Psychophysics & Signal Detection Theory

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Lec. 3

Chapter 1
Outline for today:

- Weber-Fechner law (review)
- Stephen’s power law
- Psychophysics
- Signal Detection Theory
Weber-Fechner Law

Fechner’s law:
\[ S = k \log R \]

Weber’s law:
\[ dS = k \frac{dR}{R} \]

my rating: this is super deep + important!
Stevens’ Power Law

\[ S = kR^b \]

Psychological magnitude (arbitrary units)

Stimulus magnitude (arbitrary units)

Electric shock

Apparent length

Brightness
Stevens’ Power Law

- subjective
- based on rating data
- no “right” answer: just a mapping between one unknown scale (‘pain’) and another unknown scale (‘numbers’)

(my rating: “meh”)
Test yourself: at which intensity are changes most detectable?
For this stimulus/sensation relationship, which stimulus changes are most detectable?

A

B

C
How to measure perception?
müller-lyer illusion
müller-lyer illusion

“percept” is internal
Psychophysics

• detection (yes/no)
• discrimination (e.g., bigger than)
• estimation (report the stimulus exactly)

All provide indirect measure of internal mental state!
Detection

(a) 

perfect threshold

"I hear it"

"I don't hear it"

Percentage of times reported present

Stimulus level (arbitrary units)
## Table 1.1

### Absolute thresholds in the real world

<table>
<thead>
<tr>
<th>Sense</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vision</td>
<td>Stars at night, or a candle flame 30 miles away on a dark, clear night</td>
</tr>
<tr>
<td>Hearing</td>
<td>A ticking watch 20 feet away, with no other noises</td>
</tr>
<tr>
<td>Vestibular</td>
<td>A tilt of less than half a minute on a clock face</td>
</tr>
<tr>
<td>Taste</td>
<td>A teaspoon of sugar in 2 gallons of water</td>
</tr>
<tr>
<td>Smell</td>
<td>A drop of perfume in three rooms</td>
</tr>
<tr>
<td>Touch</td>
<td>The wing of a fly falling on your cheek from a height of 3 inches</td>
</tr>
</tbody>
</table>

*Source: From Galanter, 1962.*
Detection

The graph illustrates the relationship between stimulus level and the percentage of times a stimulus is reported as present. The perfect threshold divides the graph into two regions:

- Below the threshold, labeled "I don’t hear it".
- Above the threshold, labeled "I hear it".

The x-axis represents the stimulus level in arbitrary units, while the y-axis shows the percentage of times the stimulus is reported as present.
Detection

perfect threshold

noise
psychometric function

• relates physical quantity to the probability of detecting it
Signal detection theory: A psychophysical theory that quantifies the response of an observer to the presentation of a signal in the presence of noise

( On board )
Detecting a stimulus using the signal detection theory (SDT)

(a) Number of instances

Less ← More

Your perception

(b) Sounds like phone

Less ← More

(c) NO Criterion YES

Number of instances

Less ← More

Sounds like phone

- Red: Shower “noise” alone
- Blue: Ring + noise
Detecting a stimulus using the signal detection theory (SDT)

(d) Correct rejection

(e) Hit

(f) False alarm

(g) Miss

Number of instances

NO  Criterion  YES

Less  More

Sounds like phone
Sensitivity to a stimulus: The separation between the distributions of response to noise alone and to signal plus noise

(a) No sensitivity

\[ d' = \sim 0 \]

(b) Moderate sensitivity

\[ d' = \sim 1 \]

(c) High sensitivity

\[ d' = \sim 4 \]

- Red: Shower "noise" alone
- Blue: Ring + noise

Less \rightarrow \text{Sounds like phone} \rightarrow More

Number of instances
For a fixed $d'$, shifting the response criterion

(a) “Gotta get that call!”

(b) “Is that the phone?”

(c) “What phone?”

- Red: Shower “noise” alone
- Blue: Ring + noise
note about book figures:

- The x axis in signal detection plots shouldn’t be “your percept”. It should have physical units like “sound intensity”
Signal detection theory

- **Hit**: Stimulus is presented and observer responds “Yes”
- **Miss**: Stimulus is presented and observer responds “No”
- **False alarm**: Stimulus is not presented and observer responds “Yes”
- **Correct rejection**: Stimulus is not presented and observer responds “No”
Signal Detection Theory Terms to know:

“noise” distribution: values arising when stimulus not present

“signal” distribution: values arising when signal + noise present

Type I error: rate of “false alarms”, or false positives

Type II error: rate of “misses”, or false negatives

psychometric function: describes probability of saying “I heard it” as function of stimulus intensity
Chapter 1 Summary

• Weber-Fechner law
• Stevens’ power law
• psychophysics
• psychometric function
• signal detection theory: threshold, criterion, Hit/Miss, FA/CR, d’ (i.e., “d-prime”)
• spikes, synapses, neurotransmitter
You can safely ignore (for now)

- method of constant stimuli / method of adjustment
- ROC curves
- Fourier analysis (though we will come back to it!)
- Cranial nerves (Fig 1.20)
- brain anatomy (Fig 1.21, but we will come back as needed)
Next: Read Chapter 2