Is this a van, or a van and a car?

We spent the first part of the course looking at the neurophysiological properties of the visual system.

Now we turn to a discussion of the perceptual experience itself.

What do we actually perceive?

How do we describe it?

How do we measure perceptual experiences?

- It's not as easy as you might think!
- (But it's not as bad as Fourier analysis either)

There is a temptation to trust our intuition about what we see.

- Introspection
- Philosophy

However, what we report is often biased by more than just the "pure" perceptual experience.

We tend to see objects in the world.

Our interpretation of those objects is based on memory and learning.

It all seems effortless because it works correctly most of the time.

But we know that the neurophysiology is complicated.

And with some stimuli the difficulties become clear.

- What is the object here?

The perceptual process:

- Perception
- Recognition
- Action
- Environmental stimuli
- Stimulus on receptors
- Attended stimulus
- Processing
- Transduction
- Signal detection

Signal detection

PSY 310

Greg Francis

Lecture 12

PSY 310: Sensory and Perceptual Processes
Perceptual process

- Notice that there is a difference between perception and recognition
  - You can see the black and white parts of this image
    - But it is difficult to recognize

Perceptual process

- With a bit of help it is obvious what the image is
  - And once you know, you cannot see it any other way

Reporting

- Percepts are subjective experiences
  - I cannot know what you perceive unless I ask you to do something
- On the basis of your actions I can deduce what you perceive
  - “I see something”
  - You chose the correct label
  - You push a certain button
- What kind of questions get the best deductions?

Measuring thresholds

- Suppose you wanted to identify the faintest spot of light that someone can detect
  - Method of constant stimuli
    - Or method of adjustment, method of limits
  - Present lots of spots of various intensities
  - For each one the subject indicates whether he sees it or not

Measuring thresholds

- Do this for many trials, repeating stimuli
  - For a faint stimulus, sometimes the subject will report seeing it and sometimes not

Measuring thresholds

- Do this for many trials repeating stimuli
  - For a faint stimulus, sometimes the subject will report seeing it and sometimes not
  - Make a graph

PSY 310: Sensory and Perceptual Processes
Measuring thresholds
- Identify a threshold by finding the intensity at which the subject reports seeing the spot 50% of the time

Why percentages?
- Why don’t you always see the same thing?
- For very faint stimuli there is noise from neural processes

Why percentages?
- The noise intensity varies from trial to trial
- Sometimes the stimulus signal is much stronger than the noise

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Why percentages?

- On some trials the noise will produce a pattern that looks like the stimulus.
- Even though the stimulus was not shown.

Measuring thresholds

- In experiments of this type, when no stimulus was shown, subjects sometimes report that it was shown!

Environmental noise

- It’s not just neural noise that can make a task difficult.
- Suppose you are waiting for a phone call.
- The phone is in another part of your apartment and you are listening for its ring.
- You may hear other sounds as well (noise):
  - Washing machine
  - Dishwasher
  - Television
  - Radio
  - Other apartments
- You have to decide if a sound you heard was your phone within the noise or just the noise alone.
- Detection is a discrimination task.

Discrimination

- In a discrimination task there are four kinds of responses that can be made:
  1) Hit: the stimulus was presented, and you reported it was presented.
  2) Correct Rejection: the stimulus was not presented, and you reported it was not presented.
  3) False alarm: the stimulus was not presented, but you reported it was presented.
  4) Miss: the stimulus was presented, but you reported it was not presented.

Discrimination

- The situation is complicated further because your reports of whether the stimulus was present depends on more than just the perceptual experience.
- For example, if it is a very important phone call, you will “respond” to many sounds, even if you think they are unlikely to be the phone.
  - Hits and false alarms will be frequent.
  - Misses and correct rejections will be rare.
- If the call is not important and you are busy doing something else, you might decide that what you heard was not the phone.
  - Hits and false alarms will be rare.
  - Misses and correct rejections will be frequent.

Bias

- Likewise, some subjects may be biased to say “I saw the spot of light.”
- While other subjects may be biased to say “I didn’t see the spot of light.”
- These biases change the proportions of hits, correct rejections, false alarms, and misses.
- These biases may have almost nothing to do with perception.
- Both subjects might describe what they see in exactly the same way, but come to different conclusions about whether to report the spot as visible or not.
- We would like to be able to separate these two effects on reporting.
- And isolate the perceptual aspects.
- Sensitivity to the stimulus.
Signal detection theory (SDT)
- A model of how decisions are made
  - Based on perceptual information
  - And lots of other kinds of information too
- Provides a mathematical definition of perceptual sensitivity to a stimulus
  - That does not depend on biases in reporting

Perceptual effect
- We know that millions of neurons are involved in perceiving any stimulus
  - And we don’t know which neurons or exactly what they do
- Let us simplify everything and suppose that a stimulus generates an internal response to a stimulus
  - Could be a few neurons
  - Or millions of neurons
- We suppose that the internal response has a magnitude (number value)
  - It includes responses from the stimulus and any noise

Internal response
- Note, the internal response cannot distinguish signals from noise
  - It just responds to stimuli

Distribution of responses
- For a fixed stimulus
  - As noise changes from trial to trial, the internal response to signal + noise will change
  - A noise changes from trial to trial, the internal response to the noise alone will change
- Plot the probability of internal responses

Making a decision
- When a stimulus is presented (noise alone or noise+signal)
  - An internal response is generated
  - You have to decide, was it noise alone, or noise+signal?
Criterion

- Signal detection theory proposes that a person picks a criterion value.
- If the internal response is bigger than the criterion, it is signal + noise.
- Otherwise, it is noise alone.

Hits and misses

- Consider trials where the signal is actually present.
- Due to noise, the internal response may be larger or smaller than the criterion value.
  - Larger -> Hit
  - Smaller -> Miss
- Area under the curve is the proportion of trials for hits and misses.

Correct rejections and false alarms

- Consider trials where only noise is present.
- Due to noise, the internal response may be larger or smaller than the criterion value.
  - Larger -> false alarm
  - Smaller -> correct rejection
- Area under the curve is the proportion of trials for correct rejections and false alarms.

Criterion

- Changing the location of the criterion changes the proportion of hits and false alarms.

Note what doesn’t change!

Sensitivity

- We will measure perceptual sensitivity to a stimulus, relative to noise as the peak-to-peak distance between the two distributions.
- Call it d’
  - $d'$-prime
Sensitivity
- The more separated the distributions, the larger the \( d' \) value
- A \( d' \) of zero would mean that the systems respond the same to
  - Noise alone
  - Signal + noise

\( d' = 1 \) (lots of overlap)
\( d' = 3 \) (not much overlap)

Calculation
- If you have taken PSY 201, the calculation is fairly straightforward
- If not, this won't make much sense
- Take the proportion of hits
  - \( \text{Hits} = 97.5\% \)
  - False Alarms = 84%

Calculation
- Take the proportion of false alarms
  - \( \text{Hits} = 97.5\% \)
  - False Alarms = 84%

Calculation
- Changing the criterion does not change \( d' \)
- Percentiles
  - \( z(H) = z(0.828) = 0.9544 \)
  - \( z(FA) = z(0.429) = -0.02 \)
- \( d' \) is the difference of the percentiles
  - \( d' = z(0.828) - z(0.5) = 0.9544 - (-0.02) = 0.9744 \)

Calculation
- A key property of \( d' \) is that it does not depend on the judgment a subject makes about whether the target is present or not
- It is a pure measure of the perceptual representation of the signal and the noise
- You can also calculate a measure of the bias a person might have in setting the criterion
  - But that generally does not matter so much for perception
  - Important for decision making, memory, applied psychology

\( \text{d-prime} \)
- So \( d' \) is measure of how sensitive the internal representation is to the presence of the signal
  - In the context of noise
  - If the noise changes, \( d' \) will also change
    - which is why the calculation is done with z-scores
    - Kind of like power

\( \text{d-prime} \)
- Low \( d' \)
  - High noise, lots of overlap
- High \( d' \)
  - Low noise, not much overlap
Conclusions

- Measuring percepts
  - Thresholds
  - Noise
- Discrimination
  - Bias
  - Signal + noise
- Internal representation
  - Calculating d'

Next time

- Perceiving objects
- Gestalt psychology
- Perceptual organization