Information Aquisition

- Information is the key to survival.
- Information about our external world is acquired by exteroceptors (5 senses - vision, audition, olfaction, tactile, gustation).
- Information about our internal state is acquired by interoceptors (e.g. kinesthesia, proprioception).
- The brain must sift this constant information stream for relevant cues (signals) rather than irrelevant cues (noise).

Quantifying Information: Information Theory

- Information is the reduction of uncertainty.
- Highly probable events convey little information and merely confirm what we anticipate.
- Highly improbable events convey greater information because they are not anticipated.

Information and Behavior

- Information load has functional effects on human performance.
- Information load dramatically affects the speed of a response.
- Information load dramatically affects the accuracy of a response.
Information: Reaction Time

- The speed of reaction to information depends on the time to:
  - Activate the sensory receptor
  - Transmit nerve impulses from the sense organ to the brain
  - Process nerve impulses in the brain
  - Transmit nerve impulses to muscles
  - Energize and activate muscles
  - Execute movement

Simple Reaction Time

- Simple reaction time (SRT):

  Stimulus $\rightarrow$ Response

- SRTs typically range between 150-200 milliseconds (0.15 - 0.2 seconds).
- Auditory SRTs approx. 50 msec. faster than visual SRTs (at 55 mph this equates to ~ 4 feet difference in braking distance).

Choice Reaction Times

- When the operator has choices among alternative stimuli and/or responses (choice reaction time - CRT) then the information load affects reaction times.

  $S_1 R_1$
  $S_2 R_2$
  $\vdots$
  $S_n R_n$

CRTs: Hick's Law (1952)

- In making choices a person gains information at a constant rate:

  $\text{Mean CRT} = K \log_2 (n+1)$

  where $n$ = number of choices
  
  $+1$ = has event occurred or not
  
  $K$ = constant
CRTs: Hick's Law

Information Theory

- Information is quantified in bits (binary digits), and represented by H
- \( H = \log_2 N \) (number of alternatives)
- With 2 alternatives \( H = 1 \) \( (\log_2 2 =1) \)
- With 4 alternatives \( H = 2 \) \( (\log_2 4 =2) \)
- With 8 alternatives \( H = 3 \) \( (\log_2 8 =3) \)

Information and CRT

Information Theory

- When alternative choices are not equiprobable, then the information associated with an even \( (H_i) \) is:
  \( H_i = \log_2 \left( \frac{1}{p_i} \right) \) where \( p_i \) = probability of i
- For a series of events of differing probabilities:
  \( H_{av} = \sum_{i=1} p_i (\log_2 1/p_i) \)

Example

- Assume 2 events of unequal probabilities, \( p_1 = 0.9 \) and \( p_2 = 0.1 \)

  \[
  H_{av} = [(0.1(\log_2 1/0.1))+(0.9(\log_2 1/0.9))]
  = 0.332 + 0.137
  = 0.469 \text{ bit}
  
  \]

Redundancy

- In information theory, redundancy is the reduction in information from the maximum information because of unequal probabilities of occurrence:
  \( \% \text{ redundancy} = (1 - (H_{av}/H_{max})) \times 100 \)
- From previous example:
  \( \% \text{ redundancy} = (1-(0.47/1.0)) \times 100 \)
  \( = 0.53 \times 100 = 53\% \)
- Because certain letter combinations are highly probable (th, qu, st) and others highly improbable (cw, tx, xq) the English language is \(~68\%\) redundant.
Bandwidth

- Bandwidth is the rate of information transmission over a channel.
- Bandwidth of the eye is ~ 1,000 bits/sec
- Bandwidth of the ear is ~ 10,000 bits/sec
- Bandwidth of the brain is much lower than that of the sensory systems!
- Most sensory information is filtered out of the system at a peripheral level to better match the capacity of the brain, which functions as a limited single channel capacity system.

Functional Information Processing

- Sensory Input transduce external energy in a limited spectrum into nerve impulses.
- Sensory information is actively organized by perceptual processes to create and internal representation of our external world.
- Perceptual organization occurs in a 'top-down' manner to impose order on sensory information.

Perceptual Processes

- Detection - determination of whether a stimulus is present or absent. Not a foolproof process.
  - False alarm - report that stimulus is present when absent.
  - Miss - report that stimulus is absent when present.
- Recognition - noticeable familiarity without the ability to label the stimulus.
- Identification - full identification of the stimulus (recognition + labeling).
Perceptual Organization

- **Gestalt principles:**
  - Proximity
  - Similarity
  - Closure
  - Continuity
  - Figure-ground

- **Constancies:**
  - Size
  - Shape
  - Color
  - Brightness

**Constancies**

- **Color** - colors appear the same under a wide range of lighting conditions (e.g. snow looks white and coal looks black in sunlight or moonlight).
- **Brightness** - object brightness looks the same under a range of lighting levels (e.g. the paper of a book looks white under low through bright light.

**Perceptual Processes**

- **Perception** - is an active process whereby the brain strives to make sense of sensory information and fit this to a known pattern.
- **Perception** creates our reality.
- **Perception** can easily be fooled to create illusions.

**Visual Illusions**

- **Illusions** can arise because of **cue conflicts**.
- **Illusions** can arise because of **cue competition**.
- **Illusions** can arise because of **cue ambiguity**.
- **Illusions** can arise because of **cue orientation**.
- **Illusions** can arise because of **time and redundancy**.
Visual Illusions

• Illusions can arise because of context.

Visual Illusions

• Illusions can arise because of mixed cues.

Depth Perception

• Linear environmental cues help with depth perception.

Depth Perception

• Environmental texture cues help with depth perception.

Display Design

• There are principles of perception that apply to each of the senses.
• Ignoring the principles of perception can create dysfunctional information displays.
• Knowledge of the principles of perception helps us to design more effective information displays.