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)
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

- 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)

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.

“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 between behavioral responses and BOLD response in FFA (identified individually in each subject in a prior “localizer” scan).

Kalanit Grill-Spector
Task: is this
i) Harrison Ford
ii) some other guy
iii) nothing

Stimulus images not repeated

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

Stimulus images not repeated
Right FFA Response to Target Faces or Guitars
As a Function of Performance, N=5

FFA involved in:
Detec & 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?
Binocular Rivalry and Visual Awareness

*Tong, Nakayama, Vaughan & Kanwisher (1998)*

Rivalry

Stimulus

Percept

Rivalry

House $\rightarrow$ Face

Face $\rightarrow$ House

Tong, Nakayama, Vaughan, & Kanwisher, 1998

Binocular Rivalry and Visual Awareness

Tong, Nakayama, Vaughan & Kanwisher (1998)

Rivalry

Stimulus

Percept

Nonrivalry

Yoked Stimulus

Time (s)

Tong et al 1998

Rivalry

Non-Rivalry

% MR Signal

S1

0.0 0.2 0.4 0.6 0.8 1.0

-8 -4 0 4 8 12

Time (s)

Rivalry Non-Rivalry

House Face

0.0 0.2 0.4 0.6 0.8 1.0

-8 -4 0 4 8 12

Time (s)

Face House

0.0 0.2 0.4 0.6 0.8 1.0

-8 -4 0 4 8 12

Time (s)

Tong, Nakayama, Vaughan & Kanwisher (1998)

Rivalry vs. Nonrivalry

Change in % MR Signal

FFA PPA Subject

S1
S2
S3
S4

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 arent 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.

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 psychophysi. 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

Some examples…..
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

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

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 McCollough Effect:
Representation without Awareness

Example 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

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.”

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:

Mental/neural representations extracted from a stimulus.

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

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...
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.
1. If we can have 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.

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…
Uncoupling Perception and Awareness

1. If we can have 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.

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

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?

Courtesy of Jody Culham. Used with permission.
Patient DF: no visual form perception

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

 Courtesy of Jody Culham. Used with permission.
Patient DF: acting without perceiving

<table>
<thead>
<tr>
<th>DF</th>
<th>Control</th>
<th>Posting task</th>
</tr>
</thead>
</table>

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….

Images removed due to copyright restrictions.

Courtesy of Jody Culham. Used with permission.
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
Fang & He (2005) Experiment 1

Invisible stimuli

Visible stimuli

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

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

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

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 ± s.e.m.) were averaged across eight subjects.

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.

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:

   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.

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:

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.

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….
1. If we can have 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.

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...*

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.....

That was X then H
Ready for the next one?

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?

**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:

![Graph showing T2 Accuracy (%) vs. T1-T2 SOA (ms)](image)

fMRI Data - Response of PPA:

![Graph showing % Signal change vs. Time (s)](image)

Representation without awareness

Activation Strength hypothesis

Uncoupling Perception and Awareness

1. If we can have 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.

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...
Dehaene et al (2001)

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?

<table>
<thead>
<tr>
<th>Unmasked Words</th>
<th>Masked Words</th>
</tr>
</thead>
</table>

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:

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.

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
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…. 
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.

If $r(\text{Within}) > r(\text{Between})$
the region contains category information.
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.:

\[ r(w/in) - r(betwn) \] on correct trials > \[ r(w/in) - r(betwn) \] 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:
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?

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

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?)*
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

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.......
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 arent 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?

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


*FFA Response in 5 Car Experts*

(a) Faces

(b) Cars

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

\[ R^2 = 0.052 \]
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.
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:
  PPA: memory w/out awareness

• More…..

Images removed due to copyright restrictions.
Toy at decision point and non-decision point.
How can this be?

Standard Ventral object recognition pathway

Alternate Subcortical pathway
Uncoupling Perception and Awareness

1. If we can have 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.

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)
Binocular Rivalry

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

Right (suppressed) eye sees: moving house, fearful face, or chair
IT cortex shows no specificity for suppressed image type
But Amygdala does!