Perception Lecture 1

Sensation vs Perception

- Sensation is detection
- Perception is interpretation

The distal and proximal stimulus

- Distal stimulus: the object out there in the world (distal=distant).
- Proximal stimulus: the pattern of sensory activity determined by the distal stimulus (proximal=close).
- The major computational task of perception can be thought of as the process of determining the distal stimulus from information contained in the proximal stimulus.

Psychophysics

- Relate magnitude of the physical stimulus to the psychological response
- Absolute threshold: smallest stimulus you can detect
- Difference threshold: the smallest change in magnitude you can detect

Absolute Threshold

- Intensity level at which you can detect a stimulus 50% of the time
- Problems:
    - Not an absolute threshold

- Rather, it is a relative level

Signal Detection Theory

- Need to score both correct detections and incorrect detections
- What if said "Yes, I detect it" on every trial?

Detection Responses

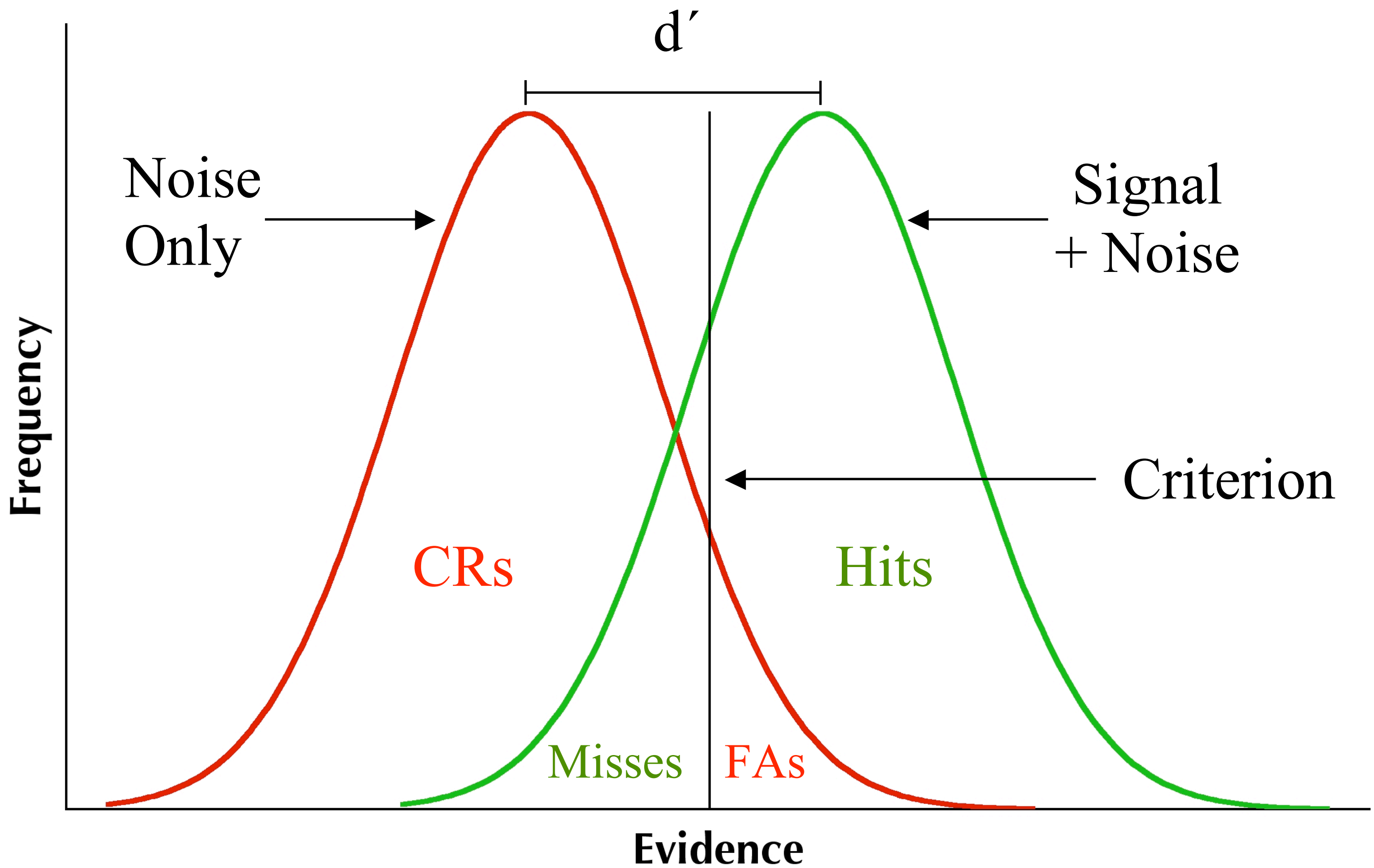
	Stimulus Present	Stimulus Absent
Respond Yes	Hit	False Alarm
Respond No	Miss	Correct Rejection

Signal Detection

- d' (d prime): ability to discriminate between just noise and signal+noise
- C: criterion or bias
  - Liberal: more willing to say item was there
  - Conservative: less willing to say item was there

Distribution of Evidence

- Assume there are two normal distributions of evidence
  - Noise only: target absent
  - Signal + noise: target present



Calculate

- Convert probability of a false alarm into a z score (get zn)
- Convert probability of a hit into a z score (get zsn)
- d' = zn - zsn
- d' = zn - zs+n

$$d' = z_n - z_{s+n}$$

p(Hit)	p(FA)	Z_{s+n}	z_n	d'	C
0.90	0.90	-1.282	-1.282	0.00	-1.282
0.90	0.70	-1.282	-0.524	0.76	-0.904
0.90	0.02	-1.282	2.054	3.34	0.384
0.50	0.02	0.000	2.054	2.05	1.029

Example:

Table 2.1 Example Hit Rates (proportion of faulty products removed) and False Alarm Rates (proportion of good products removed) for Early Versus Late in the Day When (a) Sensitivity Decreases, (b) a More Conservative Criterion Is Adopted, and (c) Both Sensitivity and Bias Change

Measure	*Early in Day*	*Late in Day*
Sensitivity change		
Hit rate	0.84	0.75
False alarm rate	0.16	0.25
d'	1.98	1.35
β	1.00	1.00
Criterion change		
Hit rate	0.84	0.47
False alarm rate	0.16	0.02
d'	1.98	1.98
β	1.00	8.22
Sensitivity and criterion change		
Hit rate	0.84	0.60
False alarm rate	0.16	0.10
d'	1.98	1.54
β	1.00	2.20

Difference Threshold

- Ernst Heinrich Weber (1795-1878)
- Gustav Theodor Fechner (1801–1887)

Weber's Law

- Just Noticeable Difference (JND): smallest detectable change in a stimulus
- JND is a constant proportion of the magnitude of the standard stimulus
  - bigger stimulus requires a bigger change

Weber's Law--JND

$$\Delta I / I = k$$

- Change in intensity of a stimulus (delta I) divided by the original intensity equals a constant.

- *Relative* change, not absolute change, is important.
- 100-105 Hz ~ 1000-1050 (5% change)

Fechner's Law

- What is the value of any sensation?
- Sensation (*S*) is directly proportional to the logarithm of the magnitude of the physical stimulus (*P*) multiplied by a constant, *k*

$$s = k \log P$$

Stevens' Power Law

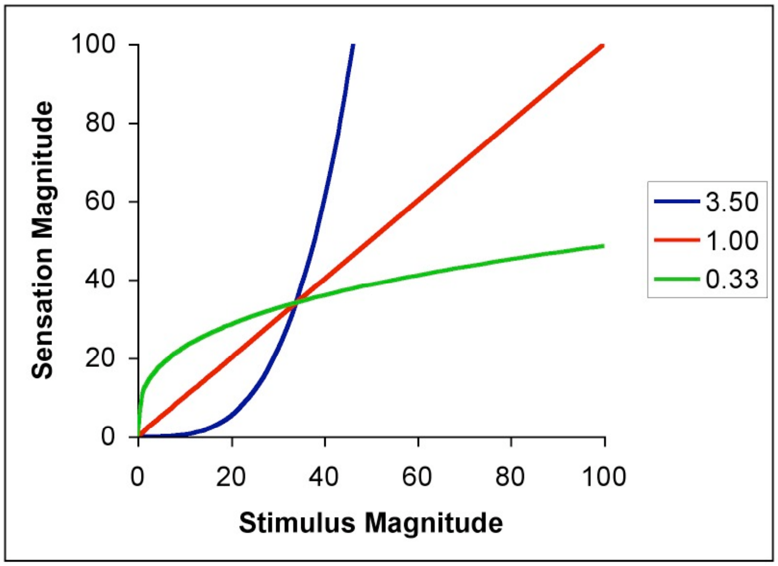
- The magnitude of the sensation (*S*) is equal to a constant (*k*) multiplied by the intensity of the physical stimulus (*I*) raised to the power *a*

$$S = kI^{a}$$

  - If a < 1, compressive
  - If a > 1, expansive
  - If a = 1, veridical

Stevens' Power Law

- Greater than 1.0:
  - magnitude of sensation (S) grows faster than magnitude of stimulus (I)
- Less than 1.0:
  - magnitude of sensation (S) grows slower than magnitude of stimulus (I)



Exponents

- Brightness 0.5
- Loudness 0.6
- Taste (sweet) 0.8
- Duration 1.1
- Pressure (palm) 1.1
- Taste (salt) 1.3
- Electric shock 3.5

  - ➢ 1.0 means accurate perception
  - ➢ Greater than 1.0 or less than 1.0 means systematic distortion

Methodology

- Generally, use precise measurement with (literally) hundreds or thousands of replications

- Magnitude Estimation: assign a number that is proportional to your percept
- Method of Constant Stimuli

Muller-Lyer Illusion

- Franz Müller-Lyer (1889)

Measurement

- How much longer? How much shorter?
- Show line without wings, show line with wings, ask subject to compare percepts
- Systematically vary the length of the line without wings to see when the perceived line lengths match (i.e., 50% responding)
- Line with wings was 100 pixels long

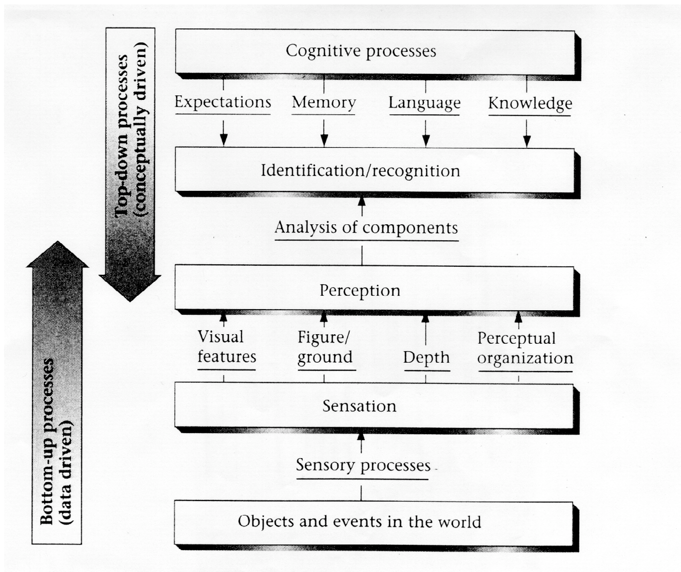
Results

- The line with wings was 100 pixels
- The addition of wings makes it look ~10 pixels longer
    - subjects say the lines are the same when the standard is approximately 110 pixels

Perception

- An internal representation of a stimulus
- Not just the stimulus itself but the interpretation of the stimulus.

Top-down/bottom-up



Senses

- Vision
- Hearing
- Kinesthetic (touch)
- Olfactory (smell)
- Gustatory (taste)

Approaches to the study of perception

- Empiricism v. nativism
- Classical theory (empiricist)
  - experience is paramount
  - outside of awareness (unconscious inference)
  - emphasis on learned strategies

    - break down the stimulus into smaller pieces and then reassemble the bits
- Gestalt theory
    - emphasis on innate structures
    - "the whole is more than the sum of its parts'
    - we hear music, not notes, we see objects not bits of light.
- Ecological optics
    - active exploration of the environment
    - evolved in a dynamic environment
    - focus on motion to solve the problems of perception

Hearing and listening

- Very different from visual system in the sensory transduction
- Similar to visual system in actively processing the environment

Nocturnal Niche

- Warm blooded so can maintain stable metabolic rate

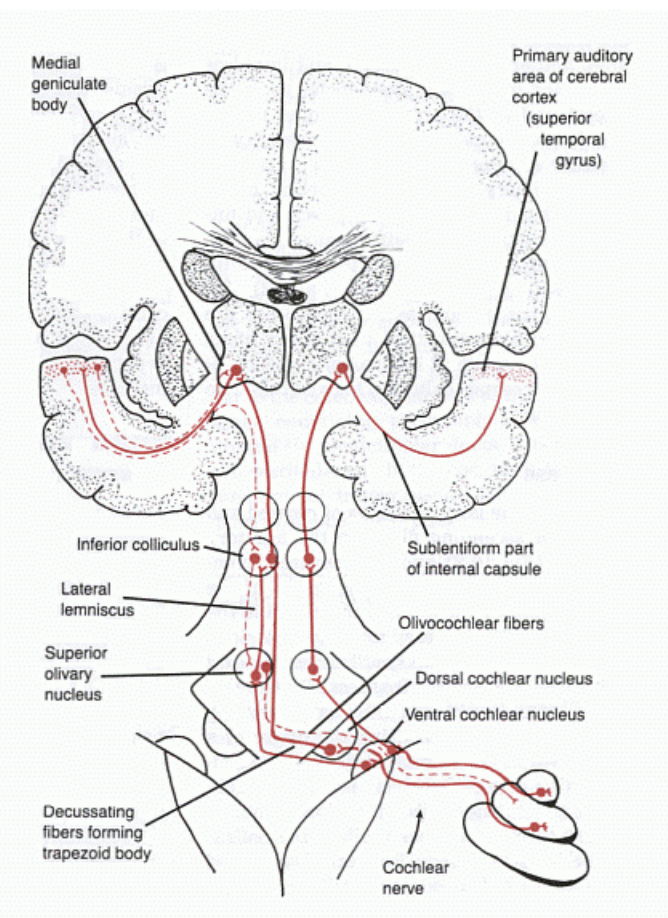
- Could operate in the cold and dark, a niche where there was often less competition for food, and where there were fewer other species that may prey on them.

Mammalian advantages

- Specialized auditory structures (ear bones, OHC) to allow them to hear extremely soft sounds with high resolution
- Higher metabolic rate enabled high frequency hearing
- Cochlear blood supply

  - No direct contact between its structures and the vascular system
  - Keeps noise levels to a minimum
- The ability to hear a variety of soft sounds enhanced localization, an important survival functions for avoiding predation, hunting prey and finding a mate.
- Shrews and bats use high frequency sound pulses to navigate the environment and locate prey at night
- This is the process of echolocation, also known as biosonar, a skill shared with dolphins and whales.

Human hearing



The principal central connections of hearing.

Solid coloured lines show the ascending pathways to the primary auditory cortex.

Descending connections are represented by broken lines.

Sound localization

- Surprisingly, the sensory receptors of the ear contain no capacity for spatial representation like the receptive fields of the eye or skin.
- Instead, each cochlea encodes the temporal, spectral and intensity aspects of sounds to be used by the brainstem to compute a panoramic scope of auditory space.

How does it work?

- Ears separated by enough distance will provide slightly different information regarding sound arrival time provided the sound is not directly in front of or behind the head.
- High frequency sounds, having shorter wavelengths more easily blocked by the head, will differ in relative sound intensity at the two ears referred to as interaural level differences.

Ear Differences

- Arrival Time Differences: sound reaches one ear before the other
    - Interaural Time Differences (ITDs)
- Intensity Differences: sound is a more intense level in one ear than the other
    - Interaural Level Differences (ILDs)
- Both ITD and ILD are used to help localize signals in background noise in the horizontal plane
- Detecting elevation and front-to-back locations are more reliant on spectral cues (frequency)

Changing the pinna

- Sound localization less accurate
- Long-term adaptation
  - After 6 weeks, sound localization back to normal
  - Normal localization obtained even after plugs are removed (original signature remained in memory)

Neural Representation of Auditory Space

- SOC neurons are tuned to timing and intensity level differences existing between the ears for each frequency
- Output from the SOC arrives at the central nucleus of the inferior colliculus, where ITDs and ILDs are combined into frequency–specific maps of interaural differences.
- Inferior colliculus provides an essential relay via the thalamus in the transmission of information to the primary auditory cortex.

How do we localize sound?

- Within the superior colliculus (SC) auditory cues and visual cues are systematically aligned mapping auditory space onto visual space creating a multimodal map that guides orienting movements of the eyes and head.
- The auditory system transforms information from one frame of reference into another to create a map of space in the brain of the barn owl.

Multimodal cells in the frontal lobe

Ears vs. eyes

- Contradictory information, which wins?
  - Ventriloquism
  - Movie theaters
- Pseudophone
  - Male->right
  - Female->left
  - Eyes closed--hear male left, female right
  - Eyes *open*--hear male right, female left
  - ➢ Brain believes your eyes, not your ears.
- Sound v. light
  - Sound bounces/echoes; light doesn't
  - Sound travels slowly; light quickly

Binocular vision and hearing

- Sound localization guides the eyes to a sound of interest
- Panoramic vision (eyes on side of head); large portions of retina of maximum acuity; bad sound localization; prey
- Binocular vision (both eyes in front of head); region of high acuity small; good sound localization; predators

What happens with hearing loss?

- Altered auditory experience such as significant long term hearing loss can have a profound influence in how acoustic space is represented and organized within the brainstem, particularly in infant and juvenile animals.

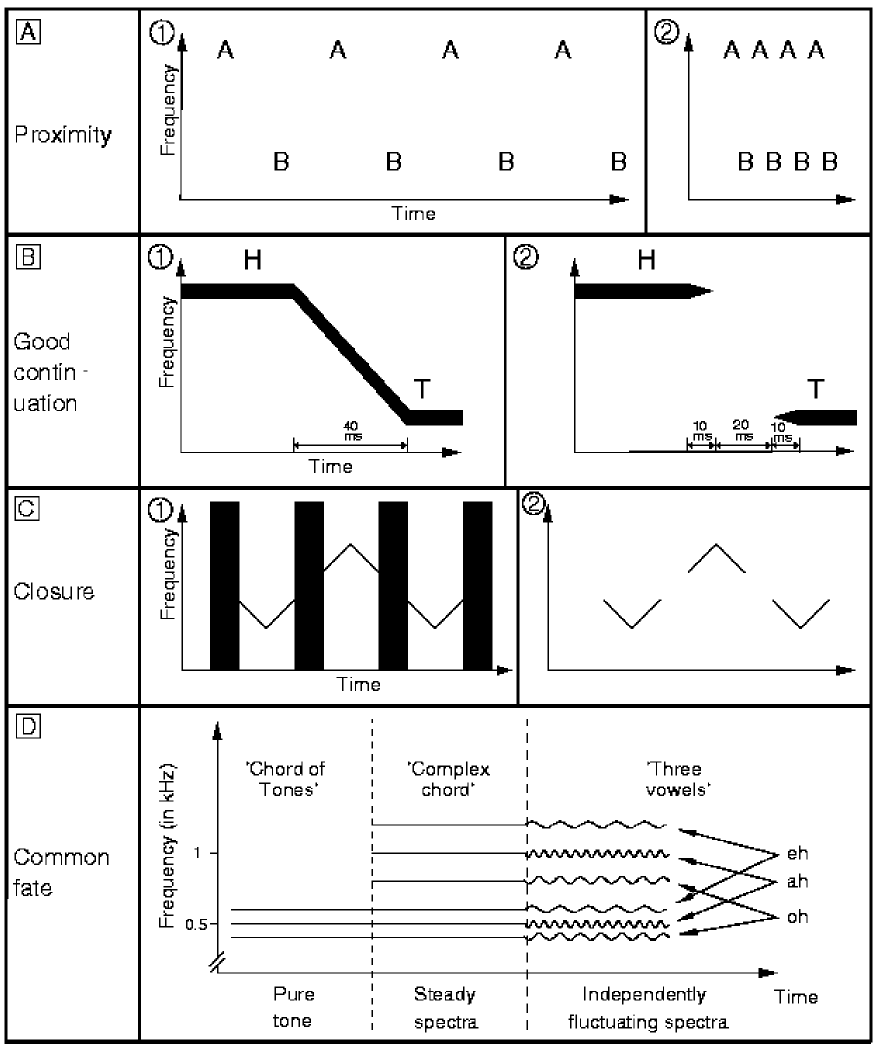
- Recently there has been evidence that the mature auditory system is capable of significant reorganization as well under certain conditions such as intense auditory training.
- Impact on Perception
- Often ignored and left to spontaneously resolve, conductive hearing impairment is far from innocuous despite the ability of many to cope with its effects
- Animal experiments with ear plugging have shown that unilateral hearing impairment is not isolated to the affected ear but impacts on brain function because the central auditory system responds to altered binaural cues by remapping multimodal areas such as the superior colliculus

Plasticity: Reorganization

- The mature nervous system is capable of reorganization consequently adaptive changes do happen, and these can be advantageous or detrimental depending on the circumstance.
- Example: unilateral hearing loss creates impairments in sound localization that can be ameliorated by better utilizing cues available to the unaffected ear.
- This may explain the failure to seek treatment among those who experience unilateral hearing loss because they can manage with their “good” ear.
- However what many fail to realize is that the “good” ear is not as good as it once was for tasks of sound localization in noise because of changes taking place in the CNS in response to altered ITDs and ILDs.

- If audibility is restored, dysfunction may continue for a number of months for tasks that involve utilizing interaural cues.
- This situation can be discouraging for those who sought intervention as it may not appear to be effective.

Gestalt grouping principles



Summary

- Translation of stimulation into signals the brain can read.
- Noisy system--affected by situation (criteria)
- Can determine the form of the translation (psychophysics)--not always 1 to 1
- Perception is modifiable by experience
- Some aspects seem ‘built-in’ (innate)
- Perception is supplemented by top-down influences