

Human

- Human Models
- Human Senses
- Human Memory and Reasoning
- Mental Model

Why Study Human?

We are the **users**

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

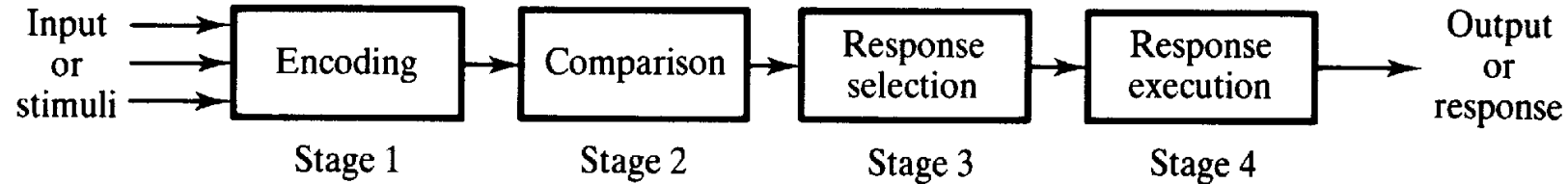
- What our **senses** (sight, hearing, touch, smell, taste) are telling
- Past **experience**
- Our **expectations**

e.g., When we browse a new Web, our past experience tells us that underlined blue text is supposed to be a link

e.g., When we are given a new product with buttons, we expect that it is operated by pressing the buttons

Human Model

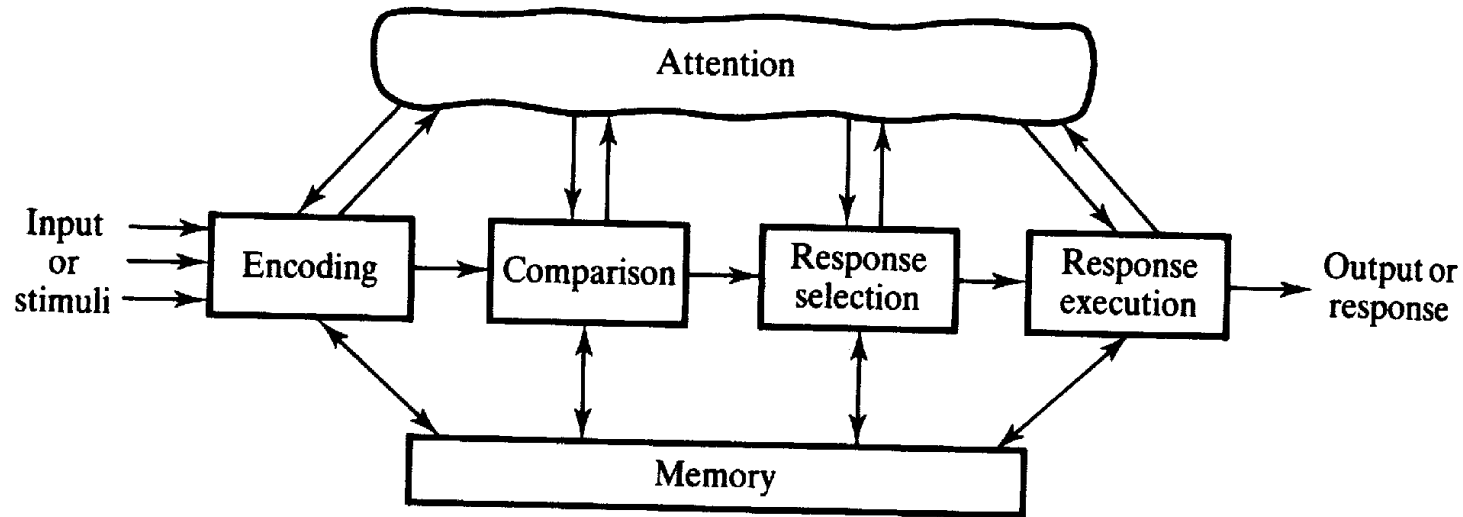
Modelled as information processing system



- Stage 1: **encode** information (sight, hearing, touch, smell, taste) from environment into internal representation
- Stage 2: internal representation of the stimuli is **compared** with the memorized representations in brain
- Stage 3 is concerned with **deciding** on a response to encoded stimulus
- Stage 4 deals with organization of response & necessary **action**

Human Model

Extending the human information processing model



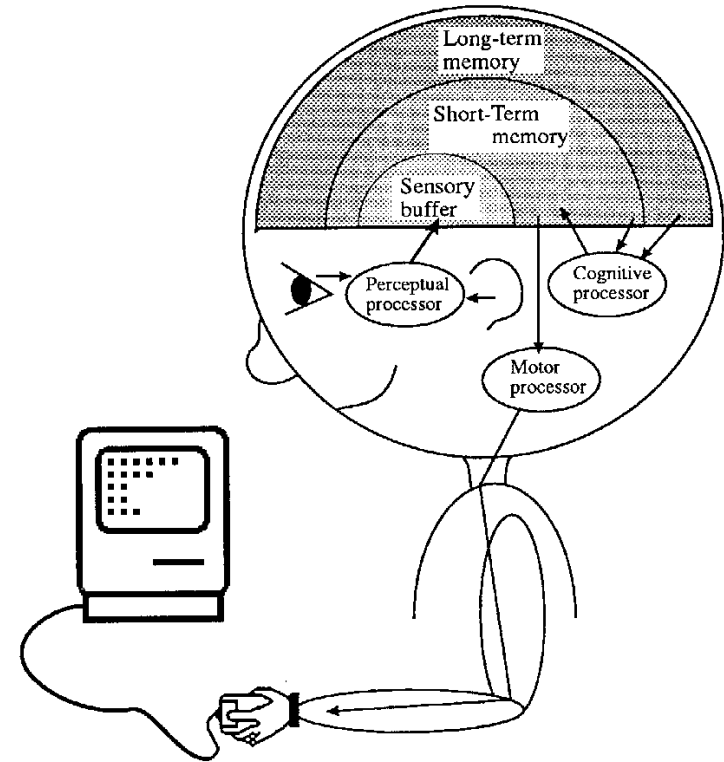
Attention

- Selective 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 simultaneously (driving and holding a conversation)

Human Model

Card, Moran & Newell's Model:

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



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

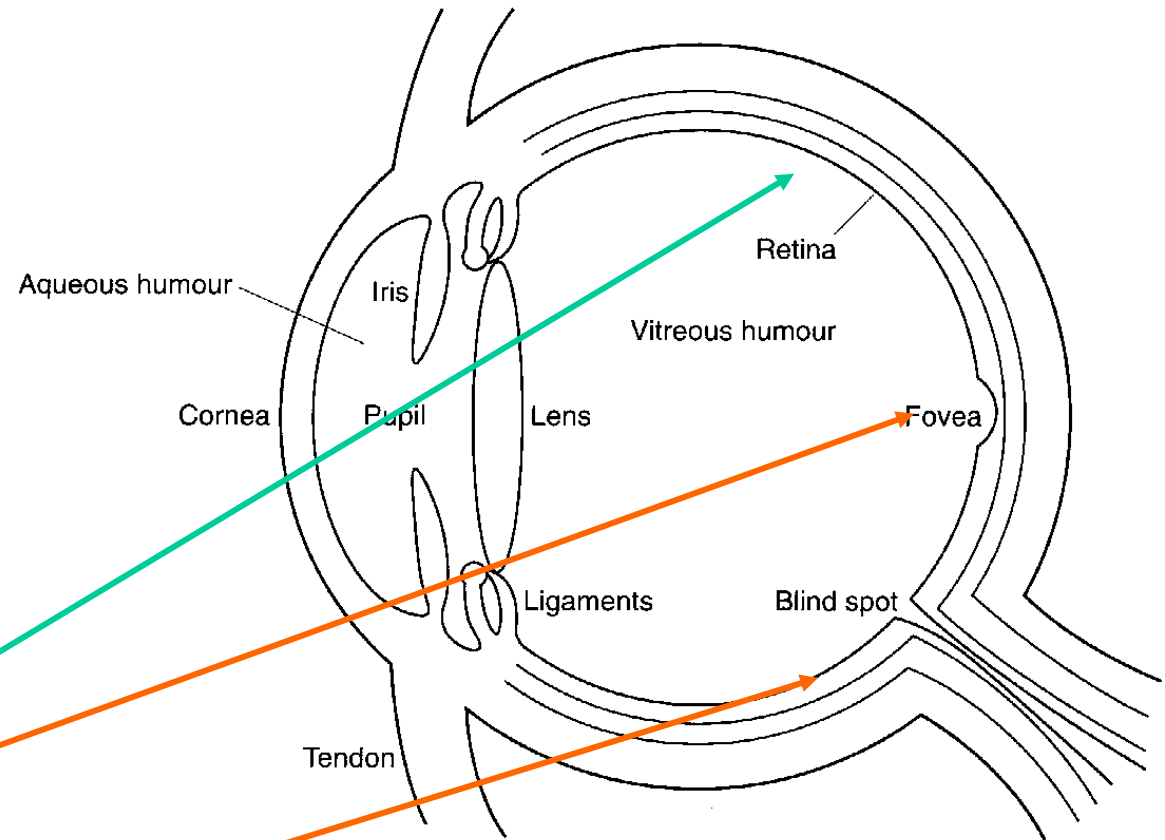
Motor Control

Biometrics, e.g., fingerprint

Vision

■ Eye

- Mechanism for receiving light & transforming it into electrical energy
- Light reflects from objects; their images are focused upside down on **retina**
- Retina contains
 - **Fovea**: colour vision, pattern detection
 - **Outer part**: sensitive to light, movement detection



Vision

Design implication:

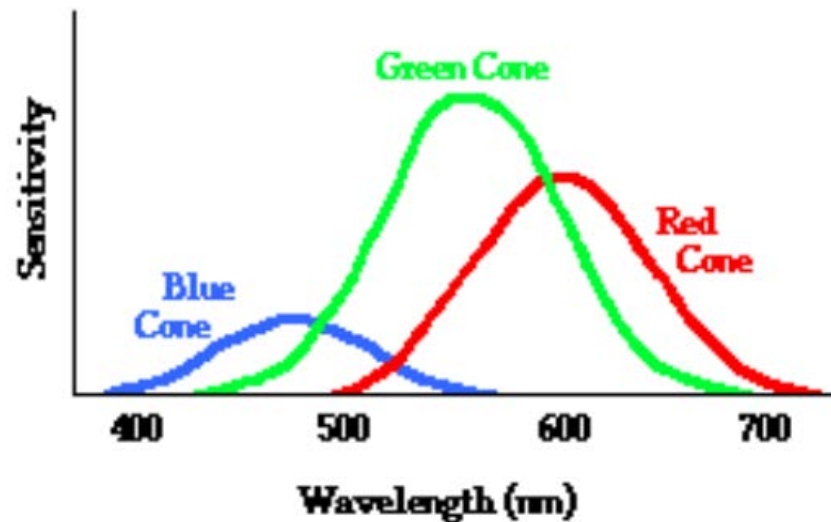
- A user concentrating on the middle of the screen cannot be expected to read text on the bottom line because outer part is not good for pattern detection



⇒ If we want a user to see an error message at the bottom of the screen, since the outer part is capable for change detection, the message should be flashing

Vision

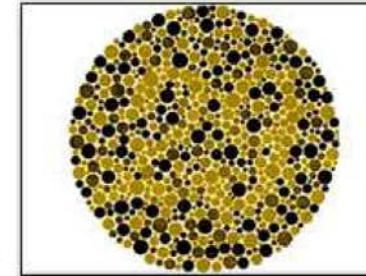
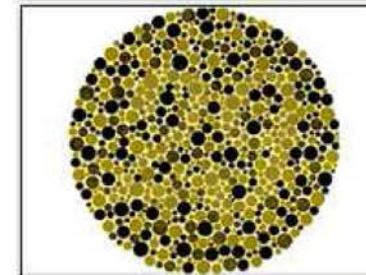
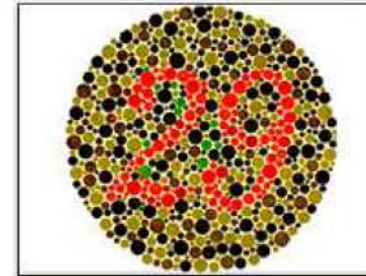
- The cones are the color-sensing cells of the retina
- There are three kinds of cones, each sensitive to its own range of wavelengths within the visible light spectrum, which are referred to as red cones, green cones, and blue cones
- Eyes are most sensitive to green but least sensitive to blue



Vision

- Defective colour vision is not uncommon:
 - 8% males, 0.5% females
 - Red-Green colour blindness is most common

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



human computer interaction 2013, fiv

From webexhibits.org

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

How many items are there on top menu bar of <https://www.cityu.edu.hk/> ?

Constructivism

Constructivist theory states that **context** plays a major role in what we see in an image

What do you see?



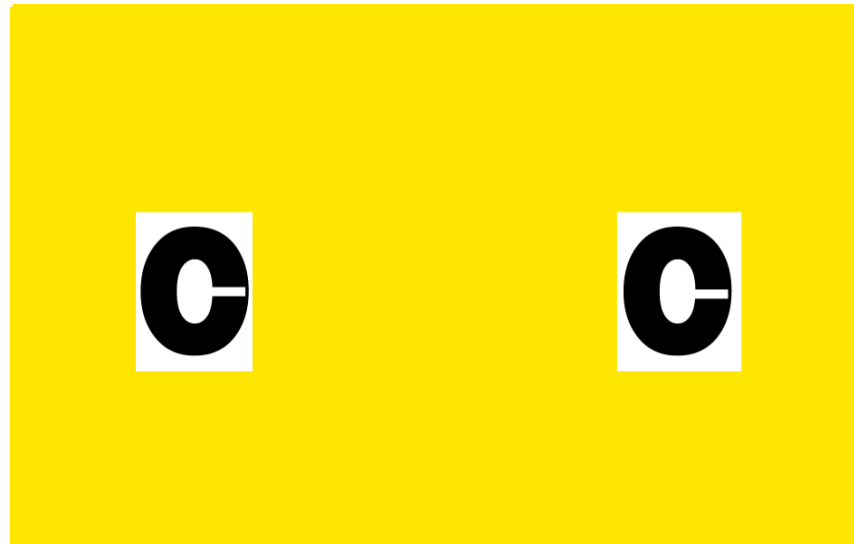
Constructivism

Why we cannot see it at first?

- The image is too blurry
- 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?



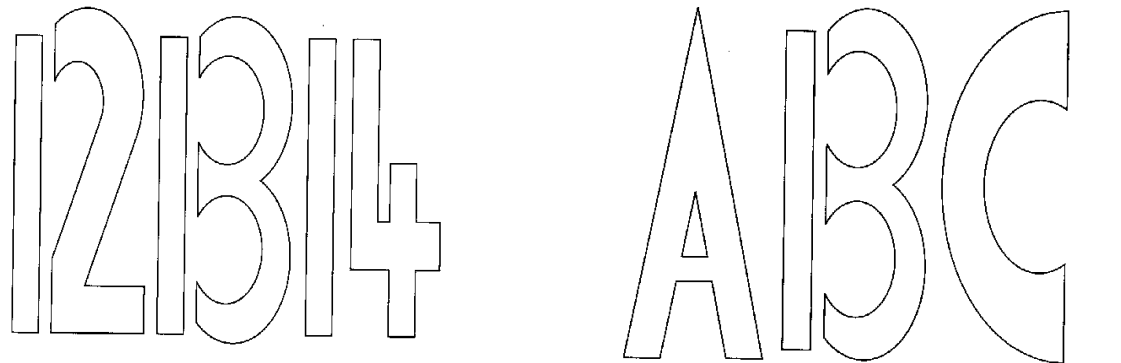
Constructivism

With context, the answer will be different:

top ace

Design implication:

- Context can help in resolving **ambiguity**



Constructivism

HEAD

HEAD or HERO?

DEPARTMENT OF COMPUTER ENGINEERING & INFORMATION TECHNOLOGY <http://www.it.cityu.edu.hk>

IT FLASH

PROVIDING QUALITY EDUCATION AND INITIATING TECHNOLOGY ADVANCEMENTS

ISSUE NO. **03**
APRIL 2005



PROF. H. YAN

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 MONARCHY OF JAPAN.

BAYMAX

FRED

HONEY LEMON

WASABI NO-FINGER

GO-GO TOMAGO

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

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

THEY'VE FOUND ANOTHER WAY.

BIG HERO 6 in BRAVE NEW HEROES!

BY CHRIS CLAREMONT & DAVID NAKAMIZIMA

LEARN PALLOT EDWIN WARREN ED DUNE SHIRE

DAVID LEE JORDAN O. WATTE MARRA PARRIS PARRIS

JOE QUERADA DAVID QUICHALI

Constructivism

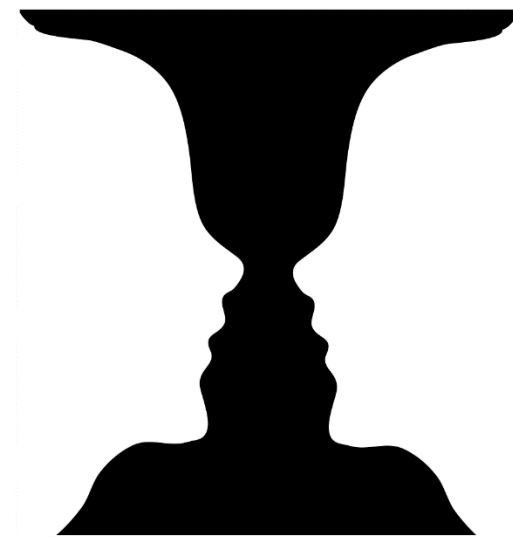
Another concept from constructivism: images are partitioned into

- **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 a person who likes observing people's faces may see **two faces**



Constructivism

What do you perceive?



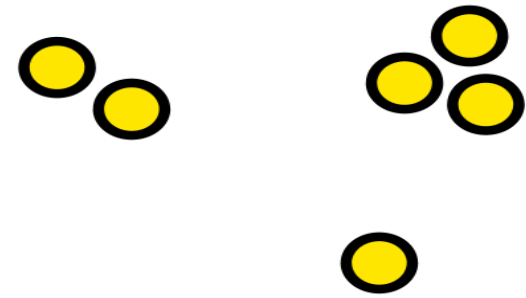
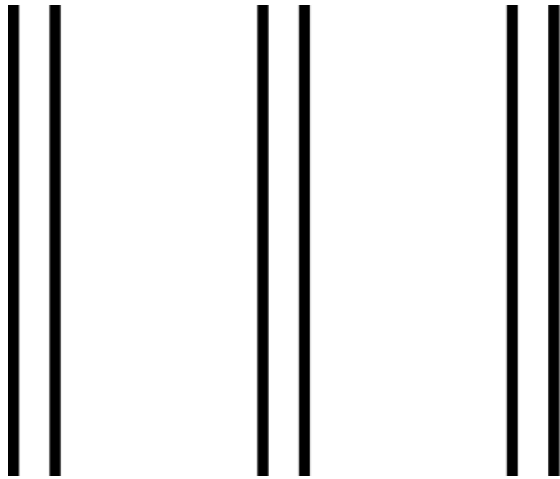
Gestalt Psychology

- 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:

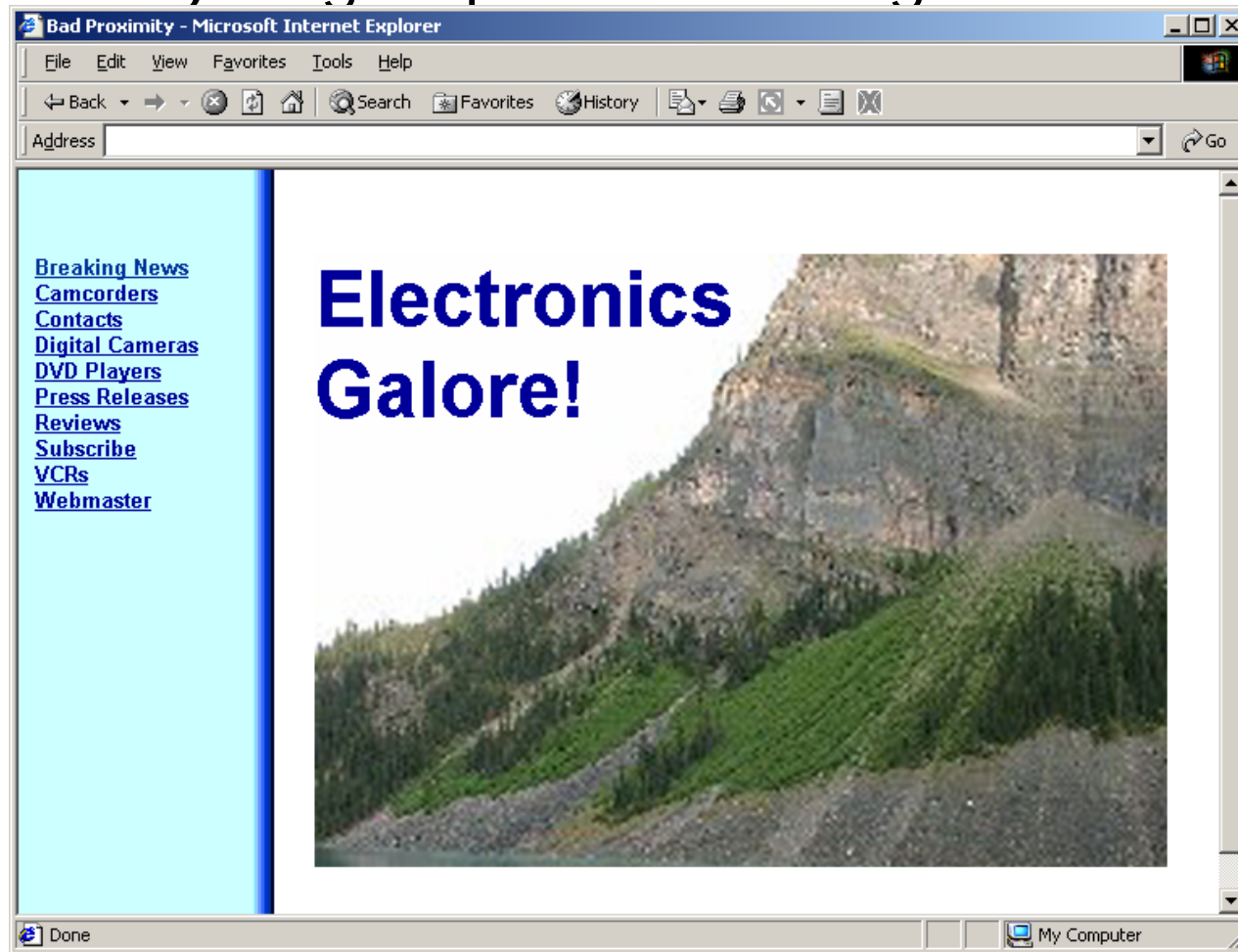


We tend to perceive any closely clustered objects as a group

Gestalt Psychology

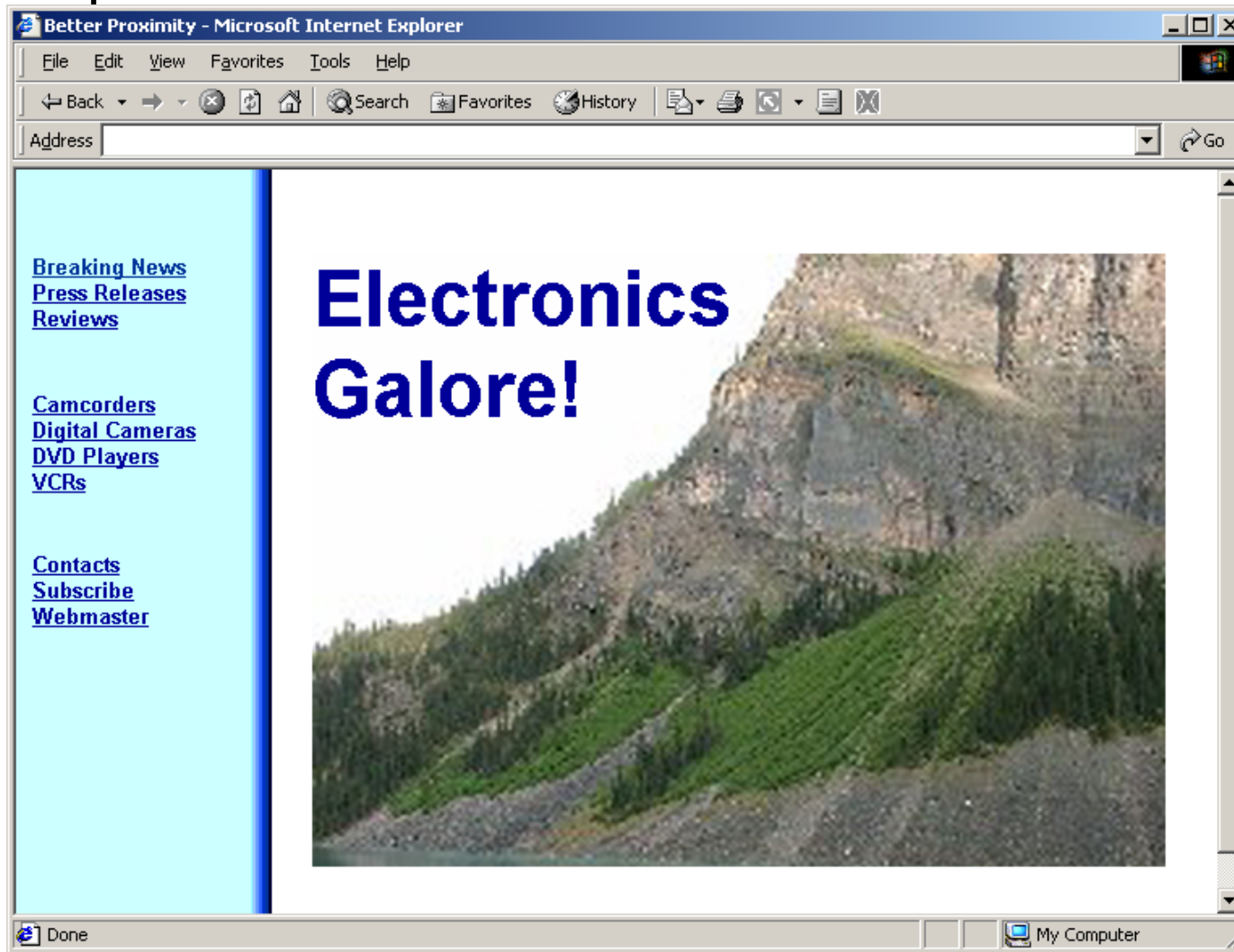
Design implication:

- Use proximity to group **related** things



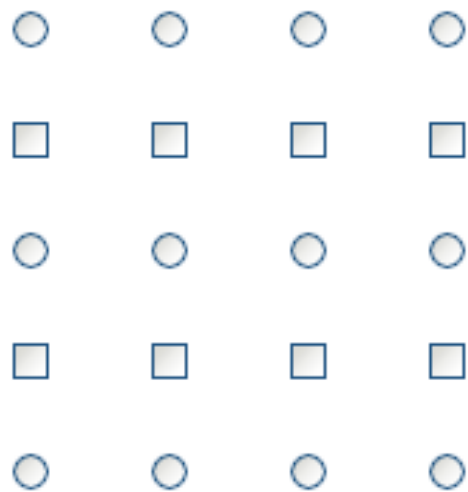
Gestalt Psychology

Improved version:

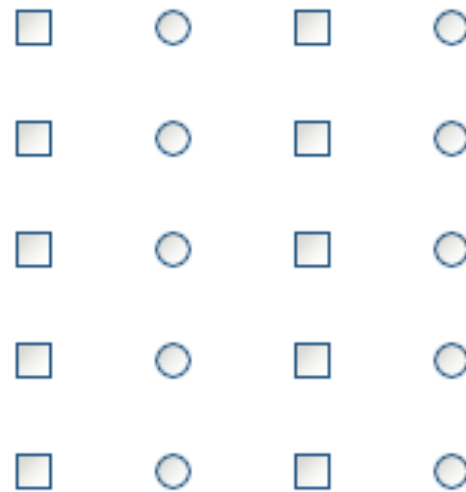


Gestalt Psychology

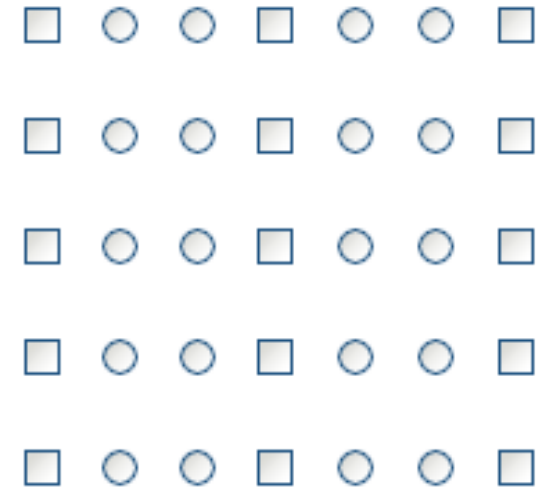
Principle of similarity: Objects that have similar visual characteristics, such as size, shape or colour will be seen as a group



Rows of similar objects



Columns of similar objects

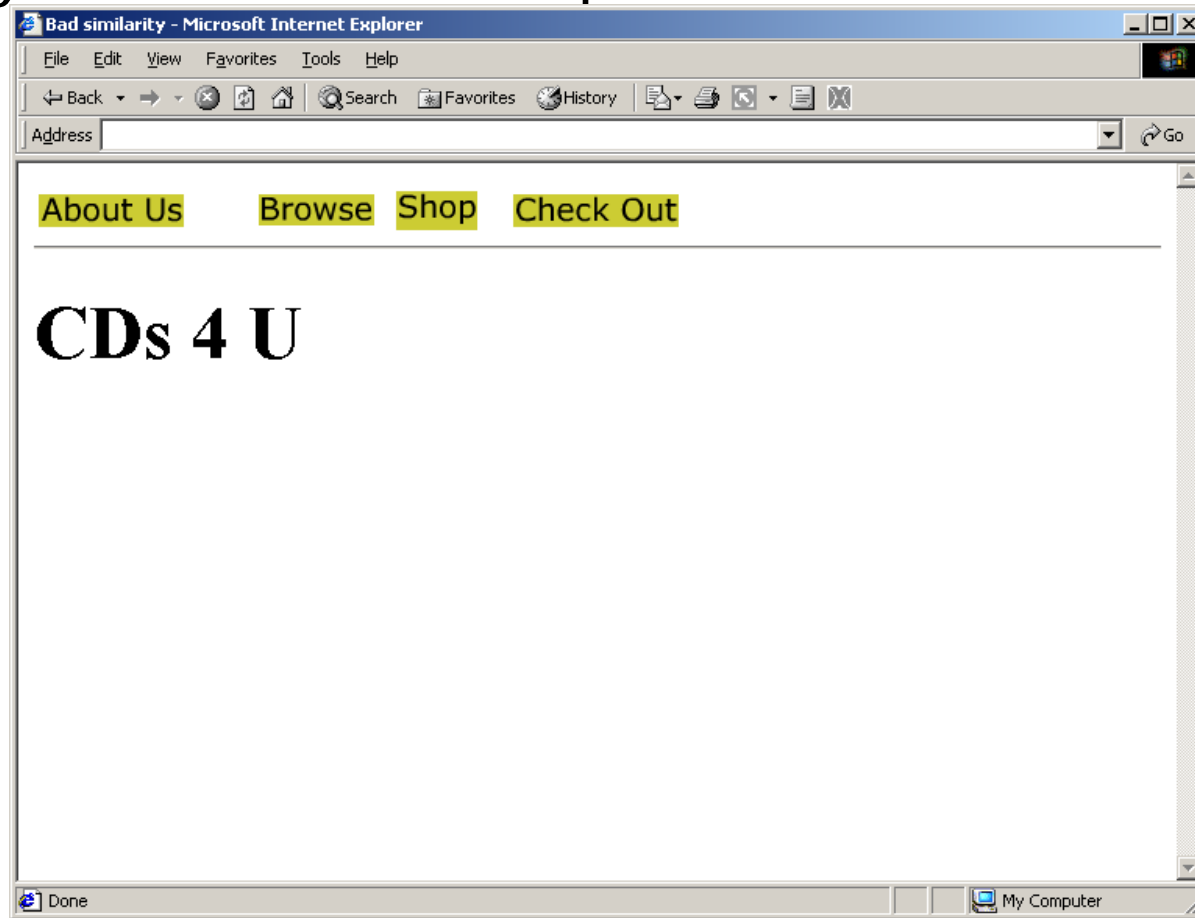


Grouped columns

Gestalt Psychology

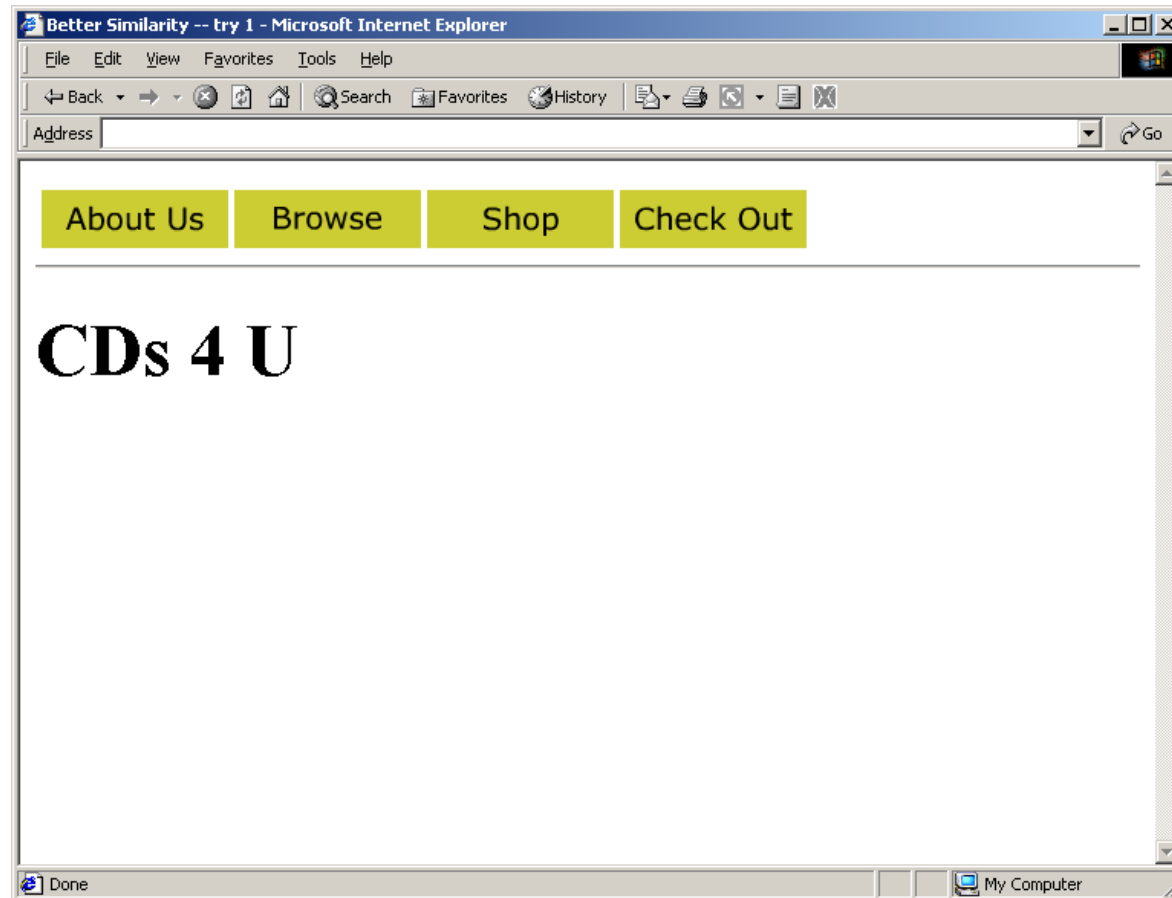
- Design implication:

Use similarity to make menu options the same size:



Gestalt Psychology

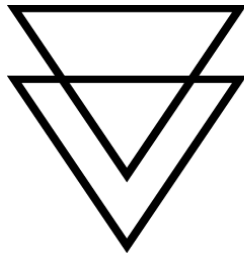
Improved version:



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



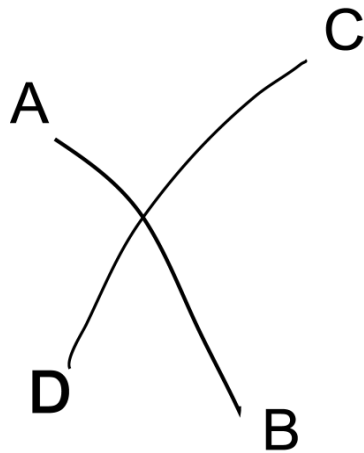
We see two triangles



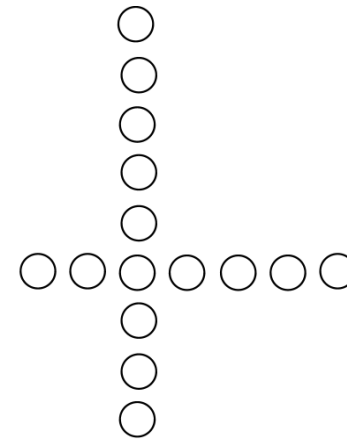
We see three groups of paired square brackets

Gestalt Psychology

Principle of continuity: we group by flow of lines, that is, we tend to see things as smooth, continuous representations rather than abrupt changes



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)

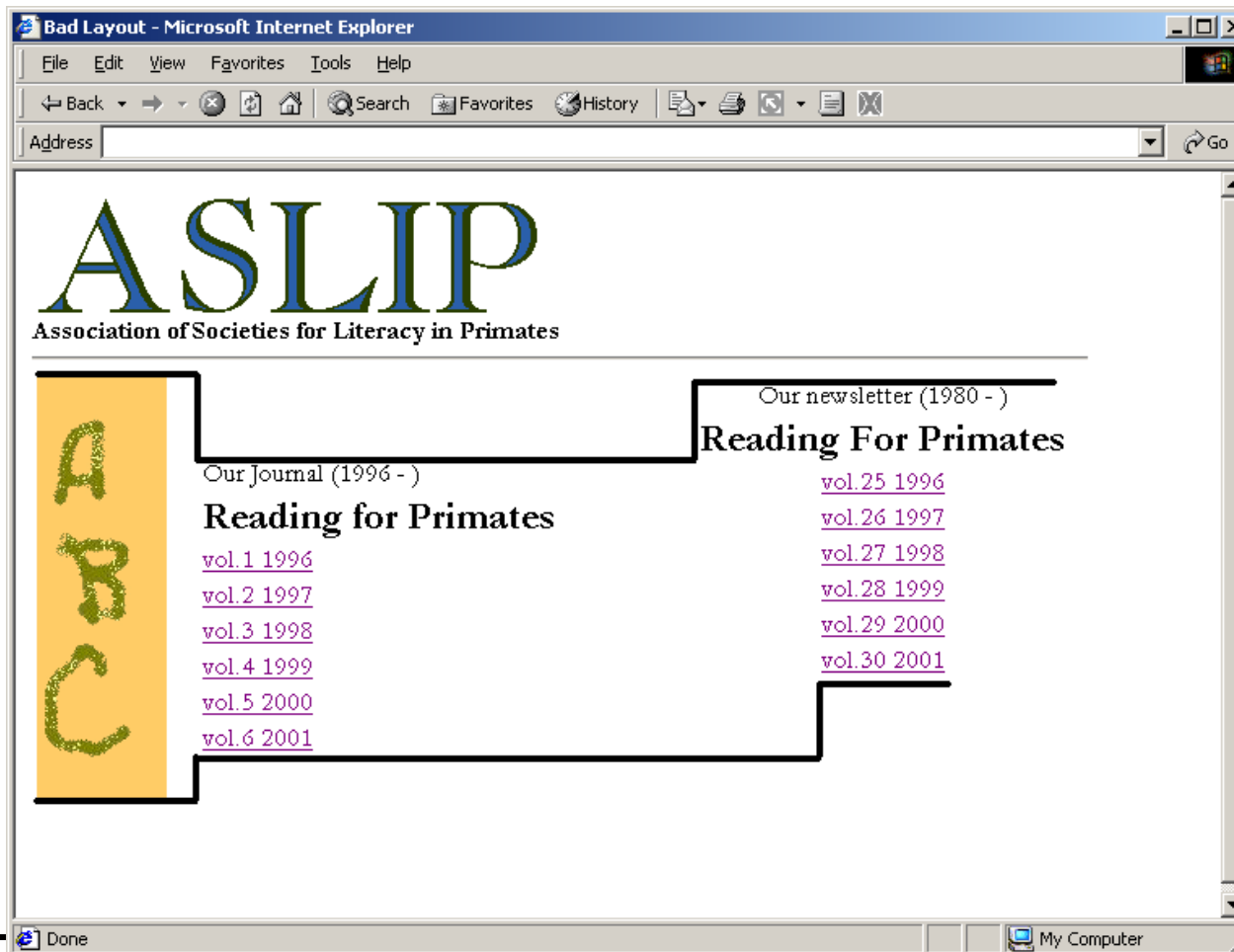
The Principle of Common Fate ▼
The Principle of Common Fate ▼
The Principle of Common Fate ▼
The Principle ▼

(b)

Gestalt Psychology

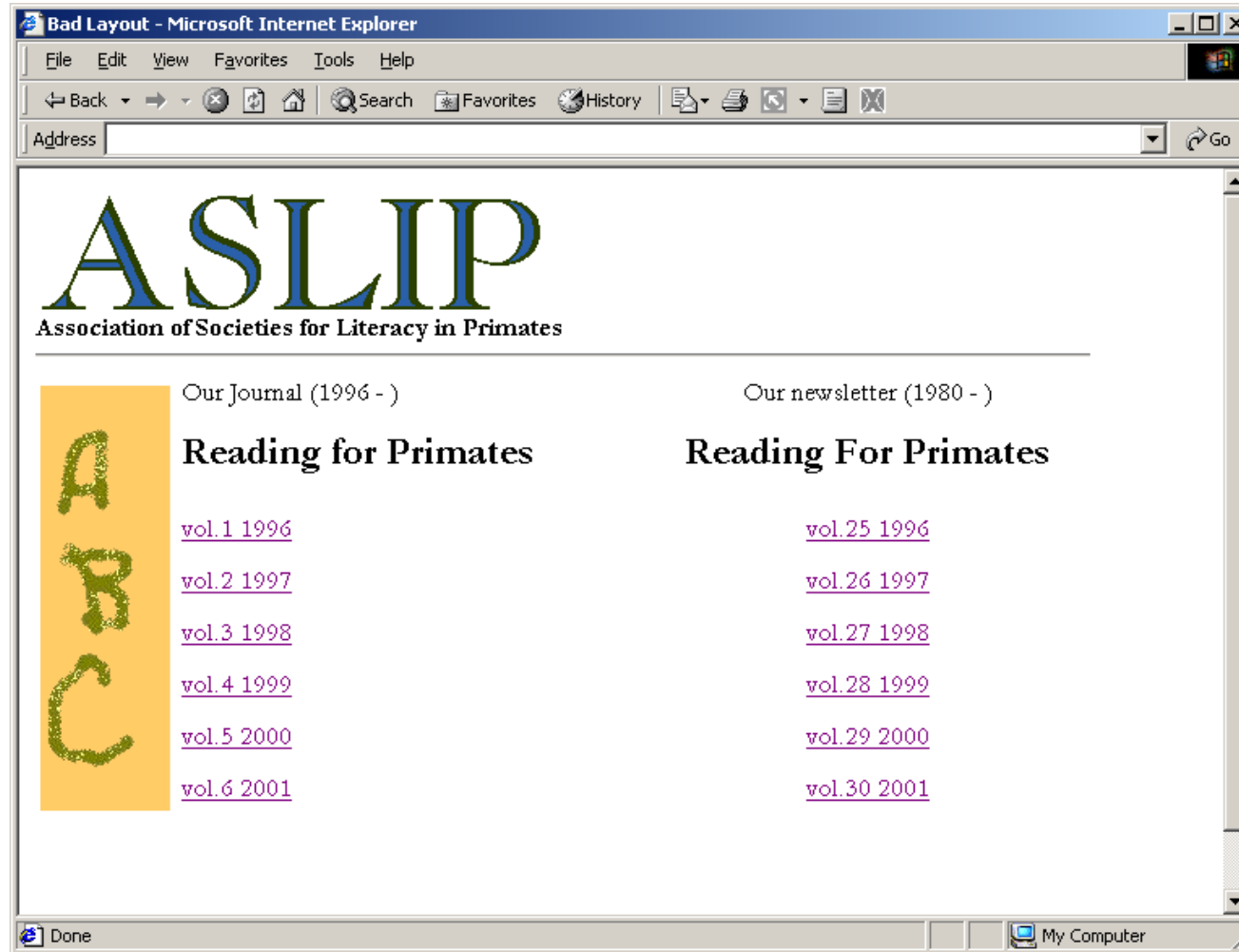
Design implication:

- Use alignment to improve layout



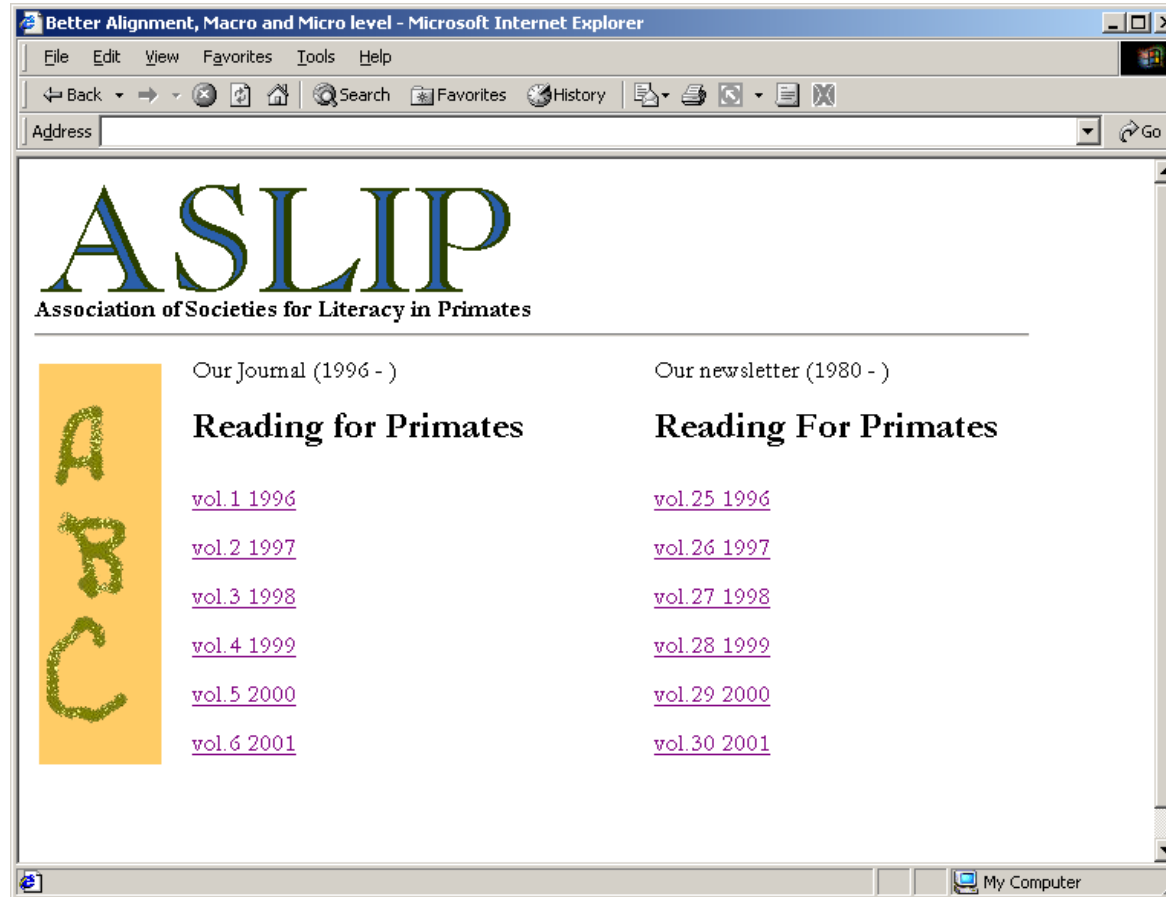
Gestalt Psychology

An improved version:



Gestalt Psychology

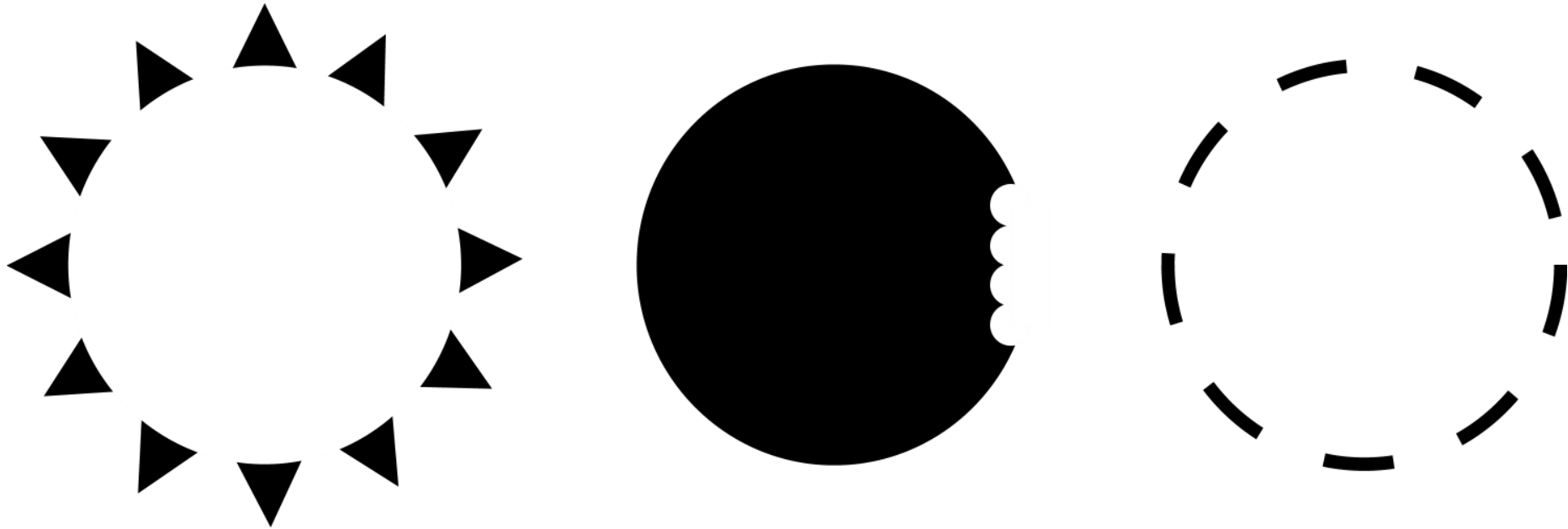
Can be further improved:



Gestalt Psychology

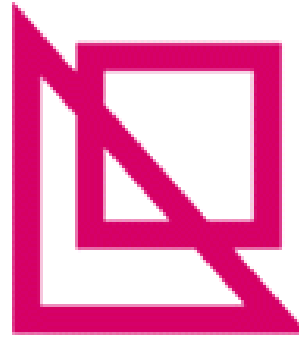
Principle of closure: we mentally “fill in the blanks”

Examples:



All are seen as circles although they are not exactly

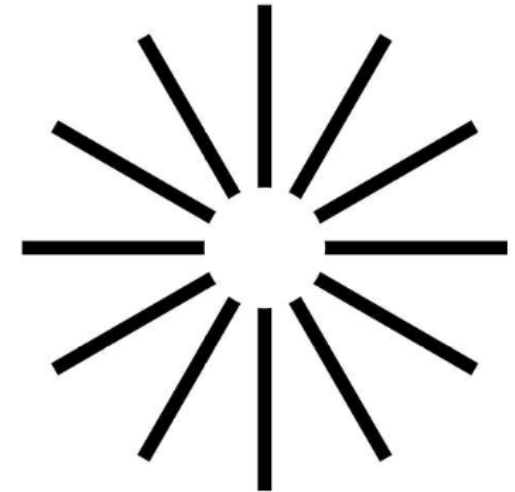
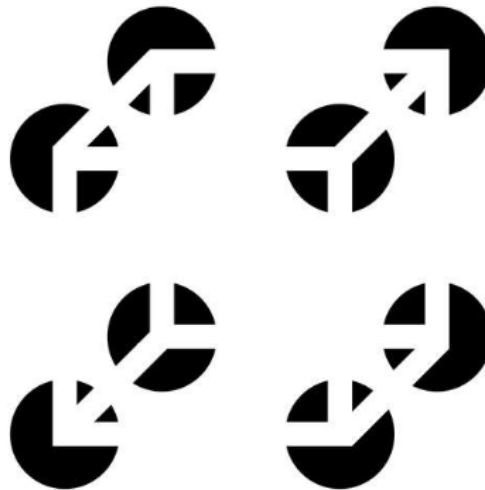
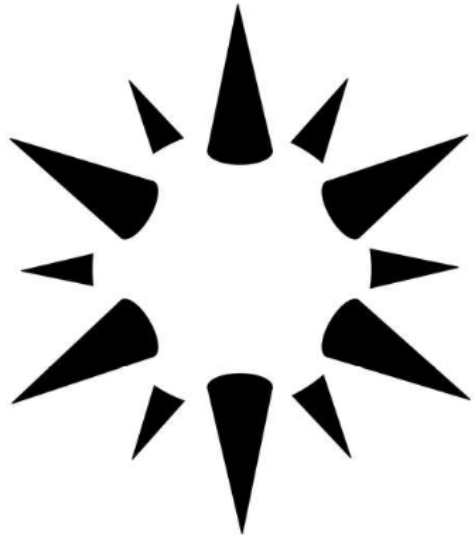
Gestalt Psychology



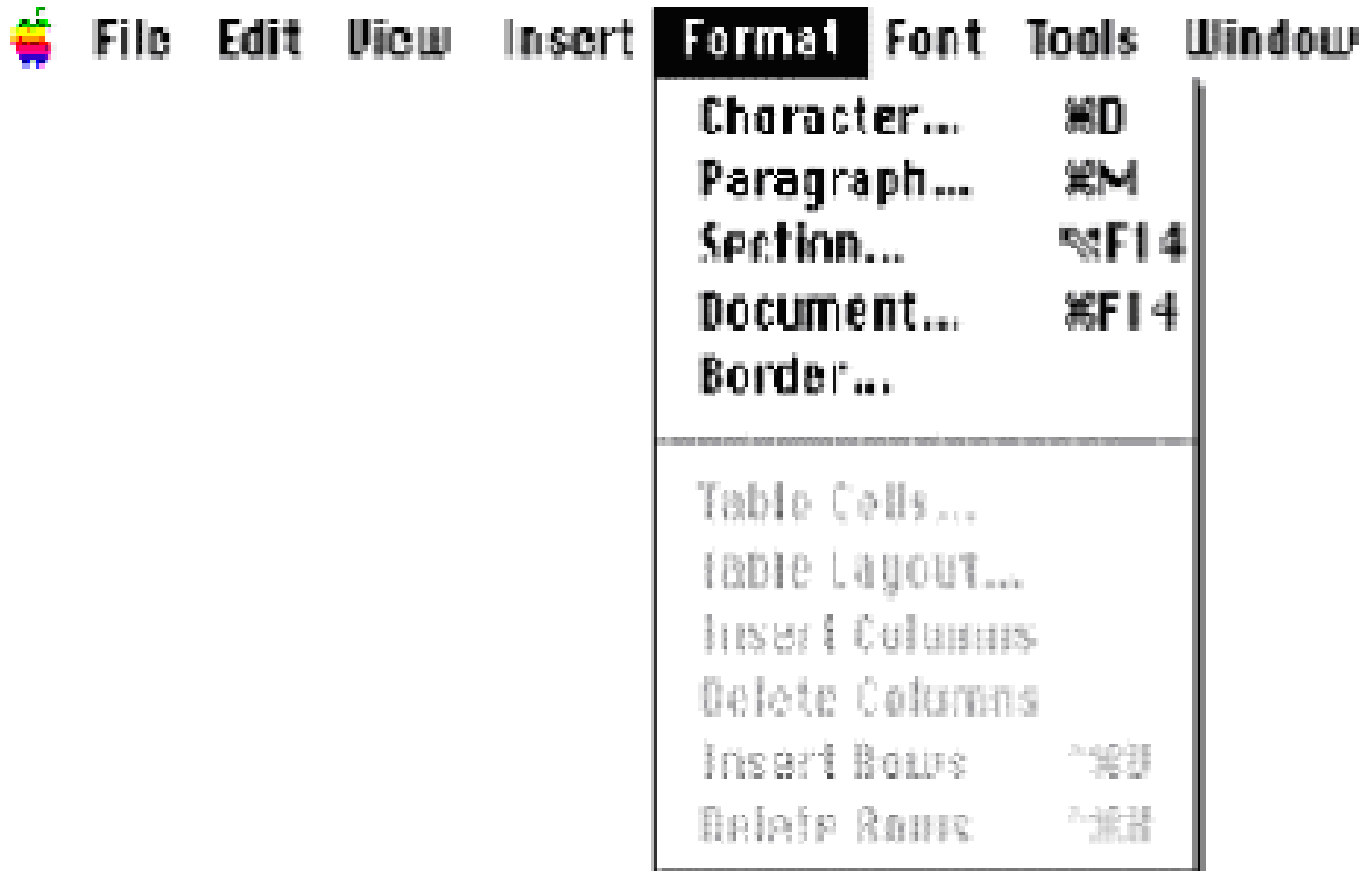
Any Gestalt's principles have been applied in the above two figures?

Gestalt Psychology

How about these?



Gestalt Psychology



Any Gestalt's principles have been applied?

Reading Speed/Accuracy

Speed of reading:

- Word shape is important to recognition

Which one is easier to recognize?

INTRODUCTION

Introduction

This was an advertisement appeared several times in Ming Pao, 2001

Any problem?

新科技預科書院
SUN INSTITUTE OF TECHNOLOGY & MATRICULATION

本校科系結構

Matriculation (預科一統制) 科書院開創，乃建基於知識 與新時代必須擁有大學學 業要求，為資助有志入讀大學 同學，並為學生作出考 關，由專科導師負責授課， 下一階中學，缺乏方向與對 策，浪費學生光陰，助發學	B 電腦及專業部 (新科技教育：塑造新科技人才) 新科技預科書院設立新科技時代高點，響應時代呼喚，以 電腦科技教育培育新科技人才，因應時代人力市場需求， 提供青少年新科技專業電腦訓練，使成專業人才，於新科技時代 與眾創新。 本校電腦及專業部各項課程，均由專業資深資深導師任 教，理論實踐並重，以最新科技設施，教授最新科技知識技 術，培訓學生成為新科技時代精英。
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課程：A 預科及中學部 B 電腦及專業部
A. 預科及中學部 THROUGH-TRAIN MATRICULATION PROGRAMME [預科一統制]
F6-F7 大學預科部 (保證2002/3 HKAL)
校方根據學生志願，輔導各生選讀相關預科科目，以考進其理想學系。本校預科設有①工程組②醫科組③電腦組④科學組⑤法學組⑥文科組⑦社會科學組⑧商業學金融組等。凡修讀F6預科之新生，除必修中文及英文二科高級補充程度科目外，均由本校預科班資深老師指導，選修其相關志願之高程度科目三科，以便成功考入其理想學系。
F4-F5 中學部 (保證2002/3 HKCE, 及 2004/5 HKAL)
凡於~~香港~~中學會考成績未達預科要求，但志切進讀大學者，可申請入讀本校「F5預科先修班」。本校F5，設文理與電腦組，學生可依其興趣選讀各組別，並由本校老師指導修讀有關科目，預先為學生入讀大學理學專業作準備。由

目標：於新科技時代，以新科技教育，塑造新科技人才。
使命：培訓本港中學生，德智體群美，全面發展，貢獻社會。
組織：本校為「新科技國際集團」屬下之本港註冊教育機構。
校舍：本校規模宏大，由三幢獨立校舍組合而成，互相毗鄰。

設施：
11/F 學生活動中心/ 學校禮堂/ 藝海中心/ 網上咖啡室(Cyber)
10/F 圖書館/ 電子圖書館/ 學生匯報及閱讀室/ 學校海外區總部
9/F 生物實驗室/ 課室
8/F 化學實驗室/ 課室
7/F 物理實驗室/ 課室
九龍校址
6/F 電腦多媒體語言實驗室
5/F 電腦及科技教育中
2/F 校務處/ 輔導處/ 升學及就業輔導處

Reading Speed/Accuracy



Intended Action No 137 /2019

HCA / 2019

IN THE HIGH COURT OF THE
HONG KONG SPECIAL ADMINISTRATIVE REGION
COURT OF FIRST INSTANCE
ACTION NO _____ OF 2019

BETWEEN

MTR CORPORATION LIMITED

Plaintiff

MTR obtained interim injunction from High Court

Any problem? Any design implication?

Reading Speed/Accuracy

This was an advertisement
appeared in Hong Kong Economic
Times, Sep. 2019

Proofread is important even for
lower-case words!

An Open Letter to HKUST Students

Dear HKUST students,

We are a group of alumni graduated from HKUST. We hope this letter finds you well.

Autumn comes and the school year restarts soon. It brings us back to the days that we still lived on campus - working hard in the library and enjoying our lives in the ivory tower. However, a lot of things seem to have been changed.

We are writing to express our deep concerns about the incoming strike on campus. We would like to ask you to think twice before participating.

Just like you, we love freedom. However, we know that freedom does not mean you can do whatever you want to do, instead, freedom means you can refuse to do whatever you don't agree with. There are faculties and students who do not want to participate in the strike. Please bear in mind that their freedom does not value less than those who go on strike.

Just like you, we pursue democracy. However, we know that there is a bottom line of democracy. We are all Hong Kongers, and we are also Chinese. Do not be misled by Separatism. Please remember that one's home can be called a home only when the national sovereignty and territorial integrity is safeguarded.

Just like you, we cherish the rule of law. So we cannot agree that violent criminals we have seen recently on news should be granted pardons, no matter what intensions they had. No one should be above the law.

Just like you, we support freedom of speech. That is to say, even though I disapprove of what you say, I will defend to the death your right to say it. However, violence is never a solution but a troublemaker. We thank President Wei Shyy for hosting president forums to encourage open discussion. Let's have politics stay in politics, academics remain with academics.

We also know that there are injustices and inequalities all around the world. We'd like to share a quote from former US President John F. Kennedy, "Ask not what your country can do for you, ask what you can do for your country."

Located in the east of Hong Kong, our beautiful campus is the best place for you to enjoy the splendid sunrise. We hope you remain positive and optimistic. We strongly believe that tomorrow will be better in Hong Kong.

Best regards,
A group of HKUST alumni

Reading Speed/Accuracy

- For font size, 9 to 12 points are good and similar
- For text width, 2.3 and 5.2 inches are good and similar

LETTER

2137

$$\begin{aligned} \sigma_x^2 &\triangleq E\{(\hat{x} - x)^2\} = c^2 E\{(\hat{r} \cos(\hat{\phi}) - r \cos(\phi))^2\} \\ &\approx c^2 E\{(e_r \cos(\hat{\phi}) - r \sin(\hat{\phi}) \sin(\epsilon_\phi))^2\} \\ &\approx c^2(\sigma_r^2 \cos^2(\phi) + r^2 \sigma_\phi^2 \sin^2(\phi)) \end{aligned} \quad (3)$$

In a similar manner, the variance of \hat{y} is derived as

$$\begin{aligned} \sigma_y^2 &\triangleq E\{(\hat{y} - y)^2\} \\ &\approx c^2(\sigma_r^2 \sin^2(\phi) + r^2 \sigma_\phi^2 \cos^2(\phi)) \end{aligned} \quad (4)$$

As a result, the variance of the range error, denoted by σ_z^2 , is

$$\sigma_z^2 \triangleq E\{(\hat{z} - z)^2\} + E\{(\hat{y} - y)^2\} \approx c^2(\sigma_r^2 + r^2 \sigma_\phi^2) \quad (5)$$

which is a function of r , σ_r^2 and σ_ϕ^2 .

The CRLB gives a lower bound on variance attainable by any unbiased estimators and thus it can be served as a benchmark to contrast with the mean square error of the positioning algorithm. The CRLBs for x and y are computed from [7]

$$\text{CRLB}(\theta_i) = [I^{-1}(\theta)]_{i,i}, \quad i = 1, 2 \quad (6)$$

where

$$[I(\theta)]_{i,j} = -E \left\{ \frac{\partial^2 \ln p(\mathbf{z}|\theta)}{\partial \theta_i \partial \theta_j} \right\}, \quad i = 1, 2 \quad \text{and} \quad j = 1, 2 \quad (7)$$

and

$$\begin{aligned} p(\mathbf{z}|\theta) &= \frac{1}{\sqrt{2\pi\sigma_z^2}} \\ &\cdot \exp \left(-\frac{1}{2\sigma_z^2} \left(\hat{z} - \sqrt{(x-x_s)^2 + (y-y_s)^2} \right)^2 \right) \\ &\cdot \frac{1}{\sqrt{2\pi\sigma_\phi^2}} \exp \left(-\frac{1}{2\sigma_\phi^2} \left(\hat{\phi} - \tan^{-1} \left(\frac{y-y_s}{x-x_s} \right) \right)^2 \right) \end{aligned} \quad (8)$$

is the probability density function (PDF) of $\mathbf{z} = [\hat{z}, \hat{\phi}]$ parameterized by the MS position, and $[I(\theta)]_{i,j}$ represent the (i, j) th element of $I(\theta)$, which is known as the Fisher information matrix (FIM). The FIM is computed as

$$I(\theta) = \frac{1}{c^2} \begin{bmatrix} \frac{\cos^4(\phi)}{2} + \frac{\sin^4(\phi)}{r^2 \sigma_\phi^2} & \frac{\sin(2\phi)}{2} \left(\frac{1}{r^2} - \frac{1}{r^2 \sigma_\phi^2} \right) \\ \frac{\sin(2\phi)}{2} \left(\frac{1}{r^2} - \frac{1}{r^2 \sigma_\phi^2} \right) & \frac{\sin^2(\phi)}{c^2} - \frac{\cos^2(\phi)}{r^2 \sigma_\phi^2} \end{bmatrix} \quad (9)$$

Taking the inverse of $I(\theta)$ yields $[I^{-1}(\theta)]_{1,1} = c^2(\sigma_r^2 \cos^2(\phi) + r^2 \sigma_\phi^2 \sin^2(\phi))$ and $[I^{-1}(\theta)]_{2,2} = c^2(\sigma_r^2 \sin^2(\phi) + r^2 \sigma_\phi^2 \cos^2(\phi))$, which indicates the optimality of the TOA-AOA hybrid algorithm at sufficiently small noise conditions. As a result, the CRLB for the range is also given by $c^2(\sigma_r^2 + r^2 \sigma_\phi^2)$. It is noteworthy that (2) is in fact the maximum likelihood estimate because (8) is maximized at (\hat{x}, \hat{y}) .

3. Simulation Results

Extensive computer simulations were conducted to evaluate the TOA-AOA hybrid mobile positioning algorithm using a single BS with multiple antennas in the LOS scenario. It was assumed that necessary changes to the mobile networks had been made [4] so that the measured TOA and AOA were of high accuracy, even in the presence of multipath propagation [8]. We considered a microcell with radius of 500 m and the measurement errors were uncorrelated zero-mean Gaussian processes. The worst-case performance was investigated such that the MS was randomly located at the cell boundary with ϕ uniformly distributed over $[0, 2\pi)$.

Figure 1 shows the standard deviation of the range error for $\sigma_r \in [-80, -50]$ dBs at $\sigma_\phi = 0$ and $\sigma_\phi = 0.1$ rad. It can be seen that the estimation accuracy of the hybrid estimator met the CRLBs for the range in both cases. Note that at $\sigma_r = 0.1$ rad, the range deviation was approximately equal to 17 dBm at $\sigma_r \approx 50$ m, for $\sigma_r < -68$ dBs because the AOA error dominated. Another similar test to examine the location error versus σ_ϕ at $\sigma_r = 0$ and $\sigma_r = 0.1 \mu\text{s}$ was also performed and the results are shown in Fig. 2. Again, the range deviations agreed well with the CRLBs except that there was slight discrepancy for $\sigma_\phi > -3$ dBrad because (3) and (4) were derived based on small ϵ_ϕ assumption. For

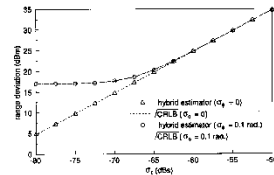


Fig. 1 Range standard deviation versus σ_r .

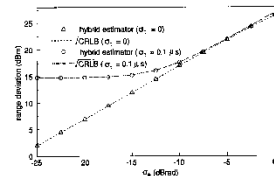


Fig. 2 Range standard deviation versus σ_ϕ .

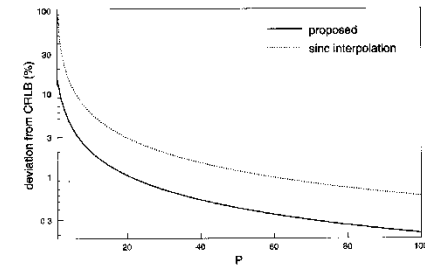


Fig. 3 Deviation from CRLB versus P for white signal.

limiting value $\lim_{P \rightarrow \infty} \sum_{j=-P}^P \text{sinc}^2(j-D) = \pi^2/3$ even for a small P , and it can be shown that (10) is an unbiased estimator for white $s(\hat{k})$, the mean square delay error (MSDE) of the proposed method will approach the CRLB for a wide range of filter lengths. On the other hand, the delay variance using sinc interpolation is given by

$$\text{var}(\hat{D}^{\text{sinc}}) \approx \text{CRLB} \frac{3 \sum_{j=-P}^P \text{sinc}^4(j-D)}{\pi^2 (\sum_{j=-P}^P \text{sinc}^2(j-D) \text{sinc}^4(j-D))^2}, \quad (16)$$

where it also attains the CRLB as $P \rightarrow \infty$ but has a convergence rate lower than (15). To illustrate this, Fig. 1 plots the deviation from the CRLB, that is, $(\text{var}(\hat{D}^{\text{sinc}}) - \text{CRLB})/\text{CRLB}$, for both schemes versus P at $D = 0.7$ s, and it can be observed that the percentage error of (15) is less than that of (16) for the whole range of P by approximately 3–6 times. It is noteworthy that since the sinc interpolator is biased for finite P , the resultant MSDE will be much larger than (16).

4. Numerical examples

Simulation tests were carried out to evaluate the performance of the proposed delay estimator using least-squares filter weights. Comparisons of MSDEs were also made with the sinc interpolator and the CRLB. The searching procedures of (2) and (10) were performed by the bisection method. The source signal was Gaussian distributed with unity power and different SNRs were obtained by proper scaling of the random noise sequences. For simplicity, the additive noises were assigned to have identical power. The time difference D was set to 0.7 s, the data length N was 1000 and $\alpha = 1$ was selected. The MSDEs obtained were based on 1000 independent runs.

In the first test, the source signal was a white process. Fig. 2 shows the MSDEs of the proposed method and sinc interpolator using $P = 3$ and $P = 15$, as well the CRLB, for $\text{SNR} \in [-10, 20]$ dB. It can be seen that when $\text{SNR} \geq -6$ dB, the proposed approach was superior to the sinc interpolation method using $P = 3$ and $P = 15$, for the whole range of SNRs and for $\text{SNR} \geq 4$ dB, respectively. Furthermore, the proposed method with $P = 3$ and $P = 15$ had very similar performance and both met the CRLB for $\text{SNR} \geq -6$ dB, which indicated that the delay estimation performance of (10) was almost

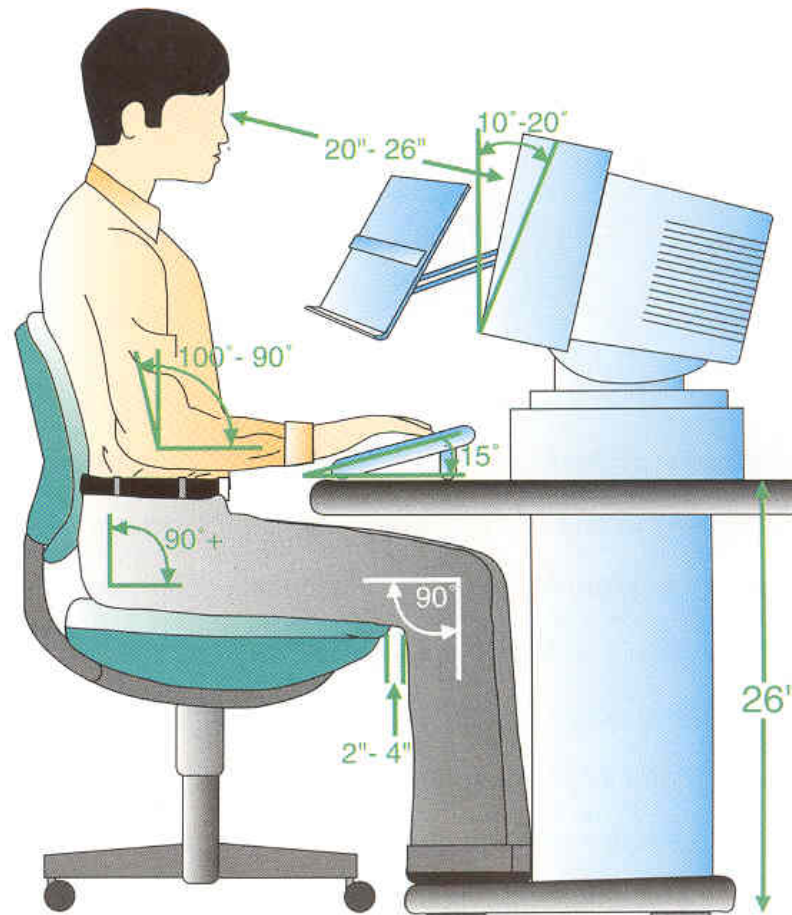
Hearing

- Human can hear frequencies from 20Hz to 15kHz
- Less accurate in distinguishing high frequencies than low frequencies
- Auditory system filters sounds - can attend to sounds over background noise/interference. For example, we can talk with our friend in a very noisy Chinese restaurant (cocktail party phenomenon)
- A sound's loudness is measured in decibels (dB), and level between 20 dB and 70 dB constitutes comfortable
- Apart from hearing sound, our ears are capable to get the distances and directions of the sound sources

Why position information can be obtained?

Touch

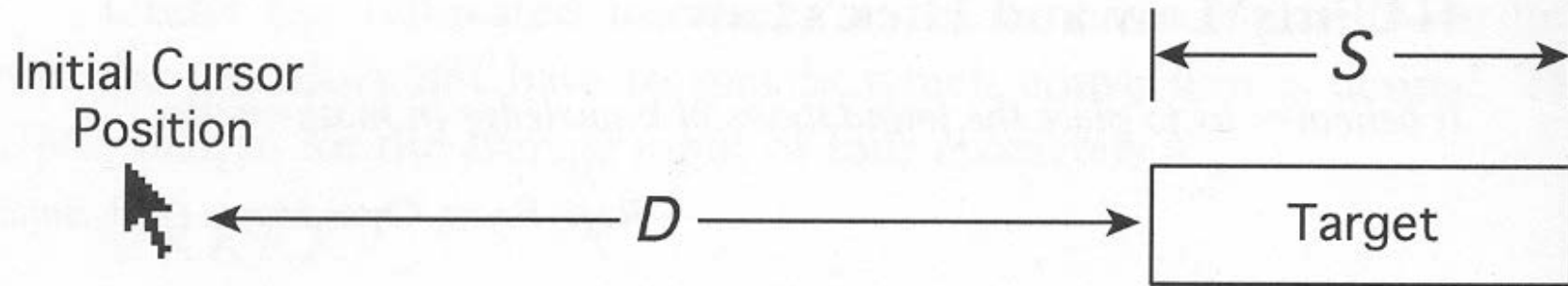
- Key sense for visually impaired persons
- Aspects include



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

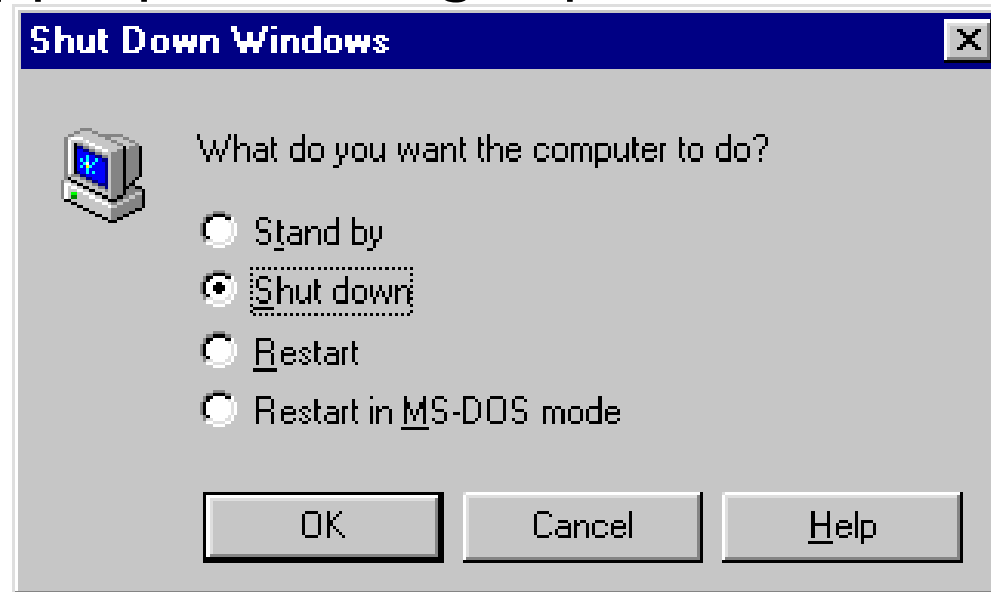
$$T_M = 50 + 150 \log_2(80/50 + 1) = 256 \text{ ms}$$

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**:

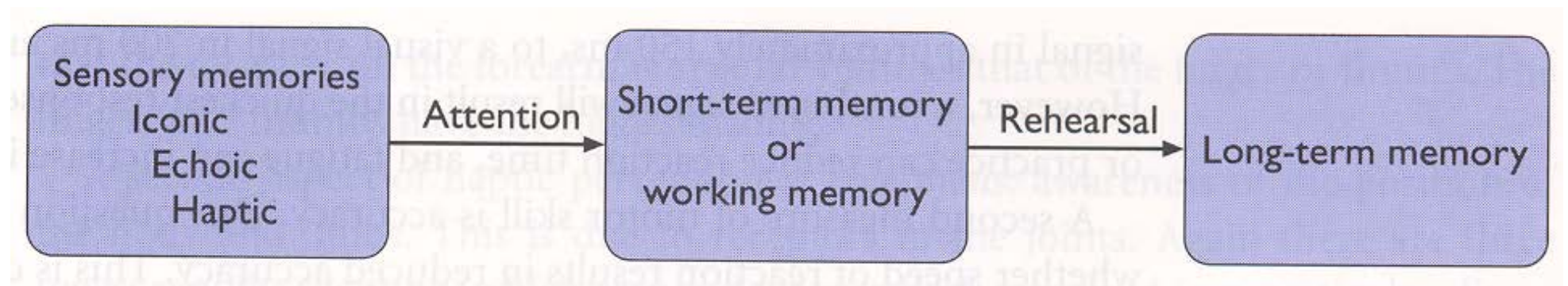
$$T_c = a + b \log_2(N+1)$$

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 and other voices 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?

85234427780

The chunks can be 852, 3, 4, 4, 2, 7, 7, 8, 0 \Rightarrow 9 chunks

How about this?

852 3442 7780

There are now 3 chunks: 852, 3442, 7780

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.bestbookbuys.com

The chunks are:

www.

best

book

buys

.com

Another application is to use chunking in memorizing phone number, 3442, 7780

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 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
⇒ It is valid deduction but not true
- Human deduction poor when truth & validity clash

Reasoning

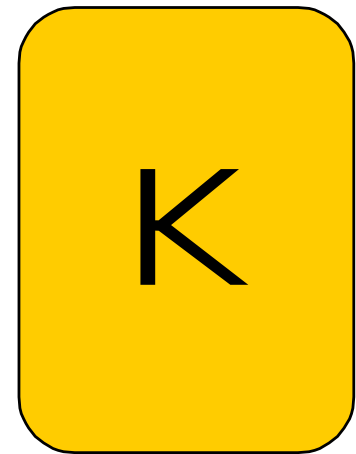
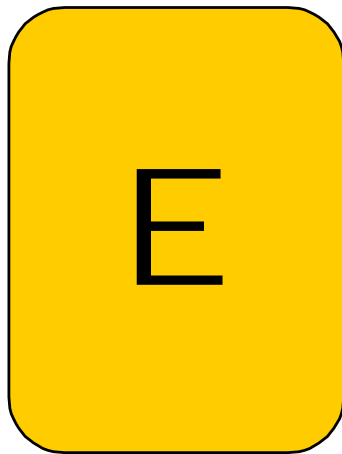
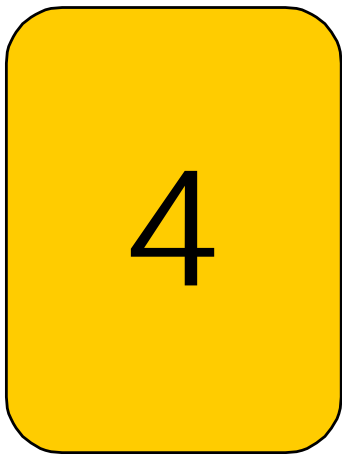
2. Inductive reasoning

- 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

Reasoning

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"

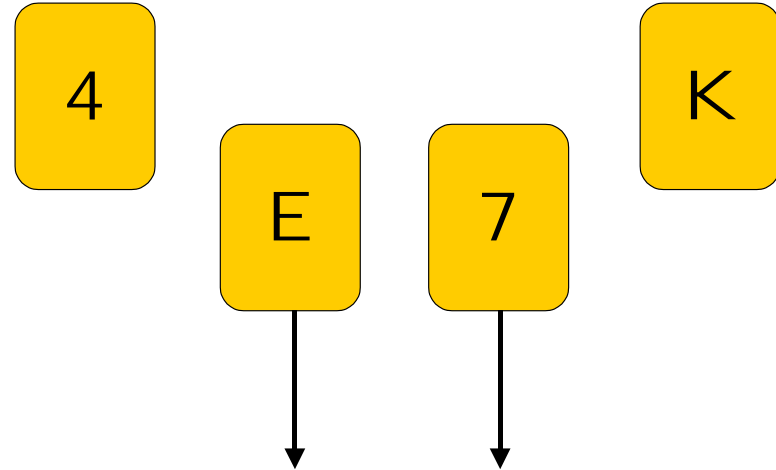


Which card(s) would you need to pick up to check this statement?

Reasoning

Most people: E & 4

In fact, we need to check E & 7



Because "If A, then B."

\Leftrightarrow "If NOT B then NOT A."

- (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)

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

Reasoning

How about if the condition “each card has a number on one side and a letter on the other” is not stated? Which card(s) would you need to pick up to check the statement?

Design implication:

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

3. **Abductive** reasoning

- Reasoning from event to cause
e.g., Sam drives fast when drunk
If you see Sam driving fast, assume he is drunk
- Unreliable: can lead to false explanations.
e.g., 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?

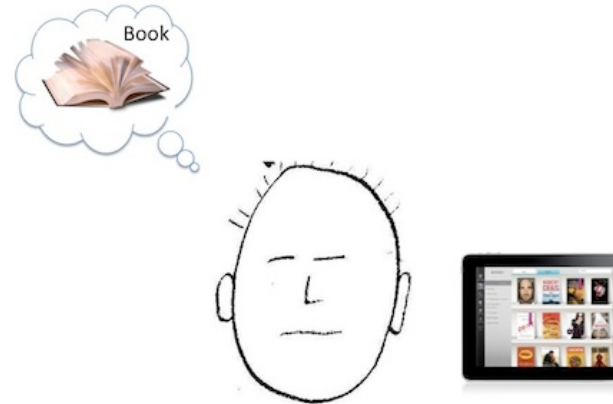
e.g., Make a phone call:

- 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 book reading

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

Mental Model

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