Sensation, Part 1
Gleitman *et al*. (2011), Chapter 4

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Origins of Knowledge

Empiricism – knowledge is acquired through experience
(“nurture”)

Nativism – knowledge is innate
(“nature”)

Origins of Knowledge

Empiricism – knowledge is acquired through experience

John Locke (1632-1704) – when born, the mind
is blank – a *tabula rasa* (blank tablet)

Experience refers to working with the
information provided
to us by our senses
and other faculties like memory

Psychology, 8/e Figure 4.1

Basic Distinction

Distal stimulus: object or event in the world
out there, like a tree
Proximal stimulus: pattern of energy from that object
which stimulates our sensory organs, such
as the light from the tree reaching our eyes

What we want: knowledge of the distal stimuli

What we get: proximal stimulation

Problem: the proximal stimulus does not tell us
directly what the distal stimulus is!

Example

Consider how the size of a visual image of some object depends on viewing distance.

Hold up your thumb at arm's length.

Look at a nearby person and see how big the image is, relative to your thumb.

Do the same for a far-away person.

Proximal image size does not directly tell us how big the real-world distal stimulus is...

Bishop George Berkeley (1685-1753)

two stages are needed to understand how the mind works to interpret proximal stimuli

(1) our senses provide raw input: *sensations*

(2) our minds link these sensations to provide a meaningful organization of our perceived world: *associations*

sensations

-patch of green

-a note on a piano

-a salty taste

-touch of a feather

associations

a spherical patch of green

above a cylindrical patch of brown

-*a tree*

Origins of Knowledge

Nativism – knowledge is innate

Immanuel Kant (1724-1804)

Psychology, 8/e Figure 4.4

There are *categories* according to which sensory material is organized

Space, time and causality are *a priori* (built-in or innate)

Experience provides sensory input ordered according to the *a priori* categories

Psychophysics

- Relates characteristics of a proximal stimulus to the quality and intensity of its sensory experience.

Detection

Important Distinction

Absolute Threshold

-What is the smallest amount of light that you can detect if viewed in an otherwise completely dark room?

-What is the intensity of the faintest sound you can hear?

-How many sugar molecules must a glass of water contain for you to taste the sugar?

Difference Threshold

TABLE 4.1 Absolute Thresholds

Modality	Example of minimal stimulus that can be detected
Vision	A candle flame 30 miles away on a dark, clear night
Hearing	A ticking watch 20 feet away with no other noises
Taste	A teaspoon of sugar in 2 gallons of water
Smell	A drop of perfume in 3 rooms
Touch	The wing of a fly falling on your cheek from a height of 3 inches

Source: Galanter, 1962.

Psychology, 8/e Table 4.1

Important Distinction

Absolute Threshold

Difference Threshold

-What is the smallest amount that two lights can differ in physical intensity and still differ in perceived brightness?

-How much change in sound frequency is needed for you to tell the difference between a 256 Hz tone (middle C on a piano) and a tone of higher frequency?

-How much sugar must be added to a glass of water that already has a teaspoon of sugar in it so that you can just tell the difference?

Discrimination

Tell two stimuli apart.

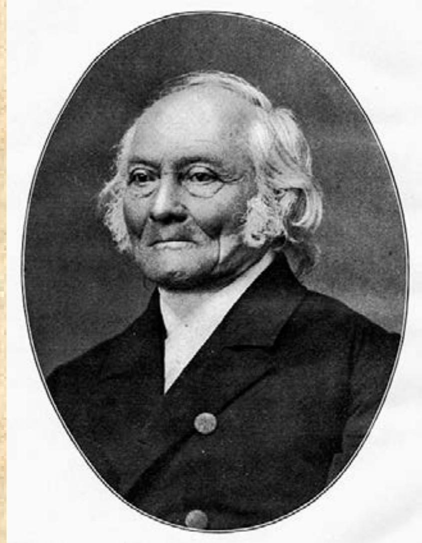
If the physical difference between two stimuli is
as small as possible for us to tell
two stimuli apart, then we are
measuring a difference threshold.

The difference threshold corresponds to a
just noticeable difference (JND)

In the standard experiment,
one compares a *test* or *comparison* stimulus to
the *standard* or *reference* stimulus

Weber's Law

-E.H. Weber (1795-1878)



The change in a stimulus required for a difference to be detected increases in proportion to the magnitude of the standard stimulus.

$$c = \Delta I / I$$

or

$$\Delta I = c\, I$$

I	intensity of standard
ΔI	change in intensity required for difference to be detected
c	a constant (*Weber fraction*) characteristic of a particular task

Weber's Law $c = \Delta I / I$

Problem 1.

Betty finds that she can just discriminate a light of intensity 102 from a standard light of intensity 100. Assuming that Weber's Law holds, how intense must a light be for Betty to be able to discriminate it from a standard light of intensity 200? Of intensity 400?

Weber's Law $c = \Delta I / I$

Problem 1.

Betty finds that she can just discriminate a light of intensity 102 from a standard light of intensity 100. Assuming that Weber's Law holds, how intense must a light be for Betty to be able to discriminate it from a standard light of intensity 200? Of intensity 400?

Answer:

(1) Find Betty's Weber fraction c.

$\Delta I = 102 - 100 = 2$. $I = 100$. Therefore, $c = 2/100$ or 0.02 or 2%.

(2) Apply the same Weber fraction $c = 0.02$ to a standard intensity of 200.

$0.02 = \Delta I / 200$. $\Delta I = 0.02 \times 200 = 4$. The brighter light has an intensity of $I + \Delta I$, namely $200 + 4 = 204$.

Weber's Law

$c = \Delta I / I$

Problem 2.

Betty and George measure their sensitivity to differences in sound intensities in the same experiment.

Betty finds that her Weber fraction is 0.05.
George finds that his Weber fraction is 0.07.

Who is the more sensitive observer in this experiment?

Weber's Law $c = \Delta I / I$

Problem 2.

Betty and George measure their sensitivity to differences in sound intensities in the same experiment.

Betty finds that her Weber fraction is 0.05.
George finds that his Weber fraction is 0.07.

Who is the more sensitive observer in this experiment?

Answer: Betty's Weber fraction (0.05) is smaller than George's (0.07). She needs less of a change in sound intensity to perceive the difference. Therefore she is the more sensitive observer.

TABLE 4.2

Representative (Middle-Range) Values for the Weber Fraction for the Different Senses

Sensory modality	Weber fraction ($\Delta I/I$)	Weber fraction as a percentage
Vision (brightness, white light)	1/60	1.6%
Kinesthesia (lifted weights)	1/50	2.0%
Pain (thermally aroused on skin)	1/30	3.3%
Hearing (tone of middle pitch and moderate loudness)	1/10	10.0%
Touch (cutaneous pressure "spot")	1/7	14.2%
Smell (odor of India rubber)	1/4	25.0%
Taste (table salt)	1/3	33.3%

Psychology, 8/e Table 4.2

Fechner's Law

Gustav Fechner (1801-1887)

$$S = k \log I$$

S = subjective magnitude
I = physical intensity
k = constant
log = logarithm function

"The subjective magnitude of a stimulus increases as the logarithm of its physical intensity."

Fechner's Law

$$S = k \log I$$

S	= subjective magnitude
I	= physical intensity
k	= constant
log	= logarithm function

The log in Fechner's law takes a huge range of physical inputs (I) and turns them into a much smaller range of subjective outputs (S)

Input	Output = log(Input)
1	0
10	1
100	2
1000	3

Signal Detection Theory

Developed to help interpret radar signals after World War II

Takes into account both

1. Sensory Processing
2. Decision-Making Mechanisms (Criterion)

A standard signal detection experiment
involves a large number of ***trials***

During each trial, a faint, barely detectable ***signal***
is either ***present*** or ***absent***

For each trial, the ***observer*** must respond whether
the signal was present or absent

This can be difficult because all trials have ***noise***

Typically, the signal is present on only half of the trials,
chosen randomly by the experimenter, so that
the observer does not know in advance what
the correct answer is.

Let's classify responses in such an experiment.

		Observer Responds	
		Present	Absent
Signal Was	Present		
	Absent		

Signal Was	Observer Responds: Present	Observer Responds: Absent
Present	HIT	
Absent		

Signal Was	Observer Responds	
	Present	Absent
Present	HIT	MISS
Absent		

Signal Was	Observer Responds: Present	Observer Responds: Absent
Present	HIT	MISS
Absent	FALSE ALARM	

Response Classification

Signal Was	Observer Responds: Present	Observer Responds: Absent
Present	HIT	MISS
Absent	FALSE ALARM	CORRECT REJECTION

Some responses are correct

Signal Was	Observer Responds: Present	Observer Responds: Absent
Present	HIT	MISS
Absent	FALSE ALARM	CORRECT REJECTION

Some responses are errors

		Observer Responds	
		Present	Absent
Signal Was	Present	HIT	MISS
	Absent	FALSE ALARM	CORRECT REJECTION

An observer's decision-making depends on the
costs of incorrect responses and
benefits of correct responses: the **payoff matrix**

How can you, the experimenter, induce an observer to adopt a more conservative criterion (less willing to respond "signal present")?

-pay the observer one cent for each hit
-have the observer pay you one dollar for each false alarm

How can you, the experimenter, induce an observer to adopt a more liberal criterion (more willing to respond "signal present")?

-pay the observer one dollar for each hit
-have the observer pay you one cent for each false alarm

Sensory Codes

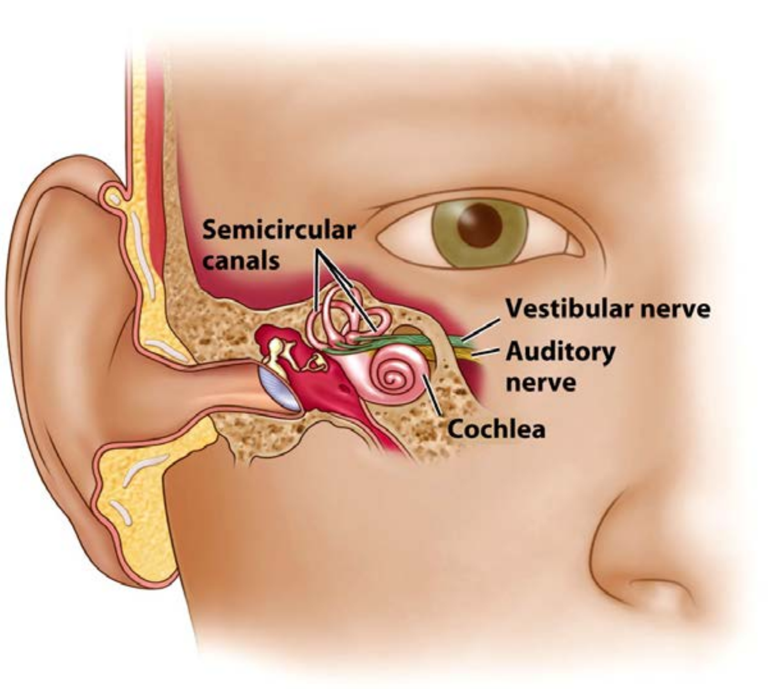
- *Sensory codes*
  - nervous system uses them to translate a proximal stimulus into neural impulses; first step is *transduction*
- Proximal stimulus *intensity* is coded by
  - rates of neuron firing
  - total number of neurons triggered
- Proximal stimulus *qualities* are also coded
- *Specificity theory* (Hermann Müller)
  - different sensory qualities are signaled by different neurons
  - describes qualitative differences within a *sensory modality* (labeled lines)
- Sensory coding is often best described by *pattern theory.*
  - Certain sensory qualities arise because of different patterns of activation across a whole set of neurons.

Kinesthesis

- The name for sensations from receptors in the muscles, tendons and joints that inform us of our skeletal position and movement

Vestibular Sense

- The *vestibular sense*
  - signals movements of the head
  - helps us know which way is "up" and which is "down"
- The receptors for the vestibular sense are in the semicircular canals in the inner ear.



Psychology, 8/e Figure 4.10a
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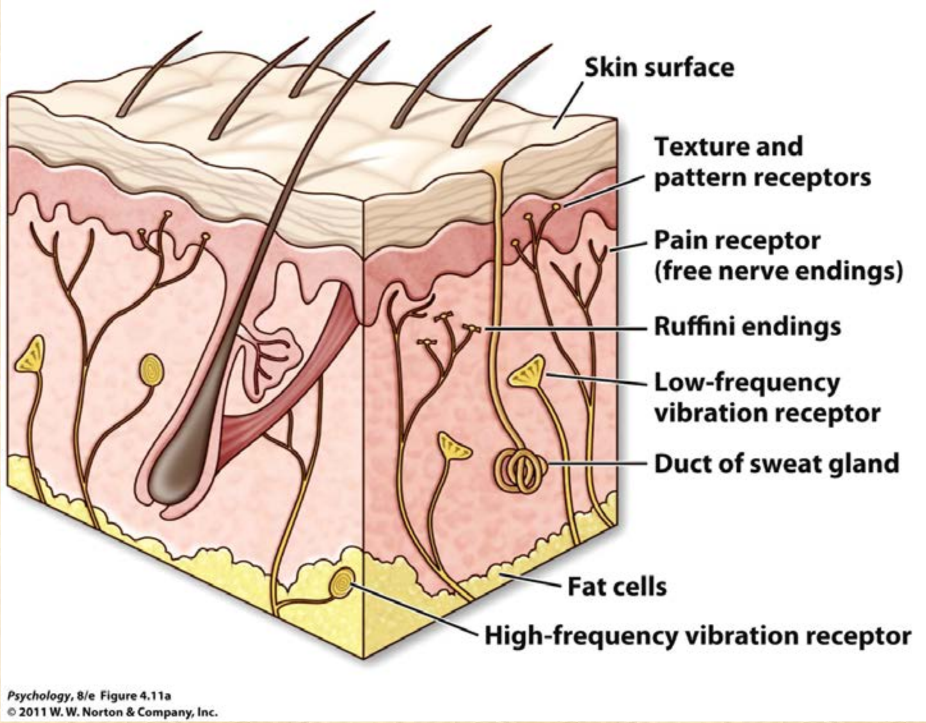
Skin Senses

- The *skin senses* include several distinct subsystems.
  - produce feelings of pressure, temperature, and pain
- Different types of receptors
  - examples: one type fires when the temperature rises; another type fires in response to a drop in skin temperature



Pain

- *Pain* depends on receptors responding to various forms of tissue damage and temperature extremes.
  - A-fibers: respond rapidly (myelinated) to provide rapid signaling of tissue damage
  - C-fibers: respond in a slow and sustained fashion (unmyelinated) and responsible for dull aches after injury
- Also influenced by other mechanisms
  - endorphins (natural internal painkillers)
  - neural circuits
    - "gateways" blocking the transmission of some signals from the *nociceptors*