

Welcome!

What color is this dress?

Vote here before class starts:

<http://etc.ch/RLZ8>



Is the dress *blue/black* or *white/gold*???



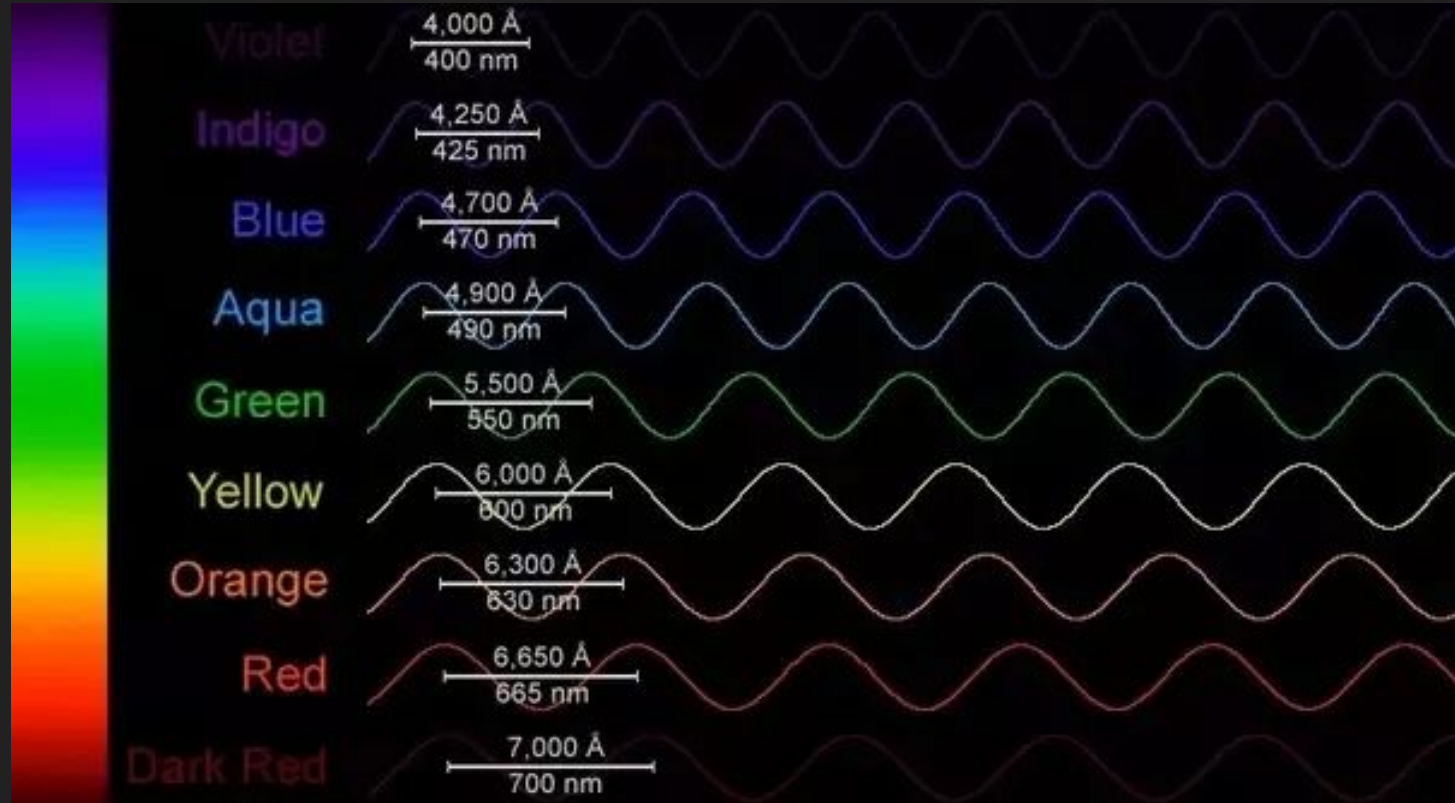
The Neuroscience of Human Vision

Christina & Zawad

Outline for Today

- What even are colors?
- Lighting conditions and #TheDress
- Is there a brain region for color?
- Is this region *required* for color processing?

What even are colors?



What even are colors?

Is 665 nm “red”?

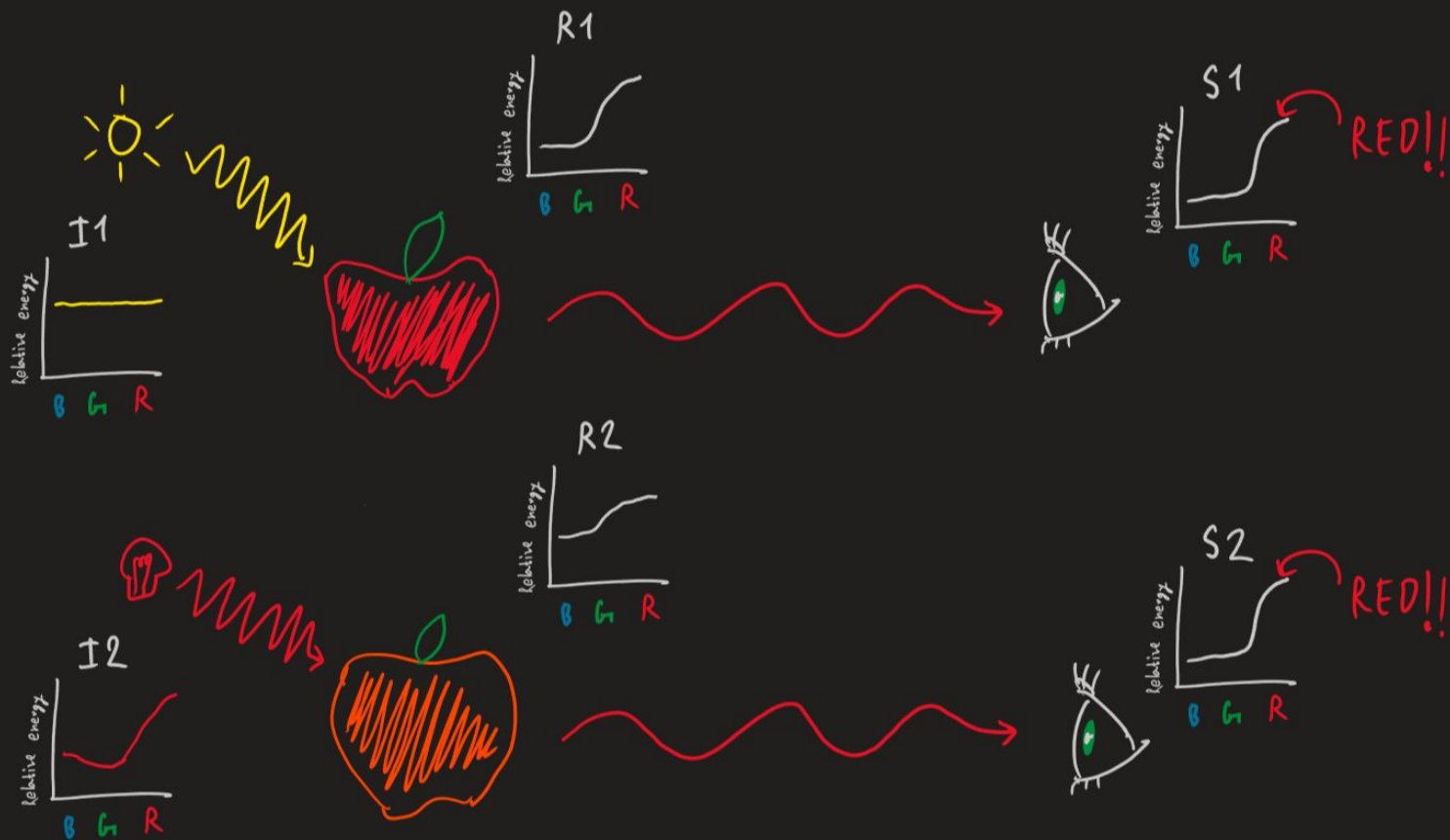


What even are colors?

Is the presence of red light “red”?



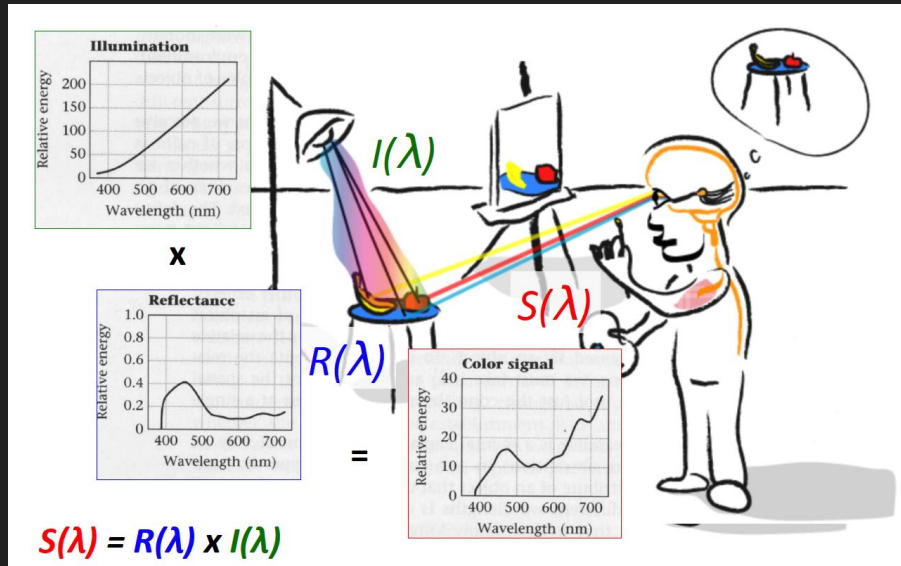
What even are colors?



It's an ill-posed problem!

If I tell you $xy = 10$, can you solve for x ?

Similarly, your eyes know *(light source I)**(*object reflectance R*), but neither individually!



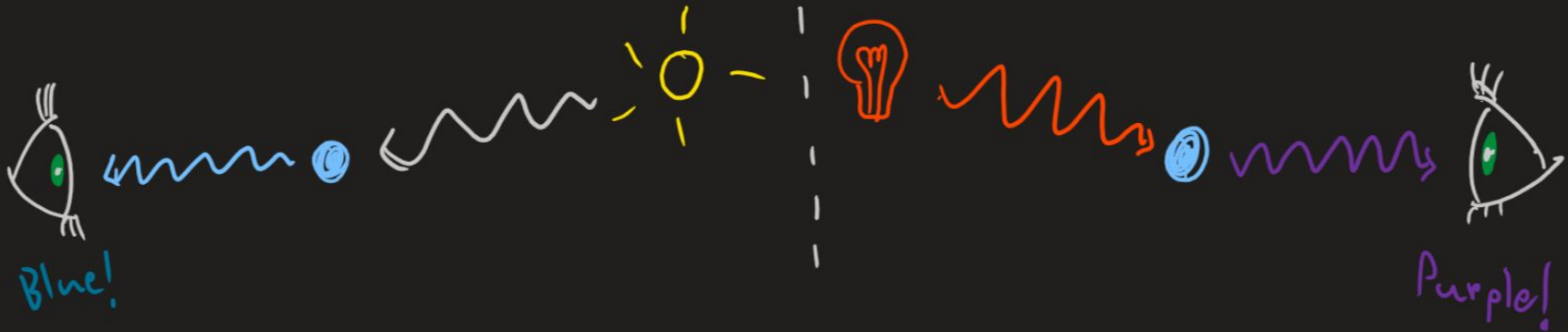
Questions so far?

Outline for Today

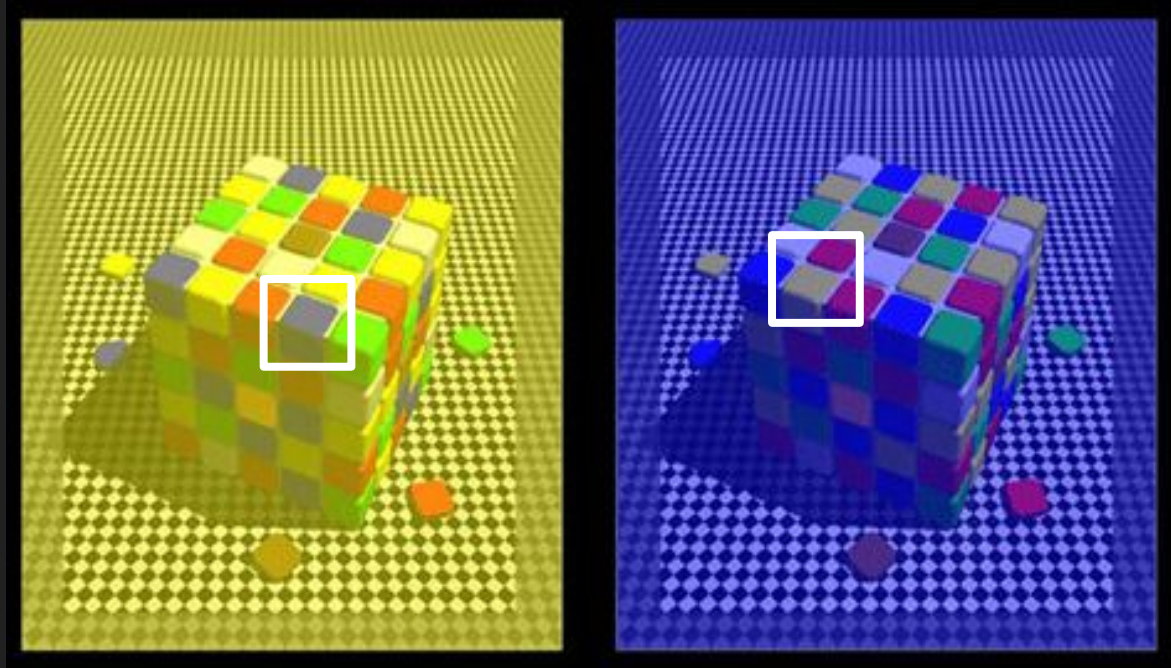
- What even are colors?
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Color constancy

- A green apple (R) under daylight illumination ($I1$) & under room light ($I2$)
 - -> two very different signals $S1$ & $S2$, but you perceive both as “green”
- But this might not be perfect! What if two different lighting conditions make you see two different colors?

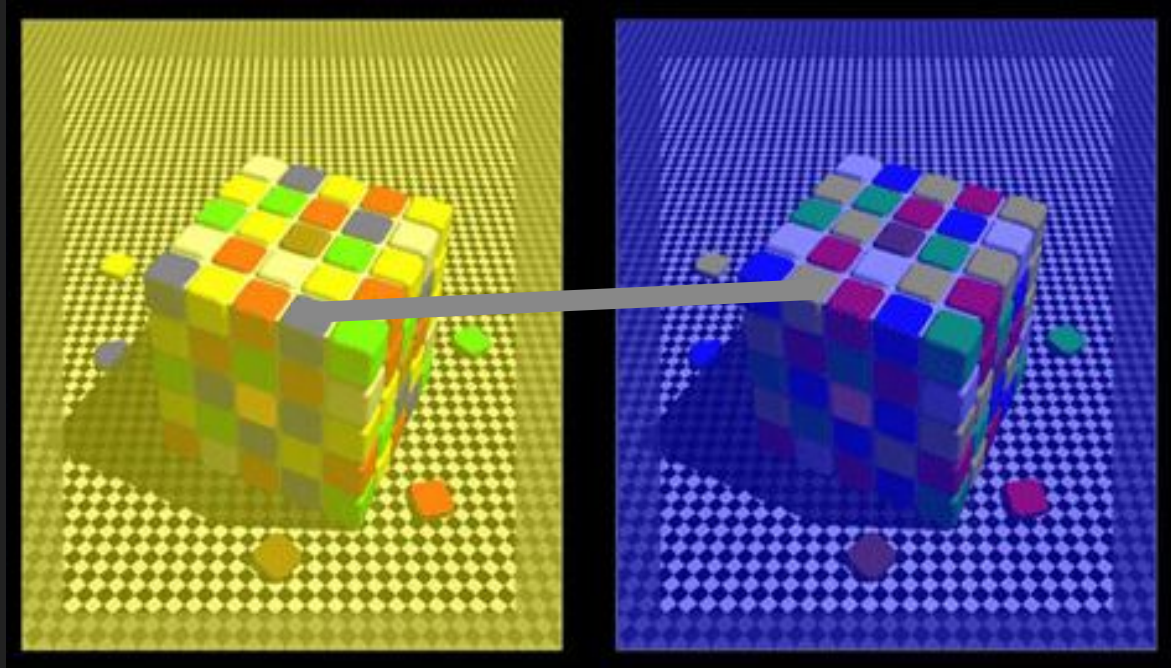


Effect of Lighting Condition: Background



What color(s) are the two squares?

Effect of Lighting Condition: Background



They are the SAME!

Yellow background

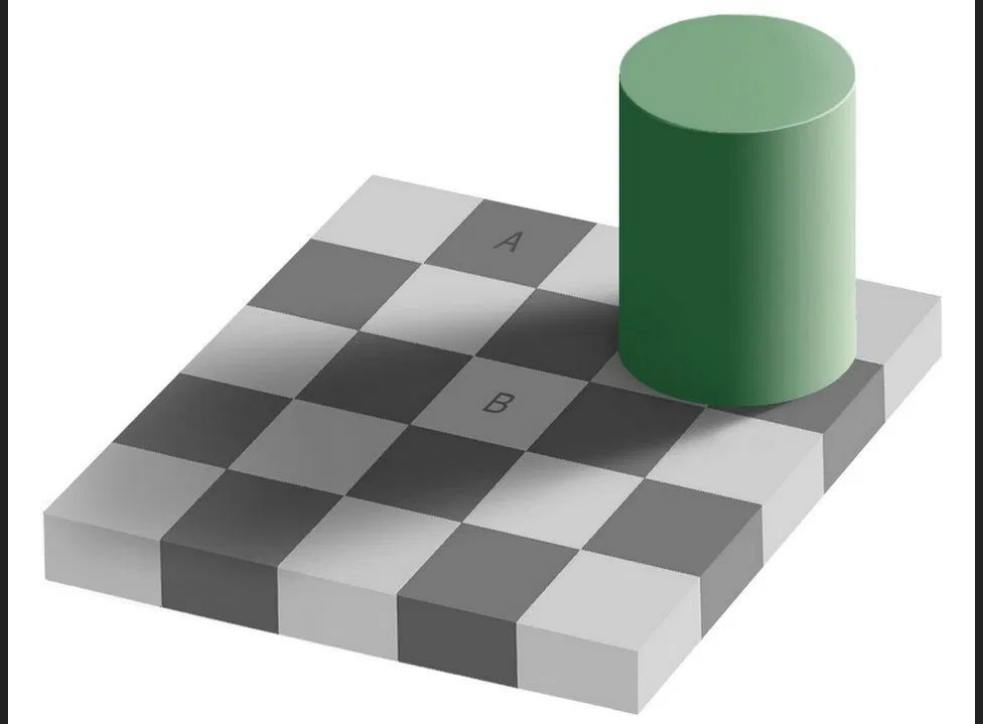
-> infer lighting is yellow

-> subtract the yellow
part from input signal
[think it's due to the
lighting]

-> see "blue"

Effect of Lighting Condition: Shadow

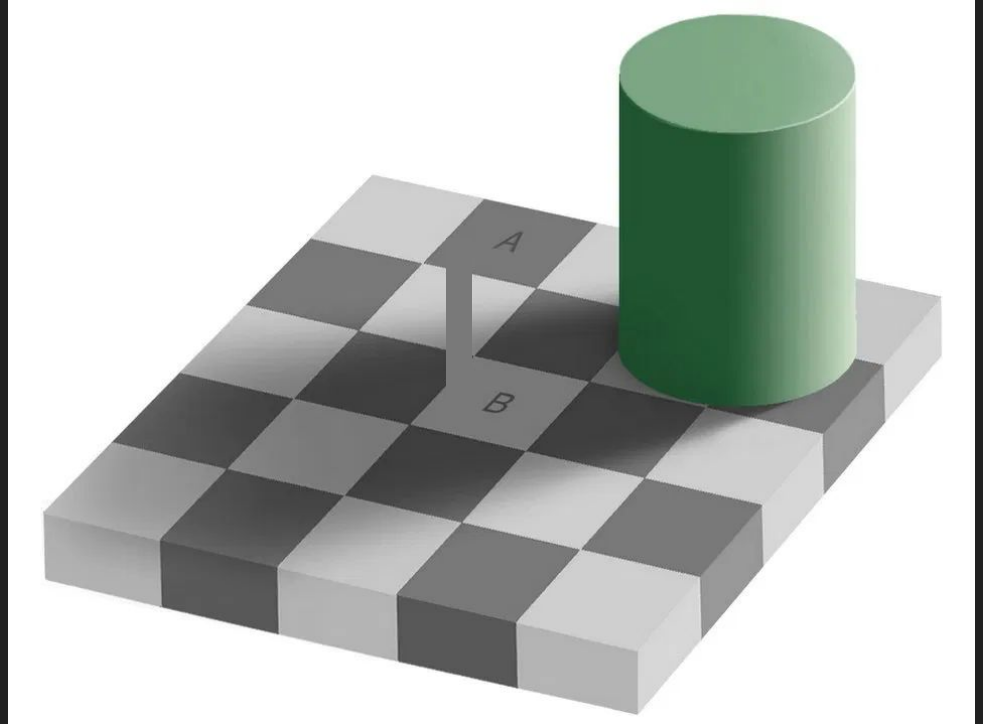
Square A v. Square B:
same color? Or one is
darker?



Effect of Lighting Condition: Shadow

lighting condition &
cylinder throws **shadow**
on square B

-> infer square B is
actually lighter than the
perceived signal



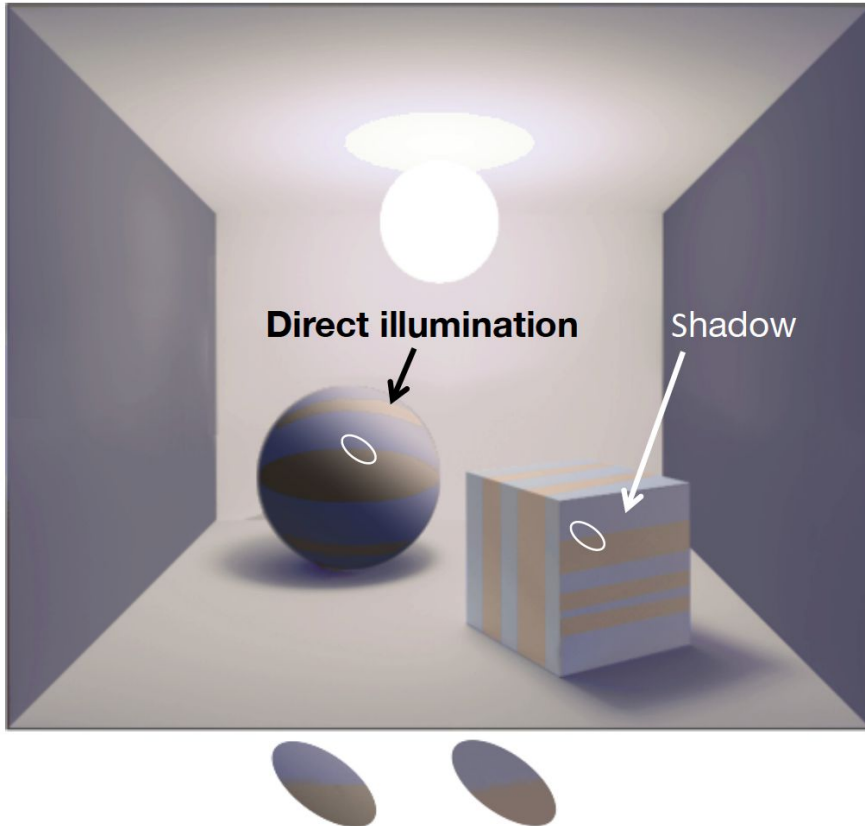
Where is the light source?

- Behind the dress?
- In front of the dress?

<http://etc.ch/Apat>

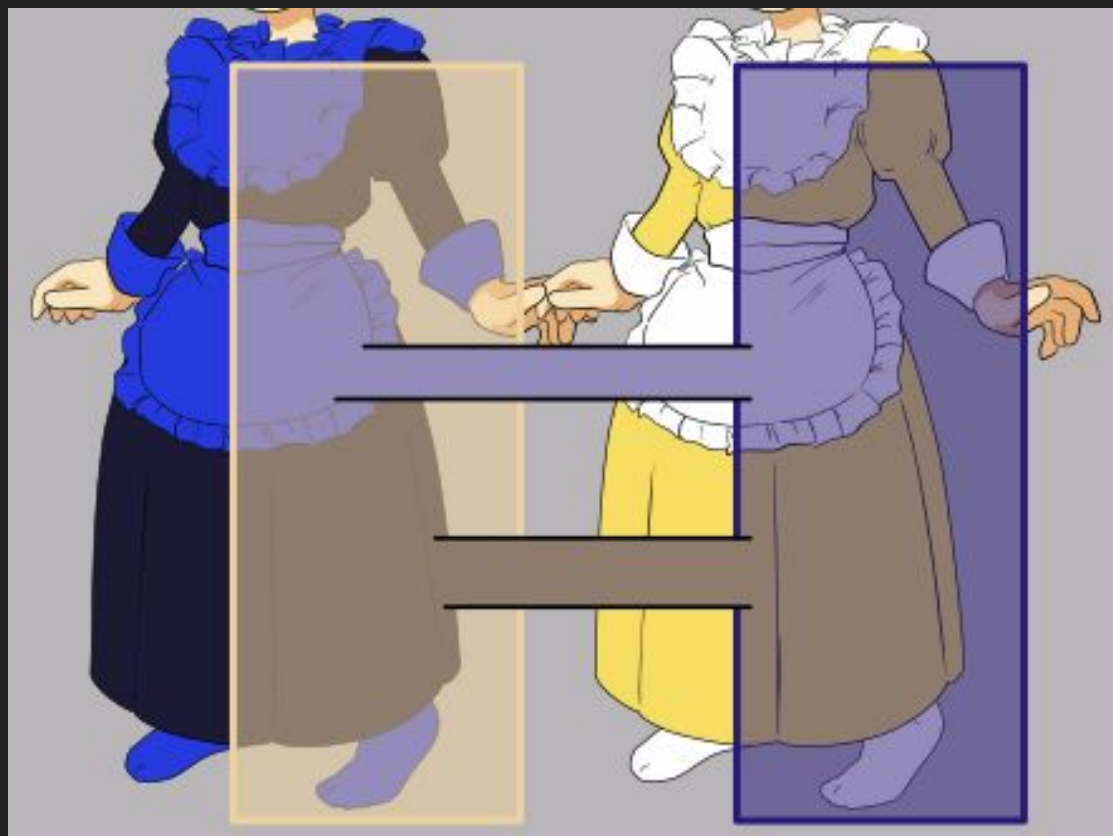


Effect of Lighting Condition

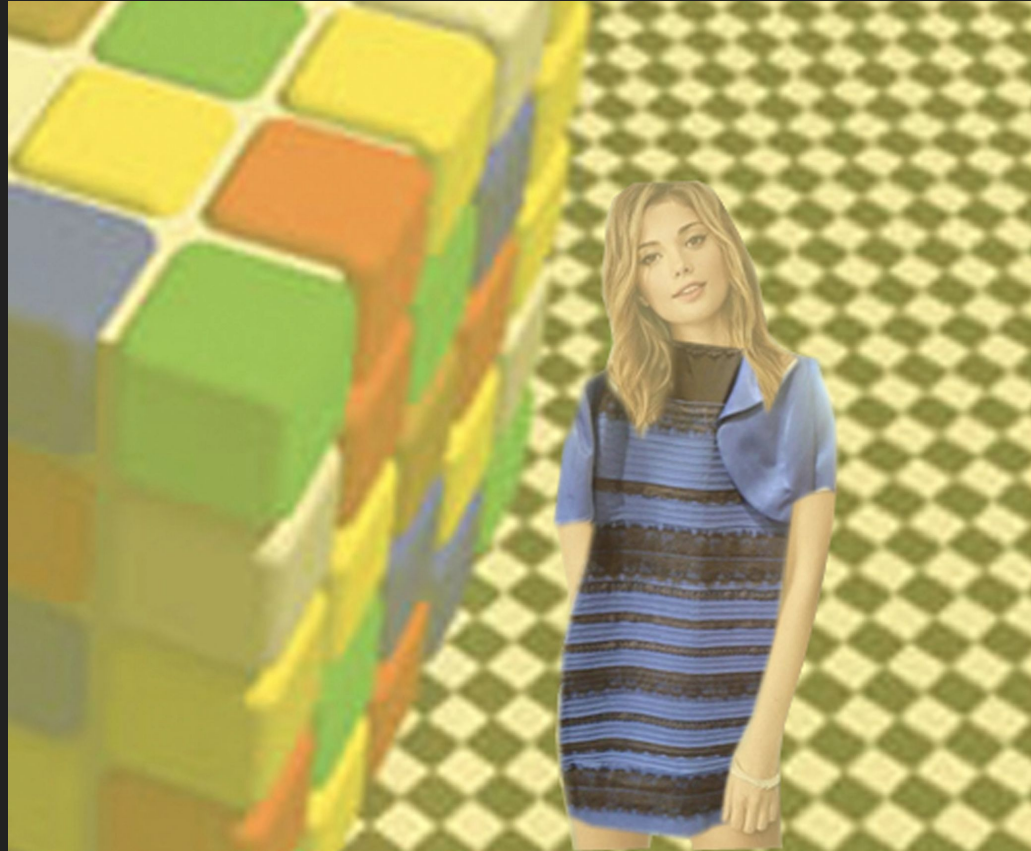


- Infer the dress is backlit, cast in **cool shadow**
-> see **White** & **Gold**
- Infer dress is directly illuminated by **warm light**
-> see **Blue** & **Black**

Color is subjective!







Questions so far?

Hidden Illusion 1

In the image on the next slide...

Stare at the upper white dot for 20 seconds. Don't look away!

Then shift your stare to the lower white dot. What do you see?

Why do you see these colours?

Hidden Illusion 2

After going to the next slide, stare at the black dot at the center for 20-30 seconds.

Then suddenly move to the next slide. What do you see?

Once again, think about the exact colors you saw!





Wanna learn more? Check out:

[https://www.illusionsindex.org/ir/negative
-afterimages](https://www.illusionsindex.org/ir/negative-afterimages)

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- Is there a brain region for color?
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Where in the brain is all this processing?

In other words, what sort of machinery does the brain have for processing all this?



Where in the brain is all this processing?

There are two possibilities

- Many parts of the brain look at the whole picture, general processing
- Brain divides and conquers the problem of vision, specific processing

How would we distinguish between the two?

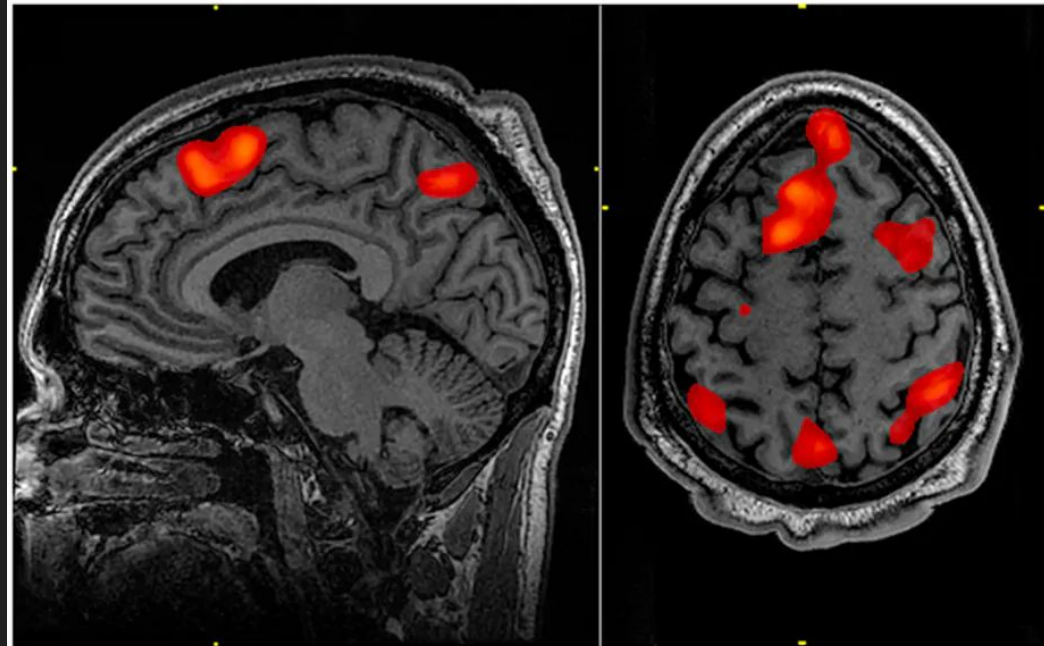
fMRI -- functional MRI

Tells you which neurons are active!

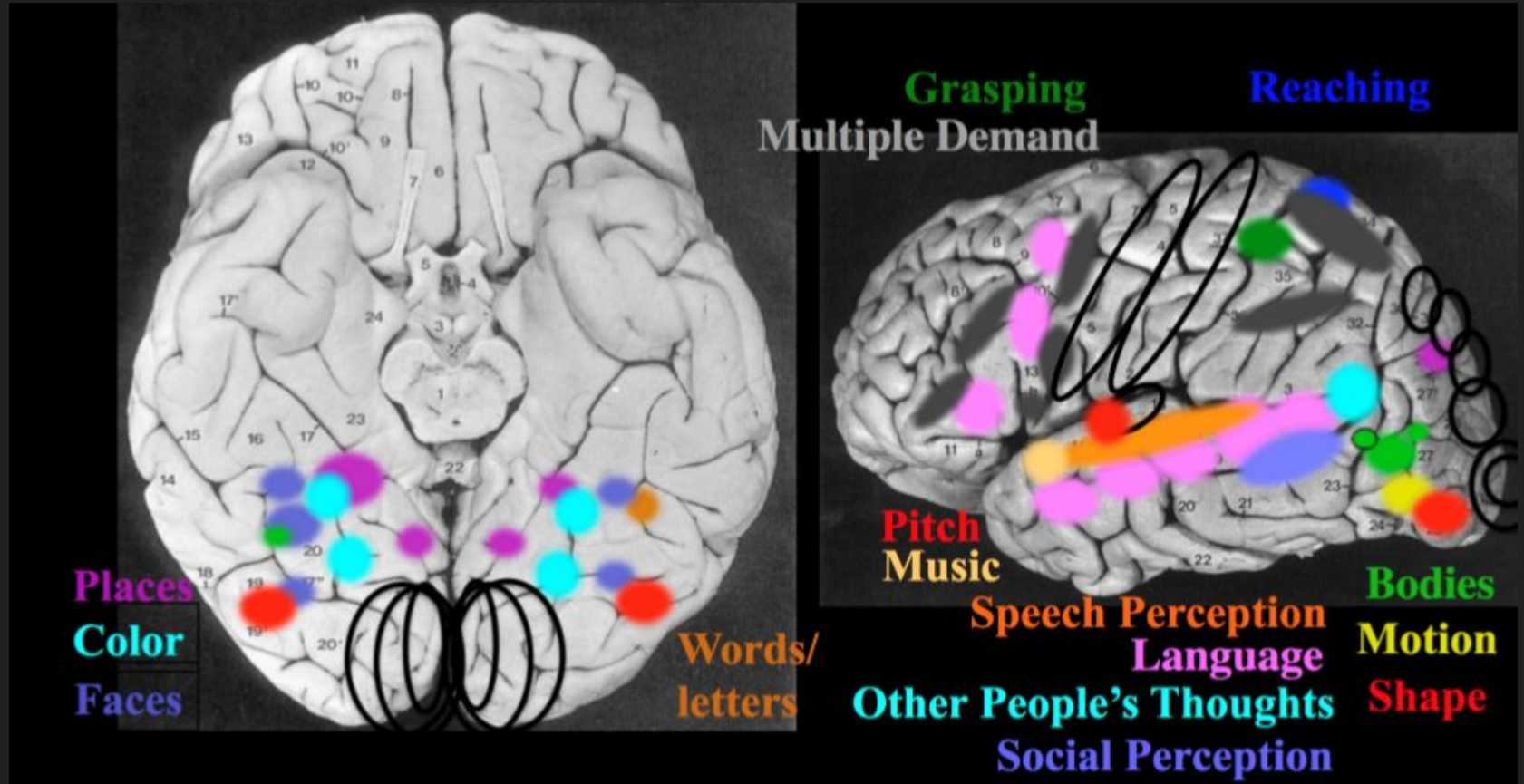
Active neurons need blood for metabolism

-> blood flow increases

-> change in magnetic signal



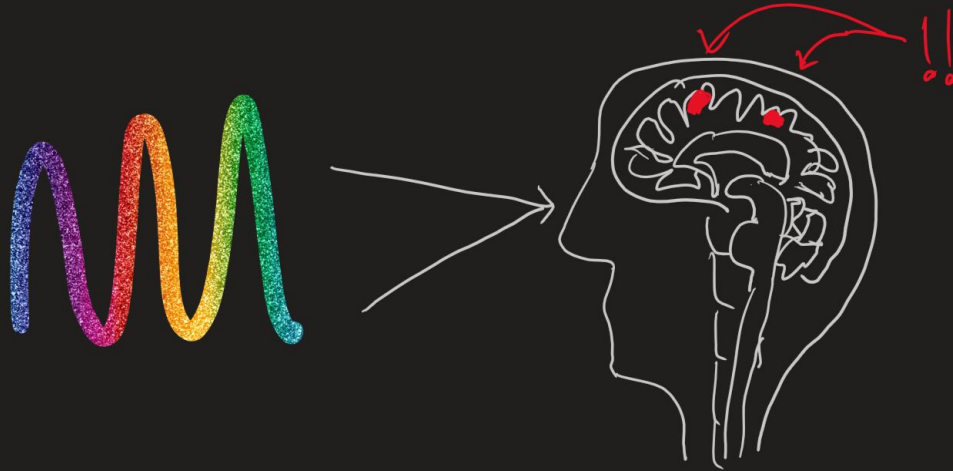
The Brain has specialized machinery for:



Questions so far?

Using fMRI to find brain regions

What sort of fMRI signal might we find in specialized machinery (or a brain region) for **color**?



Using fMRI to find a color-specific region



Color
image



Brain's color
region:
activated

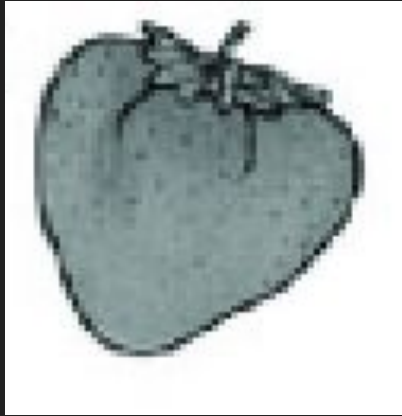


Increased
Blood flow

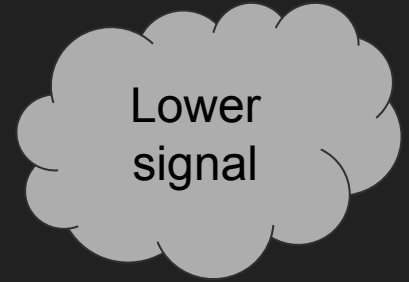


**Big
signal!**

Using fMRI to find a color-specific region



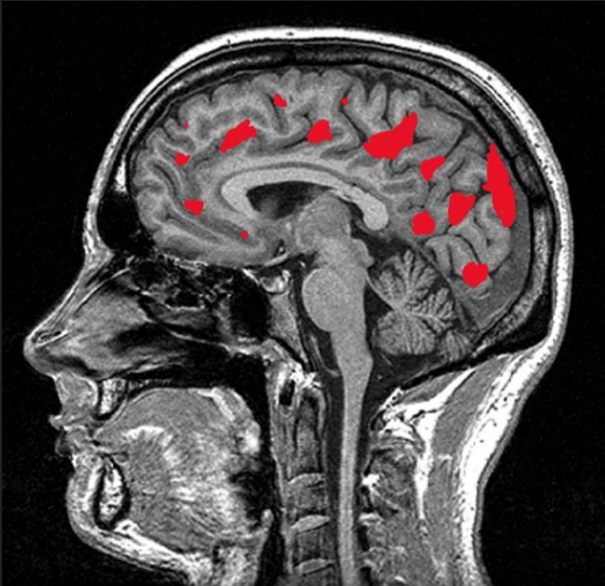
Black-and-white
image



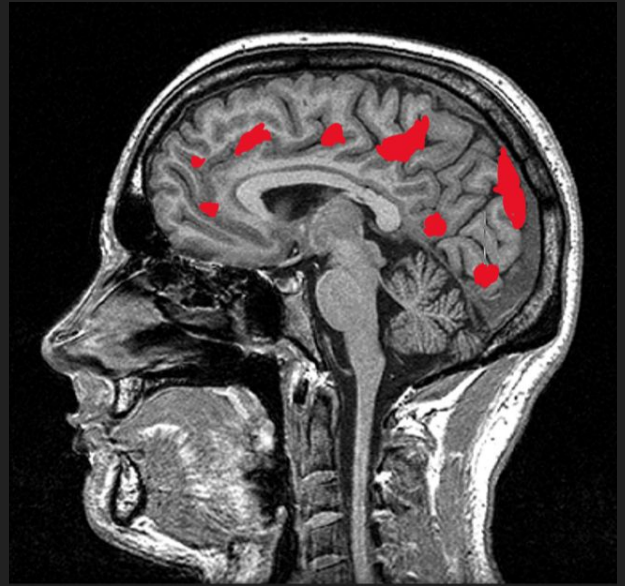
Using fMRI to find a color-specific region

Look for a region that shows bigger signal

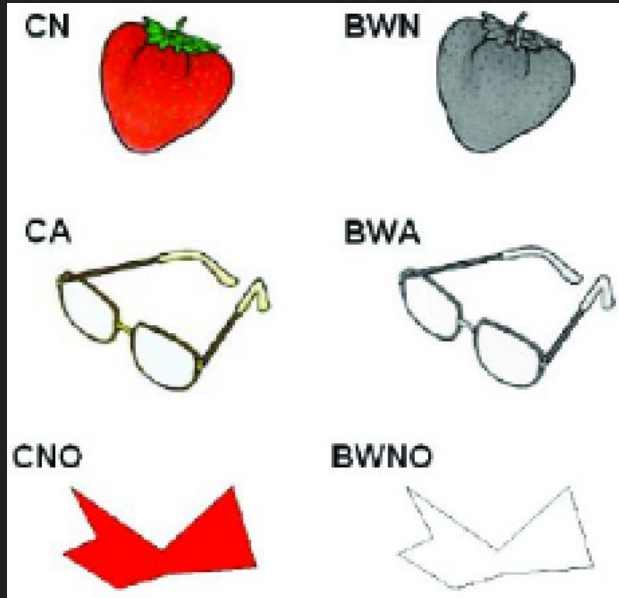
when
subject
views
color
images



vs.
black-and
-white
images



Test Alternative Hypothesis!



But what if those brain regions are looking at other things?

e.g. visual patterns, not just color.

What are some other alternative hypotheses?

What sort of experiments might resolve them?

Questions so far?

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 - Yes! (from fMRI)
- Is this region *required* for color processing?

Is the region *required* to see color?



What if the region is activated by color, but it doesn't process color for vision.

e.g. it might process color to see if something is poisonous!

Lesion Studies

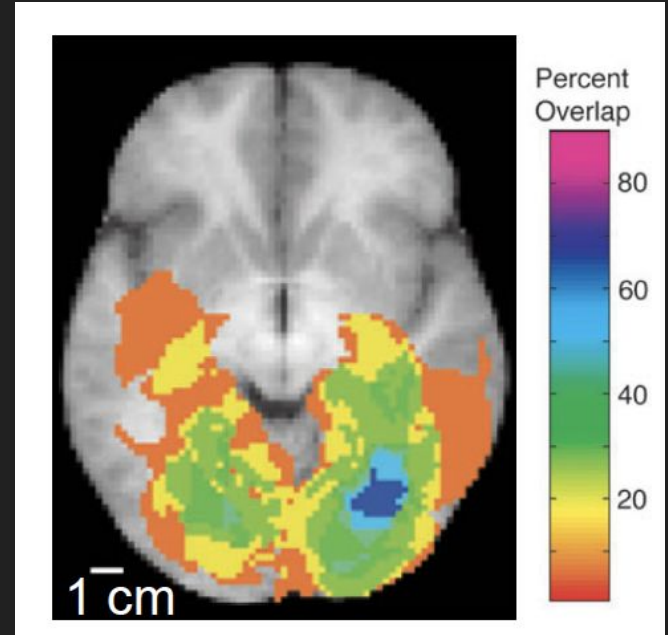
Hits the nail on the head, quite literally!

If you hit your head and damaged region X, and you lost function of Y

-> X is necessary for Y (specifically)

Lesion Studies

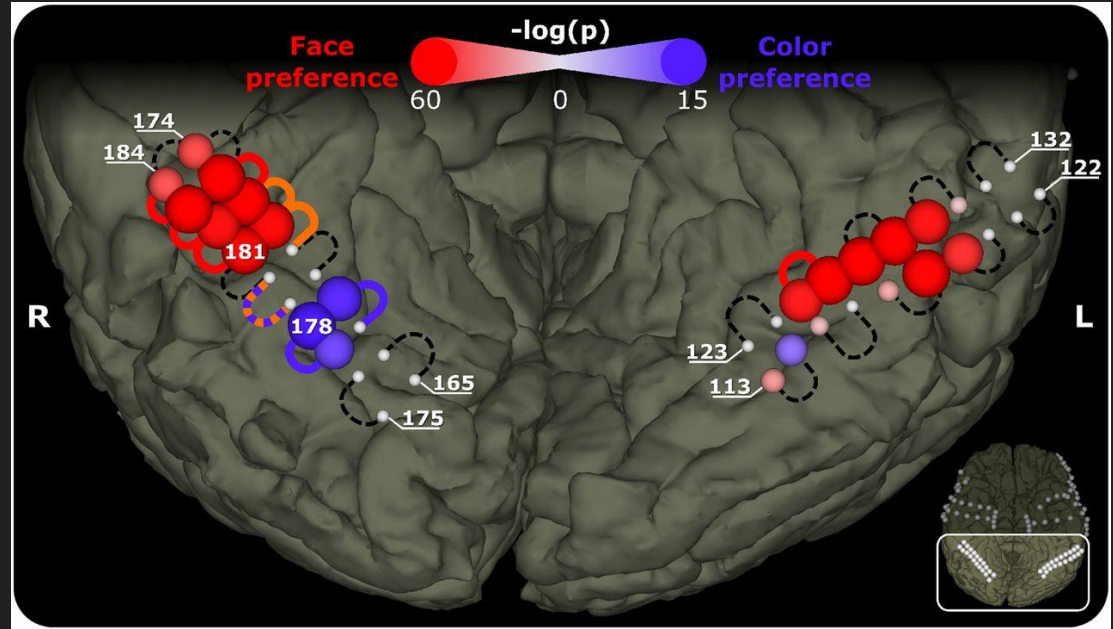
- Achromatopsia - Loss of color-vision
 - Not equivalent to color blindness!
https://en.wikipedia.org/wiki/Color_blindness#Classification
- Location of brain damage in achromatopsia patients: **high overlap**



Electrode Stimulation

Patient: array of
electrodes implanted
in brain

Stimulate electrode
in color region



Stimulation of the face area



„...just for the very first second...
I saw an eye, an eye, and a mouth.“



„How do I explain this? Just like the previous one,
I see an eye, an eye, and a mouth, sideways.“



„Your face completely changed...I don't know
what's going on. Your eyes change.“



„Hm. Am I just imagining things? Can you do it again?
...OK, just as I thought I see a face.“

Stimulation of the color area



„The left side of the box looks like a rainbow.“



„If I look at the ball, the rainbow is there,
wider than before, and blinking.“



„If I look at the face, this side looks
like a rainbow and glowing.“



„It's kind of the same, this half is colorful.“

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 - Yes! (from fMRI)
- Is this region *required* for color processing?
 - Yes! (from lesion studies of Achromatopsia, and electrode stimulation)

Takeaways

- Neuroscience is cool!
 - Recommended: MIT Professor Nancy Kanwisher's TED talk & class "The Human Brain" (<https://nancysbraintalks.mit.edu/>)



Questions?

- You can email us at S14194-teachers@esp.mit.edu
- We will email out these slides



THANKS FOR LISTENING!

QUESTIONS?