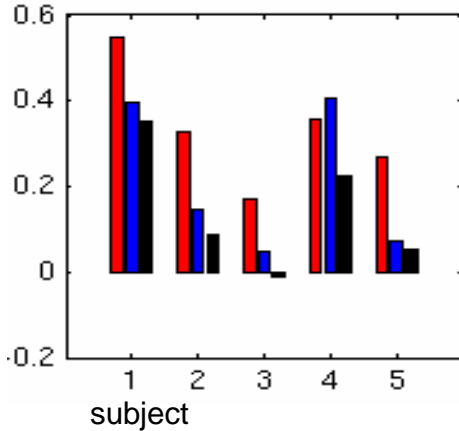
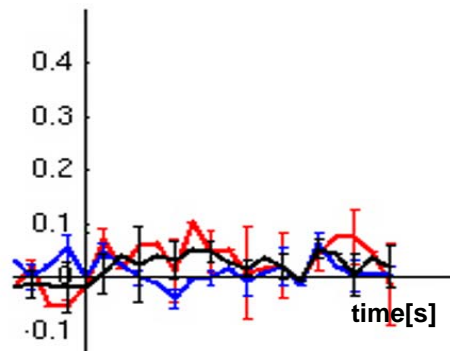
FFA Response in 5 Car Experts

% signal

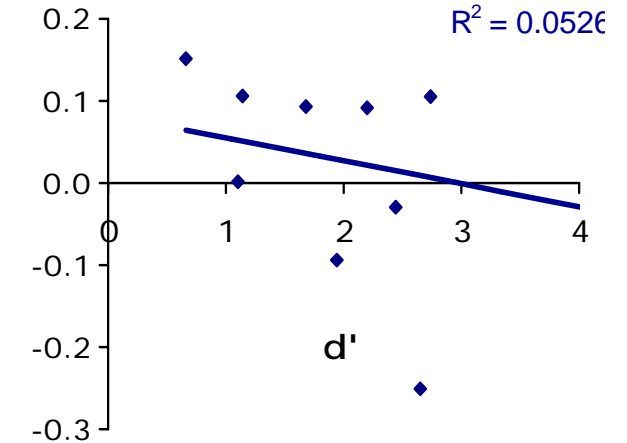
(a) Faces



(b) Cars



(c) FFA response for cars as a function of expertise



■ identification hit ■ detection hit ■ detection miss

No evidence that FFA is involved in car identification in “car experts”.

Grill-Spector, Knouf, & Kanwisher (2004), *Nature Neuroscience*.

Considerable hoopla (from Crick, Koch, others) about the “neural correlates of consciousness” (NCC).

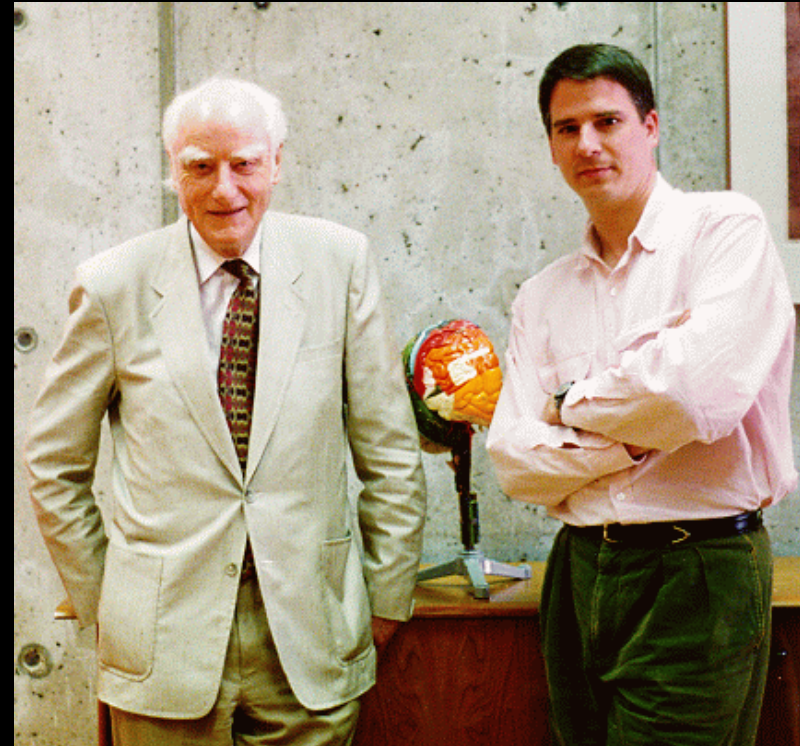
We have just described several NCCs, unconfounded from the stimulus.

In fact, they are a dime a dozen.

What are we supposed to do with them, now that we have them?

They aren't all in the same single “awareness area” in the brain, instead: *The neural correlates of awareness of a given stimulus attribute are apparently found in the neural structure that analyzes that stimulus attribute.*

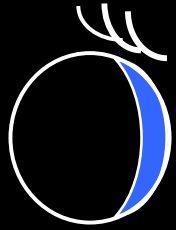
Really we want to understand not just *correlation*, but *causal connection*



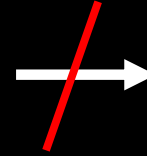
Courtesy of Christopher Koch. Used with permission.

Uncoupling Representation and Awareness

Representation without awareness



Mental/neural
representations
extracted from a
stimulus (whether
reportable or not).



Awareness:
The ability to explicitly
report about the presence or
properties of the stimulus.

One maybe-example seen before:

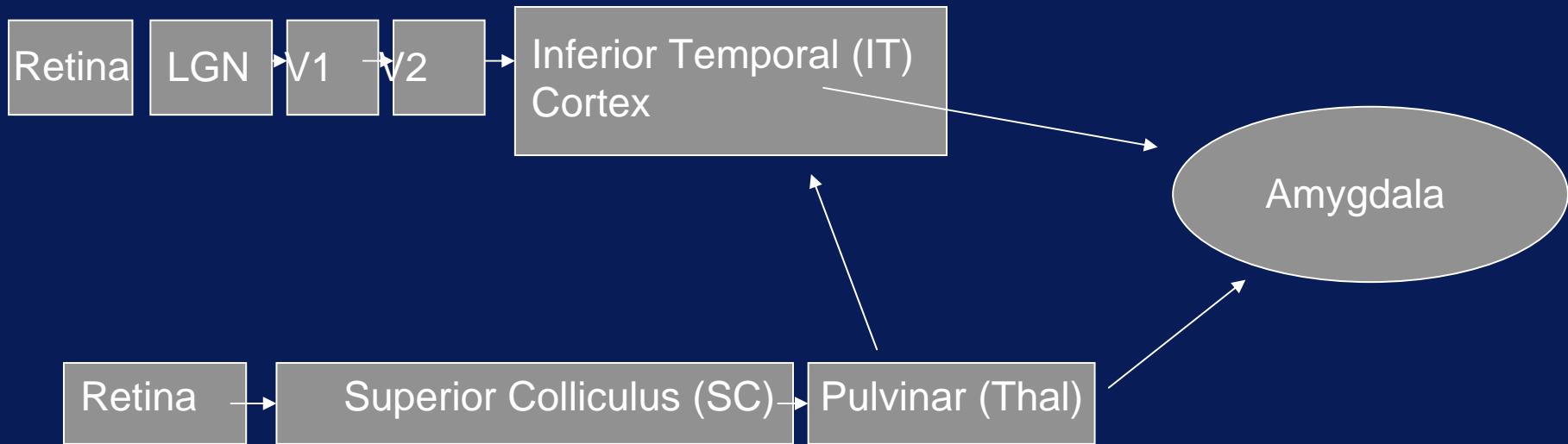
- Janzen et al (2004):
PPA: memory w/out awareness

- More.....

Images removed due to copyright restrictions.
Toy at decision point and non-decision point.
See Fig. 1 in: Janzen, G., and M. van Turenout.
"Selective Neural Representation of Objects Relevant
for Navigation." *Nature Neuroscience* 7 (2004): 673-677.

How can this be?

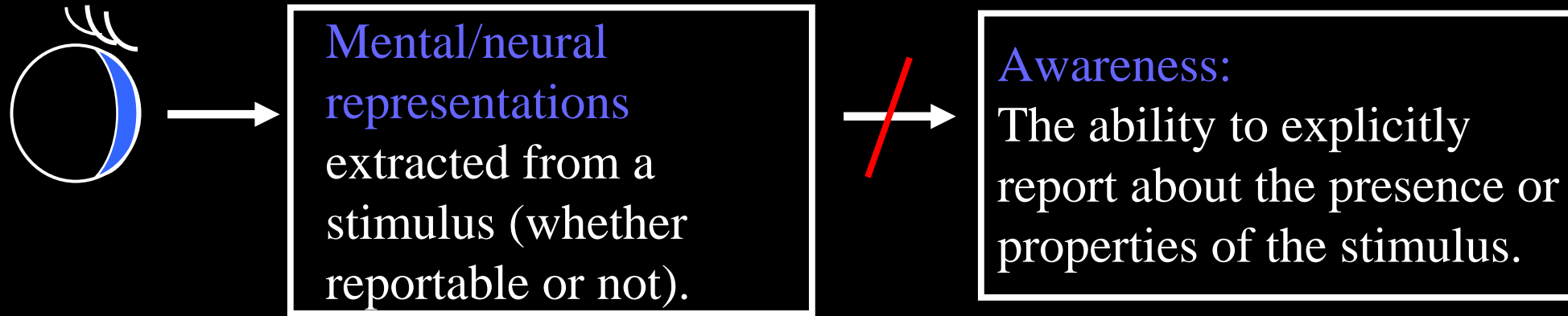
Standard Ventral object recognition pathway



Alternate Subcortical pathway

Uncoupling Perception and Awareness

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What determines which perceptual information reaches awareness??

- Kind of information (~~only low-level stuff?~~ Or semantic/Motor?).

→ • Special brain regions (e.g., cortex)?

He & MacLeod; Vul & MacLeod: info in V1 w/out awareness

So V1 representation is apparently not *sufficient*

What about other areas? (Nune's report on Pasley - amygdala)

Pasley et al(2004)

Binocular Rivalry

Question: do invisible stimuli get represented in higher-level cortex? Amygdala?

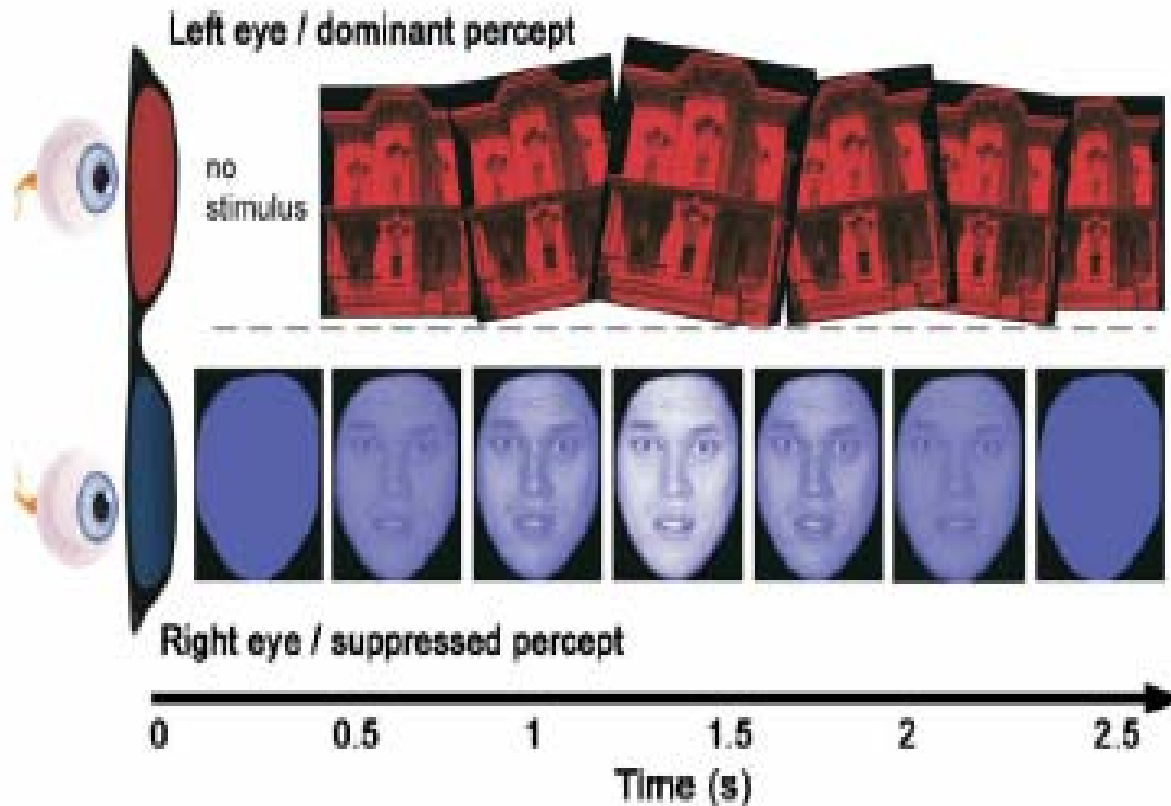


Figure 1. Binocular Rivalry Stimulus Presentation Procedure for a Suppressed Face Trial. Participants viewed blocks of four consecutive trials lasting 10 s and were instructed to indicate by button press if at any point they perceived anything besides a house, no matter how fleeting, in order to verify the successful suppression of the target image. Across all participants, unsuccessful rivalry suppression trials occurred in 2% of these blocks, which were subsequently excluded from further analysis.

Pasley, B. N., L. C. Mayes, and R. T. Schultz. "Subcortical Discrimination of Unperceived Objects during Binocular Rivalry." *Neuron* 42, no. 1 (2004): 163-172. Courtesy Elsevier, Inc., <http://www.sciencedirect.com>. Used with permission.

Right (suppressed) eye sees: moving house, fearful face, or chair

IT cortex shows
no specificity for
suppressed
image type

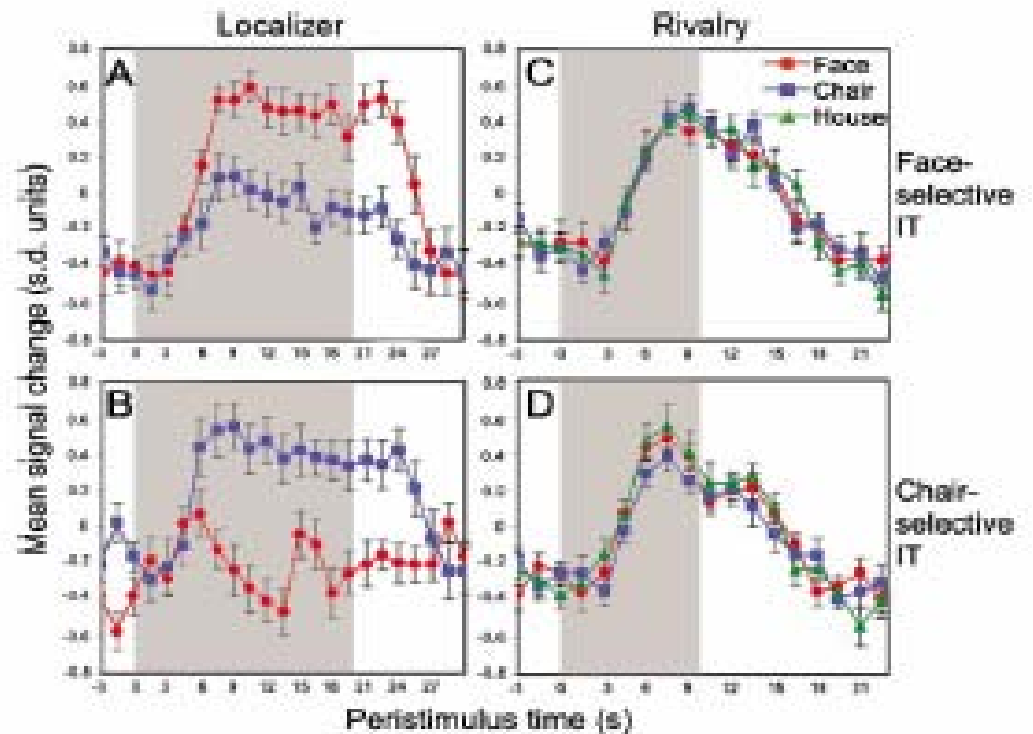


Figure 3. fMRI Responses in Face- and Chair-Selective IT during Normal Viewing and Rivalry Suppression

But Amygdala does!

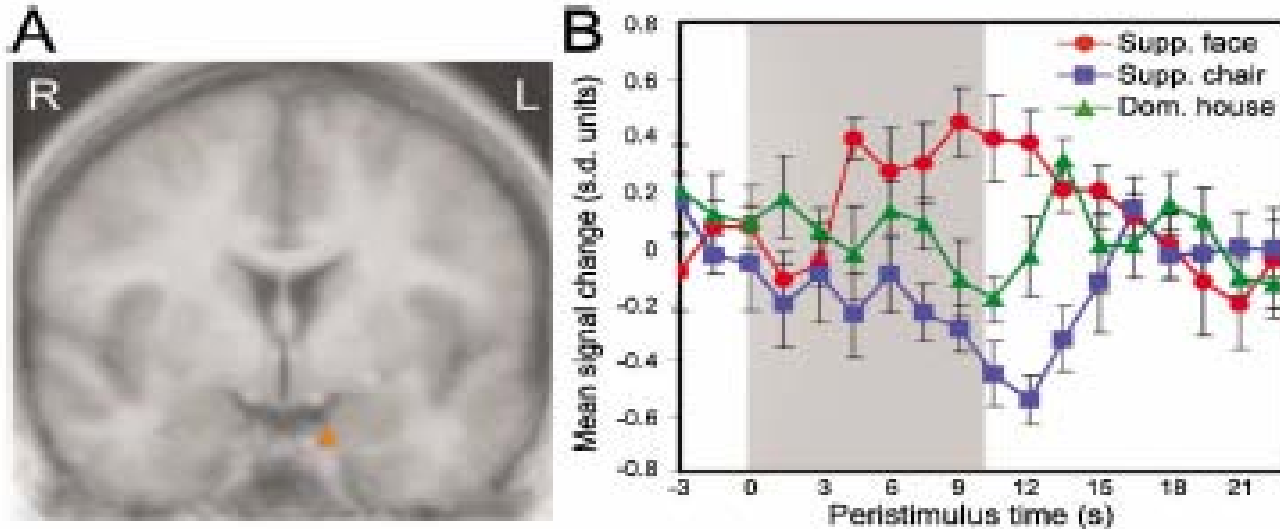


Figure 2. Differential Amygdala Activation for Perceptually Suppressed Fearful Faces and Suppressed Chairs