Human Variance (1)

Stature (Item 34) in inches

<table>
<thead>
<tr>
<th></th>
<th>1st</th>
<th>5th</th>
<th>50th</th>
<th>95th</th>
<th>99th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>63.1</td>
<td>64.8</td>
<td>69.1</td>
<td>73.5</td>
<td>75.2</td>
</tr>
<tr>
<td>Women</td>
<td>58.4</td>
<td>60.2</td>
<td>64.1</td>
<td>68.4</td>
<td>70.1</td>
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</table>

Functional Reach (Item 43) in inches

<table>
<thead>
<tr>
<th></th>
<th>1st</th>
<th>5th</th>
<th>50th</th>
<th>95th</th>
<th>99th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>28.4</td>
<td>29.1</td>
<td>31.5</td>
<td>34.1</td>
<td>35.3</td>
</tr>
<tr>
<td>Women</td>
<td>25.9</td>
<td>26.7</td>
<td>28.9</td>
<td>31.4</td>
<td>32.4</td>
</tr>
</tbody>
</table>

Data from FAA Human Factors Design Guide
Human Variance (2)

High Forward Reach Limit

High and Low Side Reach Limits

Data from Department of Justice ADA Title III, Regulation 28 CFR Part 36
Human Variance (3)

Male subject lifting an object (above)

Female subject lifting the same object

Human Activity Cycle (1)

1. **Goals**
2. **Intention to act**
3. **Sequence of actions**
4. **Execution of the action sequence**
5. **Perceiving the state of the world**
6. **Interpreting the perception**
7. **Evaluation of interpretations**
Human Activity Cycle (2)

- Goals
- Intention to act
- Sequence of actions
- Execution of the action sequence
- Evaluation of interpretations
- Interpreting the perception
- Perceiving the state of the world

Sequence of actions:
1. Goals
2. Intention to act
3. Sequence of actions
4. Execution of the action sequence
5. Evaluation of interpretations
6. Interpreting the perception
7. Perceiving the state of the world
Human Factors Model

from http://www.hf.faa.gov/Webtraining/HFModel/HFInterModel/overview.htm
Human Cognitive Component

- Attention (ความตั้งใจ)
- Memory (ความทรงจำ)
- Information Processing (การประมวลผลข้อมูล)
- Decision Making (การตัดสินใจ)
- Action Initiation (การเริ่มต้นการกระทำ)
Human Musculoskeletal Component

- Motor Co-ordination (การเคลื่อนไหว)
- Action Performance (ประสิทธิภาพ)
- Object Manipulation (การจัดการกับวัตถุ)
Brain

Human Information Processing

Human

Input (the senses)

Human Information Processing

Output

Computer

Output (e.g. monitors)

Central Processing Unit

Input (e.g. keyboard, mouse)
Human versus Machine

- Alertness
- Speed and power
- Sensor detection outside human range
- Routine work
- Computation
- Short-term memory storage
- Simultaneous activities

- Stimulus
- Generalization
- Abstract concepts
- Alertness
- Speed and power
- Sensor detection outside human range
- Routine work
- Computation
- Short-term memory storage
- Simultaneous activities

- Human
- Machine
- Differences
- Able to sense
- Able to generalise
- Abstract concepts
- Agility
- Decision making
- Memory
- Simultaneous activities

C. Patanothai
Human Information Processing
(more detailed)
PERCEPTION
Visible Spectrum
Visual perception

การมองเห็นมี 2 ระยะ

• สายตากรุ๊ปต่อสิ่งกระตุ้น
  บางอย่างที่มองไม่เห็น

• ประมวลผลและแปล
  สร้างภาพจากข้อมูลที่ไม่สมบูรณ์ได้
The Eye - physical reception

- Cornea
- Pupil
- Iris
- Lens
- Retina
- Macula
- Optic nerve
- Blind spot
- To the brain
The Eye - physical reception

- รับแสงแล้วแปลงเป็นพลังงานไฟฟ้า
- แสงสะท้อนจากวัตถุ
- ได้รูปกลับหัวที่จอตา (retina)
  - rods for low light vision and
  - cones for color vision, photoreceptors for RGB
Upside down image
Interpreting the signal

Size and depth

- visual angle indicates how much of view object occupies (relates to size and distance from eye)
- visual acuity is ability to perceive detail (limited)
- familiar objects perceived as constant size (law of size constancy)
  (in spite of changes in visual angle when far away)
- cues like overlapping help perception of size and depth
Interpreting the signal (cont)

Brightness
- subjective reaction to levels of light
- contrast – a function of the luminance of an object and the luminance of its background

Color
- made up of hue, intensity, saturation
  - lightness – light vs. dark
  - hue – light’s spectral wavelength; B -> G -> R
  - saturation – amount of whiteness in the color
Color

[Image of a color selection dialog box showing RGB and HSL models with color values and transparency settings.]
Color perception

- Cones sensitive to color wavelengths
  - 8% males and 1% females color blind (red and green)
  - Red photopigments ~64%
  - Green ~32%
  - Blue ~4%
Color Receptors - RODS

Rods - provide "scotopic" or low intensity vision.

- Provide our night vision ability for very low illumination,
- Are a thousand times more sensitive to light than cones,
- Are much slower to respond to light than cones,
- Are distributed primarily in the periphery of the visual field.
Color Receptors - CONES

- Cones - provide "photopic" or high acuity vision.
  - Provide our day vision,
  - Produce high resolution images,
  - Determine overall brightness or darkness of images,
  - Provide our color vision, by means of three types of cones:
    - "L" or red, long wavelength sensitive,
    - "M" or green, medium wavelength sensitive,
    - "S" or blue, short wavelength sensitive.
Color blind test
Cones

<table>
<thead>
<tr>
<th>Cone type</th>
<th>Name</th>
<th>Range</th>
<th>Peak wavelength</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>β</td>
<td>400–500 nm</td>
<td>420–440 nm</td>
</tr>
<tr>
<td>M</td>
<td>γ</td>
<td>450–630 nm</td>
<td>534–545 nm</td>
</tr>
<tr>
<td>L</td>
<td>ρ</td>
<td>500–700 nm</td>
<td>564–580 nm</td>
</tr>
</tbody>
</table>
Cone response

![Cone response graph showing absorbance across different wavelengths](image)
Interpreting the signal (cont)

- The visual system compensates for:
  - movement
  - changes in luminance.

- Context is used to resolve ambiguity

- Optical illusions sometimes occur due to over compensation
Color Illusion
Optical Illusions

the Ponzo illusion

the Muller Lyer illusion
Optical Illusions
Wheel
Girl Spinning (clockwise?)
Impossible Door
Optical Illusions

The quick brown fox jumps over the lazy dog.
Reading

Several stages:
- visual pattern perceived
- decoded using internal representation of language
- interpreted using knowledge of syntax, semantics, pragmatics

Reading involves saccades and fixations

Perception occurs during fixations

Word shape is important to recognition

Negative contrast improves reading from computer screen
Reading

Positive contrast
The speed at which text can be read is a measure of its legibility (easy to read)

Negative contrast
The speed at which text can be read is a measure of its legibility (easy to read)
Reading

- The pure red primary should never be used on a pure blue primary background.
- This generates chromostereopsis or depth through color perception. It also creates reading difficulties.

- The pure blue primary should never be used on a pure red primary background.
- This generates chromostereopsis or depth through color perception. It also creates reading difficulties.
Most individuals perceive the red text as being closer than the blue. Others perceive the blue text to be closer than the red. A few individuals perceive no difference.
Can you read this?

"Aoccdrnig to rscheearch at Cmabridge Uinvervtisy, it deosn’t mttae in waht oredr the litteers in a wrod are, the olny iprmoetnt tihng is taht the frist and lsat ltteer be at the rghit pclae. The rset can be a ttoal mses and you can sitll raed it wouthit a porbelm. Tihs is besauae ocne we laren how to raed we bgien to aargnre the lteerts in our mnid to see waht we epxcet to see. The huamn mnid deos not raed ervey lteter by istlef, but preecsievsthe wrod as a wlohe. We do tihs ucnsoniuscoly wuithot tuhoght."
Can you read this?

"AOCCDRNIG TO RSCHEEEARCH AT CMABRIDGE UINVERVTISY, IT DEOSN'T MTTAER IN WAHT OREDR THE LITTEERS IN A WROD ARE, THE OLNY IPRMOETNT TIHING IS TAHT THE FRIST AND LSAT LTTEER BE AT THE RGHIT PCLAE. THE RSET CAN BE A TTOAL MSES AND YOU CAN SITLL RAED IT WOUTHIT A PORBELM. TIHS IS BESAUAE OCNE WE LAREN HOW TO RAED WE BGIEN TO AARGNRE THE LTEERTS IN OUR MNID TO SEE WAHT WE EPXCET TO SEE. THE HUAMN MNID DEOS NOT RAED ERVEY LTETER BY ISTLEF, BUT PREECSIEVS THE WROD AS A WLOHE. WE DO TIHS UCNSONIUSCOLY WUITHOT TUHOGHT."
Different Perspective
Hearing

- Provides information about environment: distances, directions, objects etc.

- Physical apparatus:
  - outer ear — protects inner and amplifies sound
  - middle ear — transmits sound waves as vibrations to inner ear
  - inner ear — chemical transmitters are released and cause impulses in auditory

- Sound
  - hertz — unit of frequency
  - pitch — sound frequency
  - loudness — amplitude
  - timbre — type or quality
Hearing (cont)

- Humans can hear frequencies from 20Hz to 15kHz
  - less accurate distinguishing high frequencies than low.

- Auditory system filters sounds
  - can attend to sounds over background noise.
  - for example, the cocktail party phenomenon.
Hearing (cont)

- **Transduction**
  - translation of sound vibration into neural impulses by the ear.

- **Auditory grouping processes**
  - sound elements are
    - segregate into separated streams
    - integrated into sound in coherent streams

- **Scene analysis**
  - extraction of perceptual properties

- **Interpretation**
Suggest different ways in which information belonging to a typical desktop could be displayed using sound.
Touch

- Provides important feedback about environment.
- May be key sense for someone who is visually impaired.
- Stimulus received via receptors in the skin:
  - thermoreceptors – heat and cold
  - nociceptors – pain
  - mechanoreceptors – pressure (some instant, some continuous)
- Some areas more sensitive than others e.g. fingers.
- Kinesthesia - awareness of body position
  - affects comfort and performance.
Memory Components

- Stimuli
- Sensory Memory (Register)
- Short-Term Memory
- Long-Term Memory
Memory Component

Stimuli → Sensory Memory (Register) → encode → Short-Term Memory → Maintainance Rehearsal → Long-Term Memory

retrieval
sensory memory

Buffers for stimuli received through senses
- iconic memory: visual
- echoic memory: aural
- haptic memory: touch

Examples
- “sparkler” trail
- stereo sound

Continuously overwritten
Short-term memory (STM)

- Working memory
- Scratch-pad for temporary recall
  - rapid access ~ 70 ms
  - rapid decay ~ 30 sec
  - limited capacity - $7 \pm 2$ chunks
Examples

212348278493202
0121 414 2626
HEC ATR ANU PTH ETR EET

THE CAT RAN UP THE TREE
remember the shapes
remember the shapes
Memory Aids

- **Acronyms**
  - first letter of every word: SOTUS

- **Acrostics/Sentences**
  - first letter → create new words

- **Rhymes/Songs**
  - กรุงเทพมหานคร...
Long-term memory (LTM)

- Repository for all our knowledge
  - slow access ~ 1/10 second
  - slow decay, if any
  - huge or unlimited capacity
LTM Types

- **Declarative**
  - structured memory of facts, concepts, skills, information related to meaning
- **Episodic/autobiographical**
  - serial memory of events
- **Procedure**
  - stores our knowledge of how to do thing
LTM Types

http://www.hf.faa.gov/webtraining/Cognition/cognition_images/simple_LTM.gif
LTM Types

"I know that...even numbers end with the digits 0, 2, 4, 6, and 8!"

"I know how...to pronounce and comprehend new vocabulary!"

"I remember when...I graduated from high school!"

DECLARATIVE KNOWLEDGE

PROCEDURAL KNOWLEDGE

EPISODIC KNOWLEDGE

LONG-TERM MEMORY

http://projects.coe.uga.edu/epltt/images/8/8f/Information_2.jpg
LTM - Storage of information

- **rehearsal**
  - Information moves from STM to LTM

- **total time hypothesis**
  - Amount retained proportional to rehearsal time

- **distribution of practice effect**
  - Optimized by spreading learning over time
LTM – Retrieval

- **Recognition**
  - search memory and then decide whether the piece of information matches what you have in your memory store
  - multiple choices

- **Recall**
  - recognized and then specific, associated information found and retrieved from long-term memory.
  - Recall is more like a fill-in-the-blank test
**LTM - Forgetting**

- **accessibility**
  - whether or not we are able to retrieve information which has been stored in the memory

- **availability**
  - whether or not it was stored in memory

- Metaphor: library
LTM - Forgetting

encoding failure

- insufficient of time, lack of rehearsal

interference

- retroactive interference: new information replaces old
- proactive interference: old may interfere with new

retrieval failure

- trace decay: not access for long time
- lost linkage: The memory is still in storage, but retrieval cues or links to find it have been lost
Multi-store memory

Sensory information

Sensory input selectively attended

Central executive
Visuo-spatial sketchpad
Articulatory loop

Semantic memory
Procedural memory
Biographical memory
Permastore

Output response

Rehearsal
Store
Retrieval

Sensory memory
Short-term memory
Long-term memory
Movement

- Time taken to respond to stimulus: reaction time + movement time
- Movement time dependent on age, fitness etc.
- Reaction time - dependent on stimulus type:
  - visual ~ 200ms
  - auditory ~ 150 ms
  - pain ~ 700ms
- Increasing reaction time decreases accuracy in the unskilled operator but not in the skilled operator.
Fitts' Law describes the time taken to hit a screen target:

\[ T = a + b \log_2 \left( \frac{D}{W} + 1 \right) \]

where:  
- \( a \) and \( b \) are empirically determined constants  
- \( T \) is movement time  
- \( D \) is Distance  
- \( W \) is the Width of target

\[ ID = \log_2 \left( \frac{D}{W} + 1 \right) \]

⇒ targets as large as possible  
distances as small as possible
Thinking

Reasoning
deduction, induction, abduction

Problem solving
Thinking

Reasoning
- deduction
- induction
- abduction

Problem solving
Deductive Reasoning

**Deduction:**
- derives $b$ as a consequence of $a$.
- the process of deriving the consequences of what is assumed.
- derives logically necessary conclusion from given premises.

  e.g. If it is Friday then she will go to work
       It is Friday
       Therefore she will go to work.

**Logical conclusion not necessarily true:**

  e.g. If it is raining then the ground is dry
       It is raining
       Therefore the ground is dry
Deduction (cont.)

When truth and logical validity clash …

e.g. Some people are babies
Some babies cry
Inference - Some people cry

Correct?

People bring world knowledge to support reasoning process
Inductive Reasoning

- Induction:
  - generalize from cases seen to cases unseen
  - e.g. all elephants we have seen have trunks
  - therefore all elephants have trunks.

- Unreliable:
  - can only prove false not true

- Humans not good at using negative evidence
  - e.g. Wason's cards
Wason's cards

The cards have a letter on one side and a number on the other side.

If a card has a vowel on one side it has an even number on the other.

Is this true?
How many cards do you need to turn over to find out?
.... and which cards?
Abductive reasoning

- uses deductive + inductive reasoning from event to cause
  - e.g. Sam drives fast when drunk.
    - If I see Sam driving fast, assume drunk.

- Unreliable:
  - can lead to false explanations
Problem solving

Process of finding solution to unfamiliar task using knowledge.

Several theories.

Gestalt
- problem solving both productive and reproductive
- productive draws on insight and restructuring of problem
- reproductive uses previous experience and what is already known
Gestalt laws of perception

- Proximity
- Continuity
- Closure
- Similarity
- Pragnanz
Proximity

Law of Proximity:
Objects near each other tend to be grouped together.

The circles on the left appear to be grouped in vertical columns, while those on the right appear to be grouped in horizontal rows.
Continuity

Law of Continuity:

Lines are seen as following the smoothest path.

In the image above, the top branch is seen as continuing the first segment of the line. This allows us to see things as flowing smoothly without breaking lines up into multiple parts.
Closure

Law of Closure:

Objects grouped together are seen as a whole.

We tend to ignore gaps and complete contour lines. In the image above, there are no triangles or circles, but our minds fill in the missing information to create familiar shapes and images.
Similarity

Law of Similarity:

Items that are similar tend to be grouped together.

In the image above, most people see vertical columns of circles and squares.
Pragnanz (figure-ground)

Law of Pragnanz:

Reality is organized or reduced to the simplest form possible.

For example, we see the image above as a series of circles rather than as many much more complicated shapes.
Pre-attentive features

- symmetry
- color
- size
- shape
Interference Effects

conjunction search

pre-attentive processing
Other interference effects
**Problem solving (cont.)**

Root cause analysis (RCA)

- aims at identifying the root causes of problems or events.
Problem solving (cont.)

Analogy

- analogical mapping:
  - novel problems in new domain?
  - use knowledge of similar problem from similar domain
- analogical mapping difficult if domains are semantically different

Skill acquisition

- skilled activity characterized by chunking
  - lot of information is chunked to optimize STM
- conceptual rather than superficial grouping of problems
- information is structured more effectively
**Errors and mental models**

**Types of error**

- **slips**
  - right intention, but failed to do it right
  - causes: poor physical skill, inattention etc.
  - change to aspect of skilled behaviour can cause slip

- **mistakes**
  - wrong intention
  - cause: incorrect understanding
Emotion (cont.)

- The biological response to physical stimuli is called *affect*.

- Affect influences how we respond to situations:
  - positive → creative problem solving
  - negative → narrow thinking

  “Negative affect can make it harder to do even easy tasks; positive affect can make it easier to do difficult tasks”

  (Donald Norman)
Individual differences

- **long term**
  - sex, physical and intellectual abilities

- **short term**
  - effect of stress or fatigue

- **changing**
  - age

Ask yourself:
will design decision exclude section of user population?
Factors affecting perception

Perceptual set – our expectations of a situation

- Expectations
- Past experience
- Affect
- Motivation
- Individual differences
- Cultural factors
Model of Thought
Neural Representation

http://brainmuseum.org/circuitry/neuralreality.gif
References

FAA Human Factors websites
http://www.hf.faa.gov/Webtraining/Intro/Intro1.htm