Three methods for measuring perception

1. Magnitude estimation
2. Matching
3. Detection/discrimination

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).

\[ P = k S^n \]

- \( P \): perceived magnitude
- \( S \): stimulus intensity
- \( k \): constant

Steven’s power law

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.

Example: brightness matching

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.
• Simple forced choice.
• Two-alternative force choice
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.

Yes/no method of constant stimuli

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

Simple 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:** 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.

**Demo**
Simple forced choice:
four possible outcomes

<table>
<thead>
<tr>
<th>Tumor present</th>
<th>Doctor responds “yes”</th>
<th>Doctor responds “no”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hit</td>
<td>Miss</td>
</tr>
<tr>
<td>Tumor absent</td>
<td>False alarm</td>
<td>Correct reject</td>
</tr>
</tbody>
</table>
**Criterion shift**

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**Information and criterion**

Two components to the decision-making: **information** and **criterion**.

- **Information**: Acquiring more information is good. The effect of information is to increase the likelihood of getting either a hit or a correct rejection, while reducing the likelihood of an outcome in the two error boxes.
- **Criterion**: Different people may have different bias/criterion. Some may choose to err toward "yes" decisions. Others may choose to be more conservative and say "no" more often.

**Internal response: probability of occurrence curves**

![Probability distribution for internal responses when no tumor and when tumor present]
Hits: respond “yes” when tumor present

Correct rejects: respond “no” when tumor absent

Misses: respond “no” when present
False alarms: respond “yes” when absent

Criterion

Distribution of internal responses when no tumor

Distribution of internal responses when tumor present

Say “no” Say “yes”

Internal response

Criterion shift

$\text{d'} = 1$

Hits = 97.5%
False alarms = 84%

Hits = 84%
False alarms = 50%

Hits = 50%
False alarms = 16%

ROC
ROC

Criterion #2

ROC

Criterion #3

ROC

Criterion #4
Receiver operating characteristic (ROC)

Discriminability ($d'$) and overlap

\[ d' = \frac{\text{separation}}{\text{spread}} \]

SDT review

- Your ability to perform a detection/discrimination task is limited by internal noise.
- Information (e.g., signal strength) and criterion (bias) are the 2 components that affect your decisions, and they each have a different kind of effect.
- Because there are 2 components (information & criterion), we need to make 2 measurements to characterize the difficulty of the task. By measuring both hits & false alarms we get a measure of discriminability ($d'$) that is independent of criterion.
Measuring thresholds

Two-alternative forced choice

- Two options presented on each trial:
  - Two stimuli presented simultaneously at two different positions (e.g., one of which has higher contrast).
  - Two stimuli presented sequentially at the same position.
  - One stimulus presented with two possible choices (e.g., moving right or left).
- Subject is forced to pick one of the two options. If they’re not sure then they must guess.
- Feedback (correct/incorrect or $) provided after each trial.
- Advantage: Two options with feedback balances criterion so we can measure proportion correct.

Demo

Staircase
Absolute and relative thresholds

Weber’s law

Ernst Weber, c1850
Weber's law

Fechner's analysis

Background intensity

Increase in intensity

Internal response
Weber's law: Fechner's derivation

\[ R_1 = \log(x) \]
\[ R_2 = \log(x + dx) \]
\[ d' = \frac{R_2 - R_1}{\sigma} \]
At threshold: \[ d' = 1 \]
\[ R_2 - R_1 = \sigma \]

Weber's law: contrast ratio derivation

Internal response = \frac{\text{intensity of test flash}}{\text{intensity of background}}

\[ R_1 = \frac{x}{x} \]
\[ R_2 = \frac{x + dx}{x} \]
\[ R_2 - R_1 = \frac{dx}{x} \]
\[ \frac{dx}{x} = \sigma \]
**Weber's law:** To perceive a difference between a background level $x$ and the background plus some stimulation $x + dx$ the size of the difference must be proportional to the background, that is, $dx = k x$ where $k$ is a constant.

**Fechner's interpretation:** The relationship between the stimulation level $x$ and the perceived sensation $s(x)$ is logarithmic, $s(x) = \log(x)$.

Main difference: Fechner's is an interpretation of Weber's law, a hypothesis.