Psych 333
Sensation and Perception

Spring, 2008

Instructor: Ione Fine
Office Hours: Guthrie 233, Tues & Thurs 10:30-11.15 or by appointment

TA: Sungjun Joo and Jon Howe
Office Hours:
Jon Howe, Tues 1.30-2.30 Chem Library 130
Sungjun, Monday 1-2 Chem Library 130

Sensation & Perception 2nd edition by Wolfe, Kluender & Levi
http://www.sinauer.com/ebooks/wolfe2e

Course Website:
http://www.fineland.org
Psychology – pre 1990s

Very limited ability to measure brain responses in humans
Neuroscience – pre 1990s

stimulus → brain state → mental event → behavioral response

Could only measure very simple behaviors in animals

Psychology and Neuroscience – disappearing boundaries

stimulus → brain state → mental event → behavioral response

Late 1990s

Awake behaving monkey electrophysiology allowed us to measure complex behaviors as well as brain responses.

fMRI allowed us to measure brain responses as well as complex behaviors
PSYCHOPHYSICS

The study of the relationship between the physical properties of a stimulus in the environment and the perception of that stimulus.

Gustatory sensation of perceived pleasantness
Four fundamental questions in psychophysics

• *Detection*: Is something there? (Absolute threshold)

• *Discrimination*: Is it the same as another stimulus? (Difference threshold)

• *Rating*: How large (bright, loud, sweet, pleasant…) is it?

• *Identification*: What is it?

Methods of psychophysics

• Method of limits
• Method of constant stimuli
• 2 Alternative forced choice
• Adjustment
• Rating
• Identification
• Reaction times
What sort of psychophysical technique you use depends on the question you want to answer.

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Four fundamental questions in psychophysics

- **Detection:** Is something there?

  **Absolute Threshold:** The smallest amount of stimulus energy that can be detected by an observer at an above chance level (>50% of the time).

  “I think something was there”.

- **Discrimination:** Is it the same as another stimulus?
- **Rating:** How large (bright, loud, sweet, pleasant…) is it?
- **Identification:** What is it?
Detection: Is something there?

Absolute Threshold: The smallest amount of stimulus energy that can be detected by an observer at an above chance level (>50% of the time).

“I think something was there”.

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<th>SENSE</th>
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<tr>
<td>VISION</td>
<td>Stars at night or a candle flame 30 miles away on a dark clear night</td>
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<tr>
<td>HEARING</td>
<td>A ticking watch 20 ft away with no other noises</td>
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<tr>
<td>TASTE</td>
<td>A teaspoon of water in 2 gallons of water</td>
</tr>
<tr>
<td>SMELL</td>
<td>A drop of perfume in 3 rooms</td>
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<tr>
<td>TOUCH</td>
<td>The wing of a fly falling on your cheek from a height of 3 inches</td>
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Methods for measuring absolute threshold

**Method of limits**

- Stimuli are presented in sequential (ascending or descending) order.
- Subject reports whether he/she detects the stimulus.
- Threshold is mean of crossover values.

There is variation in when subjects detect a stimulus from trial to trial.
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**Catch trials**: Trials on which no stimulus is present.

**False Alarm rate** – proportion of trials where a subject incorrectly reports that a stimulus is present.

False Alarm rates vary: across individuals with practice across sessions.

![Graph showing catch trials vs. stimulus strength](image-url)
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- The subject increases or decreases the intensity of the stimulus (much like adjusting the volume dial on a stereo or the dimmer switch for a light).
- What does it mean to barely see a stimulus? Dave might say he barely sees the stimulus when he's just sure that it's there. Susi might say she sees the stimulus when she's pretty sure it's there. Not really a difference in sensitivity between Dave and Susi. The same subject might change their criterion over time.

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2-Alternative Forced Choice (2-AFC)

- A stimulus is presented at one of two locations or time intervals (the other location or time interval has no stimulus)

- The subject must choose the location or time interval in which the stimulus is present.

- Can be used with animals, infants, or hard-to-test subjects.

Four fundamental questions in psychophysics

- **Detection**: Is something there? (Absolute threshold)

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- **Rating**: How large (bright, loud, sweet, pleasant….) is it?

- **Identification**: What is it?
Thresholds: two types

**ABSOLUTE THRESHOLD**: The minimum intensity of stimulation (brightness of a light; loudness of a tone) required to produce a detectable sensory experience.

**DIFFERENCE THRESHOLD**: The minimum change in intensity (ΔI) required to produce a detectable change in sensory experience (this is also known as a Just Noticeable Difference or JND).

*Example: Auditory frequency discrimination.*

Can you tell the difference between pure tones of 260 and 262 Hz? (261.6 Hz is middle C on the '12 Tone Equal Tempered Scale')

![Frequency Levels](image)

What about 520 Hz? How much of an increment do you need to tell the difference? (520 Hz is the note A above middle C)

![Frequency Levels](image)

(matlab demo)
How did we measure the difference threshold?

We used the method of constant stimuli again.

1) Pick a baseline value (e.g. 260 Hz)

2) Pick a set of increments (e.g. 0, 1, 2, 3, 4, 5 Hz)

3) Present the baseline and baseline+increment in pairs

4) Randomly choose which one comes first, and ask the subject which interval had the higher frequency.

5) Plot the resulting psychometric function

6) Fit the curve. The increment threshold ($\Delta I$) is the increment that gives 80% correct.

<table>
<thead>
<tr>
<th>$I$ (Base frequency)</th>
<th>$\Delta I$ (Hz)</th>
<th>Weber fraction ($\Delta I/I$)</th>
</tr>
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<tbody>
<tr>
<td>260</td>
<td>1.34</td>
<td>0.0051</td>
</tr>
<tr>
<td>520</td>
<td>2.29</td>
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Weber's law: the increment threshold ($\Delta I$) is a fixed percentage of the reference stimulus intensity ($I$):

$$\Delta I/I = k$$

$k$ is a constant (the “Weber constant”).
Detecting differences between stimuli

- The difference threshold, or Just Noticeable Difference (JND)
- The smallest detectable difference between two stimuli
- The threshold for detecting a difference is often roughly proportional to the size of the original (reference) stimulus – Weber fraction

<table>
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<th>ΔI (Hz)</th>
<th>Weber fraction (ΔI/I)</th>
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Weber fraction of 0.01 means that subjects can reliably detect a 1% change in stimulus intensity.

Table 1.3  Weber fractions for a number of different sensory dimensions

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<th>Sensory Dimension</th>
<th>Weber Fraction</th>
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<tr>
<td>Electric shock</td>
<td>0.01</td>
</tr>
<tr>
<td>Lifted weight</td>
<td>0.02</td>
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<tr>
<td>Sound intensity</td>
<td>0.04</td>
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<tr>
<td>Light intensity</td>
<td>0.08</td>
</tr>
<tr>
<td>Taste (salty)</td>
<td>0.08</td>
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Source: From Teghtsoonian (1971).

A Weber fraction of 0.01 means that subjects can reliably detect a 1% change in stimulus intensity.

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**Rating**

- Stimuli are above threshold
- Observer is given a standard stimulus and a value for its intensity
- Observer compares the standard to the test by assigning numbers relative to the standard

*(matlab demo)*
Brightness as a function of stimulation current in a retinal prosthesis patient

Steven's Power Law: $S = aI^b$
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Models of object recognition:

Viewpoint dependent vs. viewpoint independent

Identification

1

2

3

4

5

6
What sort of psychophysical technique you use depends on the question you want to answer.
Reaction times

Visual search - observers look for one stimulus in a set of many stimuli
Is there a green circle in the display?

Reaction times

Is there a green circle in the display?
Reaction times

Is there a green circle in the display?
Reaction times

Is there a green circle in the display?
Neuroscience – pre 1990s

stimulus → brain state → mental event → behavioral response

Could only measure very simple behaviors in animals

Brains contain white matter, gray matter and cerebral spinal fluid
Gray matter contains neuronal cell bodies, dendrites and axons.

Key components of neurons:
- Cell body
- Dendrites
- Axon or nerve fiber

An axon terminal in the presynaptic cell binds to the dendrite of the postsynaptic cell.

Neurotransmitters are released by synaptic vesicles in the axon and fit into receptors on the dendrite on the other side of the synapse, thus communicating from the axon of the first neuron to the dendrite of the second neuron.
An action potential (firing) of a neuron is created when the membrane of the neuron permits sodium ions (Na⁺) to rush into the cell, thus increasing the voltage. Very quickly afterward, potassium (K⁺) flows out of the cell, bringing the voltage back to resting voltage. This process occurs along the length of the axon until the action potential reaches the axon terminal.
David Hubel recording from depth-sensitive cell in the cat:

![Graph showing various imaging techniques and time scales](image)

EEG/MEG mostly reflects postsynaptic potentials, not action potentials

Action Potential

Postsynaptic Potential
Source localization

A big problem: The “inverse solution” is mathematically ill-posed and therefore unsolveable in principle

2D set of electrodes to measure a 3d volume

EEG is most sensitive to sources in the GYRI and less sensitive to sources in the SULCI
Two general approaches to source localization:

1. dipole localization: assumes that the source can be modeled as a small number of point sources

2. distributed source modeling: attempts to estimate the current distribution throughout the entire 3-D cortex (but strong assumptions are necessary)
Lesions

HUMANS

Adapted from Churchland & Sejnowski (1988) Science 242, 741-745
Viewing fMRI data on ‘flattened’ cortex
Mapping Retinotopic Visual Areas: Response to Expanding Ring

Adapted from Churchland & Sejnowski (1988). Science 242, 741-745
Neuroscience - your generation

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Adapted from Churchland & Sejnowski (1988) Science 242, 741-745
The development of symbolic representations through visual experience

Anja Schlack and Tom Albright, 2007
untuned

Untuned for motion or shape
untuned

Tuned for motion, not shape

untuned

Tuned for motion and shape - CONGRUENT
untuned

Tuned for motion and shape - INCONGRUENT

A VERTICAL: N = 33, p<0.001

B HORIZONTAL: N = 32, p<0.01

Trained directions

Generalization to untrained directions