COSC 3461

Principles of UI Design

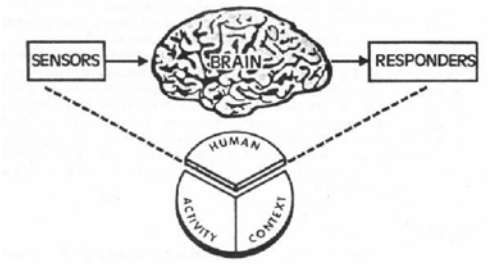
Principles of Design

- "Avoid unnecessary burden"
  - one of the fundamental principles for design
- How is burden is created?
  - what things do human users find difficult?
  - what things do human users find easy?

Human Performance Model

- People performing in systems have in common that they are each somebody, doing something, someplace" (Bailey, 1996)

The Human:
The most complex of the three elements



The Activity

Example: use a pointing device to
- select an icon
- write your name

The Context

Examples:
- physical context, such as noise
- social context, such as crowds or isolation

Parameters of Human Performance

- Sensory-Perceptual processes
  - detection and discrimination of sounds
  - detection and discrimination of visual stimuli
  - visual scene analysis
- Motor processes
  - production of input actions
- Cognitive processing
  - estimating
  - multitasking
- Combined processing
  - reaction to stimuli (latency, accuracy)

Parameters of Human Performance Key Terms

- Reaction time (RT):
  - the elapsed time between the presentation of a sensory stimulus and the subsequent behavioral response
- Mental chronometry:
  - the use of response time in perceptual-motor tasks to infer the content, duration, and temporal sequencing of cognitive operations

Reaction to Stimuli

- Example task:
  - Subject faces a monitor with two regions
    - e.g., R_L (left) and R_R (right)
  - Subject is instructed to press this button when he or she sees a change in R_R, but not R_L
    - (or vice-versa)

Reaction to Stimuli: Average Data

	Typical time req'd (msec)
Sensory receptor	1-38
Neural transmission to brain	2-100
Cognitive-processing delays (brain)	70-300
Neural transmission to muscles	10-20
Muscle latency and activation time	30-70
Total:	**113-528**

Sensory Processing

- Humans are attuned to various forms of energy
  - have multiple "windows" through which to experience the environment

mechanical stimuli: auditory, vestibular, somatosensory senses
chemical stimuli: olfactory and gustatory senses
light stimuli: vision

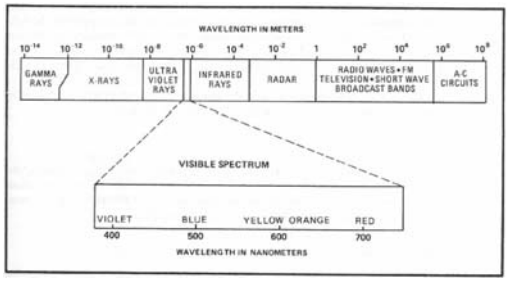
Terminology

Sense	**Other terms**
Vision	Sight
Audition	Hearing
Gustation	Taste
Olfaction	Smell
Vestibular	Tilt and acceleration of head
Somatosensory	
	Touch, pain
	Proprioreception

Detection Thresholds

Sense	Detection Threshold
Vision	Candle flame seen 30 miles on a dark clear night
Audition	Tick of a watch under quiet conditions at 20 feet
Gustation	Teaspoon of sugar in 2 gallons of water
Olfaction	Drop of perfume diffused into a three-room apartment
Touch	Wing of a bee falling on your neck from a distance of 1 cm

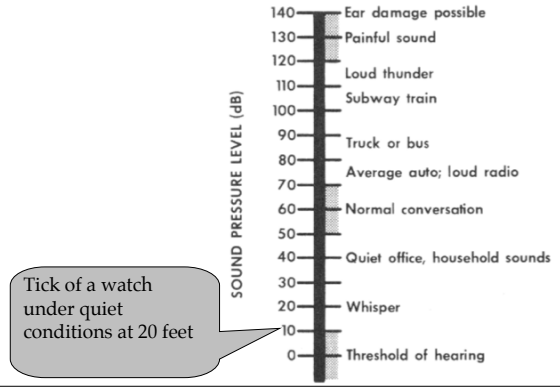
Vision Frequency Limits



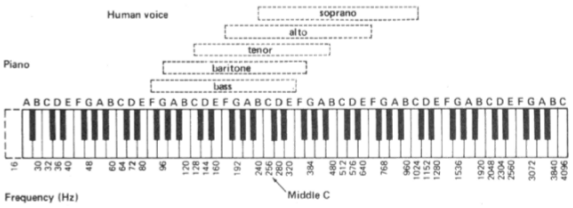
Measurement of Auditory Acuity

- Hearing is a mechanical sense
  - waveforms have a frequency and an amplitude
    - frequency is perceived as pitch
    - amplitude/intensity is perceived as loudness
  - Two Scales (for measuring hearing loss):
    - Sound Pressure Level (SPL)
      - normal hearing thresholds vary with the frequency
    - Hearing Level (HL)
      - scale has been adjusted
      - the scale for each frequency is moved so that normal hearing level is 0 dB

Hearing Intensity Limits



Hearing Frequency Limits



Interaction of Cognitive and Visual Processing

- RCN: Read color names
- NCW: Naming color words

RCN Task

BLUE
PINK
GREY
YELLOW
TAN
RED

List [A]

Task: Subject reads aloud the words in the list as quickly as possible

RCN Task

BLUE
PINK
GREY
YELLOW
TAN
RED

List [B]

Task: Subject reads aloud the words in the list as quickly as possible

NCW Task

BLUE
PINK
GREY
YELLOW
TAN
RED

List [A]

Task: Subject names the colour with which each words is printed as fast as possible

NCW Task

BLUE
PINK
GREY
YELLOW
TAN
RED

List [B]

Task: Subject names the colour with which each words is printed as fast as possible

RCN Task

BLUE
PINK
GREY
YELLOW
TAN
RED

List [A]

BLUE
PINK
GREY
YELLOW
TAN
RED

List [B]

Task: Subject says the words in each list as quickly as possible
Measure: speed and accuracy of responses
Expected Results: ???

RCN Task

BLUE
PINK
GREY
YELLOW
TAN
RED

List [A]

BLUE
PINK
GREY
YELLOW
TAN
RED

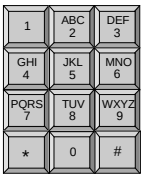
List [B]

Task: Subject says the words in each list as quickly as possible
Measure: speed and accuracy of responses
Expected Results: ???

Interaction of Cognitive and Visual Processing

- The results of the RCN and NCW tasks:
  - subjects perform better for List A than List B
  - the visual information "primes" the lexical retrieval process (in the case of RCN)
  - the lexical information "primes" the visual process (in the case of NCW)
- This illustrates interference in the reaction time of a task
- This described as the "Stroop Effect"
  - after Stroop, who conducted this research (1935)
  - sometimes referred to as "Stroop Interference"

The Stroop Effect in Interfaces



Consider the numeric keypad above

Is there Stroop interference when entering a phone number, such as 1-800-HELLO, on a telephone keypad?

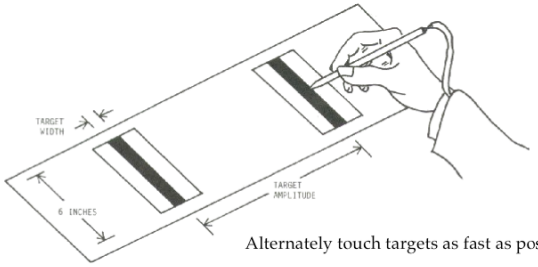
Production of Input Actions

- The term mimetic refers to a style of interaction that mimics real-life actions
  - e.g., pointing/dragging in real-life vs. pointing/dragging with a pointer (such as mouse, trackball, etc)
- How fast (or accurately) can a human manipulate on-screen objects?
  - E.g., point, drag

Production of Input Actions

- Pointing and dragging actions can be elicited by special experimental tasks
  - serial pointing
  - discrete pointing
  - These experimental arrangements are commonly described as following the Fitt's paradigm

Serial Pointing Task

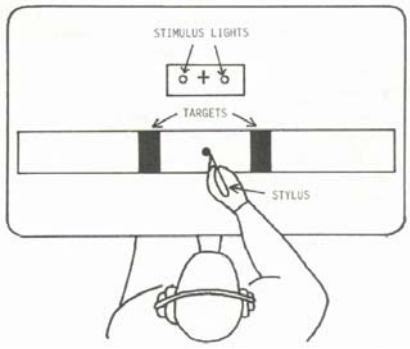


Alternately touch targets as fast as possible

Serial task is also known as the reciprocal tapping task.

(Fitts, 1954)

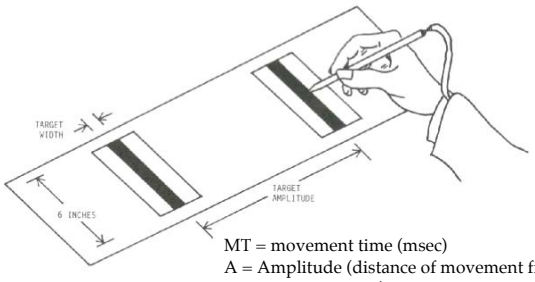
Discrete Pointing Task



Fitts' Law

- Fitts' Law is a model
  - The model predicts time required by humans to perform rapid, aimed movements
- MT denotes Movement Time (msec)
  - Discussion:
    of which variables would you expect MT to be a function?

Serial Pointing Task



MT = movement time (msec)
A = Amplitude (distance of movement from start to target center)
W = Width

MT = f(A, W)

Fitts' Law

$MT = a + b \log_2(2A/W)$

where:

MT = movement time (msec)

a, b = regression coefficients

A = distance of movement from start to target center

W = width of the target

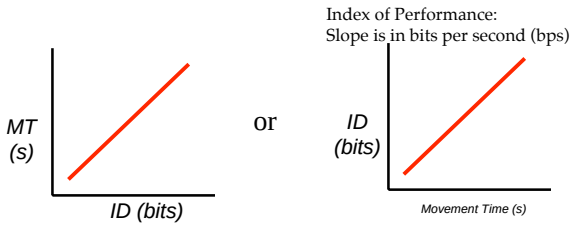
Index of Difficulty

- Fitts' actual proposal:
  - the movement time (MT) to select a target has a linear correlation to the Index of Difficulty (ID)
  - MT measured in time (msec)
  - ID measured in information (bits)
- How does this make sense?
  - How can ID be measured in bits?

"Information Processing"

- Does the human motor system have a capacity to process information?
- Shannon, Wiener, and others proposed a formal model of information in the 1940s
  - Introduced terms such as "probability", "redundancy", "bits", "noise", and "channels"
- "Information" models of psychological processes emerged in the 1950s
  - Created analogs of information-theoretic terms for human behaviour
    - A signal gets transmitted through a medium and is perturbed by noise
    - The effect of noise is to reduce the information capacity of the channel from its theoretical maximum
  - Capacity measured in bits/sec

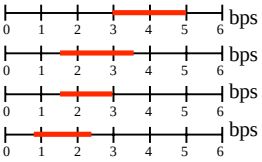
Index of Performance



- Each device has its own slope
- Slope needs to be determined empirically
  - It is a performance measure
  - The steeper the slope, the greater the throughput

Throughput for Various Pointers

- Mouse
- Trackball
- Joystick
- Touchpad



- Need to control for many factors:
  - individual differences
  - learning
  - apparatus
  - experimental procedure