hci+d lab.

Week 03

Foundation of HCI: Cognitive Aspects / Interfaces

HCI 이론 및 실습 2020 Spring

Human-Computer Interaction+Design Lab _ Joonhwan Lee

오늘 다룰 내용

- Cognition
- Cognition Frameworks
- Interfaces

Cognition

Why do we need to understand users?

- Interacting with technology is cognitive
- Need to take into account cognitive processes involved and cognitive limitations of users
- Provides knowledge about what users can and cannot be expected to do
- Identifies and explains the nature and causes of problems users encounter
- Supply theories, modeling tools, guidance and methods that can lead to the design of better interactive products

“human attention is the scarce resource” Herbert Simon, 1969

Cognitive Processes

- Attention
- Perception and recognition
- Memory
- Learning
- Reading, speaking and listening
- Problem-solving, planning, reasoning and decision-making

Model of the Human

- HCI - area of studies that understands users
- Methods and theories are developed to understand users
  - Contextual Inquiry
  - Interviews
  - Surveys
  - etc.
- How users perceive information and process it? → Human Model

Cognitive Process Example

(눈을 감고)

내가 **박수**를 치면

~~학생들은 **책상을 두드릴 것**~~

학생들은 **손을 들것 (Raise Hand)**

Cognitive Process Example

박수 소리를 듣는다

.

(잠깐 동안의 시간이 흐르고...)

.

~~책상을 두드린다~~

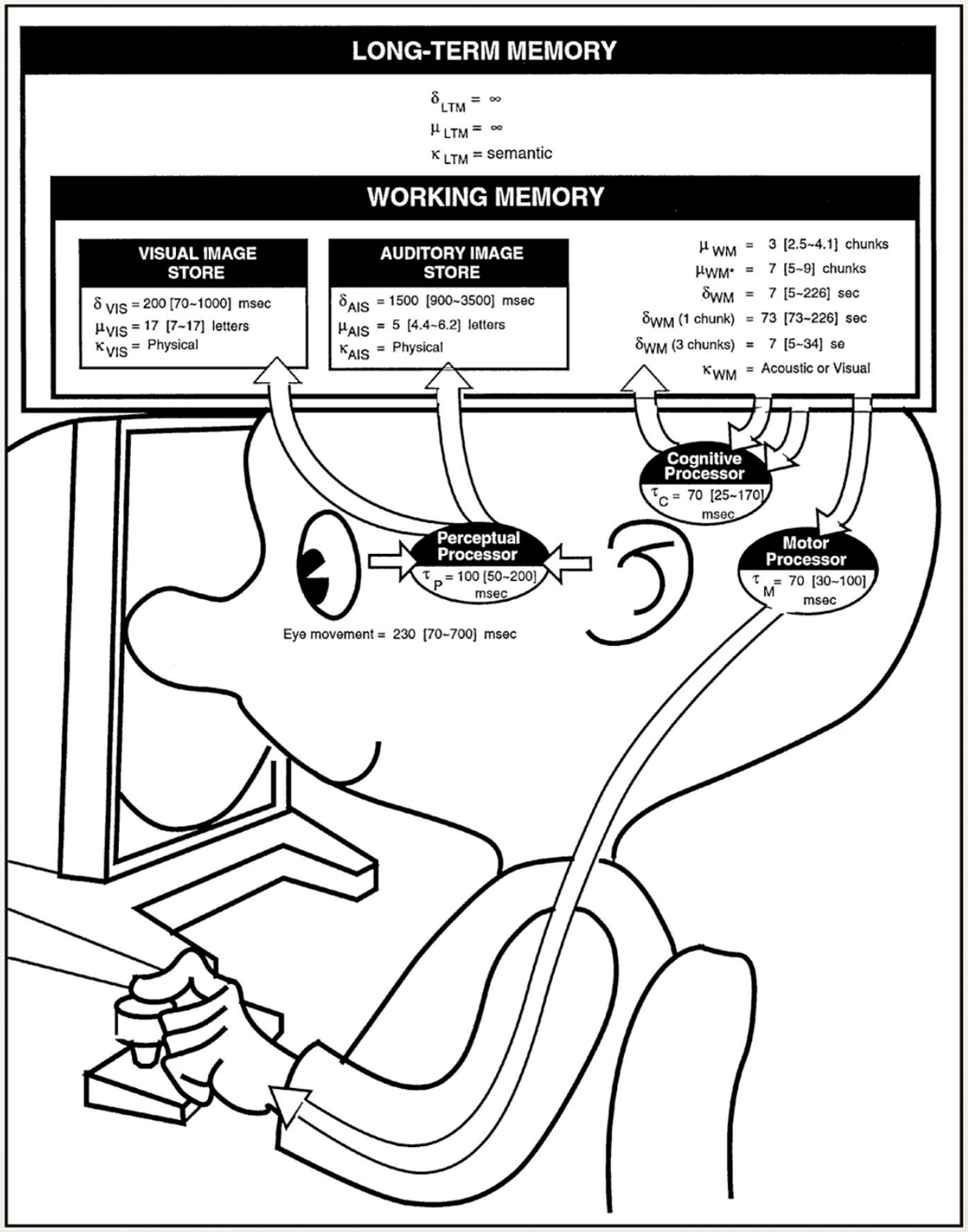
손을 든다

이 과정에서 벌어진 일은?

Cognitive Process Example

- 3 step subsystems
  - Perceptual System: hear clap sound
  - Cognitive System: process information related to the sound
  - Motor System: knock the table
  - Memory was involved in the process
    - remember the instruction - short term memory
    - remember the action (knocking the table) from our previous experience - long term memory

Model Human Processor



Attention

- **Selecting things to concentrate on** at a point in time from the mass of stimuli around us
  - Allows us to to focus on information that is relevant to what we are doing
  - Involves audio and/or visual senses
- Focussed and divided attention enables us to be selective in terms of the mass of competing stimuli but limits our ability to keep track of all events
- Information at the interface should be structured to capture users' attention
  - e.g. use perceptual boundaries (windows), colour, reverse video, sound and flashing lights

Selective Attention Test

from Simons & Chabris (1999)

https://www.youtube.com/watch?v=vJG698U2Mvo

Attention

Pennsylvania
Bedford Motel/Hotel: Crinaline Courts
(814) 623-9511 S: $18 D: $20
Bedford Motel/Hotel: Holiday Inn
(814) 623-9006 S: $29 D: $36
Bedford Motel/Hotel: Midway
(814) 623-8107 S: $21 D: $26
Bedford Motel/Hotel: Penn Manor
(814) 623-8177 S: $19 D: $25
Bedford Motel/Hotel: Quality Inn
(814) 623-5189 S: $23 D: $28
Bedford Motel/Hotel: Terrace
(814) 623-5111 S: $22 D: $24
Bradley Motel/Hotel: De Soto
(814) 362-3567 S: $20 D: $24
Bradley Motel/Hotel: Holiday House
(814) 362-4511 S: $22 D: $25
Bradley Motel/Hotel: Holiday Inn
(814) 362-4501 S: $32 D: $40
Breezewood Motel/Hotel: Best Western Plaza
(814) 735-4352 S: $20 D: $27
Breezewood Motel/Hotel: Motel 70
(814) 735-4385 S: $16 D: $18

- Find the price of a double room at the Holiday Inn in Bradley

Attention

South Carolina

City	Motel/Hotel	Area code	Phone	Rates Single	Double
Charleston	Best Western	803	747-0961	$26	$30
Charleston	Days Inn	803	881-1000	$18	$24
Charleston	Holiday Inn N	803	744-1621	$36	$46
Charleston	Holiday Inn SW	803	556-7100	$33	$47
Charleston	Howard Johnsons	803	524-4148	$31	$36
Charleston	Ramada Inn	803	774-8281	$33	$40
Charleston	Sheraton Inn	803	744-2401	$34	$42
Columbia	Best Western	803	796-9400	$29	$34
Columbia	Carolina Inn	803	799-8200	$42	$48
Columbia	Days Inn	803	736-0000	$23	$27
Columbia	Holiday Inn NW	803	794-9440	$32	$39
Columbia	Howard Johnsons	803	772-7200	$25	$27
Columbia	Quality Inn	803	772-0270	$34	$41
Columbia	Ramada Inn	803	796-2700	$36	$44
Columbia	Vagabond Inn	803	796-6240	$27	$30

- Find the price for a double room at the Quality Inn in Columbia

Attention

- Tullis (1987) found that the two screens produced quite different results
  - 1st screen - took an average of 5.5 seconds to search
  - 2nd screen - took 3.2 seconds to search
- Why, since both displays have the same density of information (31%)?
- Spacing → **Gestalt Theory**
  - In the 1st screen the information is bunched up together, making it hard to search
  - In the 2nd screen the characters are grouped into vertical categories of information making it easier

Multitasking and Attention

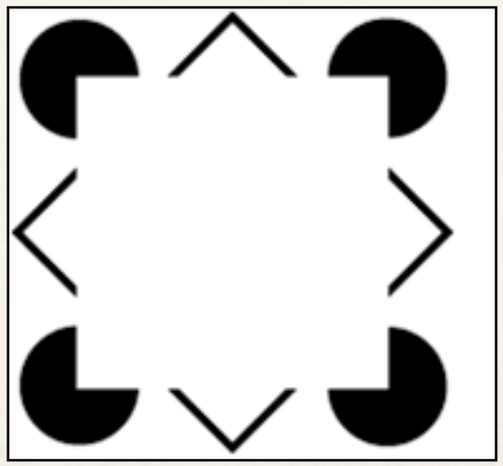
- Is it possible to perform multiple tasks without one or more of them being detrimentally affected?
- Ophir et al (2009) compared heavy vs light multi-talkers
  - heavy were more prone to being distracted than those who infrequently multitask
  - heavy multi-taskers are easily distracted and find it difficult to filter irrelevant information

Design Implications of Attention

- **Make information salient** when it needs attending to
- Use techniques that **make things stand out** like color, ordering, spacing, underlining, sequencing and animations → pop out
- Avoid cluttering the interface with too much information

Gestalt Theory

- Gestalt psychology tries to understand the laws of our ability to acquire and maintain meaningful perceptions in an apparently chaotic world.
- The central principle of gestalt psychology is that the mind forms a global whole with self-organizing tendencies.



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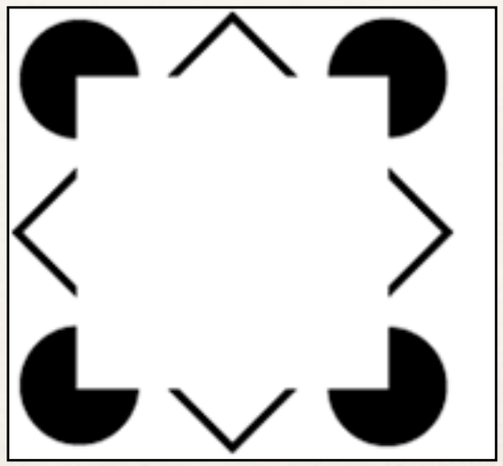
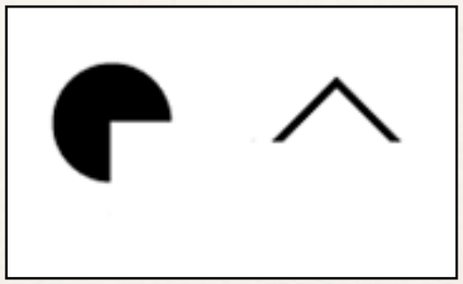
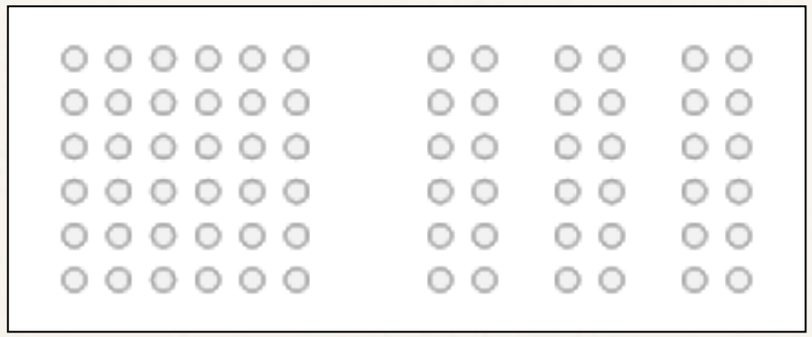


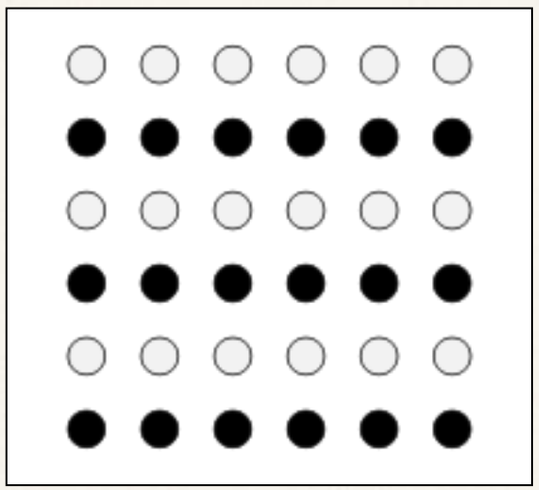


Gestalt Theory

- Law of Proximity

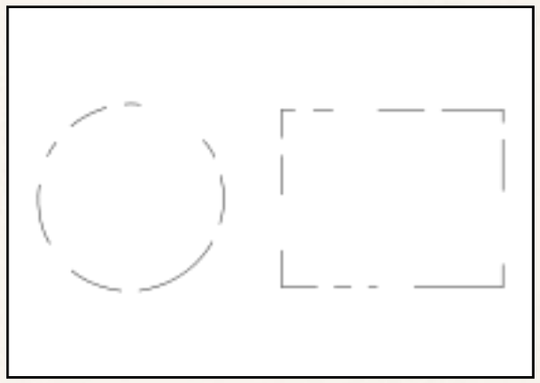


- Law of Similarity

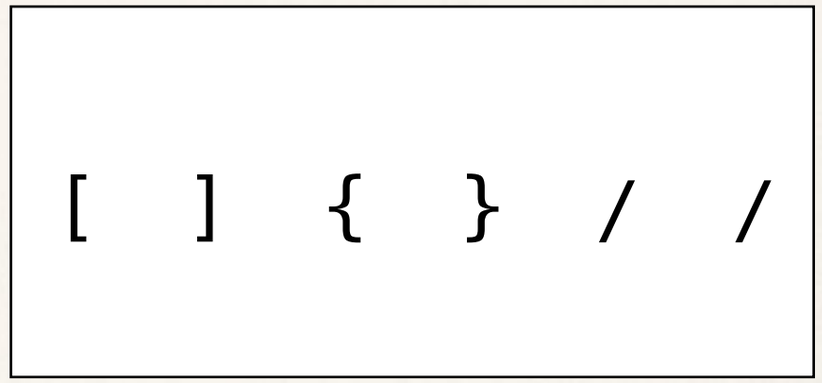


Gestalt Theory

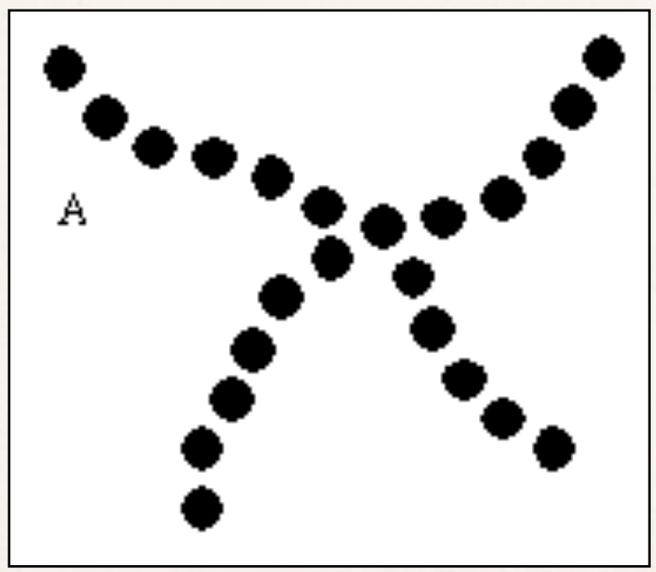
- Law of Closure



- Law of Symmetry



- Law of Continuity



Gestalt Theory

- Multistability: the tendency of ambiguous perceptual experiences to pop back and forth unstably between two or more alternative interpretations.

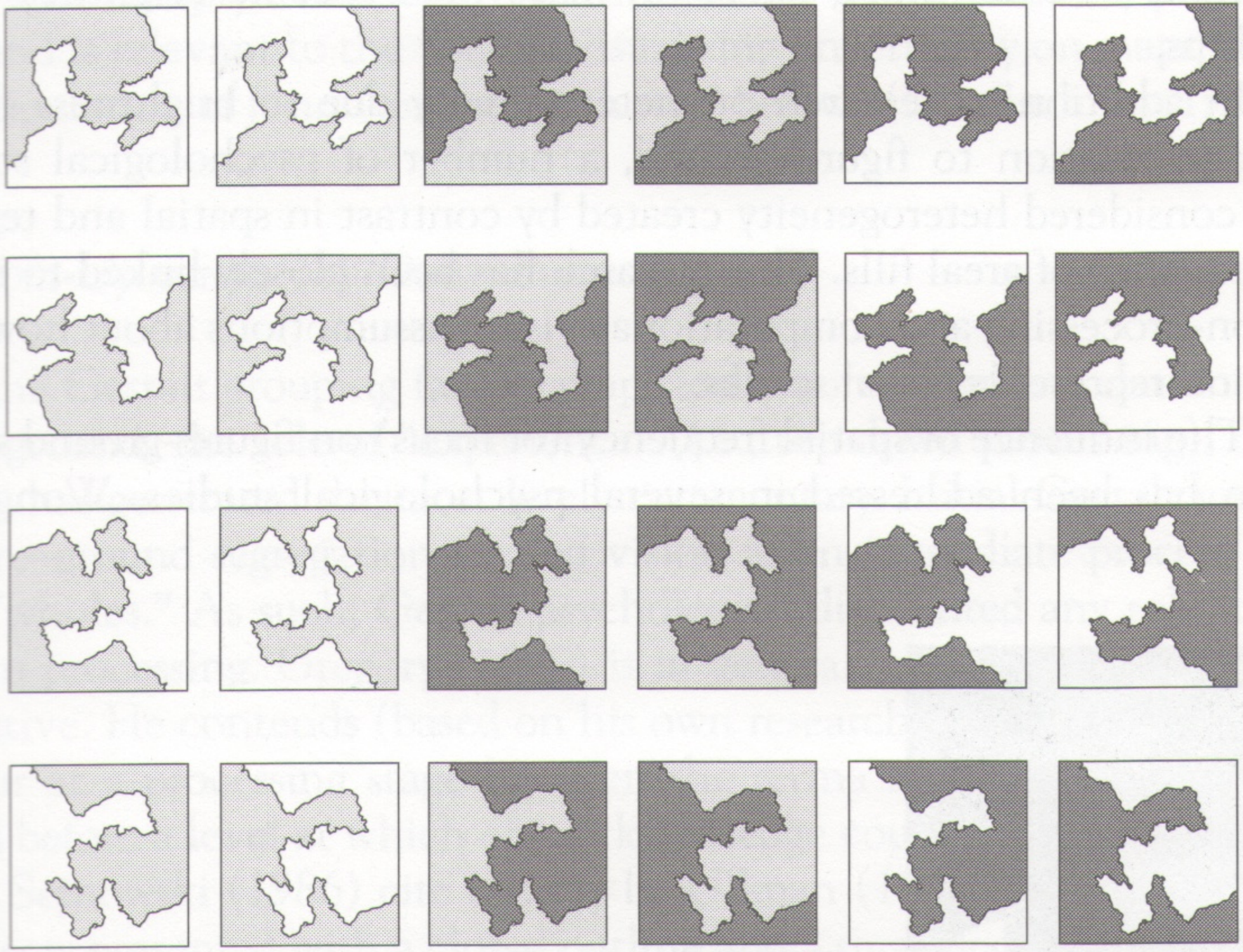


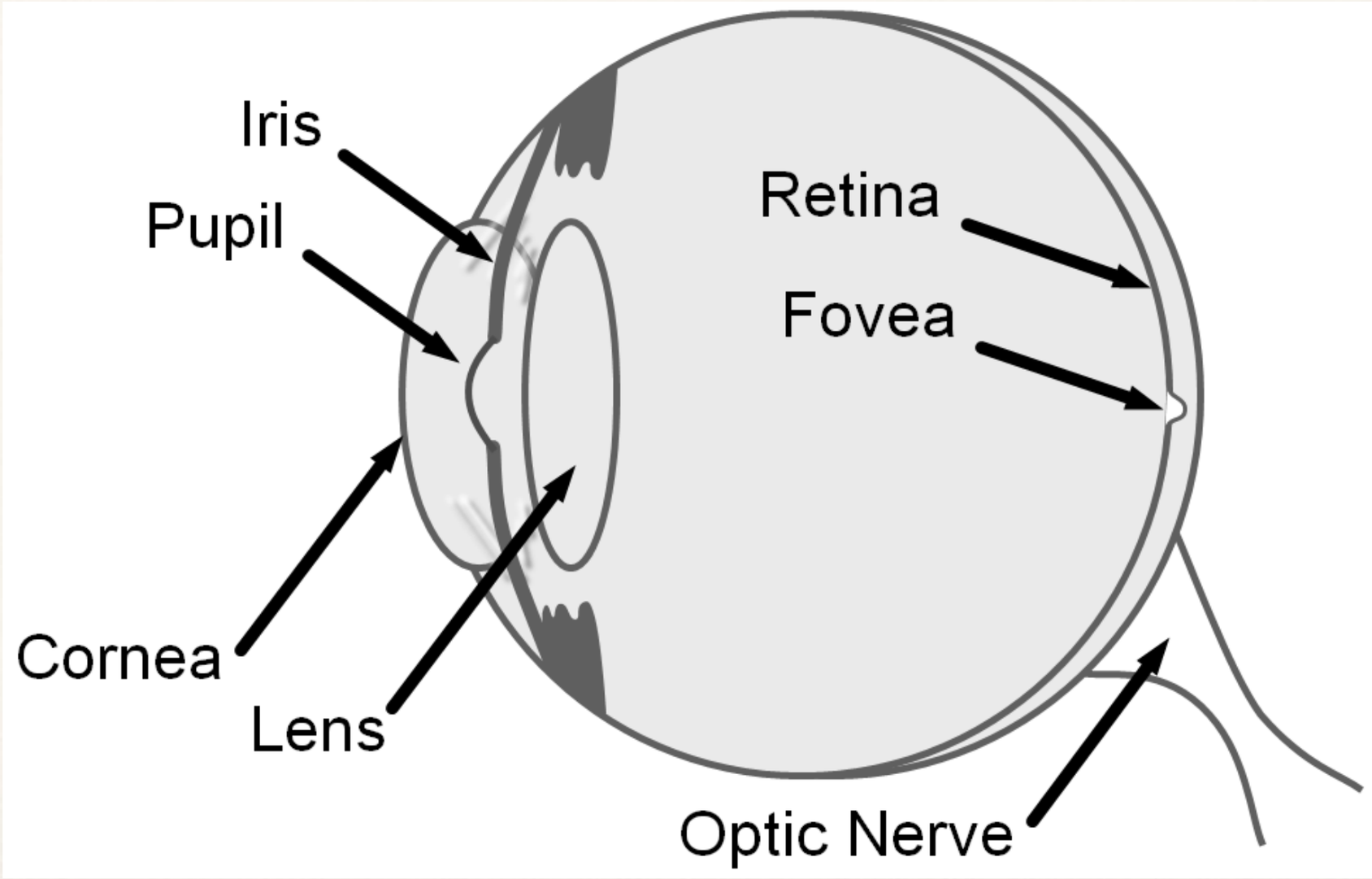
FIGURE 3.58. The complete set of maps used in Mistrick's study (at greatly reduced size). *Reproduced from MacEachren and Mistrick (1992, Fig. 6, p. 96). Reprinted by permission of* The Cartographic Journal.

Perception

- **How information is acquired** from the world and transformed into experiences
- Obvious implication is to design representations that are **readily perceivable**
  - Text should be legible
  - Icons should be easy to distinguish and read

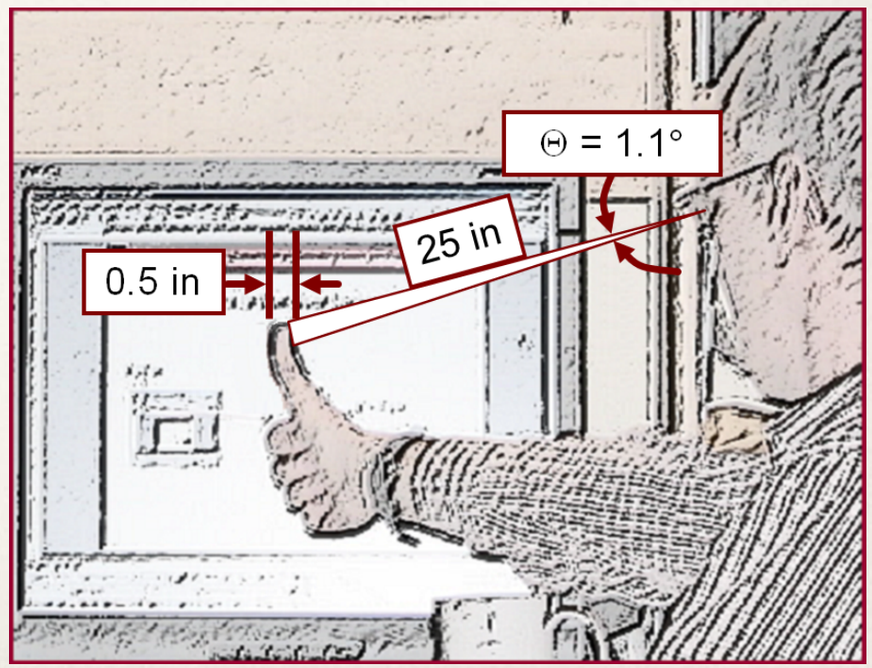
Vision

- 80% of information we perceive is acquired through vision



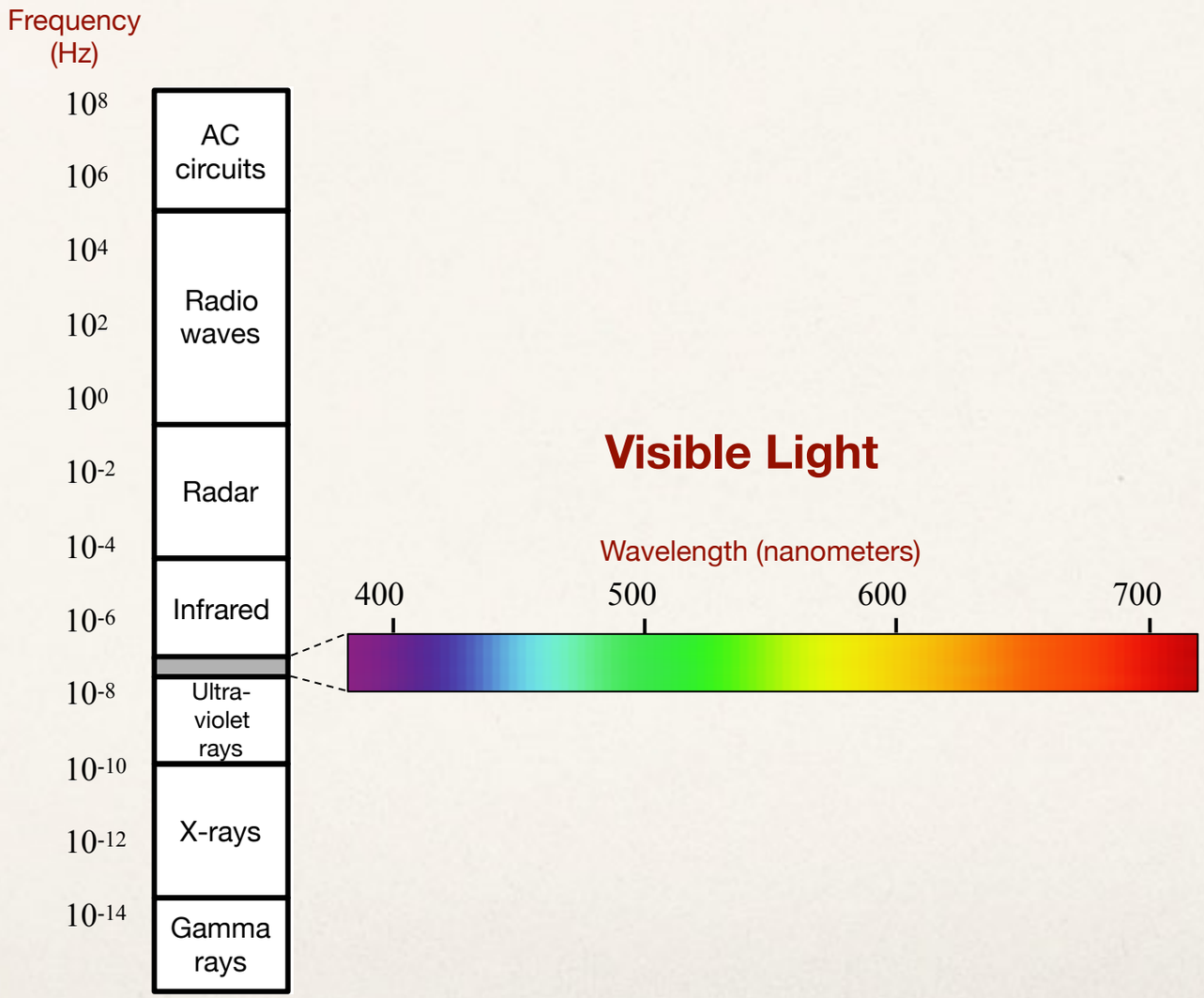
Fovea Image

- Fovea: center of retina - most focused area in vision
  - we use fovea when reading books or watching tv
- Fovea image
  - 1° of vision angle which covers 1% or retina area
  - However, it occupies 50% visual cortex (visual cortex process visual information)



Visual Stimulus

- Visual stimulus: Light
- Light has frequency and intensity (luminance)

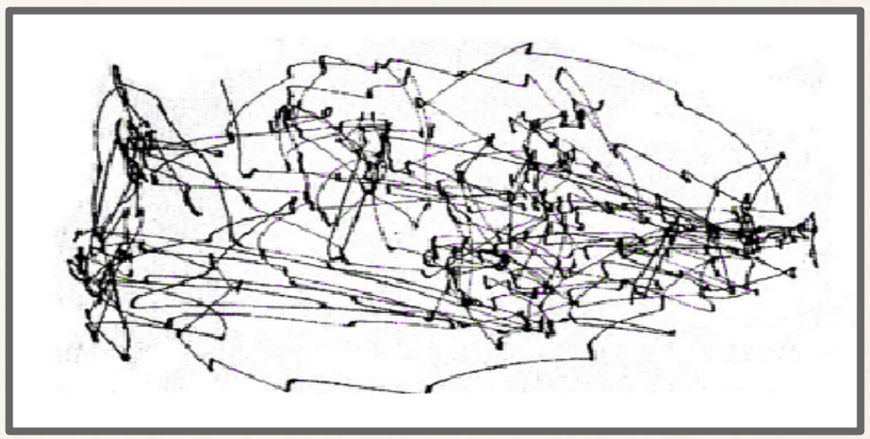


Fixation and Saccade

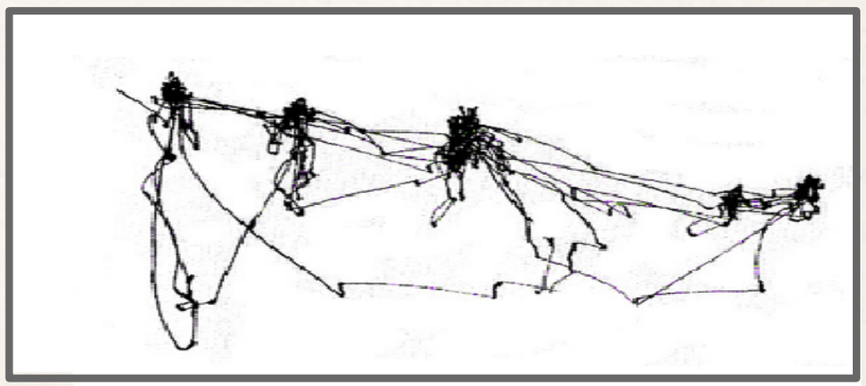
- Fixation and Saccade: two different eye movements when acquiring visual information.
- Fixation
  - Eyes stay in one position to collect detailed visual information.
  - Fixation times differ according to circumstances, but usually they are about 200ms
- Saccade
  - Move eyes (point of fixation) from one position to another in order to collect new information
  - Very fast, and usually it takes about 30~120ms
- Measurements of fixation and saccade help to understand the process of visual information

Yarbus' Eye Tracking Research (1965)

The Unwanted Visitor
by Ilya Repin (1844-1930)



"Remember the position of people and objects in the room"



"Estimate the ages of the people"

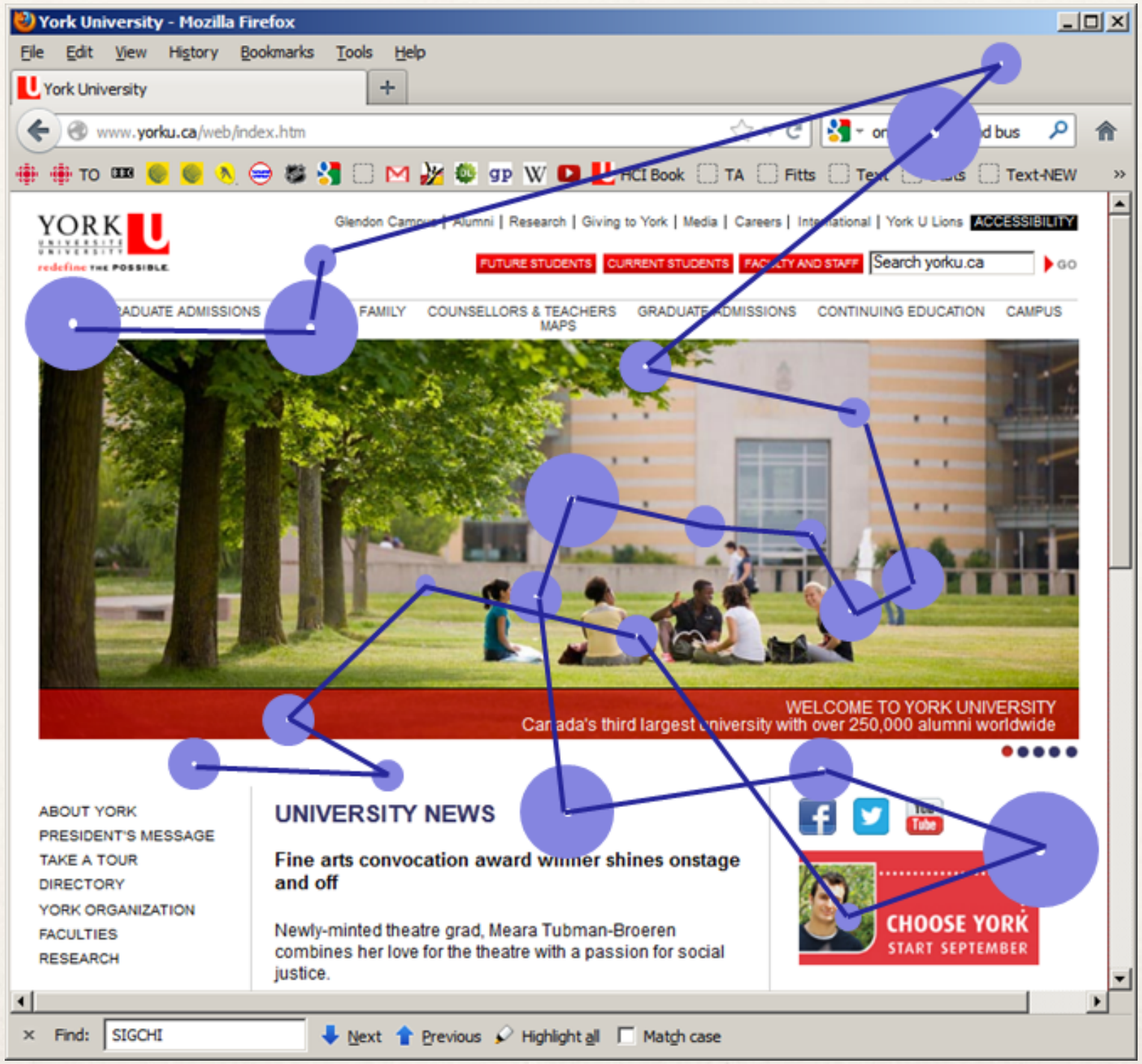
Tatler, B. W., Wade, N. J., Kwan, H., Findlay, J. M., & Velichkovsky, B. M. (2010). Yarbus, eye movements, and vision. i-Perception, 1, 7-27..

Scan Paths

- Eye tracker studies → measure fixation and saccade
- Saccades → straight lines
- Fixations → circles

- Implication?
  - Human behavior on display (e.g. reading pattern)
  - Marketing studies (e.g. ad placement)

Scan Path Example



Design Implication of Perception

- Icons should enable users to readily distinguish their meaning
- Bordering and spacing are effective visual ways of grouping information
- Sounds should be audible and distinguishable
  - 5 iconic sound bites in tech - http://www.themarysue.com/5-iconic-sound-bites-tech/
- Speech output should enable users to distinguish between the set of spoken words
- Text should be legible and distinguishable from the background
- Tactile feedback should allow users to recognize and distinguish different meanings

Memory

- Involves first encoding and then retrieving knowledge
- We don’t remember everything - involves filtering and processing what is attended to
- Context is important in affecting our memory (i.e. where, when)
- We **recognize things much better** than being able to recall things

Processing in memory

- Encoding is first stage of memory
  - determines which information is attended to in the environment and how it is interpreted
- The **more attention** paid to something
- The **more it is processed** in terms of thinking about it and comparing it with other knowledge…
- The **more likely it is to be remembered**

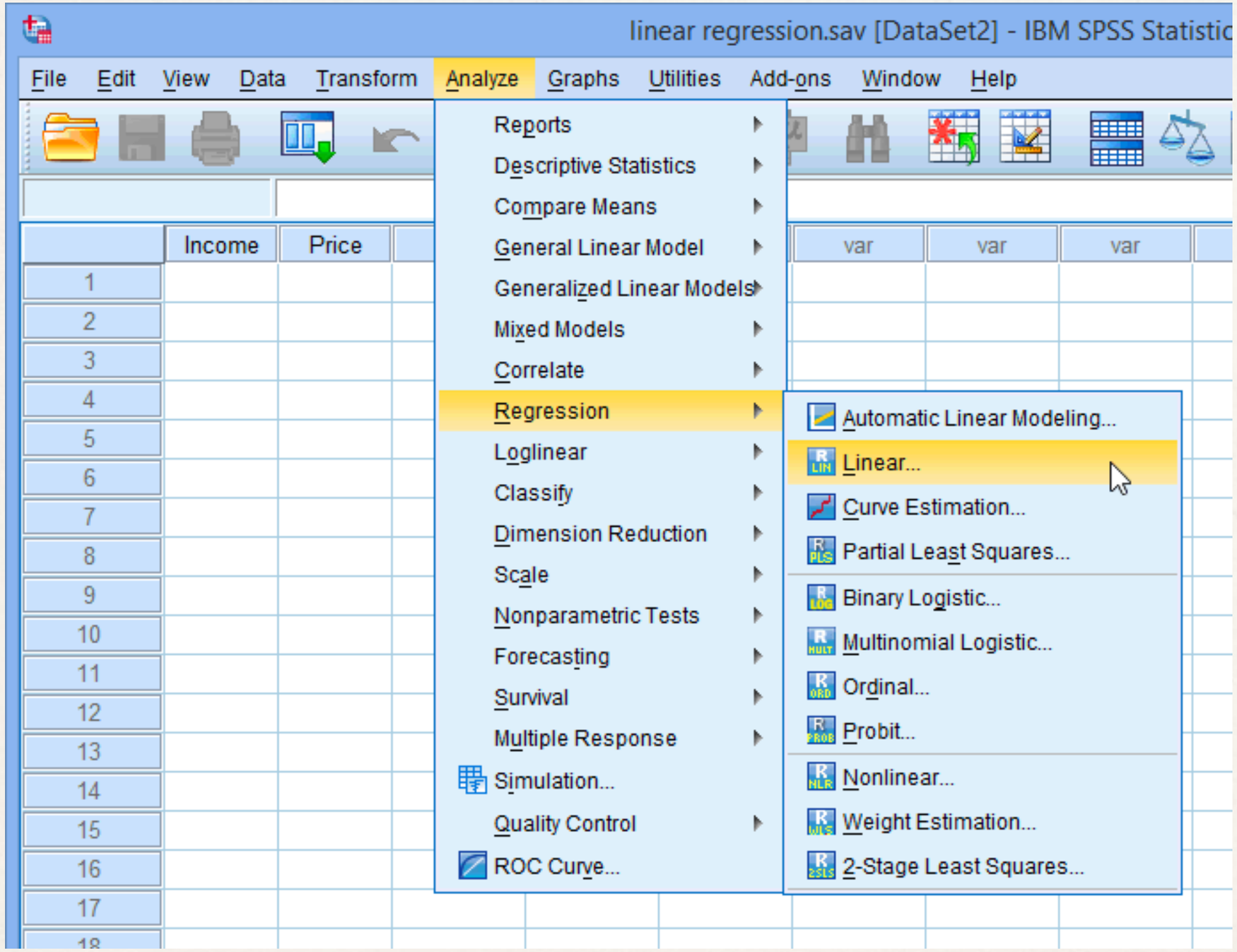
Context is important

- Context affects the extent to which information can be subsequently retrieved
- Sometimes it can be **difficult for people to recall information that was encoded in a different context**:
  - “You are on a train and someone comes up to you and says hello. You don’t recognize him for a few moments but then realize it is one of your neighbors. You are only used to seeing your neighbor in the hallway of your apartment block and seeing him out of context makes him difficult to recognize initially”

Recognition vs Recall

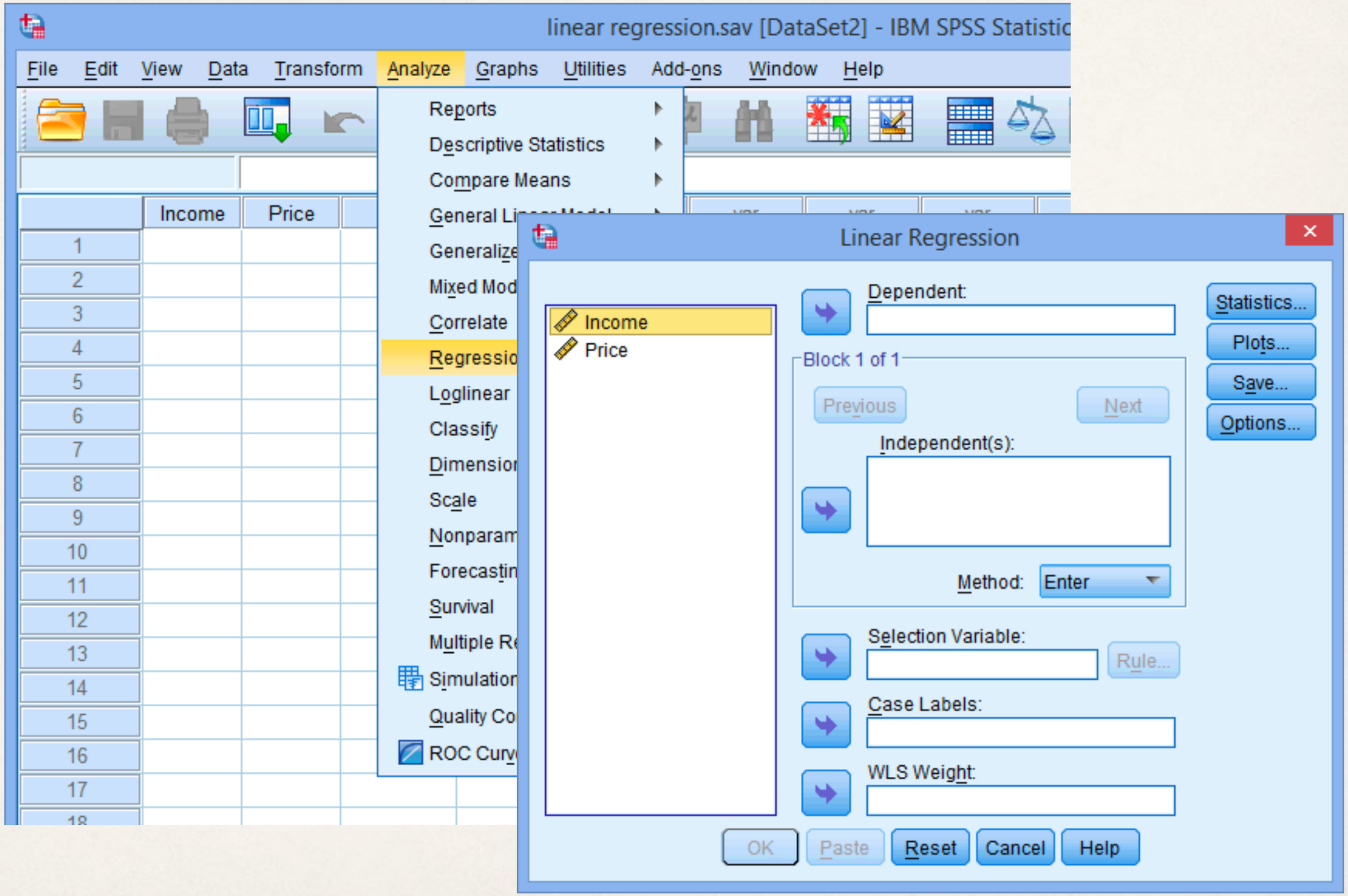
- Command-based interfaces require users to recall from memory a name from a possible set of 100s
- GUIs provide visually-based options that users need only browse through until they recognize one
- Web browsers, MP3 players, etc., provide lists of visited URLs, song titles etc., that support recognition memory

Recognition Example - SPSS



Images from: https://statistics.laerd.com/spss-tutorials/linear-regression-using-spss-statistics.php

Recognition Example - SPSS



Images from: https://statistics.laerd.com/spss-tutorials/linear-regression-using-spss-statistics.php

Recall Example - R

- Linear Model sample code:

```
model <- lm(sales ~ youtube, data = marketing)
print(summary(mode))
```

The problem with the classic ‘7±2’

- Magic number 7
- George Miller’s (1956) theory of how much information people can remember
- People’s immediate memory capacity is very limited
- Many designers think this is useful finding for interaction design

The problem with the classic ‘7±2’

- Present only 7 options on a menu
- Display only 7 icons on a tool bar
- Have no more than 7 bullets in a list
- Place only 7 items on a pull down menu
- Place only 7 tabs on the top of a website page

→ But this is wrong? Why?

The problem with the classic ‘7±2’

- Inappropriate application of the theory
- People can scan lists of bullets, tabs, menu items for the one they want
- They don’t have to recall them from memory having only briefly heard or seen them
- Sometimes a small number of items is good
- But depends on task and available screen estate

Personal Information Management

- Personal information management is a growing problem for many users
  - vast numbers of documents, images, music files, video clips, emails, attachments, bookmarks, etc.,
  - where and how to save them all, then remembering what they were called and where to find them again
  - naming most common means of encoding them
  - but can be difficult to remember, especially when have 1000s and 1000s
  - How might such a process be facilitated taking into account people's memory abilities?

Personal Information Management

- Memory involves 2 processes
  - recall-directed and recognition-based scanning
- File management systems should be designed to optimize both kinds of memory processes
  - e.g. Search box and history list
- Help users encode files in richer ways
  - Provide them with ways of saving files using colour, flagging, image, flexible text, time stamping, etc

Memory Aids

- **SenseCam** developed by Microsoft Research Labs
- a wearable device that intermittently **takes photos without any user intervention** while worn
- digital images taken are stored and revisited using special software
- Has been found **to improve people's memory, suffering from Alzheimers**

SenseCam

Life logging - Narrative Clip

http://getnarrative.com/

Design Implication of Memory

- **Don’t overload users’ memories** with complicated procedures for carrying out tasks
- Design interfaces that promote **recognition rather than recall**
- Provide users with **various ways of encoding information** to help them remember
  - e.g. categories, color, flagging, time stamping

Learning

- How to learn to use a computer-based application
- Using a computer-based application to understand a given topic
- People find it hard to learn by following instructions in a manual
  - prefer to learn by doing

Design Implications of Learning

- Design interfaces that encourage **exploration**.
- Design interfaces that **constrain and guide users to select appropriate actions** when initially learning.
- Dynamically **link concrete representations and abstract concepts** to facilitate the learning of complex material.

Reading, Speaking, and Listening

- The ease with which people can read, listen, or speak differs
  - Many prefer listening to reading
  - Reading can be quicker than speaking or listening
- Listening requires less cognitive effort than reading or speaking
- Dyslexics have difficulties understanding and recognizing written words

https://www.dyslexia-reading-well.com/dyslexia-font.html

Applications

- Speech-recognition systems allow users to interact with them by using spoken commands
  - e.g. Google Voice Search app
- Speech-output systems use artificially generated speech
  - e.g. written-text-to-speech systems for the blind
- Natural-language systems enable users to type in questions and give text-based responses
  - e.g. Ask search engine

Design Implications of Reading, Speaking and Listening

- Speech-based menus and instructions should be short
- Accentuate the intonation of artificially generated speech voices
- Provide opportunities for making text large on a screen

Problem-solving, Planning, Reasoning and Decision-making

- All involves reflective cognition
  - e.g. thinking about what to do, what the options are, and the consequences
- Often involves conscious processes, discussion with others (or oneself), and the use of artifacts
  - e.g. maps, books, pen and paper
- May involve working through different scenarios and deciding which is best option

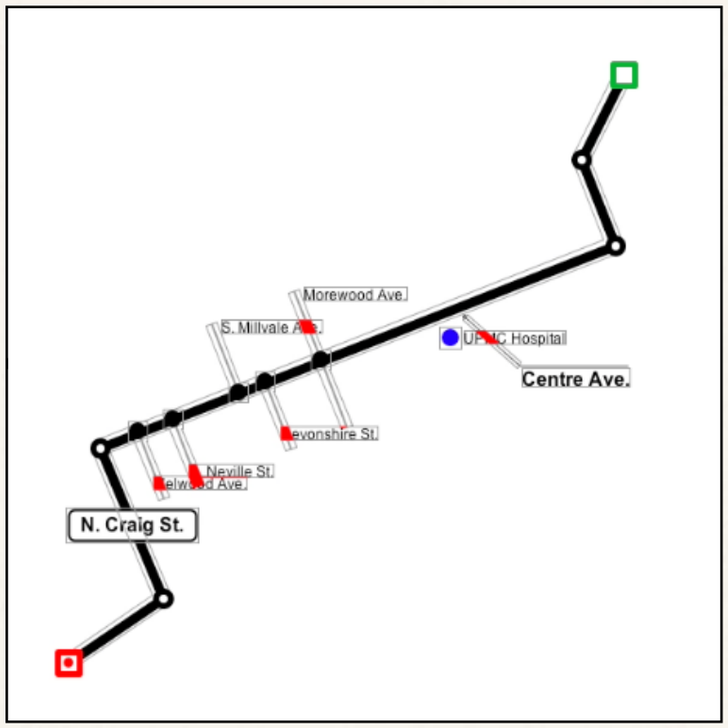
Problem Solving Process

- Problem Space Theory (Simon and Newell)
- Every problem has following 4 states.
  - Initial state
  - Goal state
  - Operator
  - Constraint

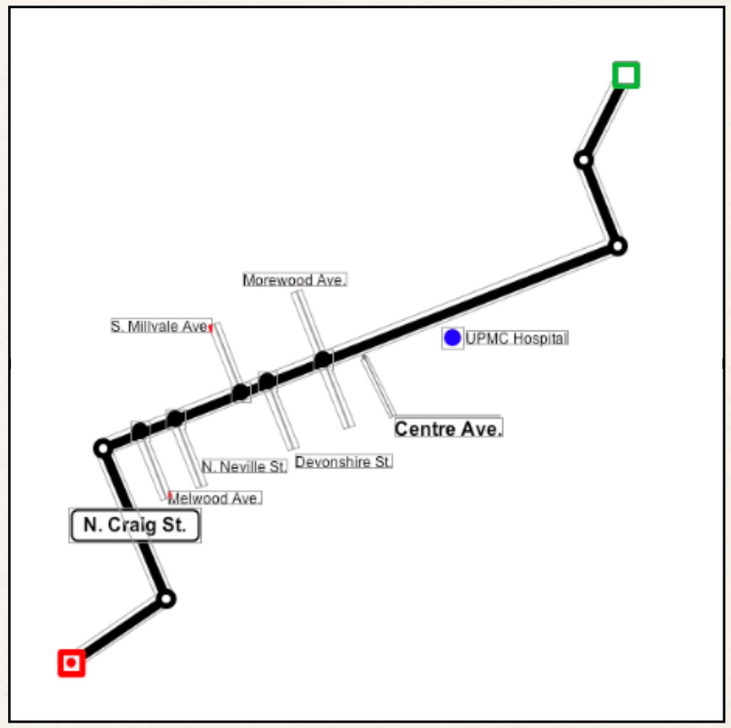
→ Understanding the each states = understanding the problem space = building the representation of the problem

Problem Solving Process

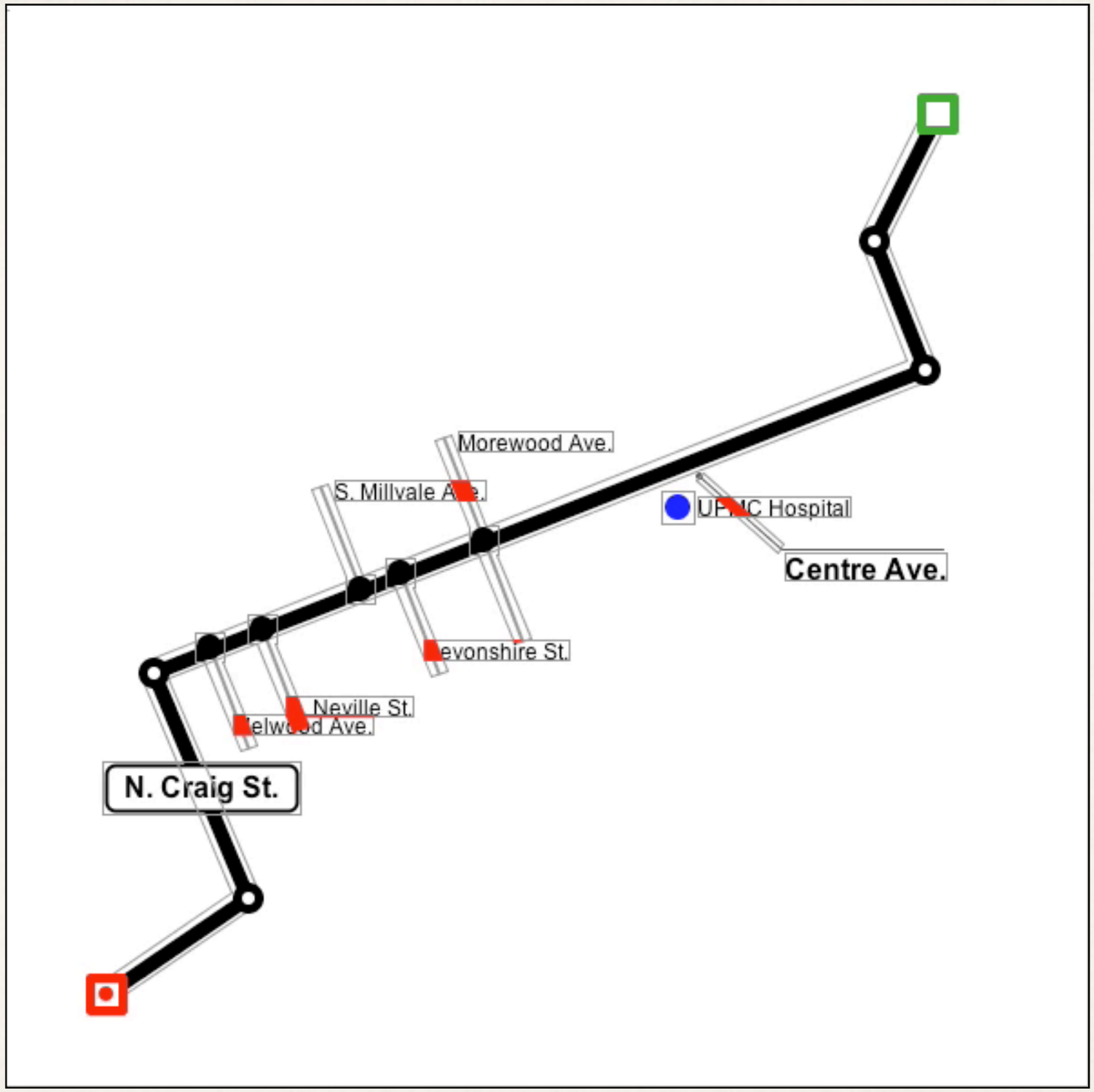
- Algorithmic problem solving



Initial State



Goal State


Morewood Ave.
S. Millvale Ave.
UPMC Hospital
Centre Ave.
Devonshire St.
Neville St.
Melwood Ave.
N. Craig St.

Design Implication of Problem-solving, Planning, Reasoning and Decision-making

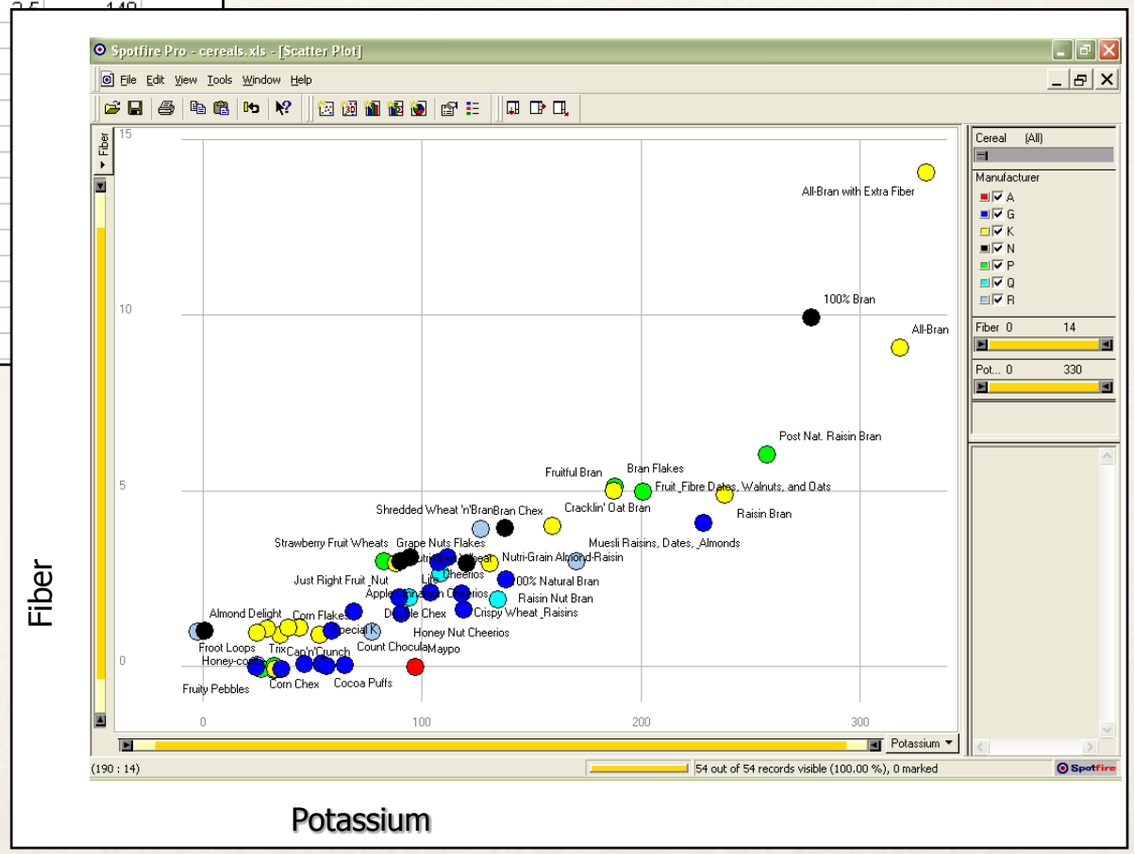
- Provide **additional information/functions** for users who wish to understand more about how to carry out an activity more effectively
- Use simple **computational aids** to support rapid decision-making and planning for users on the move → external cognition aid (e.g. information visualization)

External Cognition

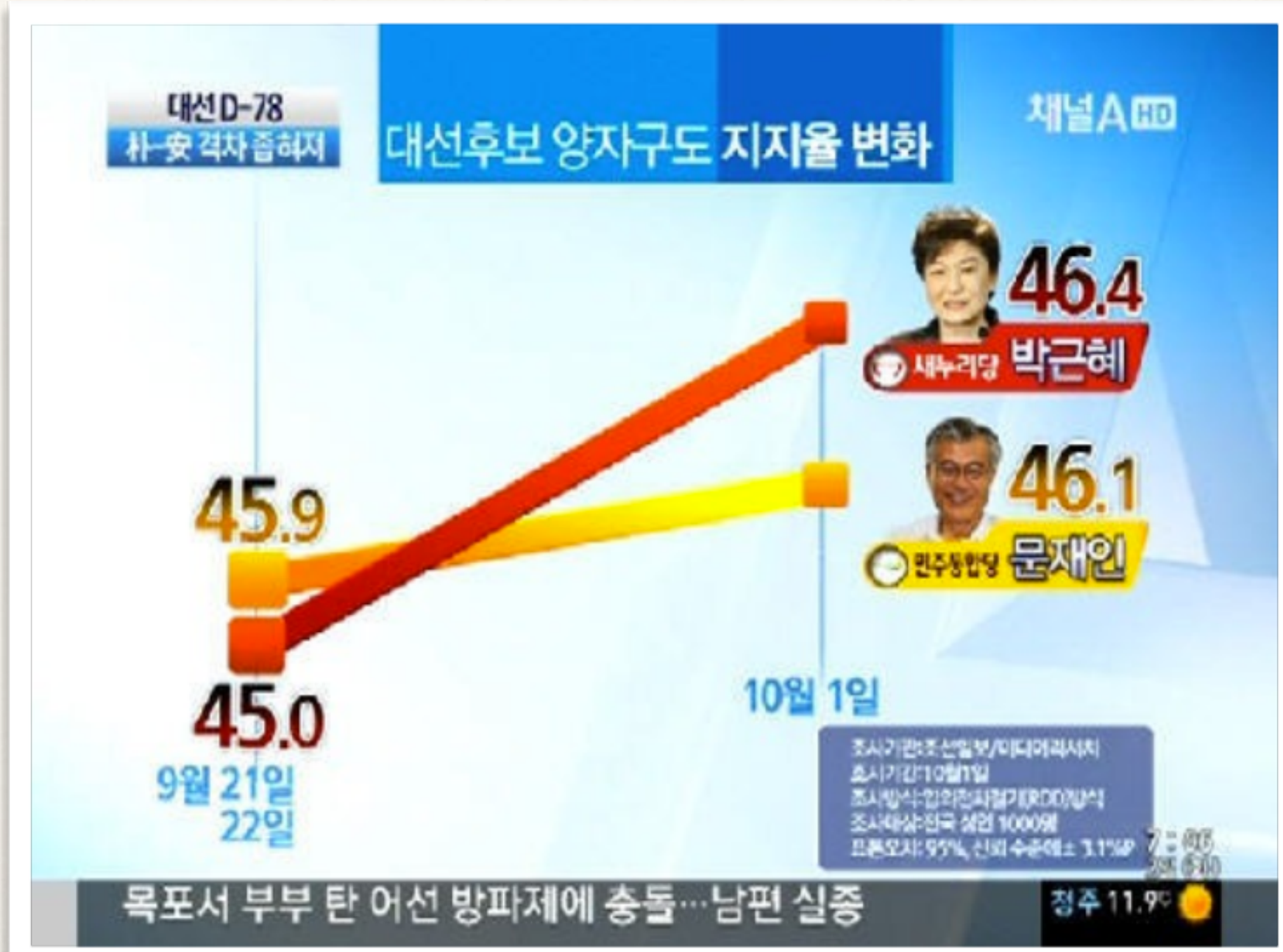
- Information Visualization

	A	B	C	D
1	Cereal	Manufacturer	Fiber	Potassium
2	100% Bran	N	10	280
3	100% Natural Bran	Q	2	135
4	All-Bran	K	9	320
5	All-Bran with Extra Fiber	K	14	330
6	Almond Delight	R	1	0
7	Apple Cinnamon Cheerio	G	1.5	70
8	Bran Chex	R	4	125
9	Bran Flakes	P	5	190
10	Cap'n'Crunch	Q	0	35
11	Cheerios	G	2	105
12	Cocoa Puffs	G	0	55
13	Corn Chex	R	0	25
14	Corn Flakes	K	1	35
15	Count Chocula	G	0	65
16	Cracklin' Oat Bran	K	4	160
17	Cream of Wheat (Quick)	N	1	0
18	Crispy Wheat & Raisins	G	2	120
19	Double Chex	R	1	80
20	Froot Loops	K	1	30
21	Frosted Flakes	K	1	25
22	Fruit & Fibre Dates, Wal	P	5	200
23	Fruitful Bran	K	5	190
24	Fruity Pebbles	P	0	25
25	Golden Grahams	G	0	45
26	Grape Nuts Flakes	P	3	85
27	Honey Nut Cheerios	G	1.5	90
28	Honey-comb	P	0	35
29	Just Right Fruit & Nut	K	2	95
30	Life	Q	2	95
31	Lucky Charms	G	0	55
32	Maypo	A	0	95
33	Muesli Raisins, Dates, &	R	3	170
34	Multi-Grain Cheerios	G	2	90
35	Nutri-Grain Almond-Rais	K	3	130
36	Nutri-grain Wheat	K	3	90
37	Oatmeal Raisin Crisp	G	1.5	120
38	Post Nat. Raisin Bran	P	6	260
39	Product 19	K	1	45
40	Quaker Oatmeal	Q	2.7	110
41	Raisin Bran	K	5	240
42	Raisin Nut Bran	G		
43	Rice Krispies	K		
44	Shredded Wheat	N		
45	Shredded Wheat 'n'Bran	N		
46	Shredded Wheat spoon	N		
47	Smacks	K		
48	Special K	K		
49	Strawberry Fruit Wheats	N		
50	Total Corn Flakes	G		
51	Total Raisin Bran	G		
52	Total Whole Grain	G		
53	Trix	G		
54	Wheaties	G		
55	Wheaties Honey Gold	G		

slide courtesy: John Stasko, GATech



But it may produce wrong insight,



But it may produce wrong insight,

Cognitive Frameworks

Mental Models

- Users develop an understanding of a system through learning about and using it
- Knowledge is sometimes described as a mental model:
  - How to use the system (what to do next)
  - What to do with unfamiliar systems or unexpected situations (how the system works)
- People make inferences using mental models of how to carry out tasks

Mental Models

- Craik (1943) described mental models as:
  - internal constructions of some aspect of the external world enabling predictions to be made
- Involves unconscious and conscious processes
  - images and analogies are activated
- Deep vs shallow models
  - e.g. how to drive a car and how it works

Breaking Mental Model

전자식 변속버튼 <현대자동차>

자동변속기 (수동변속기의 멘탈모델을 바탕으로 함)

Breaking Mental Model

전자식 변속버튼 <현대자동차>

자동변속기 (수동변속기의 멘탈모델을 바탕으로 함)

Mental Models

- Many people have erroneous mental models (Kempton, 1996)
- Why?
  - Thermostats Question:
    - You arrive home on a cold winter's night to a cold house. How do you get the house **to warm up as quickly as possible?** Set the thermostat to be at its highest or to the desired temperature?
    - General valve theory, where 'more is more' principle is generalised to different settings (e.g. gas pedal, gas cooker, tap, radio volume)
    - Thermostats based on model of on-off switch model

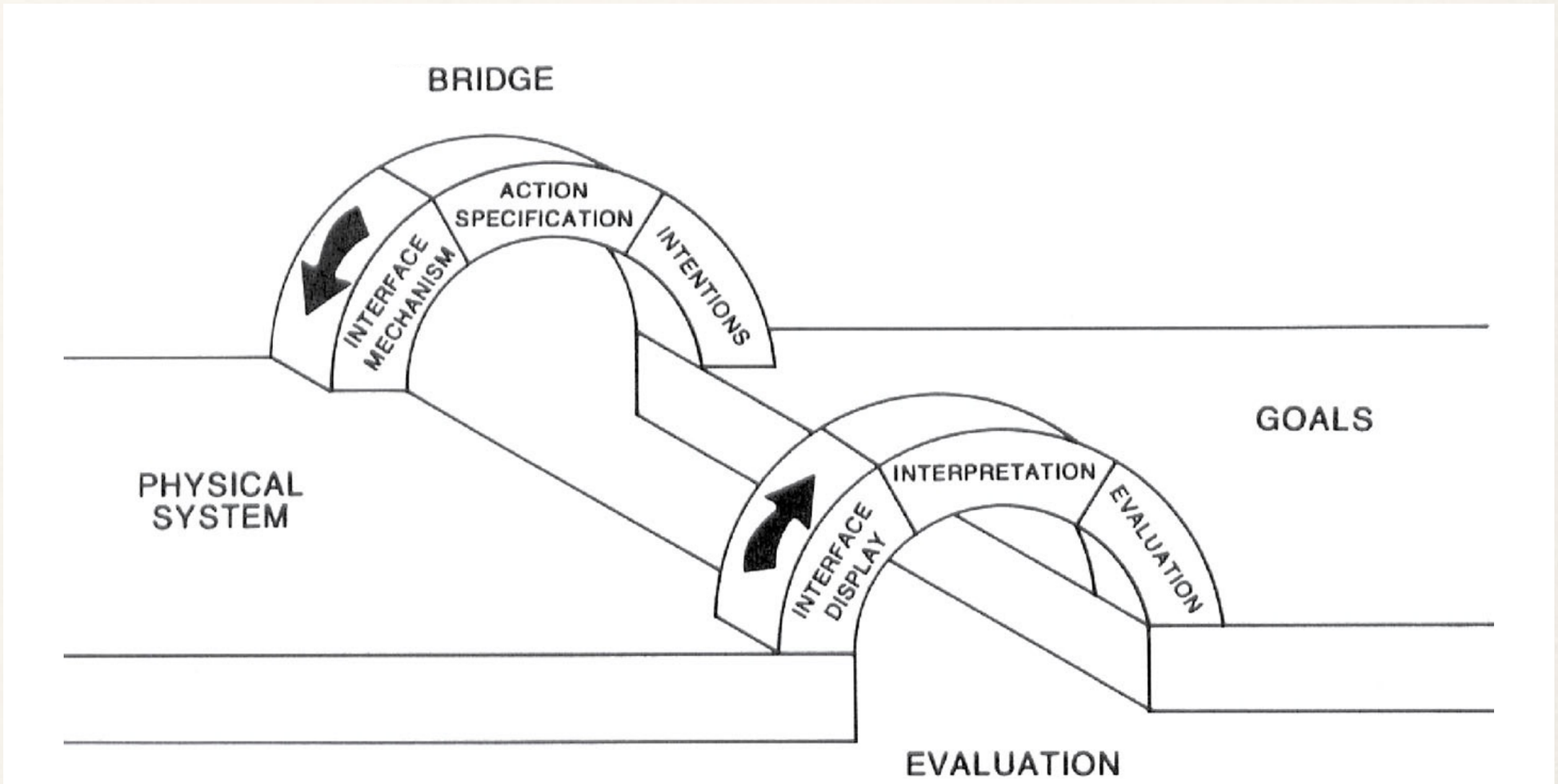
Mental Models

- Same is often true for understanding how interactive devices and computers work:
  - poor, often incomplete, easily confusable, based on inappropriate analogies and superstition (Norman, 1983)
    - e.g. elevators and pedestrian crossings - lot of people hit the button at least twice

Gulfs of Execution and Evaluation

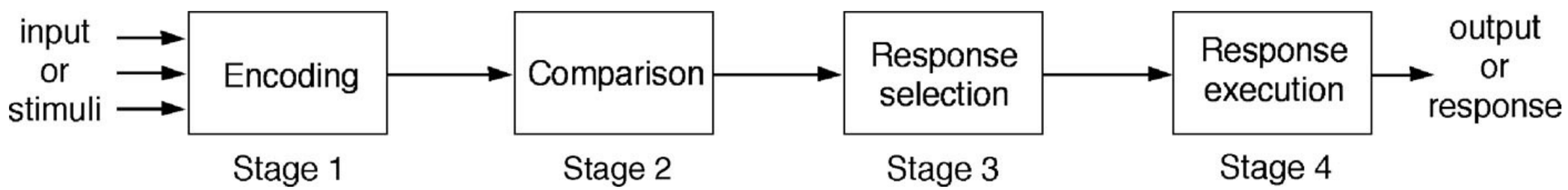
- The ‘gulfs’ explicate the gaps that exist between the user and the interface (Norman 1986; Hutchins et al 1986)
- The gulf of execution
  - the distance from the user to the physical system
- The gulf of evaluation
  - the distance from the physical system to the user
- Bridging the gulfs can reduce cognitive effort required to perform tasks

Gulfs of Execution and Evaluation



Information Processing

- Conceptualizes human performance in metaphorical terms of information processing stages

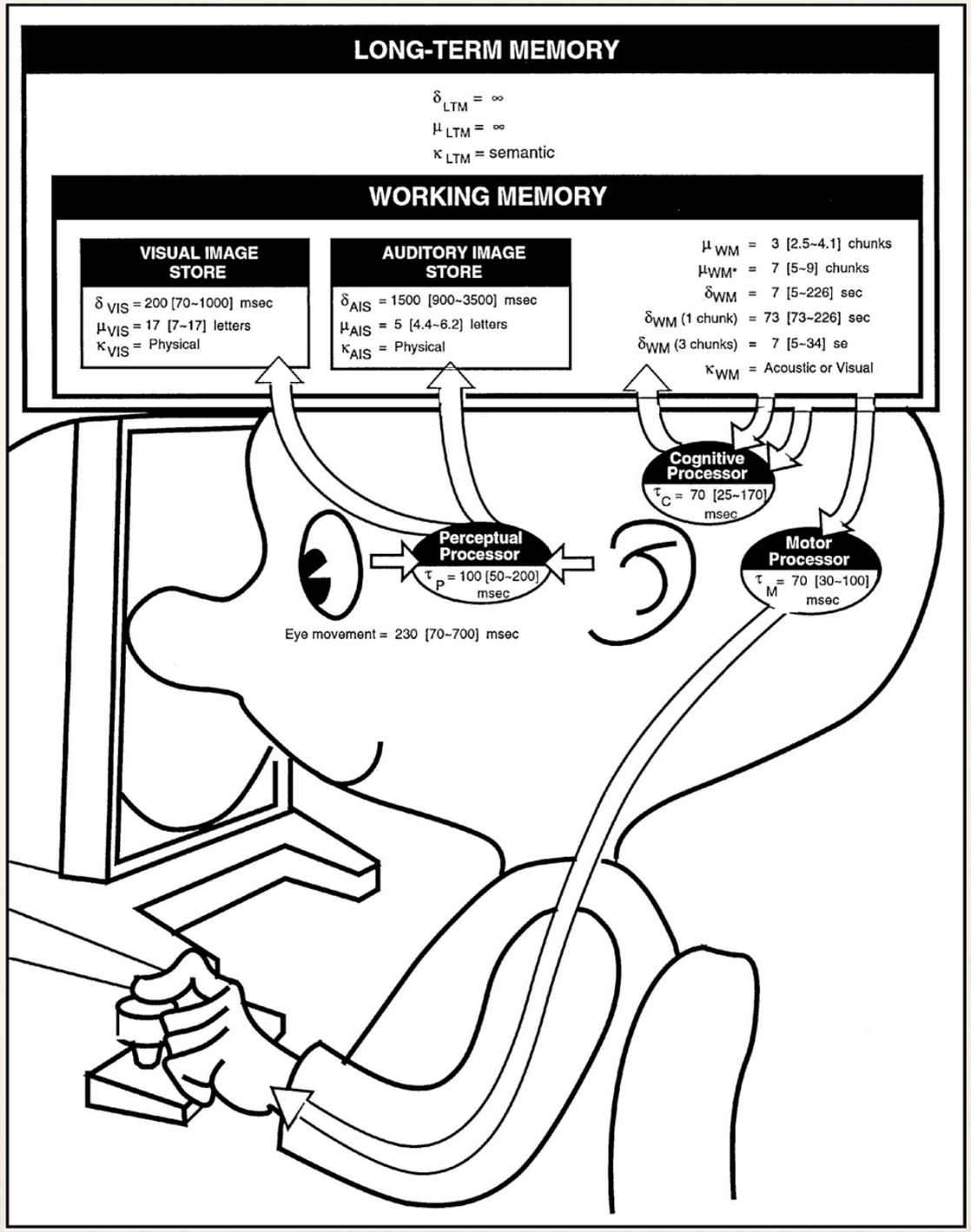


Model Human Processor

- Models the information processes of a user interacting with a computer (Card et al, 1983)
- Predicts which cognitive processes are involved when a user interacts with a computer
- Enables calculations to be made of how long a user will take to carry out a task

Model Human Processor

- Perceptual Processor
- Cognitive Processor
- Motor Processor
- Memory



External Cognition

- Concerned with explaining how we interact with external representations
  - e.g. maps, notes, diagrams
- What are the cognitive benefits and what processes involved
- How they extend our cognition
- What computer-based representations can we develop to help even more?

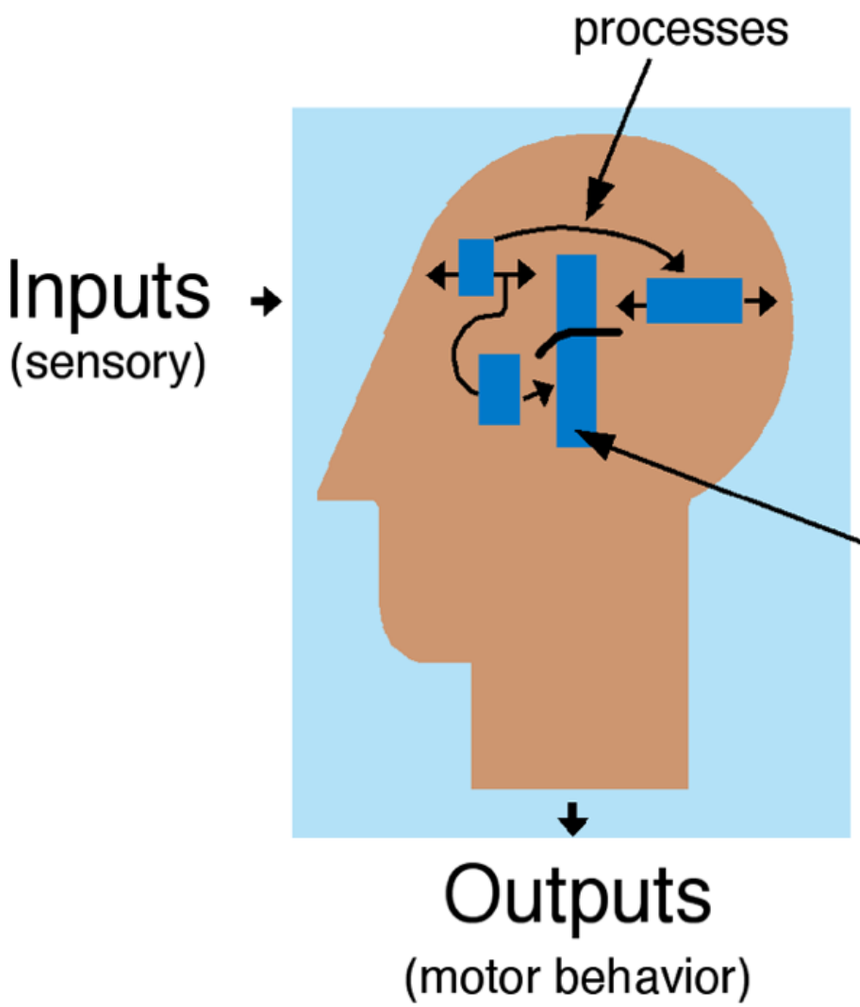
External Cognition

- Diaries, reminders, calendars, notes, shopping lists, to-do lists
  - written to remind us of what to do
- Post-its, piles, marked emails
  - where placed indicates priority of what to do
- External representations:
  - Remind us that we need to do something (e.g. to buy something for mother's day)
  - Remind us of what to do (e.g. buy a card)
  - Remind us when to do something (e.g. send a card by a certain date)

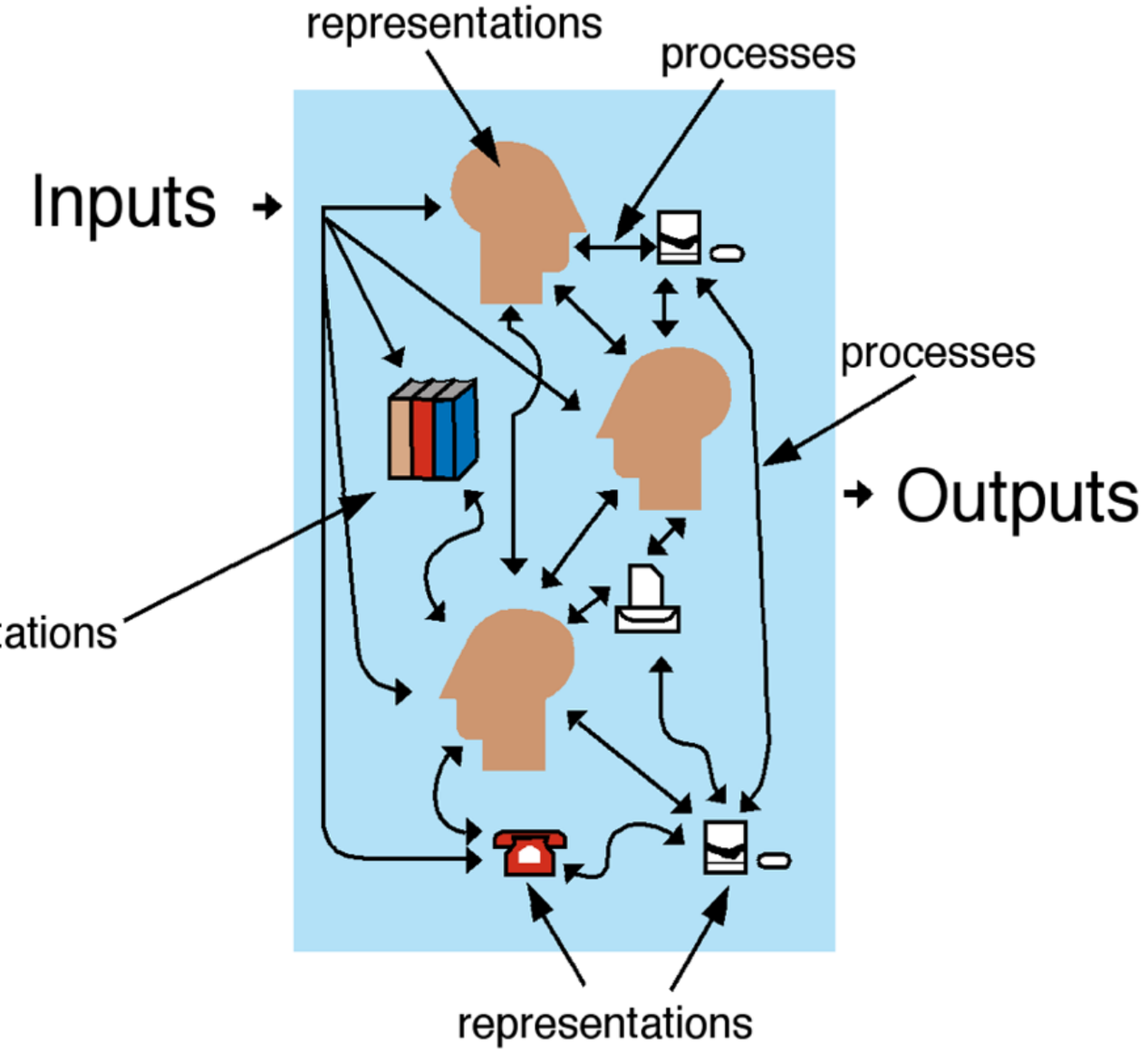
Distributed Cognition

- Concerned with the nature of cognitive phenomena **across individuals, artifacts, and internal and external representations** (Hutchins, 1995)
- Describes these in terms of propagation across representational state
- **Information is transformed through different media** (computers, displays, paper, heads)

Distributed Cognition



1. Traditional model



2. Distributed model

Interfaces

Interface Types

- Many different type of interfaces have evolved.
- Consider which interface is best for a given application or activity.

Command Line Interface

- Commands such as **abbreviations (e.g. ls) typed in at the prompt** to which the system responds
  - e.g. listing current files or move directory

    dir → directory

    ls → list

    mv → move
- Some are hard wired at keyboard, others can be assigned to keys
- **Efficient, precise, and fast**
- **Large overhead to learning** set of commands

Command Line Interface

Figure 6.1 Second Life command-based interface for visually impaired users

Source: Reproduced with permission from http://www.eelke.com/images/textsl.jpg.

Command Line Interface

- Research and design issues
- Form, name types and structure are key research questions
- Consistency is most important design principle
  - e.g. always use first letter of command
- Command interfaces popular for web scripting

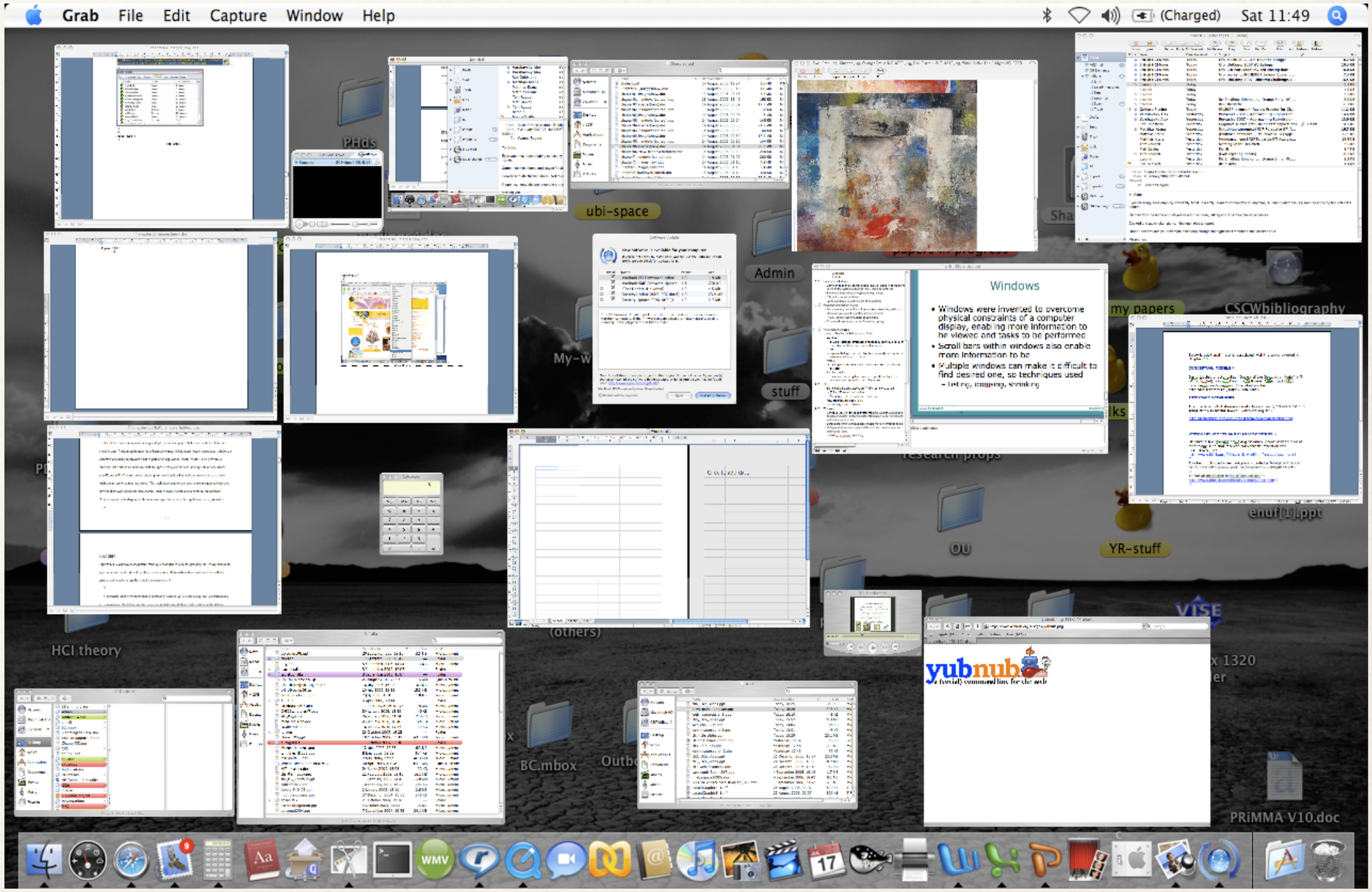
WIMP and GUI

- Xerox Star first WIMP → rise to GUIs
- **Windows**
  - could be scrolled, stretched, overlapped, opened, closed, and moved around the screen using the mouse
- **Icons**
  - represented applications, objects, commands, and tools that were opened when clicked on
- **Menus**
  - offering lists of options that could be scrolled through and selected
- **Pointing device**
  - a mouse controlling the cursor as a point of entry to the windows, menus, and icons on the screen

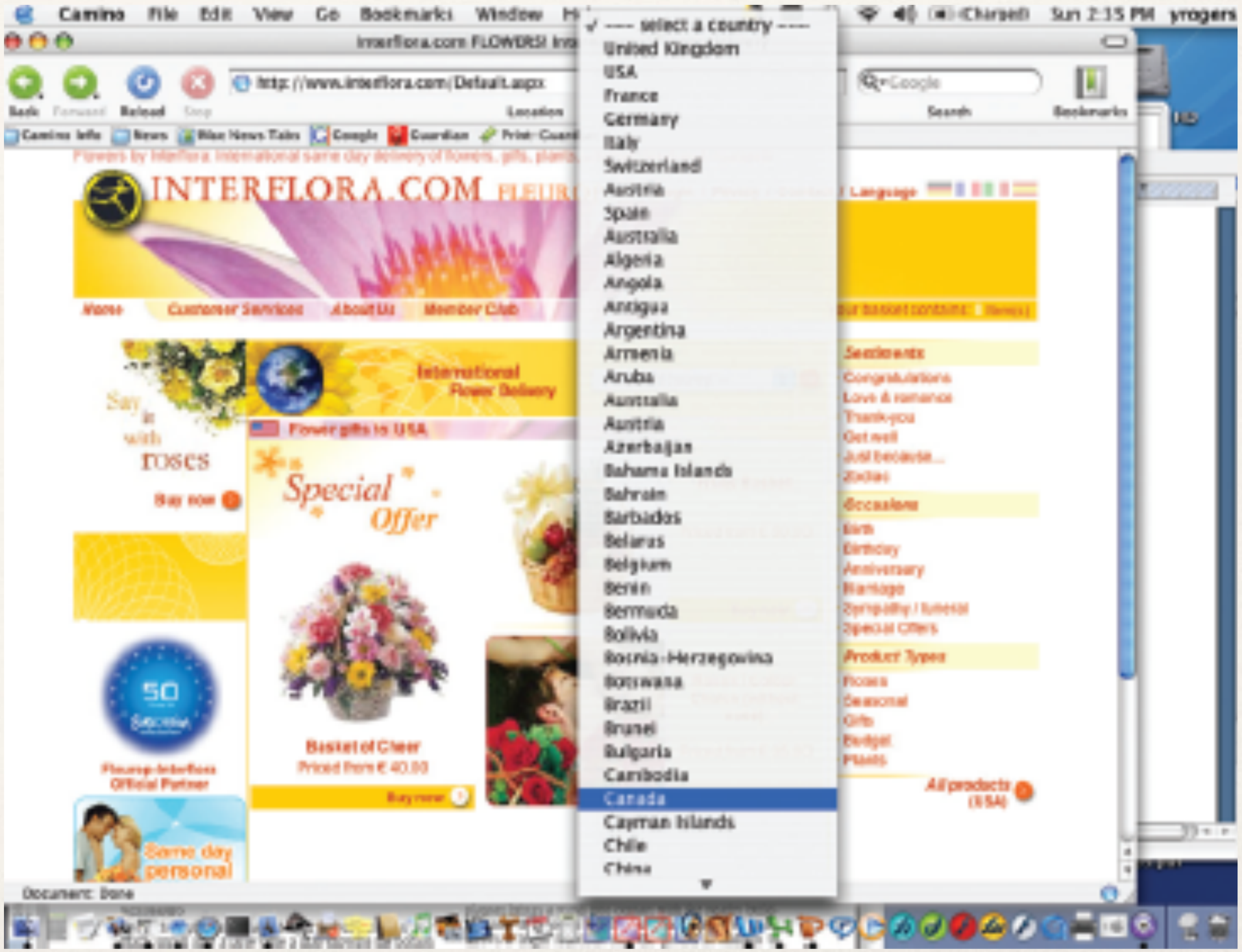
Windows

- Windows were invented to **overcome physical constraints** of a computer display
  - enable more information to be viewed and tasks to be performed
- **Scroll bars** within windows also **enable more information** to be viewed
- **Multiple windows can make it difficult to find desired one**
  - listing, iconising, shrinking are techniques that help

Windows - Focus+Context



Scrolling Issue



Scrolling Issue - Solution

F	G	H	I	J
Fiji	Gabon	Haiti	Iceland	Jamaica
Finland	Germany	Holland	India	Japan
France	Gibraltar	Honduras	Indonesia	Jordan
French Guyana	Greece	Hong Kong	Iran	
French Polynesia	Greenland	Hungary	Ireland	
	Guadeloupe		Israel	
	Guam		Italy	
	Guatemala		Ivory Coast	

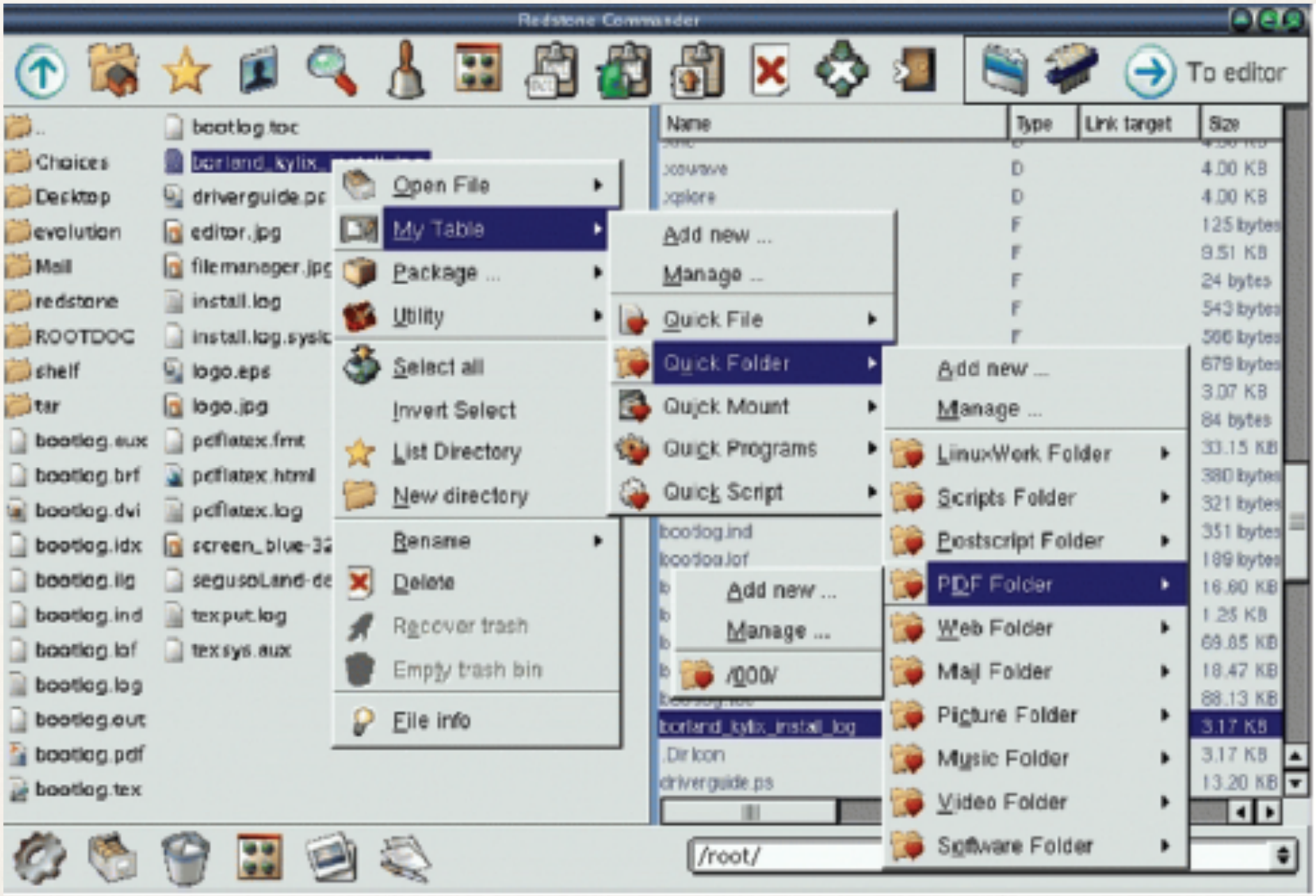
Windows

- Research and design issues
  - Window management
    - enables users to move fluidly between different windows (and monitors)
  - How to switch attention between windows without getting distracted
  - Design principles of spacing, grouping, and simplicity should be used

Menus

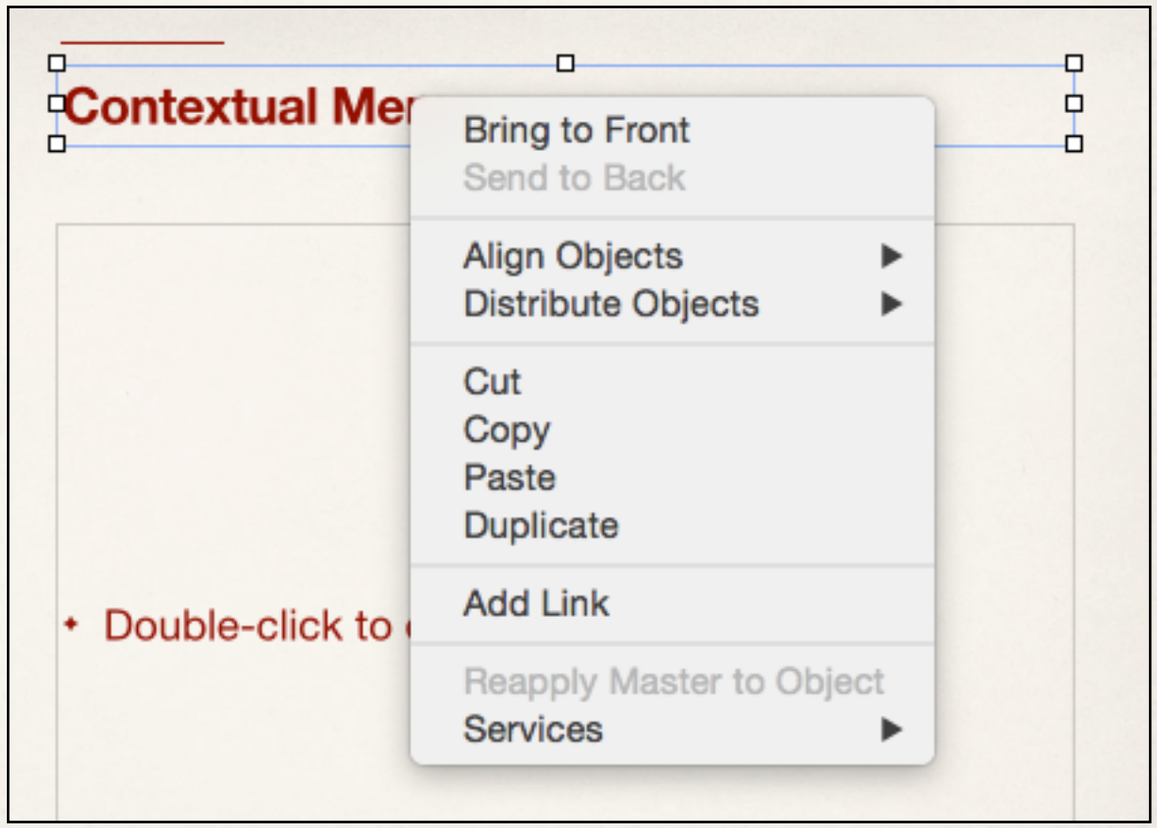
- A number of menu interface styles
  - flat lists, drop-down, pop-up, contextual, and expanding ones, e.g., scrolling and cascading
- Flat menus
  - good at displaying a small number of options at the same time and where the size of the display is small, e.g. iPods
  - but have to nest the lists of options within each other, requiring several steps to get to the list with the desired option
  - moving through previous screens can be tedious

Cascading Menu



Contextual Menu

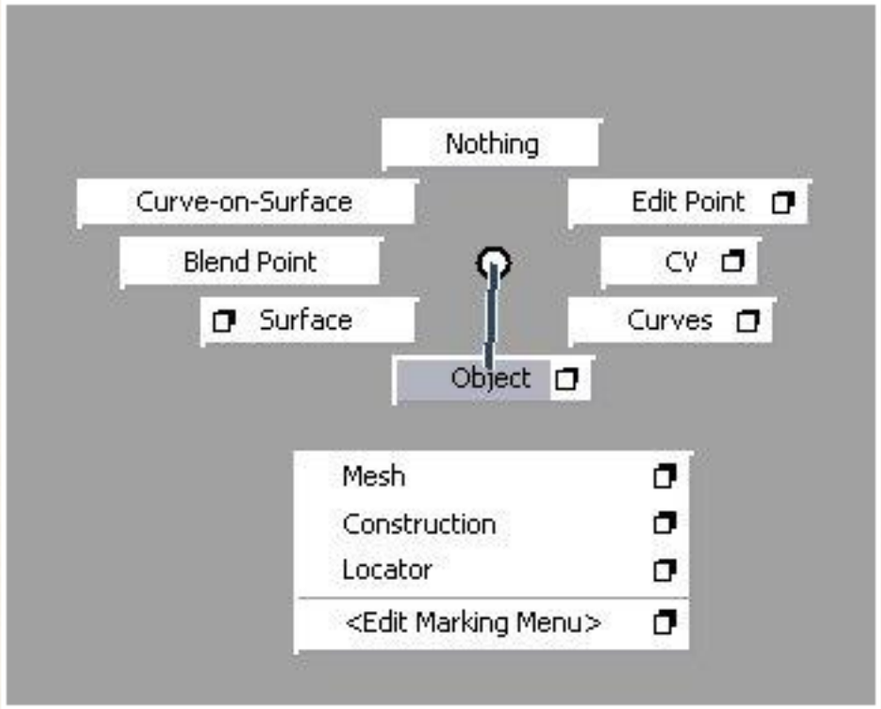
- Provide access to often-used commands that make sense in the context of a current task
- Appear when the user presses the Control key while clicking on an interface element (or mouse right click)
- Helps overcome some of the navigation problems associated with cascading menus



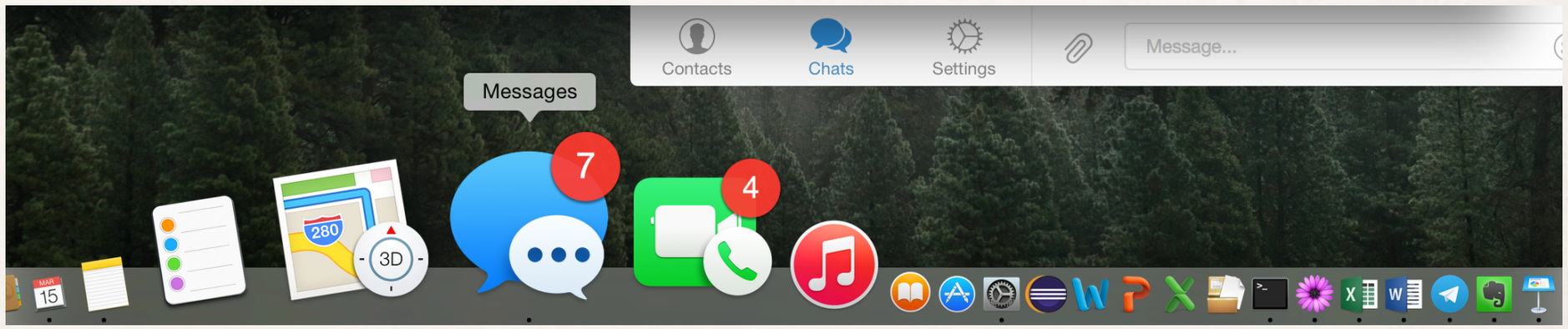
Menus

- Research and design issues
  - What are best names/labels/phrases to use?
  - Placement in list is critical
    - Quit and save need to be far apart
- Choice of menu to use determined by application and type of system
  - flat menus are best for displaying a small number of options at one time
  - expanding menus are good for showing a large number of options

Menus



Autodesk: Radial Contextual Menu



Zoomable Interface

Icons

- Icons are assumed to be easier to learn and remember than commands
- Can be designed to be compact and variably positioned on a screen
- Now pervasive in every interface
  - e.g. represent desktop objects, tools (e.g. paintbrush), applications (e.g. web browser), and operations (e.g. cut, paste, next, accept, change)

Icons

- Since the Xerox Star days icons have changed in their look and feel:
  - black and white → color, shadowing, photorealistic images, 3D rendering, and animation
- Many designed to be very detailed and animated making them both visually attractive and informative
- GUIs now highly inviting, emotionally appealing, and feel alive

Early Icons

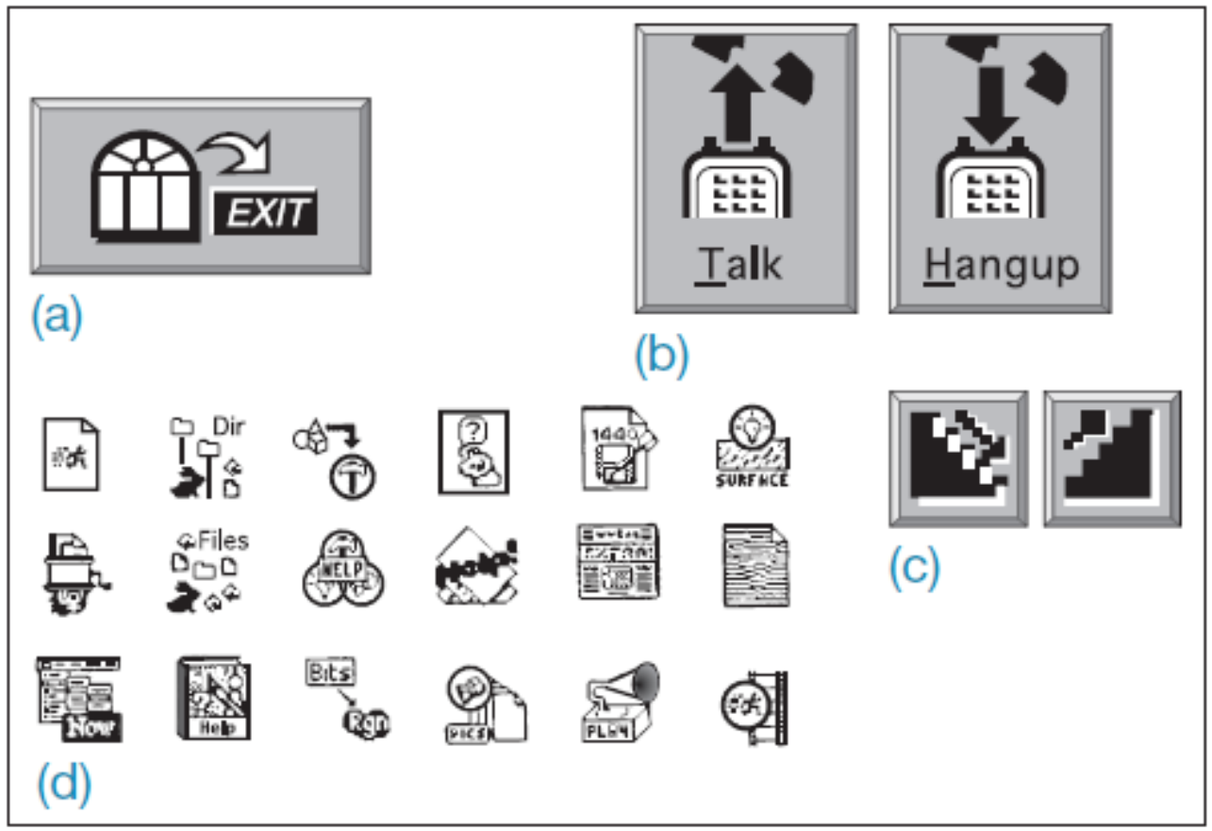


Figure 6.9 Poor icon set from the early 1990s. What do you think they mean and why are they so bad?

Source: K. Mullet and D. Sano: "Designing Visual Interfaces" Pearson 1995, reproduced with permission of Pearson Education.

Newer Icons

Aqua Interface, Mac OS

Flat 2D Icons, iOS

Reading Assignment

- Chapter 4: Social Interaction
- Chapter 5: Emotional Interaction

Questions…?