Tutorial
Psychophysics

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Psychophysics

Quantitative study of the relationship between physical stimuli and perception

Sensory Stimulus

(e.g. Image: glass of water)

Encoding models

V1

V2

V4

IT

Decoding models

Perception

Was there water in the glass?

Just a reminder of how you might start thinking about systems neuroscience
Three methods of measuring perception

Two alternative forced choice experiments and Signal Detection Theory

Brief intro to Amazon Mechanical Turk
Three methods of measuring perception

Two alternative forced choice experiments and Signal Detection Theory

Brief intro to Amazon Mechanical Turk
Three methods for measuring perception

1. Magnitude estimation
2. Matching
3. Detection/discrimination
LiveSlide Site
https://isle.hanover.edu/Ch02Methods/Ch02MagnitudeEstimationLineLength_evt.html
LiveSlide Site
https://isle.hanover.edu/Ch02Methods/Ch02MagnitudeEstimation_evt.html
Magnitude estimation

Have subject rate (e.g., 1-10) some aspect of a stimulus (e.g., how bright it appears or how loud it sounds).
Steven’s power law

Stevens (1957, 1961) developed an equation to try to encapsulate this full range of possible data sets. It is called Stevens’ Power Law

\[ P = c \cdot I^b \]

Relationship between intensity of stimulus and perception of magnitude follows the same general equation in all senses
Matching

In a matching experiment, the subject’s task is to adjust one of two stimuli so that they look/sound the same in some respect.
LiveSlide Site
https://graphics.stanford.edu/courses/cs178/applets/colormatching.html
Matching

Psychophysical vs. Physiological Results

DeValois & DeValois (1975)
Monkey LGN data

Boynton & Gordon’s (1965)
Color Naming Results

Present brief-flash of monochromatic light; Identify appearance using four color categories: RED, YELLOW, GREEN or BLUE
Detection / discrimination

In a detection experiment, the subject’s task is to detect small differences in the stimuli.

Psychophysical procedures for detection experiments

- Method of adjustment.
- Yes-No/method of constant stimuli.
- Forced choice.
The method of adjustment

Ask observer to adjust the intensity of the light until they judge it to be just barely detectable.

Example: you get fitted for a new eye glasses prescription. Typically the doctor drops in different lenses and asks you if this lens is better than that one.
The method of adjustment

Terrible Method

Ask observer to adjust the intensity of the light until they judge it to be just barely detectable.

Example: you get fitted for glasses. The optometrist fits you with lenses and asks you if this one.

* introspectionist/subjective.

* subjects can be inexperienced
Yes/no method of constant stimuli
LiveSlide Site
https://isle.hanover.edu/Ch02Methods/Ch02MethodOfConstantStimuli_evt.html
Yes/no method of constant stimuli

Yes/no method of constant stimuli

Dot intensity

Percent 'yes' responses

Low
High

Do these data indicate that Laurie’s threshold is lower than Chris’s threshold?

Something is wrong!

All of the trials are signal trials. There are no catch trials (blanks, noise-alone trials). We only get hits and misses. We can make no estimate of false alarms.
Forced Choice

- Present signal on some trials, no signal on other trials (catch trials).

- Subject is forced to respond on every trial either "Yes the thing was presented" or "No it wasn't". If they're not sure then they must guess.

- Advantage: With the forced choice method, we have both types of trials so we can count both the number of hits and the number of false alarms to get an estimate of discriminability independent on the criterion.
LiveSlide Site
https://isle.hanover.edu/Ch02Methods/Ch02Forced-Choice_evt.html
Forced Choice

Two Alternative Forced Choice

![Graph showing the relationship between stimulus intensity and probability of correct response for a 2AFC task.](image-url)
The dorsal stream has been linked with motion perception

A relationship between behavioral choice and the visual responses of neurons in macaque MT

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(Revised February 24, 1995; Accepted May 30, 1995)
Two Alternative Forced Choice

Visual motion discrimination task

Test Stimulus

Random Dot Motion stimulus (coherence = 100%)

Proportion of upward choice

Motion Strength (coherence)

Test Stimulus
Visual motion discrimination task

Random Dot Motion stimulus (coherence = 0 %)

Proportion of upward choice

Motion Strength (coherence)

Test Stimulus
Visual motion discrimination task

Random Dot Motion stimulus (coherence = -100 %)

Test Stimulus

Proportion of upward choice

Motion Strength (coherence)

Test Stimulus
1. Point of Subjective Equality
Characterizing a psychometric function

1. Point of Subjective Equality

2. Slope (Sensitivity) $\Delta y / \Delta x$
1. **Point of Subjective Equality**

2. **Slope (Sensitivity)**
   \[ \frac{\Delta y}{\Delta x} \]
Motion Aftereffect – a consequence of motion adaptation

Random Dot Motion stimulus (coherence = 100 %)

Random Dot Motion stimulus (coherence = 0 %)

Propotion of upward choice

Motion Strength (coherence)

Adapter Stimulus

Test Stimulus
Three methods of measuring perception

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Brief intro to Amazon Mechanical Turk
Brief intro to **signal detection theory**:

- Your ability to perform a detection/discrimination task is limited by internal noise.

- Information (e.g., **signal strength**) and **criterion** are the 2 components that affect your decisions. They each have a different kind of effect on the decisions.

- By measuring both hits and false alarms, we can get an estimate of d' that is a measure of task difficulty and that is independent of the criterion.
Let's revisit motion discrimination in the light of SDT.

Let's dig deep into the *Psychometric function*.
Subject with low sensitivity

down

up

criterion

Proportion of "upward" choice

Performance

Subject with high sensitivity
### Signal Detection Theory

<table>
<thead>
<tr>
<th>Dot Present</th>
<th>Subject says</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Hit</td>
</tr>
<tr>
<td>No</td>
<td>Miss</td>
</tr>
<tr>
<td>No</td>
<td>Correct reject</td>
</tr>
</tbody>
</table>

- **Signal Detection Theory**

The diagram illustrates the possible responses and their outcomes in a signal detection task. The axes represent internal response, and the probability distributions indicate the likelihood of responses such as hits, misses, false alarms, and correct rejections.
Signal Detection Theory

\[ d' = \text{separation} / \text{spread} \]
Receiver Operating Characteristic (ROC) curve

Hit Rates

False Positive
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Brief intro to Amazon Mechanical Turk
The original Turk

**The Turk**, also known as the **Mechanical Turk** was constructed and unveiled in 1770 by **Wolfgang von Kempelen** (Hungarian: Kempelen Farkas; 1734–1804) to impress the Empress **Maria Theresa of Austria**.

It was a fake chess-playing **machine** constructed in the late 18th century. From 1770 until its destruction by fire in 1854 it was exhibited by various owners as an **automaton**. The Turk was in fact a mechanical **illusion** that allowed a human chess master hiding inside to operate the machine.
Quality of Amazon Mechanical Turk data

At high levels of repetitions, mturk data is consistent with in-lab data
THANKS ...