

EE4213 Human-Computer Interaction

Week 2 Human Models

Human

1. Human Model
2. Human Senses
3. Human Memory and Reasoning
4. Mental Model

Why Study Human?

We need to the properties of Human.

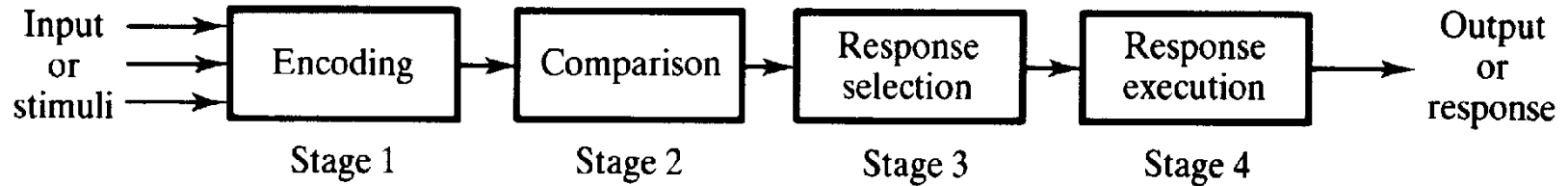
When we try to understand something, particularly new, we use a combination of

- **What our senses** (sight, hearing, touch, smell, taste) are telling
- **Past experience**
- **Our expectations**

Example: when we browse a new Web, our past experience tells us that underlined blue text is supposed to be a link

Human Model

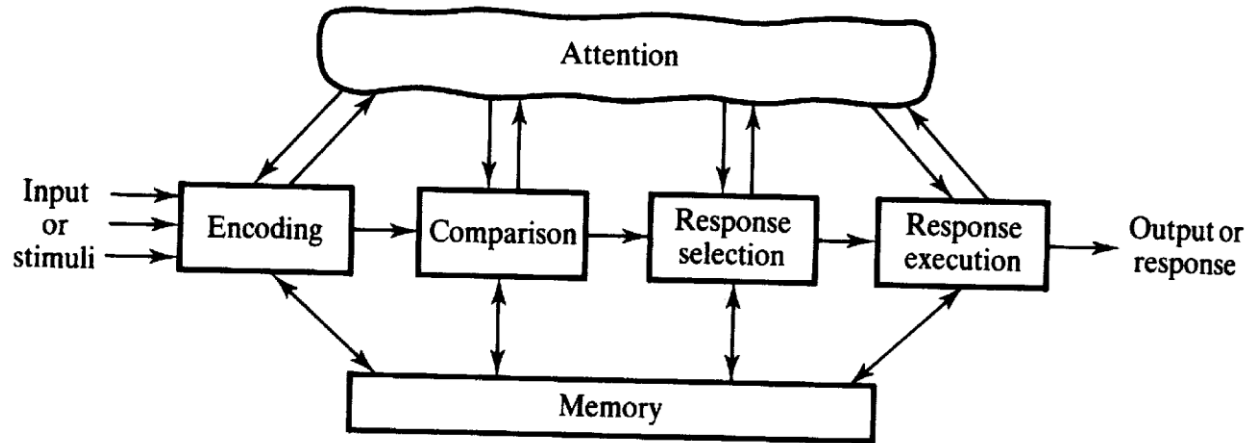
Human can be viewed as an information processing system.



- In stage 1, encoding information from the environment into internal some form of internal representation.
- In stage 2, the internal representation of the stimuli is compared with the stored information in the brain.
- Stage 3 is concerned with deciding on a response to the encoded stimulus.
- Stage 4 deals with the organization of the response and the necessary action.

Human Model

Extending the human information processing model



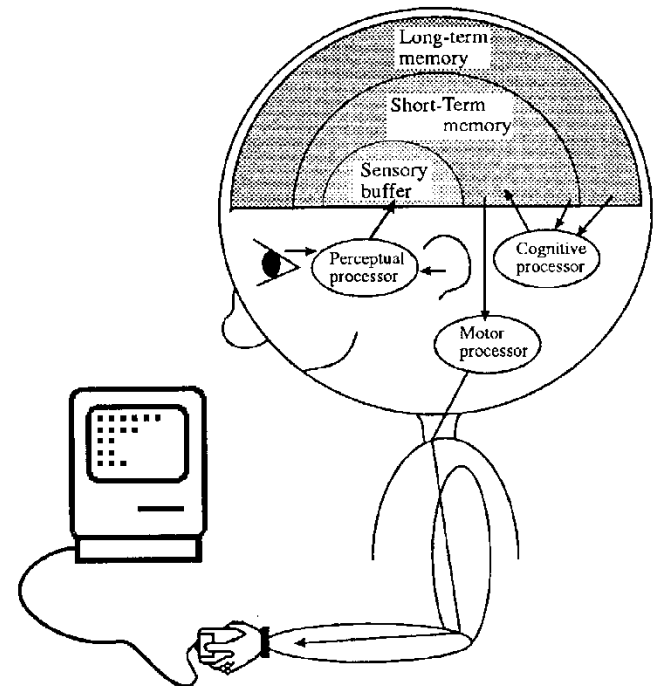
Attention

- Focusing attention - ability to attend to certain events from a number of competing stimuli. (cocktail party phenomenon)
- Divided attention – ability to carry more than one task at the same moment. (driving and holding a conversation).

Human Model

Card, Moran & Newell's Model comprises 3 interacting systems:

1. **Perceptual system** consists of sensors & associated buffer memories:
 - Visual image store
 - Auditory image store
2. **Cognitive system** consists of short-term & long-term memories
3. **Motor system** carries out response formulated by cognitive system



Capabilities of humans in these areas are important to design.

Human Senses

The “five senses” are:

- Sight
- Hearing
- Touch
- Smell
- Taste

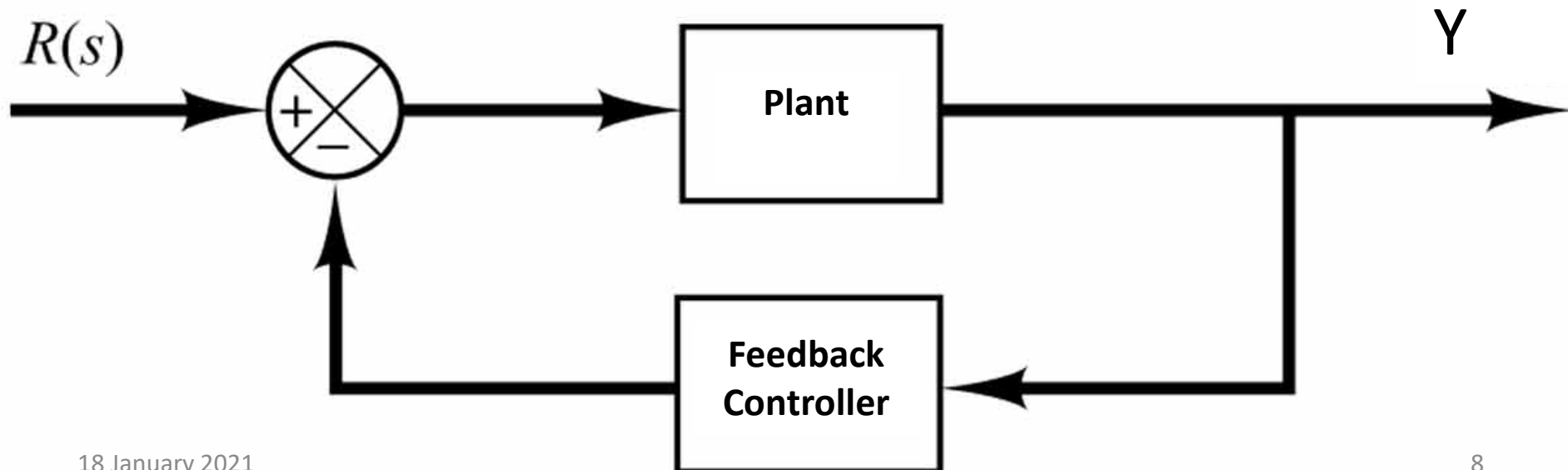
They can interact with computing systems:

Input to Human	Output from Human
Vision Audition Balance Olfaction Touch ...	Speech Motor Control Biometrics, e.g., fingerprint ...

Open-Loop Control Systems



Closed-Loop Control Systems



Open-Loop vs Closed-Loop

- Filling a glass of water



- Music



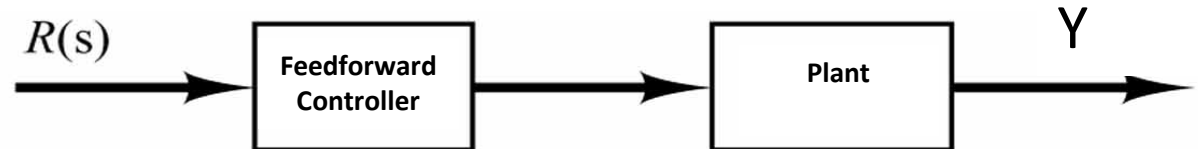
- Parking



Open-Loop Control Systems

- Advantages

- Simple
- Less expensive
- No stability problem
- Convenient when output is hard to measure

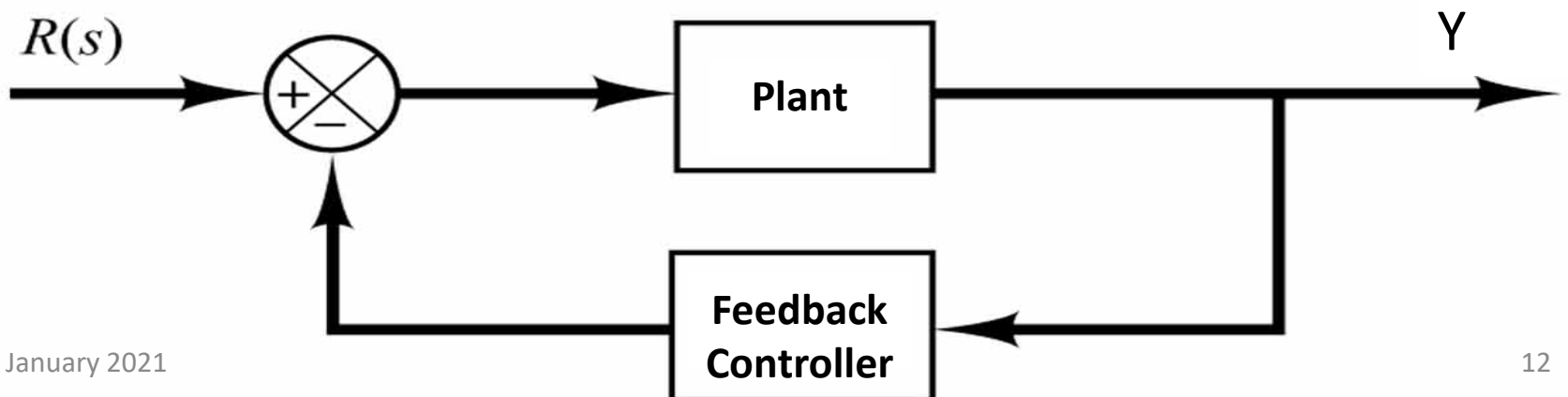


- Disadvantages

- Disturbances and changes in calibration causes errors and the output may be different from what is desired
- Recalibration is necessary to maintain output quality

Closed-Loop Control Systems

- Advantage
 - Less sensitive to modeling errors, e.g.
 - External disturbances
 - Internal variances in system
- Disadvantage
 - Stability problem (oscillations)



Human Model

Important to consider in design

- Capabilities of humans in these areas
- Individual differences

Areas of importance

- Perception - vision/reading, hearing, touch
- Memory
- Thinking and reasoning

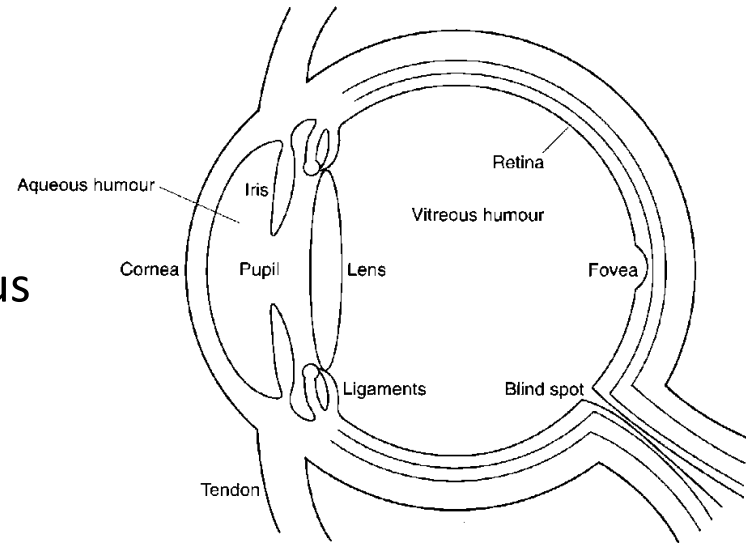
Input Channel: Vision

Two stages in vision

- physical reception of stimulus
- processing and interpretation of stimulus

The physical apparatus: the eye

1. light reflects from objects; their images are focused upside down on **retina**.
2. retina contains
 - cones (concentrated on the fovea) for colour vision
 - rods (concentrated in the outer parts) for low light vision (sensitive to light)



Remark: *We will cover more about human vision in the next lecture.*

Input Channel: Vision

Cones

- 6-7 *10⁶ per eye
- One cone-cell connected to one nerve
- Photopic vision (bright-light vision)

Rods

- 75-150 *10⁶ per eye
- Several rods connected to one nerve
- Scotopic vision (dim-light vision)

Distribution of sensors is important for vision

Distribution is radial symmetric around Fovea

Input Channel (Vision) → Design implication

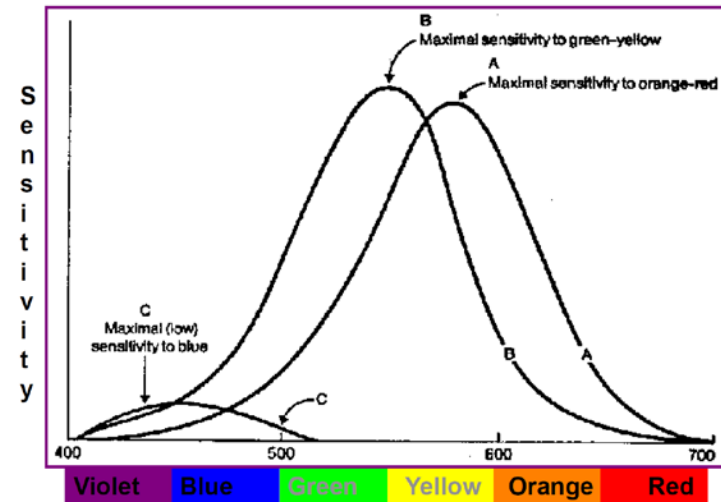
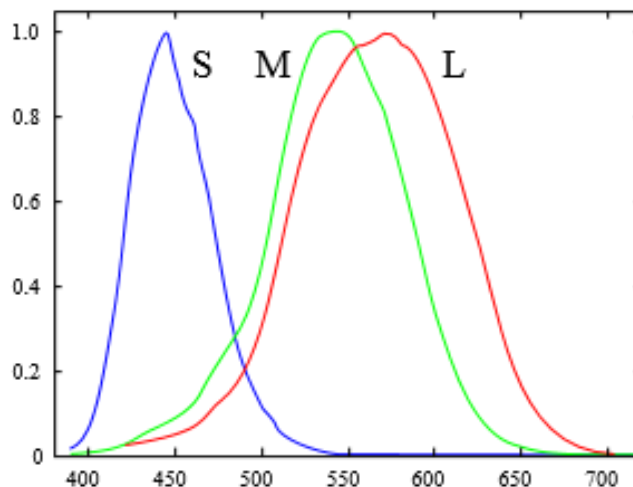
Color Vision

Color sensitivity of 3 types of cones

- A - mostly red,
- B - mostly green,
- C - mostly blue

Eye most sensitive to green/yellow

Eye least sensitive to blue

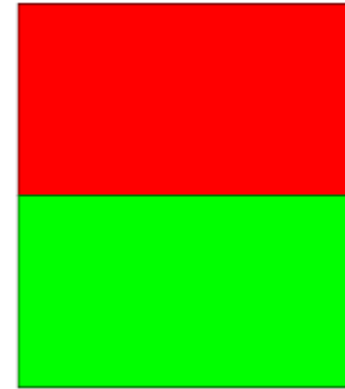


human computer interaction 2013, fiv

Input Channel (Vision) → Design implication

Defective colour vision

- 8% males, 0.5% females
- Red/green blindness is most common

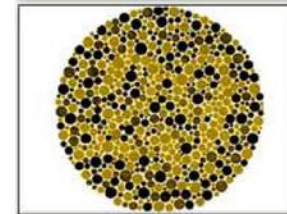
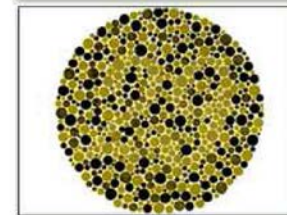
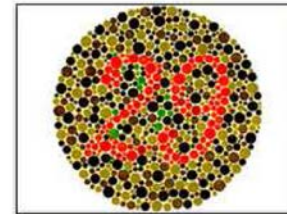


Color Blindness

- Normal
- Protans
– (red weak)
- Deutans
– (green weak)



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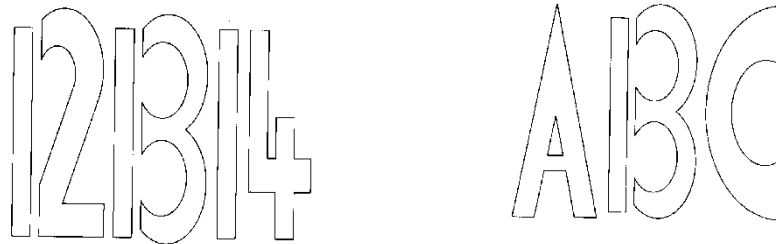
From webexhibits.org

Interpreting the signal

- The visual system compensates for:
 - movement
 - changes in luminance.
- Context is used to resolve ambiguity
- Optical illusions sometimes occur due to over compensation

Input - Output Channels (Vision: Context)

- The visual system compensates (auto-correction) for movement and changes in luminance
- Although the retinal image is moving, the image that we perceive is stable. Unless there is a large change in luminance, the brightness of an objects are perceived as constant.
- Context is used to resolve ambiguity.



Constructivism

A theory about vision is **constructivism**:

- Our brains do not create pixel-by-pixel images
- Our minds create, or *construct*, models that summarize what comes from our senses
- These models are what we perceive
- When we see something, we do not remember all the details, only those that have meaning for us

Design implication:

- **Do not expect people “see” all the details of an interface because people filter out irrelevant information and save only the important ones**

Input - Output Channels

- Constructivist theory states that **context** plays a major role in what we see in an image
- What do you see?



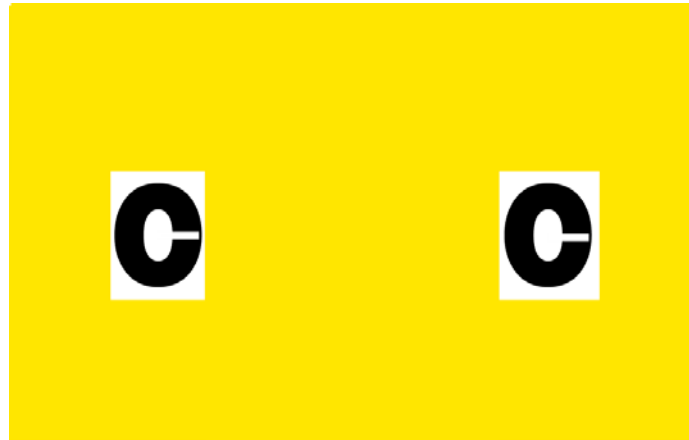
Input - Output Channels

Why we cannot see it at first?

We had no idea what to expect because there was no context

Now we have context, we can recognize easily next time

Are these letters the same?



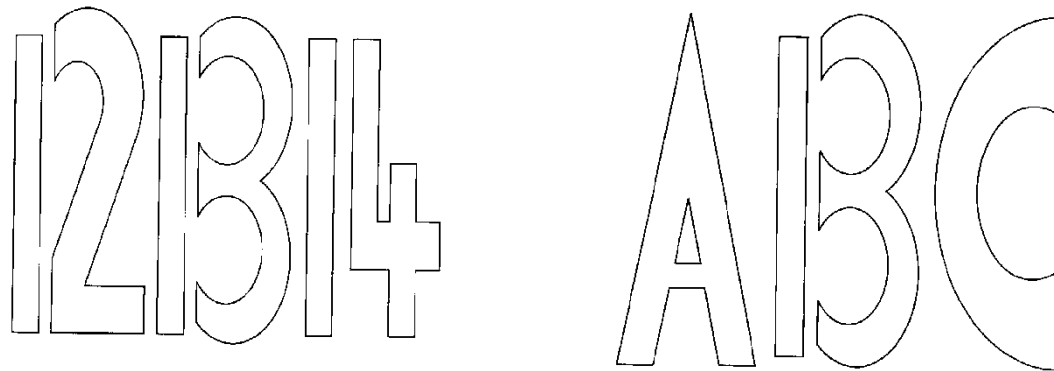
Input - Output Channels

With context, the answer will be different:

top ace

Design implication:

Context can help in resolving **ambiguity**



Input - Output channels

head or hero

HEAD

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PROF. RYAN

MESSAGE FROM ACTING HEAD

In line with the role statement of CityU, the Department emphasizes applied research and application-oriented teaching. After a few years of endeavour, I feel grateful to see that our aspiration to transfer research achievements to the society has been realized. Last year, we obtained one patent and submitted six patent applications. Moreover, seven licensing agreements with telecommunication, Internet and software companies were signed because of the high industrial relevance and marketability of our applied research. May I give thanks to our industrial partners, colleagues and the University for their support in the course of opening up the applied research frontier. Here, I am with great pleasure to introduce to you some of our applied research work in the areas of 3G mobile entertainment and communication, security and monitoring, database management, computer graphics and pattern recognition. All of them are ready for commercialization or technology transfer in form of consultancy, contract research or licensing.

While we are extending our arm to the industry, we believe that we should also interact with the general public and bring our innovative and practical work to their knowledge. To this end, we have been organizing different activities like exhibitions, road shows and seminars to share our work with the public.

Apart from developing applied research, we are also devoted to education and particularly, its synergy with our applied research strengths. Our programmes stress hands-on experience and the independent ability to master and even pioneer the state-of-the-art technology. Coupled with solid theoretical foundation, our application-oriented education stimulates students' learning and creativity. Inside this newsletter, you can find some of our students' innovative work on the prevailing mobile technology. Soon, we will revamp our undergraduate programme to better equip students with professionalism and readily applicable technical skills in response to the needs of the society.

I hope you enjoy the reading, and look forward to your continuous support and advice!

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HEAD

IN THE HISTORY OF THE WORLD, ONLY ONE NATION HAS EVER SUFFERED A DIRECT NUCLEAR ATTACK—

—THE ISLAND EMPIRE OF JAPAN.

BATMAN

FRED

HONEY LEMON

GO-GO TOMAGO

WASABI NO-SINGER

THE ATTACKS ON NAGASAKI AT THE END OF WORLD WAR 2 INFLECTED SCARS ON THE NATIONAL MEMORY THAT LAST TO THIS DAY.

LIKE ANY NATION, JAPAN NEEDS TO DEFEND ITSELF, BUT UNLIKE THE OTHER GREAT POWERS, IT HAS FORGOTTEN THE USE OF NUCLEAR WEAPONS.

THEY'VE FOUND ANOTHER WAY.

BIG HERO 6 in BRAVE NEW HEROES!

by CHRIS CLAREMONT & DAVID NAKAMURA
LEARS CALLOT EMILY WARREN ED QUINSHAW
and JORDAN D. WHITE MARRA PRADICER
with JANE QUINSHAW (cover art by) and DAVID BUCKLEY (book art by)

Input - Output channels

- Another concept from constructivism:
images are partitioned into
 - Figure (i.e., foreground)
 - Ground (i.e., background)
- Sometimes figure and ground are ambiguous
- **Example:**
A person who sells flowerpots may see a vase while person who likes observing people's faces may see two faces



Gestalt Psychology

- Main idea: We do not see things in isolation, but as parts of a whole
- We organize things into **meaningful** units using
 - **Proximity**: we group by distance or location
 - **Similarity**: we group by type
 - **Symmetry**: we group by meaning
 - **Continuity**: we group by flow of lines (alignment)
 - **Closure**: we perceive shapes that are not (completely) there

Gestalt Psychology

Principle of proximity

Example:

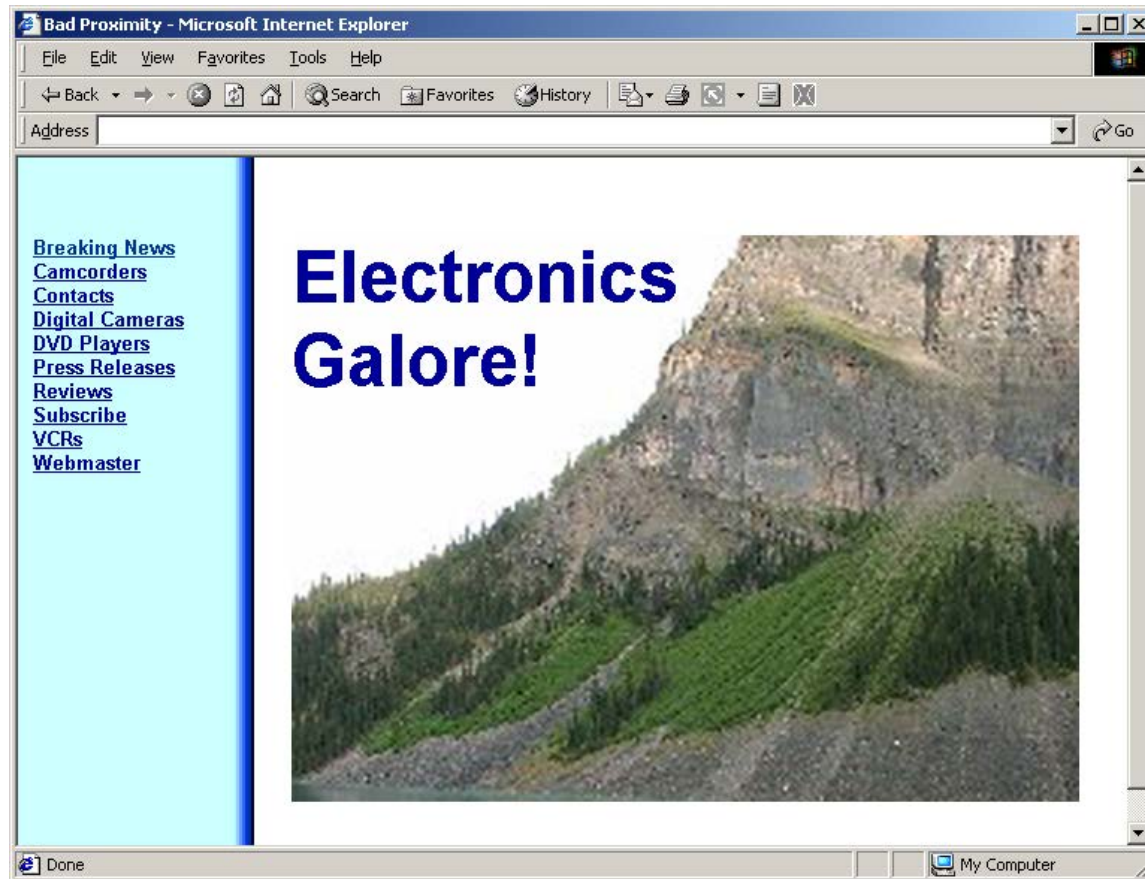


We tend to perceive any closely clustered objects as a group

Gestalt Psychology

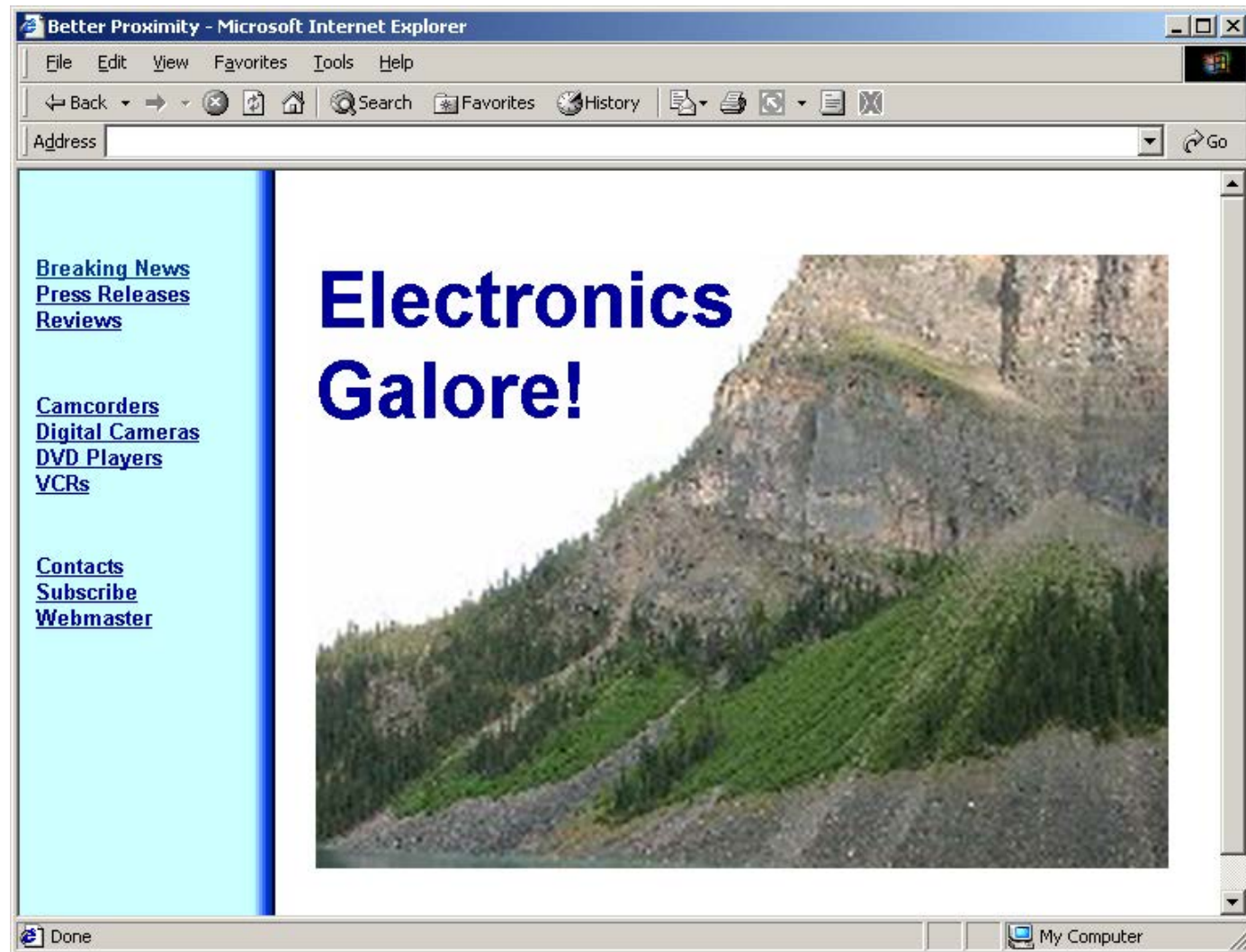
Design implication:

Use proximity to group related things



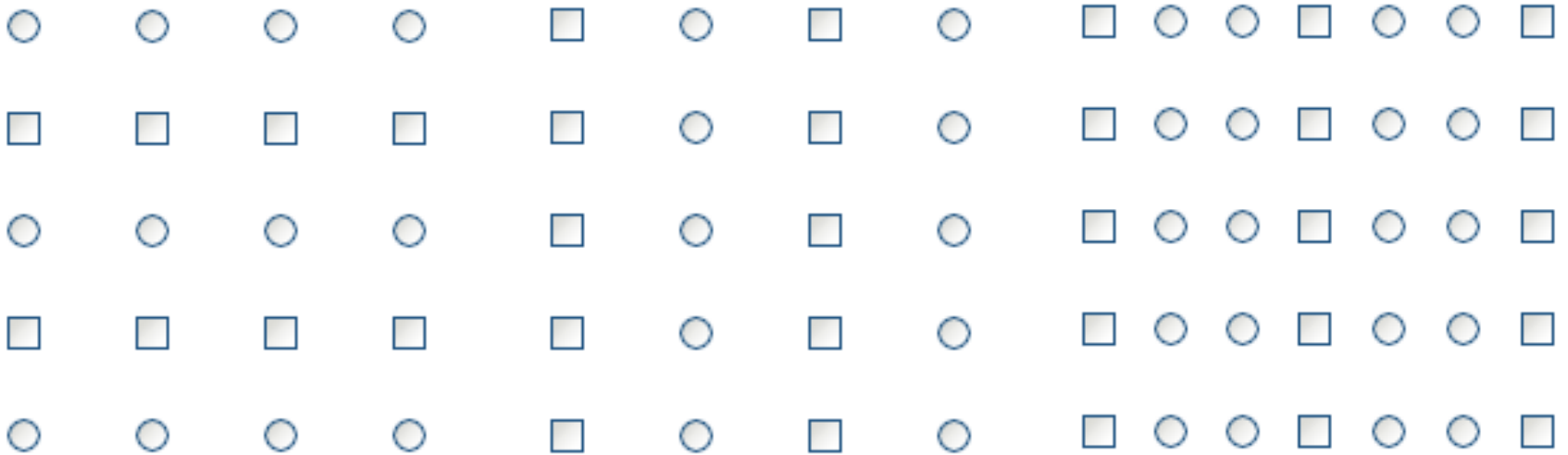
Gestalt Psychology

Improved version:



Gestalt Psychology

Principle of similarity: Objects that have similar visual characteristics, such as size, shape or colour will be seen as a group



Rows of similar
objects

Columns of similar
objects

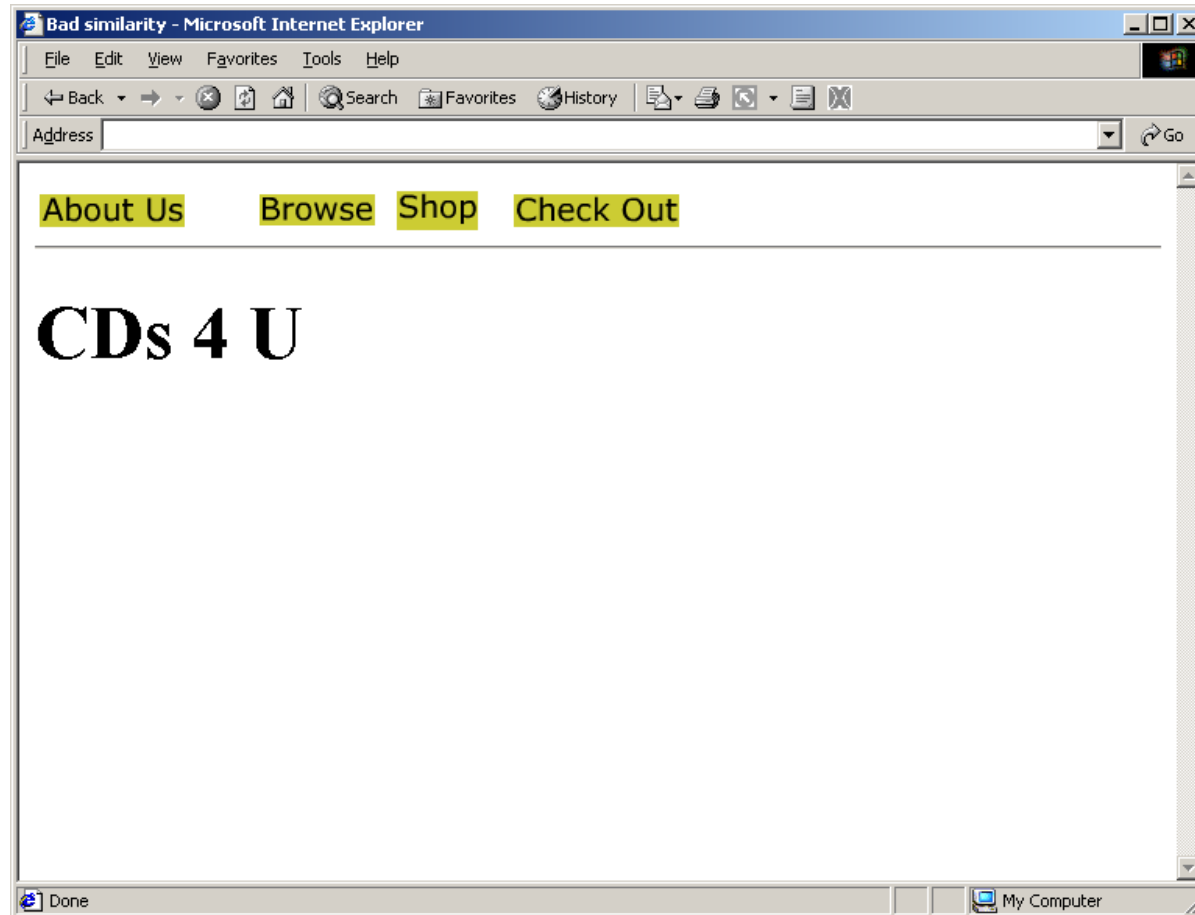
Grouped
columns

We tend to group objects according to their types

Gestalt Psychology

Design implication:

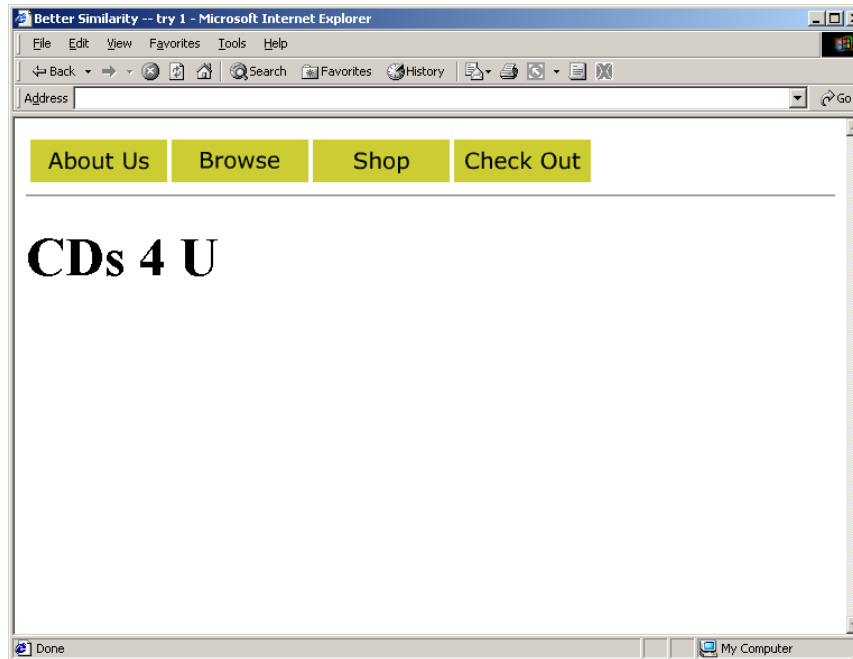
Use similarity to make menu options the same size:



Gestalt Psychology

Design implication:

Use similarity to make menu options the same size:

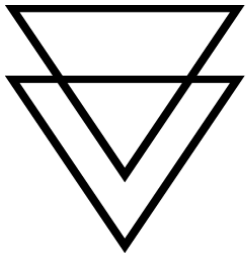


Apart from size, other similarity hints include shape, texture, boldness, etc.,

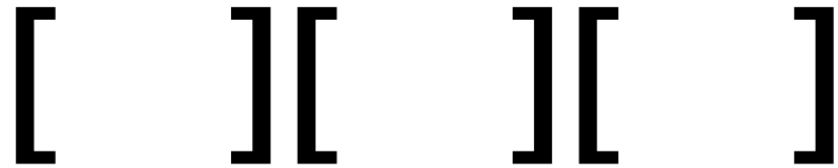
Gestalt Psychology

Principle of symmetry:

we use our experience and expectations to make groups of things



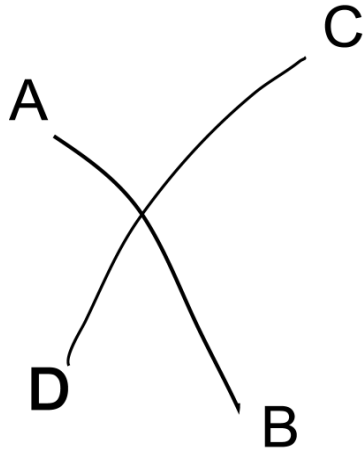
We see two triangles
brackets



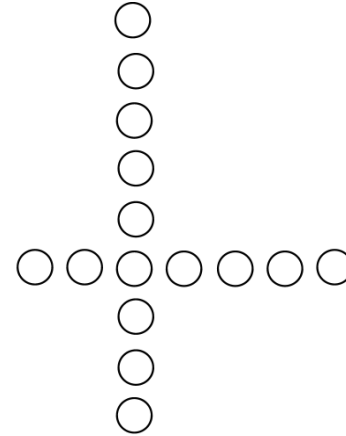
We see three groups of paired square

Gestalt Psychology

Principle of continuity: we group by flow of lines



We see curves AB and CD,
not AC and DB, and not AD and BC



We see two rows of circles,
not two L-shaped groups

Gestalt Psychology

Which is better? (a) or (b)?

The Principle of Common Fate ▼
The Principle of Common Fate ▼
The Principle of Common Fate ▼
The Principle ▼

(a)

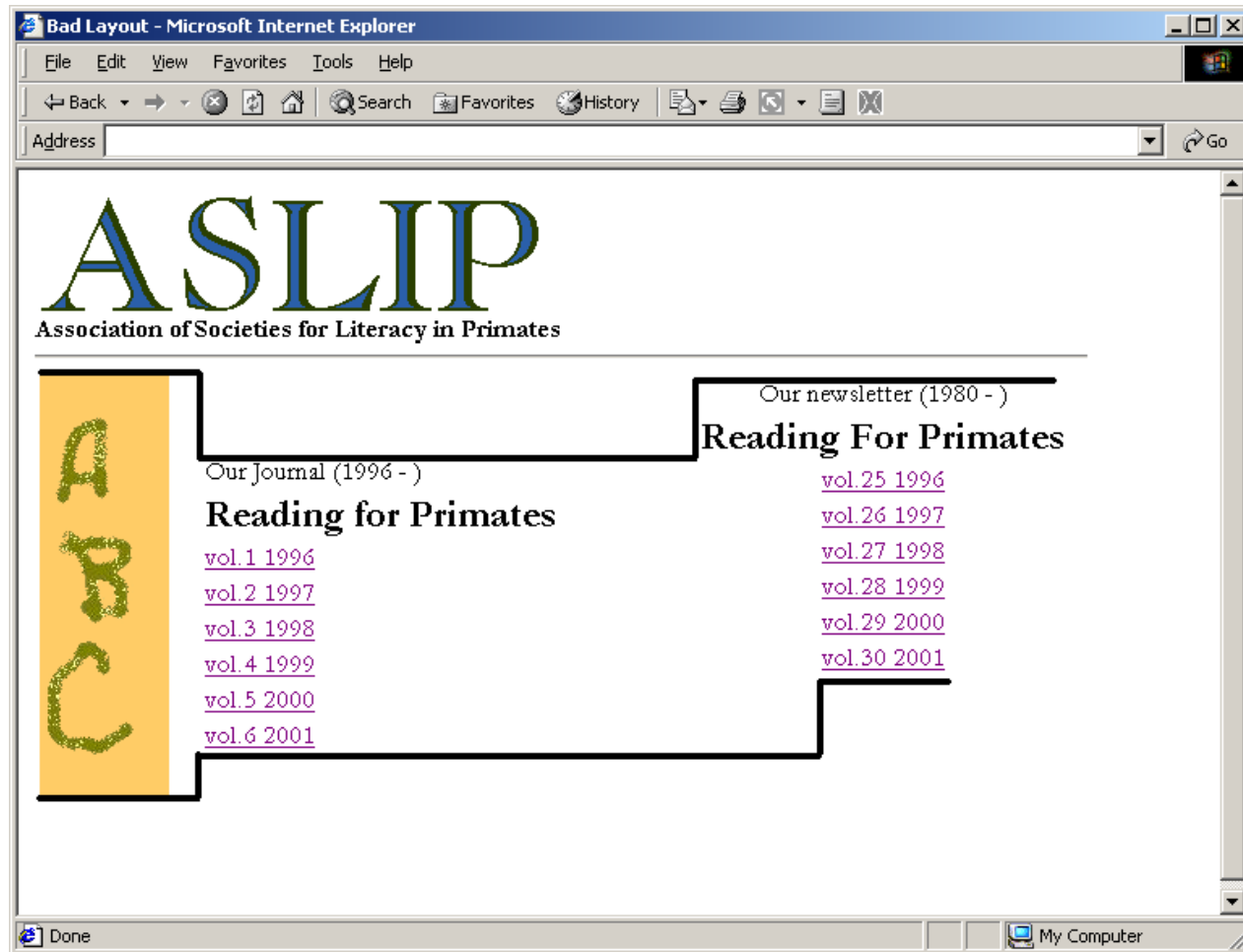
The Principle of Common Fate ▼
The Principle of Common Fate ▼
The Principle of Common Fate ▼
The Principle ▼

(b)

Gestalt Psychology

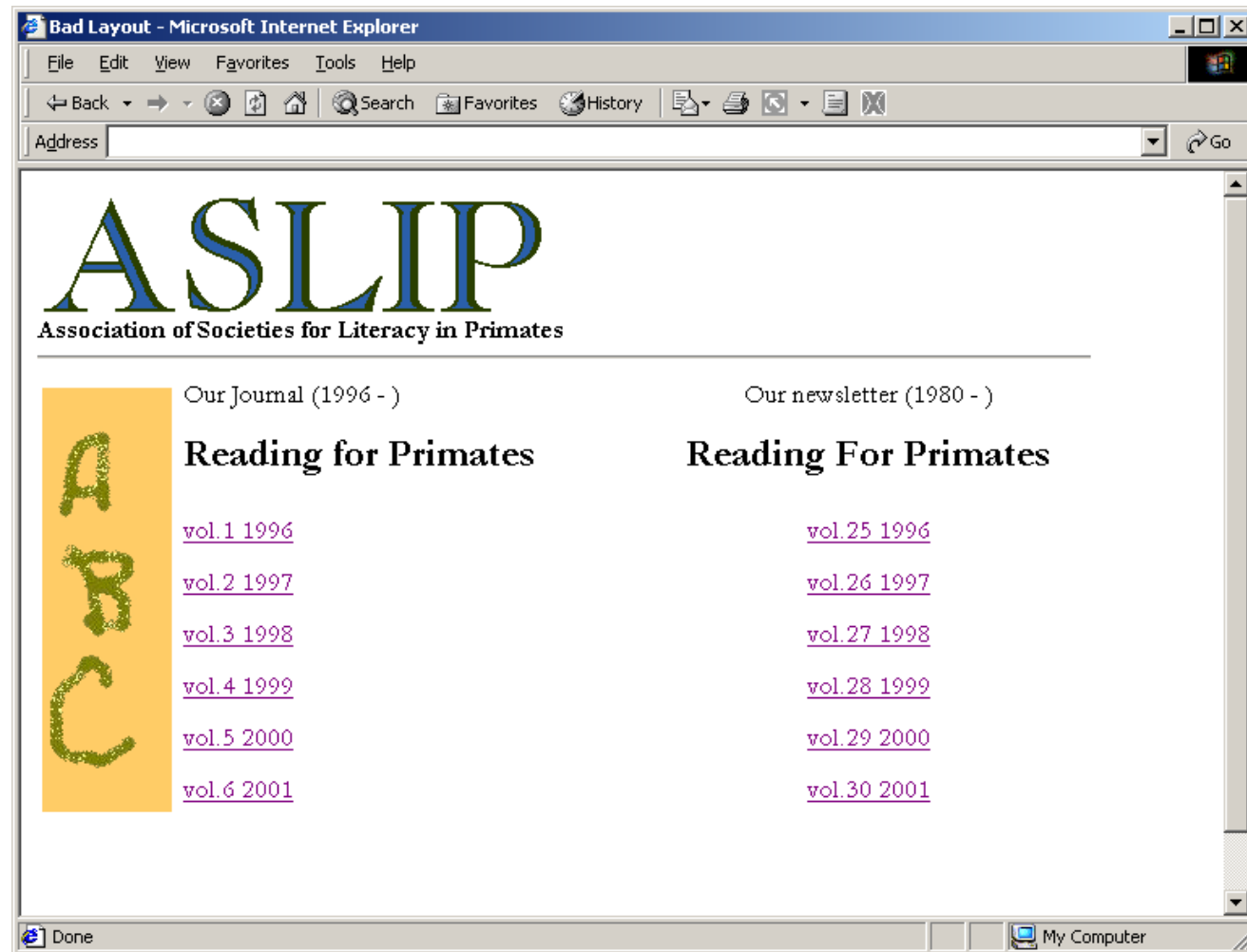
Design implication:

Use alignment to improve layout



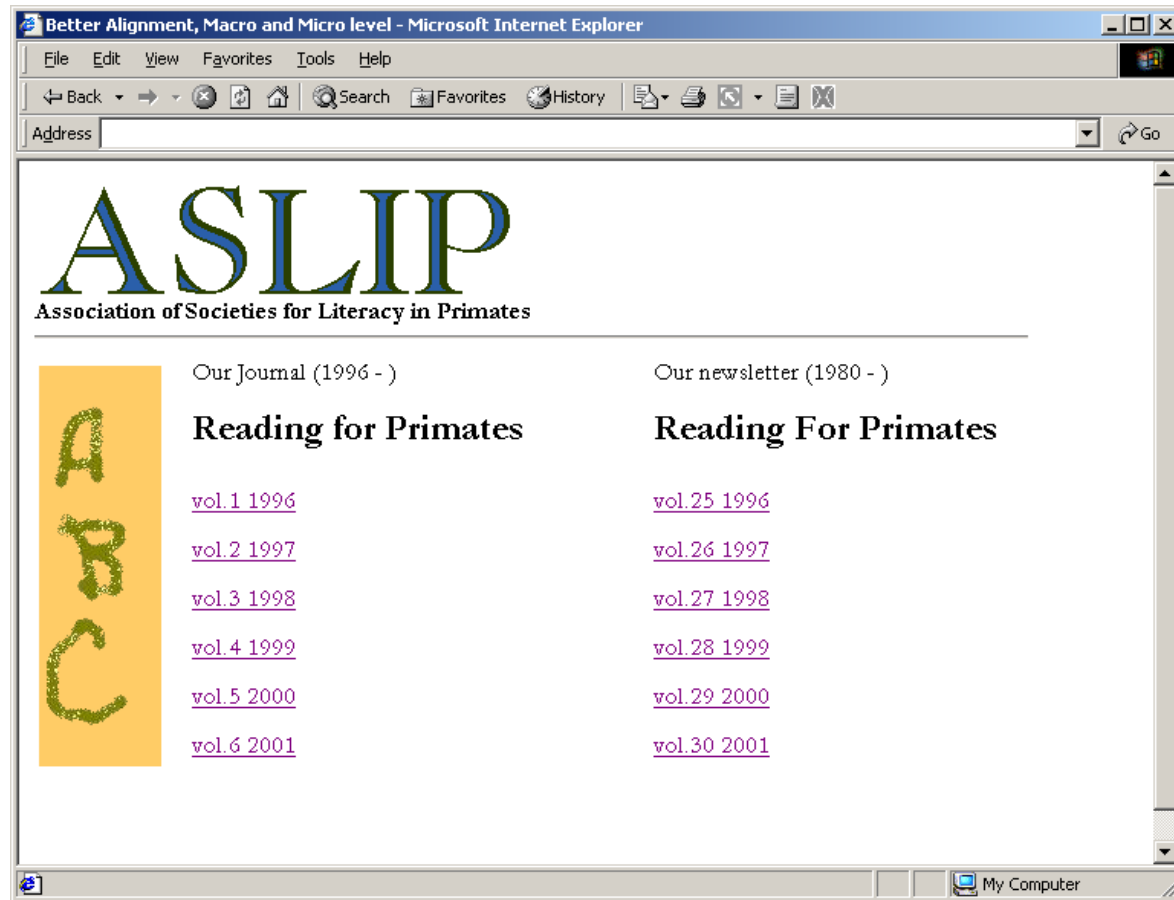
Gestalt Psychology

An improved version:



Gestalt Psychology

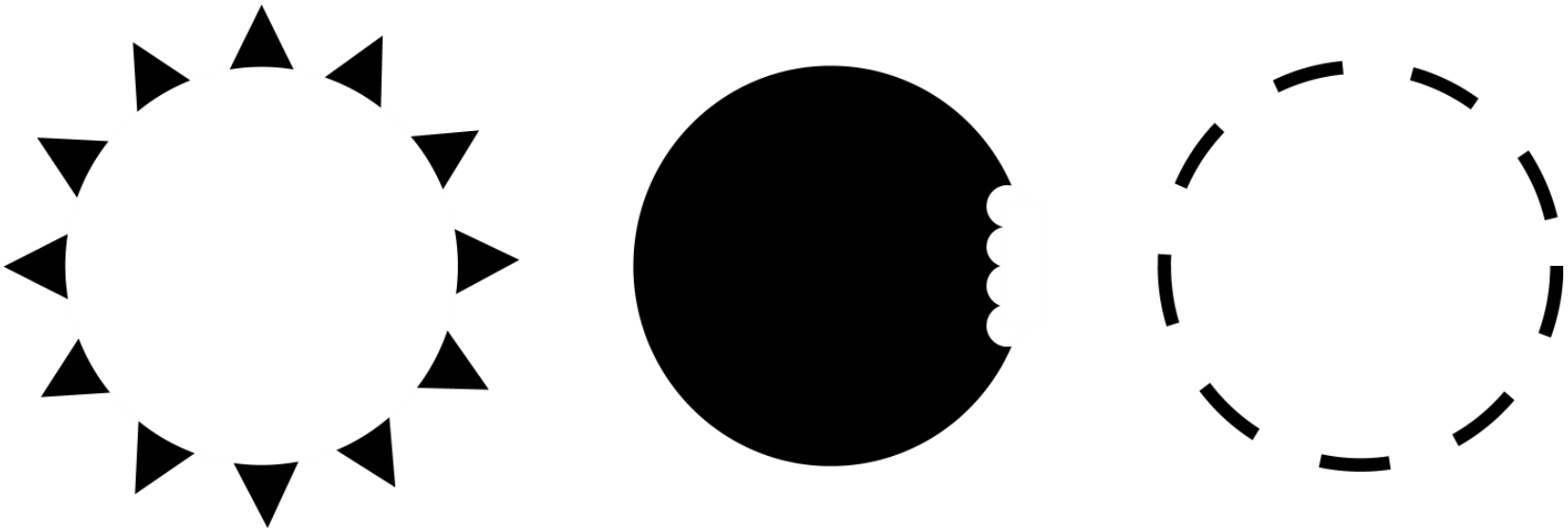
Further improved version:



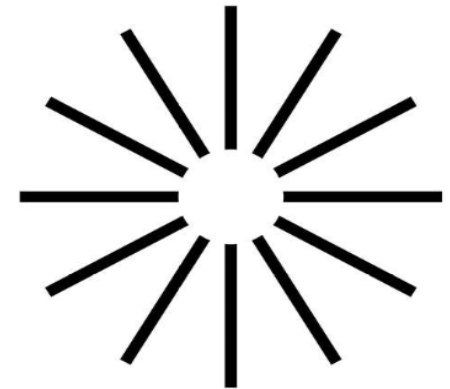
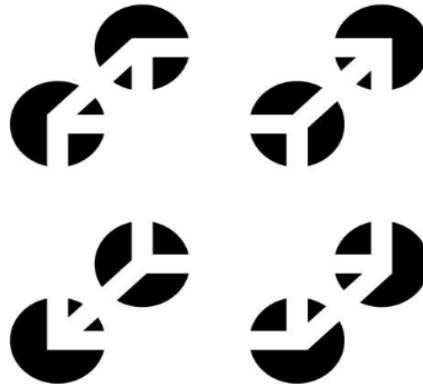
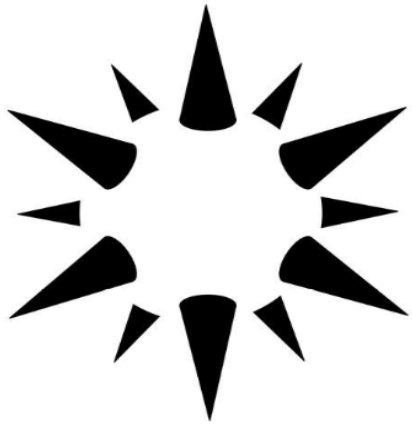
Gestalt Psychology

Principle of closure: we mentally “fill in the blanks”

Example:



All are seen as circles although they are not exactly



Any Gestalt's principles have been applied in the above figures?

Hearing

Provides information about environment:

distances, directions and objects etc.

Sound:

- pitch- sound frequency
 - loudness - amplitude
 - humans can hear frequencies from 20Hz to 15kHz.
 - less accurate distinguishing high frequencies than low.
 - Loudness in 20 dB and 70 dB constitutes comfortable
-
- Auditory system filters sounds - can attend to sounds over background noise. For example, the cocktail party phenomenon. (selective attention)

Touch (Haptic System)

Haptic system is defined as [Gibson]:

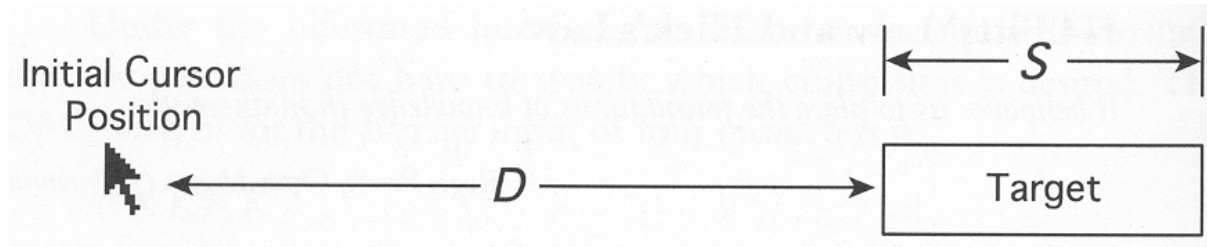
The sensibility of the individual to the world adjacent to her/his body by use of his body.

- Edges
 - Curvature
 - Texture
 - Temperature
 - Pain
-
- Provides important feedback about environment.
 - Key sense for visually impaired
 - Some areas more sensitive than others e.g. fingers.

Movement

- Time taken to respond to stimulus: reaction time + movement time
- Reaction time - depend on stimulus type
 - Visual - 200ms
 - Auditory - 150ms
 - Pain - 700ms
 - Combined signal will result in faster response
- Movement time - dependent on age, fitness, etc.
- ↓ reaction **time** ↓ accuracy in unskilled operator but not in skilled operator

Movement



Fitts' law describes the **average time** taken to hit a screen target:

$$T_M = a + b \log_2(D/S + 1)$$

where

- a & b are constants determined experimentally
 - T_M is movement time (in ms)
 - D is Distance
 - S is Size
- ➔ Targets in general should be large as possible & the distances as small as possible

Movement

Example:

- Suppose for a 15-inch flat panel display, the average distance the cursor between the menu bars is 80 mm
- Size of menu bar - Macintosh: 50 mm & Windows: 5mm
- $a=50$, $b=150$

Calculated time to move the cursor to a menu item
on Macintosh

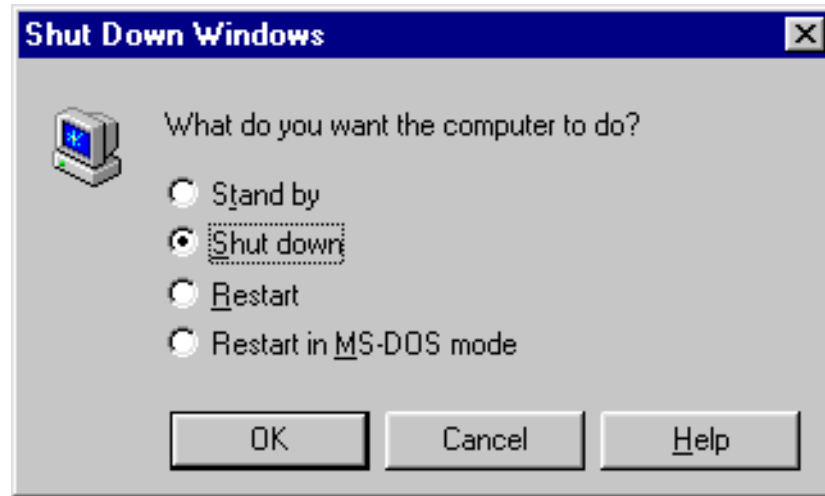
$$T_M = 50 + 150 \log_2(80/50 + 1) = 256 \text{ ms}$$

For Windows,

$$T_M = 50 + 150 \log_2(80/5 + 1) = 663 \text{ ms}$$

Movement

When there are multiplicity of choices,
we need to choose the appropriate target prior to moving the cursor:



Required time to choose can be described by **Hick's law**:

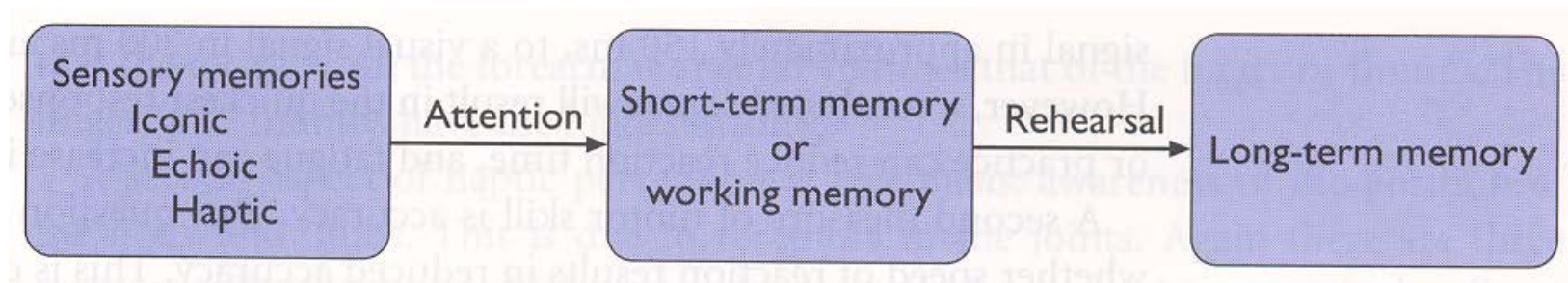
$$T_c = a + b \log_2(N+1)$$

where N is number of options and the probabilities of taking each alternative are equal

Memory

3 types of memory model

- **Sensory memory (vs I/O buffer)**
 - Hold data received from external world
- **Short-term or working memory (vs RAM)**
 - Where information is processed
- **Long-term memory (vs hard disk)**
 - Hold information for long time, although not all information can be retrieved evenly



Memory

- **Sensory memory** acts as buffers for stimuli received via senses
- **Constantly overwritten**
- Information passes from sensory to short-term memory by attention (e.g., you are constantly seeing but you will not pay attention to all things you see)
- **Attention or selection of stimuli** is governed by level of interest or need
- e.g., **cocktail party phenomenon**: we can attend to one conversation over background noise but we may choose to switch our attention to another conversation if we hear our name mentioned

Memory

- **Short-term memory (STM)** is used for temporary recall of information
 - rapid access - 70ms
 - rapid decay - 200ms
 - limited capacity - 7 +/- 2 digits or chunks
- **Long-term memory (LTM)** is the main resource for all our knowledge
 - Slow access - 100 ms
 - Slow decay, if any
 - Huge or unlimited capacity

Memory

Memory capacity can be improved via:

- **Chunking**
- Let people **recognize** information rather than **recall** it

How many chunks in the following?

85234427651

The chunks can be 852, 3, 4, 4, 2, 7, 6, 5, 1 9 chunks (no use)

How about this?

852 3442 7651

There are now 3 chunks: 852, 3442, 7651

However, sometimes we cannot do chunking, e.g.,

can you remember: vsdfnjejn7dknsdnd33s

Memory ➡ Design Implication

- Facilitate users to do chunking, e.g., make your URL easy for chunking:

www.facebook.com

www.hktvmall.com

- Another application is to use chunking in memorizing phone number, 3442, 7651

Memory: Recognition versus Recall

Is my telephone number 3442 7780?

What is my telephone number?

Which one does not belong to Norman's usability principles?

- A. Affordance
- B. Constraints
- C. Flexibility
- D. Feedback
- E. None of the above

State Norman's usability principles.

- Multiple choice: you can recognize the answer
- Essay: you must recall the answer

Memory ➔ Design Implication

- Design systems that rely on people's ability to recognize information rather than forcing them to recall it, in order to reduce user's memory burden
- e.g., a computer with a GUI allows us to recognize commands on a menu, instead of remembering them as in DOS and UNIX

Reasoning

Three forms of reasoning:

1. Deductive reasoning

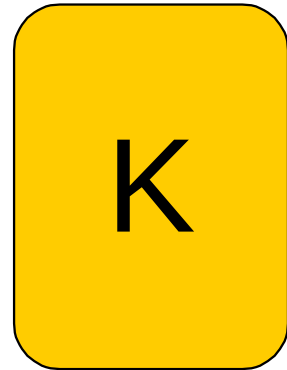
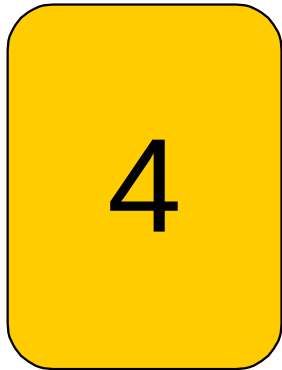
- Derive logically necessary conclusion from given premise
 - Suppose we have a statement
If it is Friday, then she will go to work.
 - Now, if the premise “it is Friday” is true, then my conclusion is “she go to work”
 - Remark: The process is logically correct.
- But the logical conclusion may not be necessarily true:
 - If it is raining then the ground is dry (it is an incorrect statement)
 - It is raining. => Therefore the ground is dry
 - It is valid deduction but not true
- Human deduction poor when truth & validity clash

Reasoning

2. **Inductive** reasoning

- Generalise 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.
- However, humans are not good at using negative evidence e.g., Wason's cards

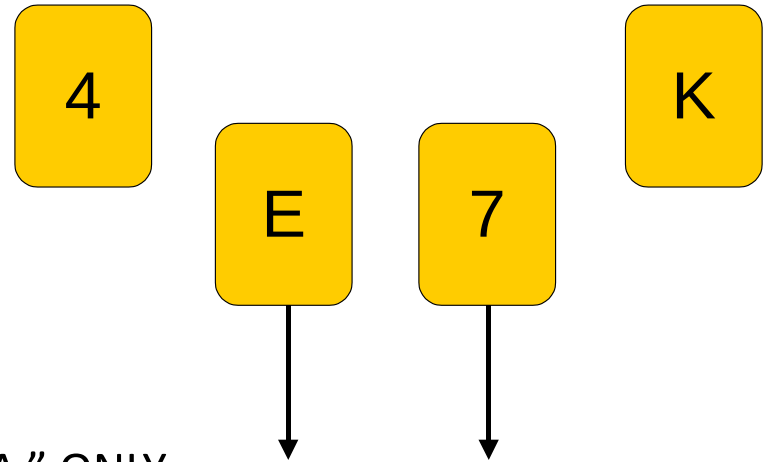
- Wason's cards: each card has a number on one side and a letter on the other.
- Statement "if a card has a vowel on one side, it has an even number on the other side"



Which card(s) would you need to pick up to check this statement?

Most people check 4 E

In fact, we need to check E and 7.



“If A, then B.” is equal to “If NOT B then NOT A.” ONLY.

- (a) E (to check if A then B)
- (b) 7 (to check if NOT B then NOT A)
- (c) 4 (to check if B then what)
- (d) K (to check if NOT A then what)

(d) and (c) are no use for checking the statement.

Design implication:

Avoid negative evidence, e.g., If not Exit, don't press “X”

Reasoning

3. **Abductive** reasoning

- Reasoning from event to cause.

Find out the cause from the outcome.

E.g.

We know Sam drives fast when drunk.

The statement is “if Sam is drunk, then the drives fast”

From **Abduction reasoning**, we see “Sam driving fast”, => he is drunk”

Unreliable: can lead to false explanations.

Sam may need to do an emergency matter.

Mental Model

- Don Norman's definition: "the model people have of themselves, others, the environment, & the things with which they interact. People **form** mental models through **experience, training & instruction**"
- An internal representation of a user's current conceptualization and understanding of a system
- The more people learn about a system and how it functions, the more their mental models develop
 - e.g., a TV engineer has a deep mental model of how TVs work that allows them to work out how to set them up and fix them, while an average citizen only has a good mental model of how to operate a TV but a shallow mental model of how it works

Mental Model

- Knowledge developed in learning & using a system – How to use it?
How it works?

e.g., Make a phone call:

- Pick up the phone
- Dial the number I want to call
- Hear the phone on the other end ringing
- The person at the other end answers

e.g., Waiting for an elevator:

- Press the button
- To reduce the waiting time, we need to press the button more than once?

Mental Model, e.g. iPad for reading a book

- Imagine that you have never seen an iPad, but I have just handed one to you and told you that you can read books on it. Before you turn on the iPad, before you use it, you have a model in your head of what reading a book on the iPad will be like. You have assumptions about what the book will look like on the screen, what things you will be able to do, and how you will do them - things like turning a page, or using a bookmark
- If you have used an iPad before, your mental model of reading a book on an iPad will be different than that of someone who has never used one, or does not even know what iPads are
- If you have been using a Kindle user, then your mental model will be different from someone who has never read a book electronically. And once you get the iPad and read a couple of books on it, whichever mental model you had in your head before will start to change and adjust to reflect your experience

Mental Model

Mental models are:

- **Unscientific**—They are often based on guesswork and approximations
- **Partial**—They do not necessarily describe whole systems, just the aspects that are relevant to the persons who formulate them
- **Unstable**—They are not concrete formulations, but evolve and adapt to the context
- **Inconsistent**—They do not necessarily form a cohesive whole; some parts may be incompatible with other parts of the same model
- **Personal**—They are specific to each individual and are not universal concepts that can be applied generally

Mental Model

- Help to **predict** the operation of an unknown/unfamiliar system
e.g., in an unfamiliar flat, we guess the light should be turned on using the nearest switch
- Users always have mental models & always **develop** & **modify** them, regardless of the particular design of a system
- By studying how people create mental models of interactive systems and by designing interactive systems that help the user create a more accurate mental model of the system, usability will improve
- Successful interface is built when
Designer's conceptual model agrees with user's mental model