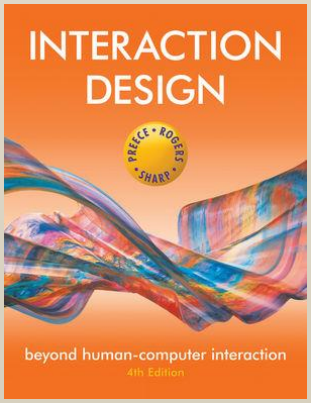
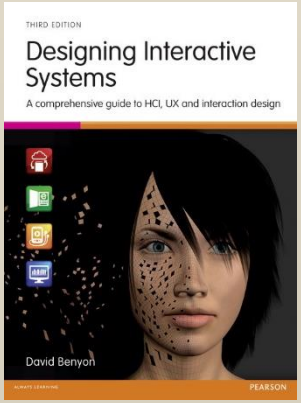




COGNITIVE ASPECTS
Lecture 3
Dr Kristina Lapin

Overview

- What is cognition?
- What are users good and bad at?
- Describe how cognition has been applied to interaction design
- Explain what are Mental Models
- Cover relevant theories of 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, modelling tools, guidance and methods
  - that can lead to the design of better interactive products

Cognitive processes

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

Attention

- Selecting things to concentrate on
  - at a point in time from the mass of stimuli around us
- Allows us 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 select of the mass of competing stimuli
    - but limits the 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

Activity: Find the price of a double room at the Holiday Inn in Columbia

South Carolina

City	Motel/Hotel	Area code	Phone	Rates Single	Rates Double
Charleston	Best Western	803	747-0961	$126	$130
Charleston	Days Inn	803	881-1000	$118	$124
Charleston	Holiday Inn N	803	744-1621	$136	$146
Charleston	Holiday Inn SW	803	556-7100	$133	$147
Charleston	Howard Johnsons	803	524-4148	$131	$136
Charleston	Ramada Inn	803	774-8281	$133	$140
Charleston	Sheraton Inn	803	744-2401	$134	$142
Columbia	Best Western	803	796-9400	$129	$134
Columbia	Carolina Inn	803	799-8200	$142	$148
Columbia	Days Inn	803	736-0000	$123	$127
Columbia	Holiday Inn NW	803	794-9440	$132	$139
Columbia	Howard Johnsons	803	772-7200	$125	$127
Columbia	Quality Inn	803	772-0270	$134	$141
Columbia	Ramada Inn	803	796-2700	$136	$144
Columbia	Vagabond Inn	803	796-6240	$127	$130

Activity: Find the price for a double room at the Quality Inn in Pennsylvania

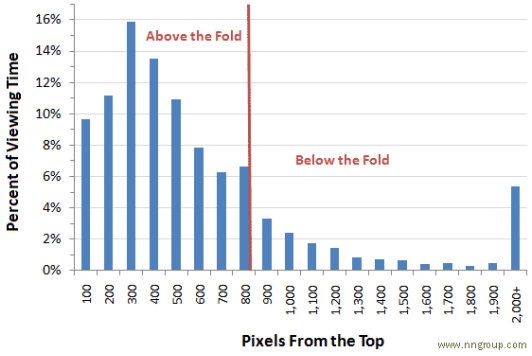
Pennsylvania
Bedford Motel/Hotel: Crinaline Courts
(814) 623-9511 S: $118 D: $120
Bedford Motel/Hotel: Holiday Inn
(814) 623-9006 S: $129 D: $136
Bedford Motel/Hotel: Midway
(814) 623-8107 S: $121 D: $126
Bedford Motel/Hotel: Penn Manor
(814) 623-8177 S: $119 D: $125
Bedford Motel/Hotel: Quality Inn
(814) 623-5189 S: $123 D: $128
Bedford Motel/Hotel: Terrace
(814) 623-5111 S: $122 D: $124
Bradley Motel/Hotel: De Soto
(814) 362-3567 S: $120 D: $124
Bradley Motel/Hotel: Holiday House
(814) 362-4511 S: $122 D: $125
Bradley Motel/Hotel: Holiday Inn
(814) 362-4501 S: $132 D: $140
Breezewood Motel/Hotel: Best Western Plaza
(814) 735-4352 S: $120 D: $127
Breezewood Motel/Hotel: Motel 70
(814) 735-4385 S: $116 D: $118

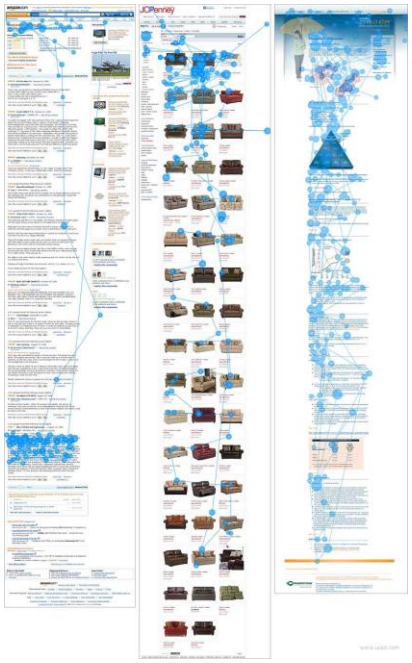
Multitasking and attention

- 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-taskers
  - 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 for attention





- Make information salient when it needs attending to
- The most important - above the fold
- People will look down if
  - the **layout encourages scanning**
  - the initially viewable information makes them **believe that it will be worth their time** to scroll
  - while placing the most important stuff on top,
    - don't forget to put **valuable information also at the very bottom**.

Design implications for attention

- Use techniques that make things stand out like color, ordering, spacing, underlining, sequencing and animation
- Avoid cluttering the interface with too much information
- Search engines and form fill-ins that have simple and clean interfaces are easier to use

Perception

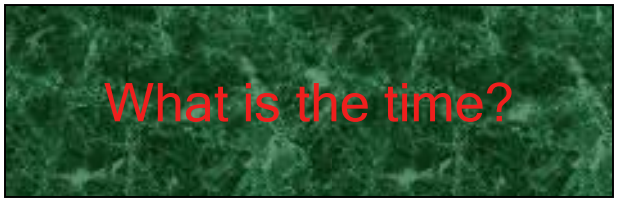
- How information is acquired from the world and transformed into experiences
- Obvious implication is to design representations that are readily perceivable, e.g.
  - Text should be legible
  - Icons should be easy to distinguish and read

Is color contrast good? Find Italian

Black Hills Forest	Peters Landing	Jefferson Farms	Devlin Hall
Cheyenne River	Public Health	Psychophysics	Positions
Social Science	San Bernardino	Political Science	Hubard Hall
South San Jose	Moreno Valley	Game Schedule	Fernadino Beach
Badlands Park	Altamonte Springs	South Addision	Council Bluffs
Juvenile Justice	Peach Tree City	Cherry Hills Village	Classical Lit
Results and Stats	Highland Park	Creative Writing	Sociology
Thousand Oaks	Manchesney Park	Lake Havasu City	Greek
Promotions	Vallecito Mts.	Engineering Bldg	Wallace Hall
North Palermo	Rock Falls	Sports Studies	Concert Tickets
Credit Union	Freeport	Lakewood Village	Public Radio FM
Wilner Hall	Slaughter Beach	Rock Island	Children's Museum
Performing Arts	Rocky Mountains	Deerfield Beach	Writing Center
Italian	Latin	Arlington Hill	Theater Auditions
Coaches	Pleasant Hills	Preview Game	Delaware City
McKees Rocks	Observatory	Richland Hills	Scholarships
Glenwood Springs	Public Affairs	Experts Guide	Hendricksville
Urban Affairs	Heskett Center	Neff Hall	Knights Landing
McLeansboro	Brunswick	Grand Wash Cliffs	Modern Literature
Experimental Links	East Millinocket	Indian Well Valley	Studio Arts
Graduation	Women's Studies	Online Courses	Hughes Complex
Emory Lindquist	Vacant	Lindquist Hall	Cumberland Flats
Clinton Hall	News Theatre	Fisk Hall	Central Village
San Luis Obispo	Candlewood Isle	Los Padres Forest	Hoffman Estates

Are borders and white space better? Find french

Which is easiest to read and why?



What is the time?

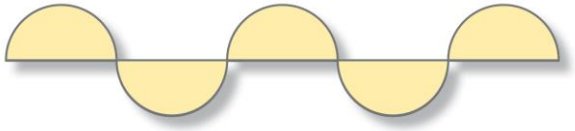
What is the time?

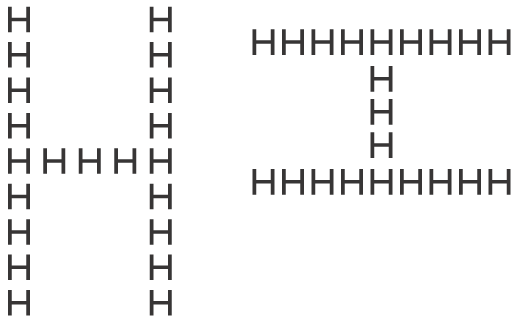
What is the time?

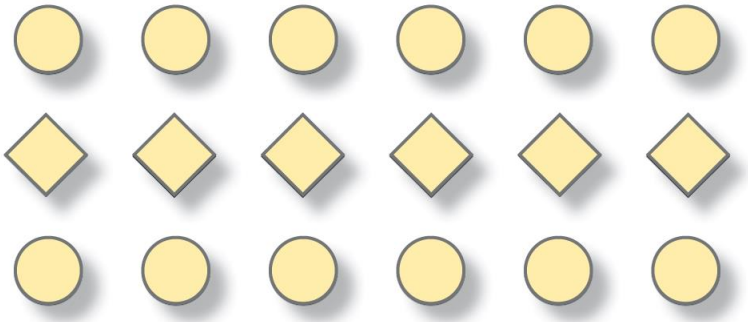
What is the time?

Intuitive perception guidelines: Gestalt laws

- Proximity
- Continuity
- Part-whole
- Similarity
- Closure
- Simplicity
- Simetry
- Parallel

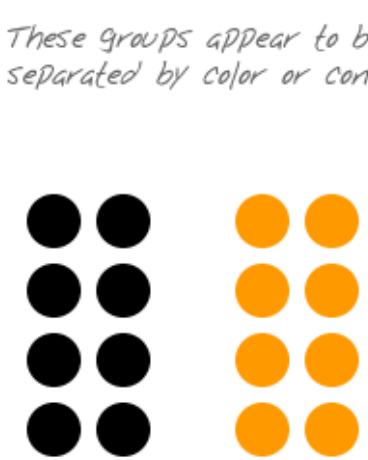


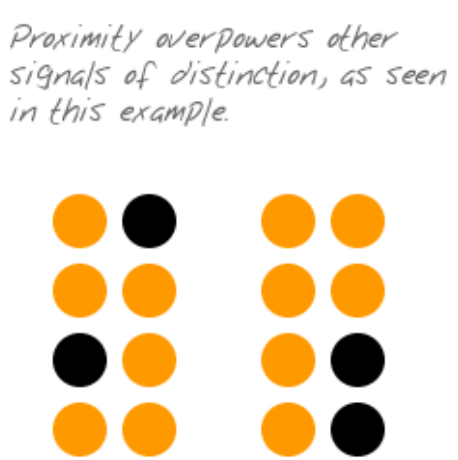




Gestalt laws

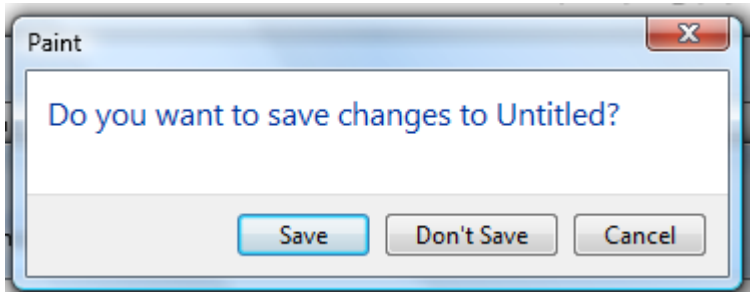
- Proximity
  - objects appearing close together in space or time tend to be perceived together.



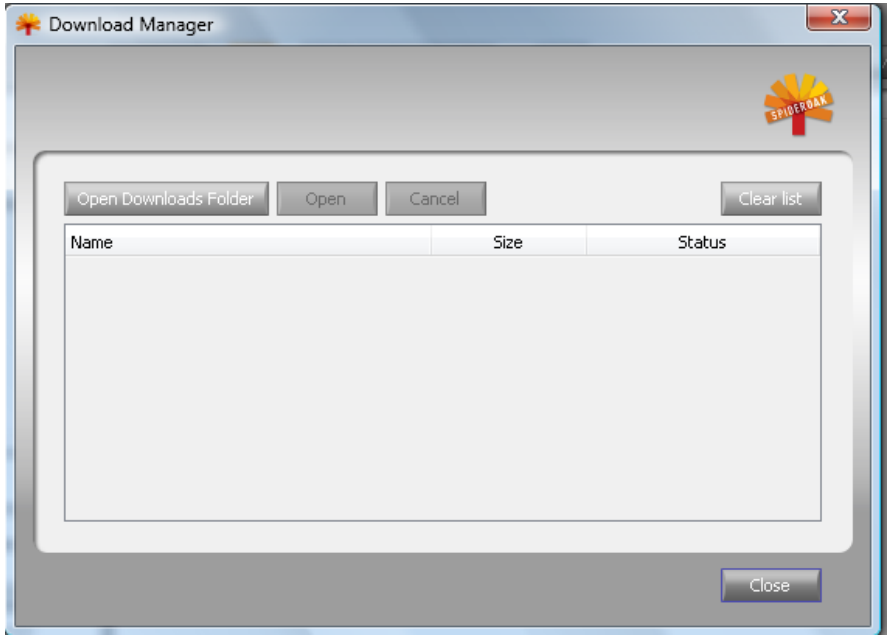


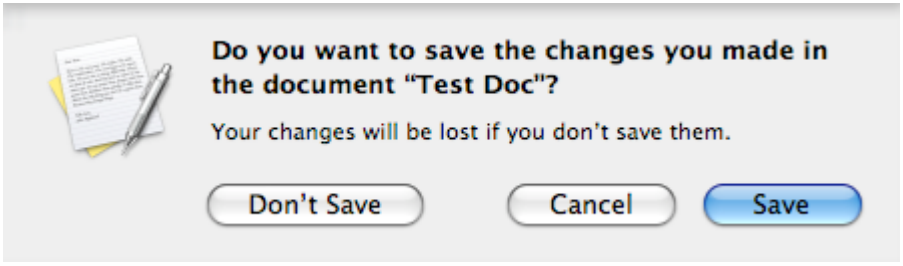
http://www.andyrutledge.com/gestalt-principles-3.php

Proximity to organize buttons



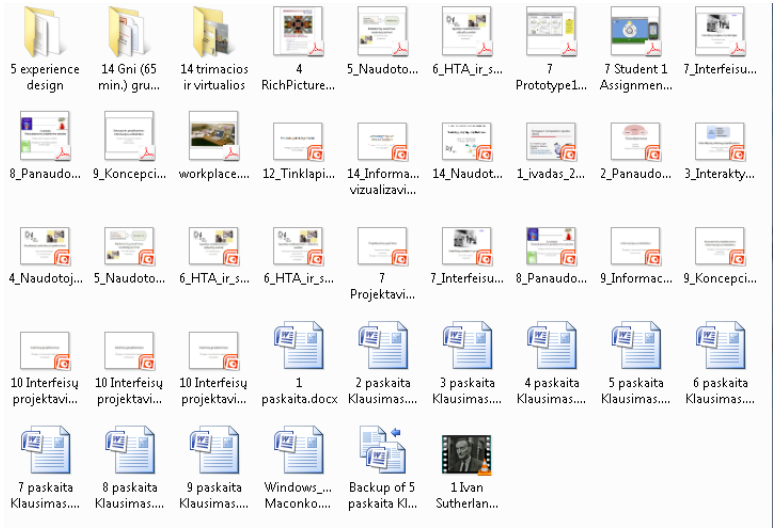
Equal distances in Windows Vista

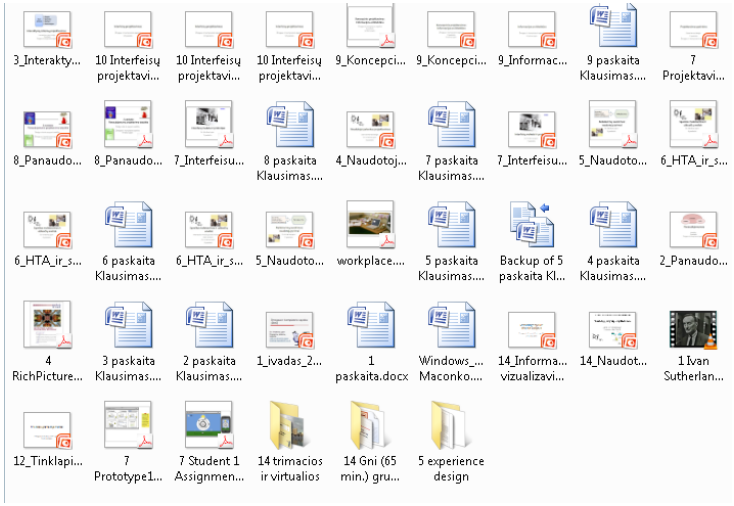




Buttons in OS X ir SpiderOak cloud

Gestalt laws - similarity

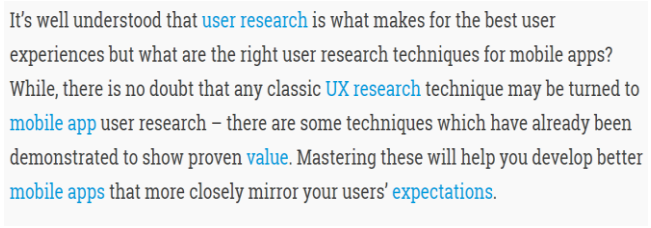




Files orgnised using similarity

Disorganised files – difficult to understand

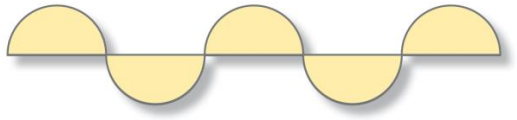
Similarity in web design



- Links distinguished
  - from other elements around them

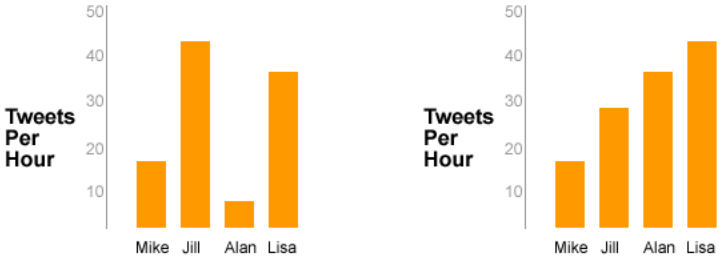
- Content relations
  - how some content components are related to one another
  - consistency of styling and presentation indicates consistency of category or context.

Gestalt laws: continuity

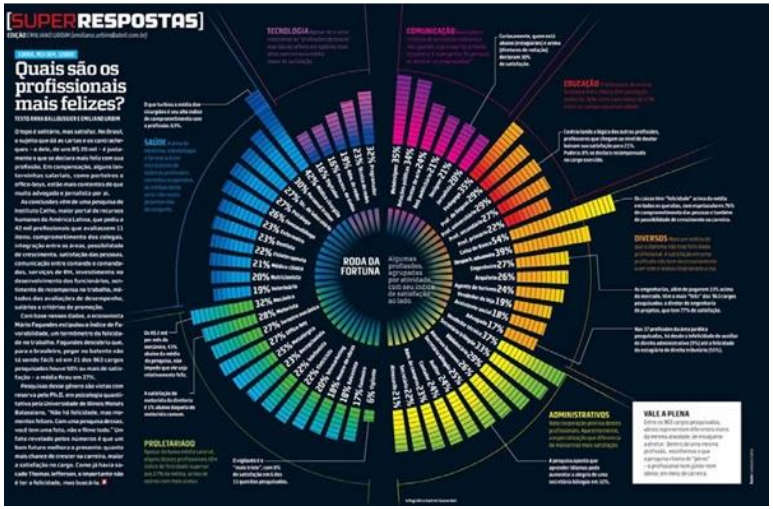


- We tend to perceive smooth, continuous patterns rather than disjoint, interrupted ones.

The graph on the right is easier to read and one may discern information from it more quickly than from the graph on the left ...because the graph on the right suggests a continuous line.

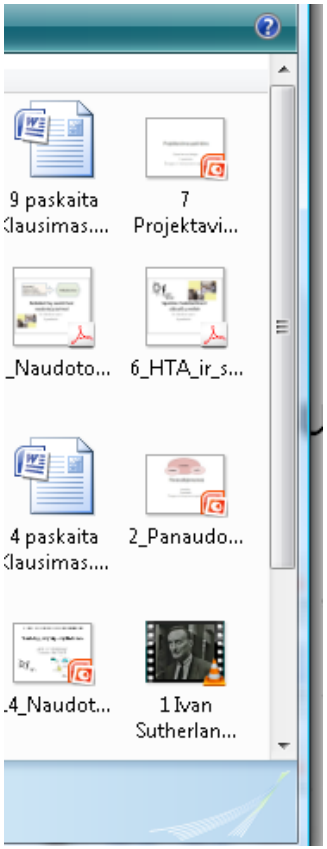


Here, the elements arranged on the curve are clearly related to each other. More so than the elements not positioned on the curve.



http://www.andyrutledge.com/gestalt-principles-3.php

Gestalt laws - continuity

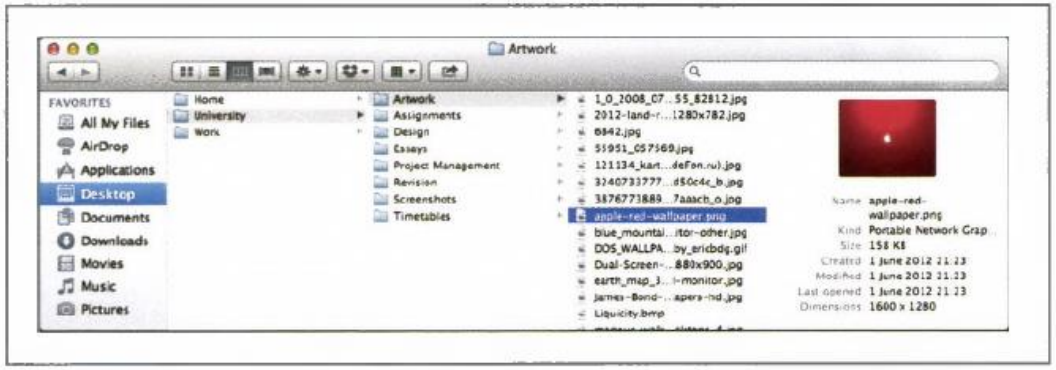


- Disconnected elements are often seen to be part of a continuous whole.
  - MS Windows scrollbar that indicates
    - that there is more of the document to be seen below the current window
  - Scrollbar refers the invisible part
    - indicates that about 80% is visible

Gestalt laws: closure

- When looking at a complex arrangement of individual elements, humans tend to first look for a single, recognizable pattern.

it takes less energy to see a pattern than to see individual

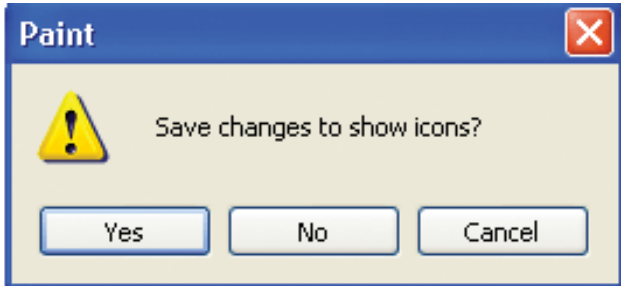


Finder application offers visual track from the top level to a file

http://www.andyrutledge.com/closure.php

The Gestalt laws of perception

- Proximity
  - objects appearing close together in space or time tend to be perceived together.
- Organising buttons



Design implications

- Icons should enable users to *distinguish* their meaning
- Bordering and spacing are effective visual ways of grouping information
- Sounds should be audible and distinguishable
- 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.
- People cannot 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
- We remember less about objects we have photographed
  - than when we observe them with the naked eye (Henkel, 2014)

The problem with the classic ‘7±2’

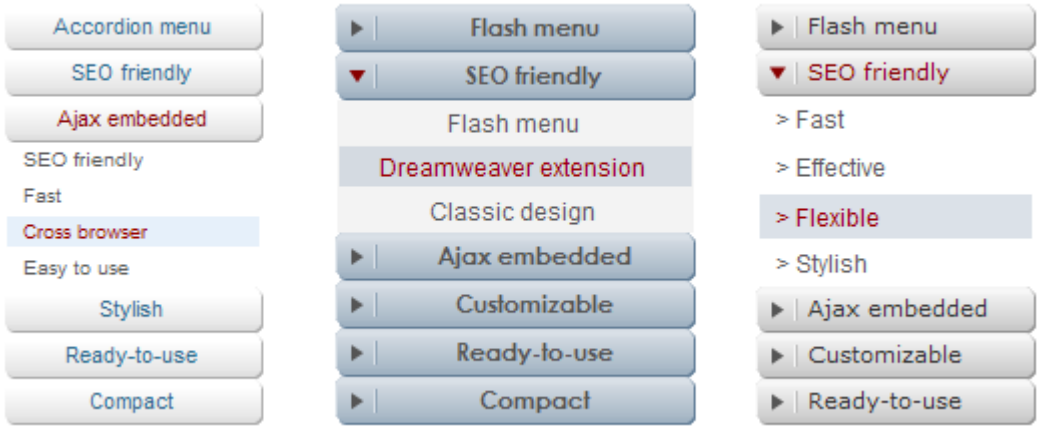
- George Miller’s (1956) theory of how much information people can remember
- People’s immediate memory capacity is very limited
- Many designers think this is useful finding for interaction design
- But…

What some designers get up to…

- 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?

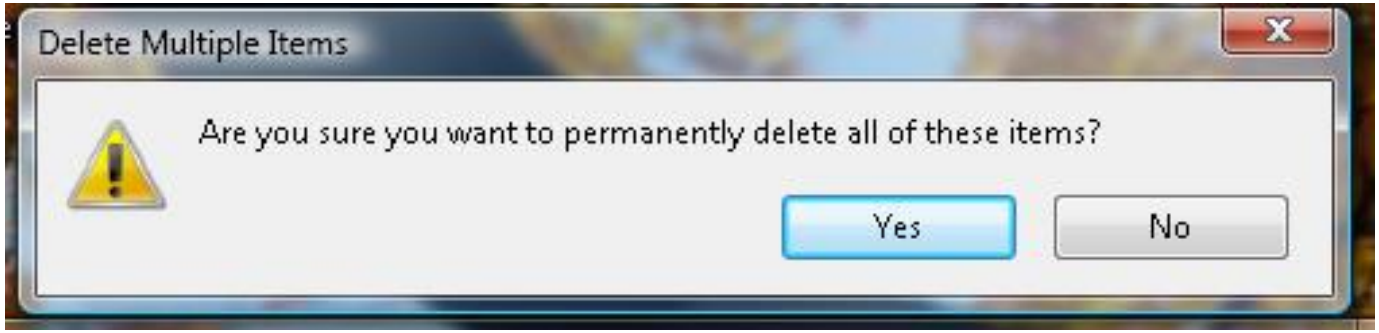
Principles for memory and attention

- Short-term memory
  - George Miller law (1956):
    - short-time memory is limited to 7 ± 2 small chunks
  - Cowan (2002): 4 ± 1
- Chunked dialogs

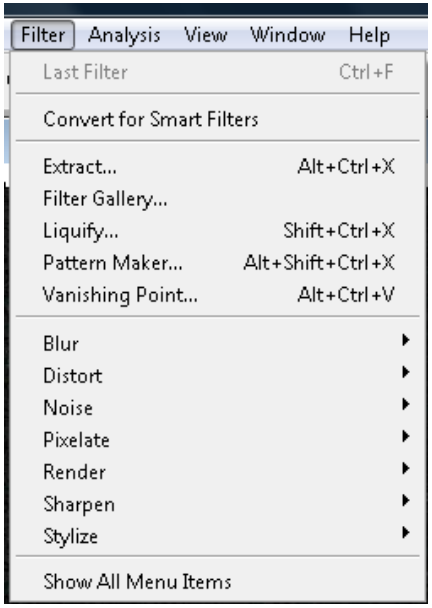


Principles for memory and attention

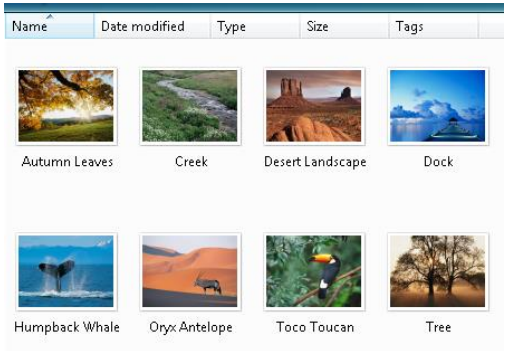
- Time limitations
  - memories in short-term memory persist for only 30 sec.,
  - Important information should be more persistent



Principles for memory and attention



- Recognition in menu
  - menu shows available options
  - Organised in chunks
  - Provided shortcuts

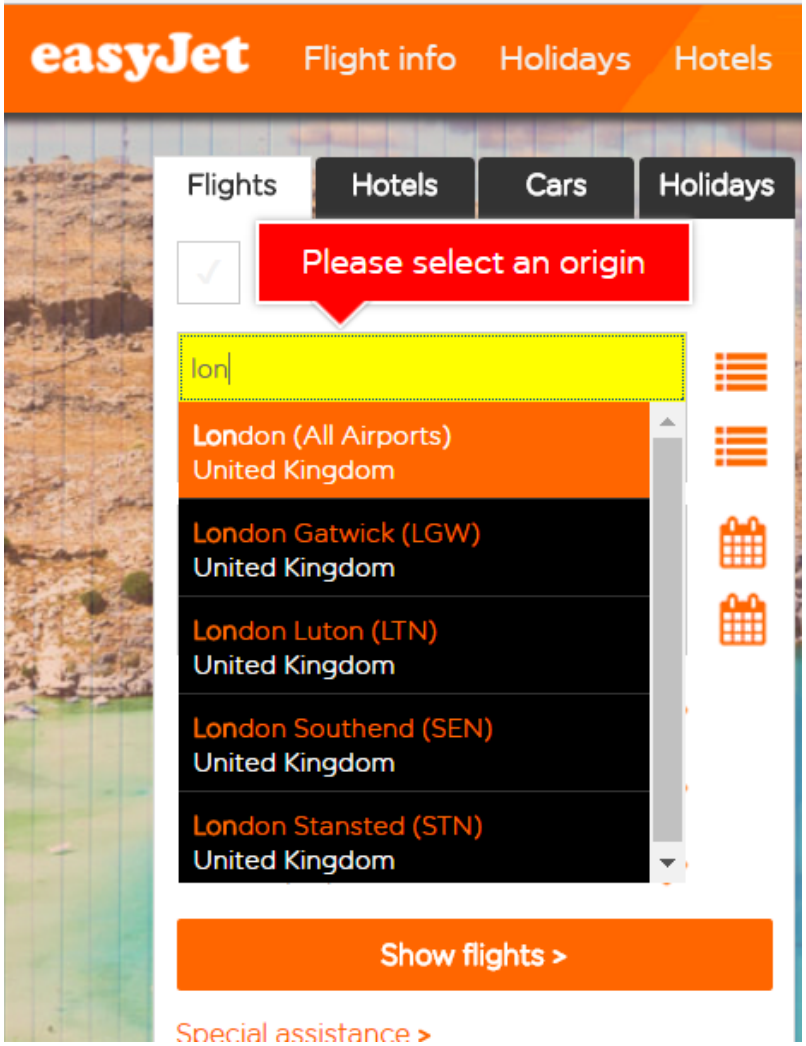


- Thumbnails
  - images help selection

Recognition versus recall

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

Principles for memory and attention



- Recognition rather than recall
  - picklists
  - autocomplete help to recall the names
    - E.g. airports

Principles for memory and attention

- colours
  - maximum 5 + 2
  - use central and peripheral colours
  - do not use simultaneous high-chroma, spectral colours
  - Use familiar consistent codings with appropriate references

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
  - e.g. when learning about HCI, it is much better to reflect upon it,
  - carry out exercises, have discussions with others about it, and write notes
  - than just passively read a book, listen to a lecture or watch a video about it

Digital content 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.

Is Apple’ s Spotlight search tool any good?

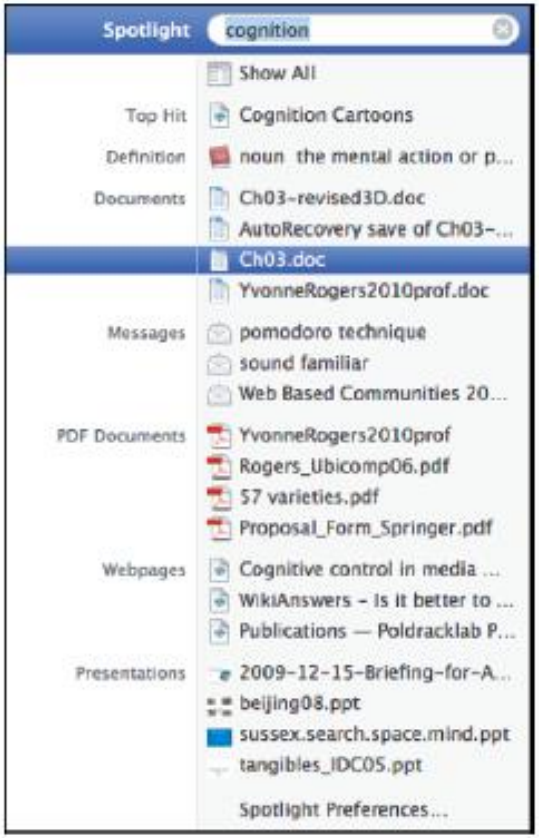


Figure 3.3 Apple’s Spotlight search tool

Memory aids

- SenseCam developed by Microsoft Research Labs (now Autographer)
- 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

Figure 3.5 The SenseCam device and a digital image taken with it

Source: ©Microsoft Research Cambridge.

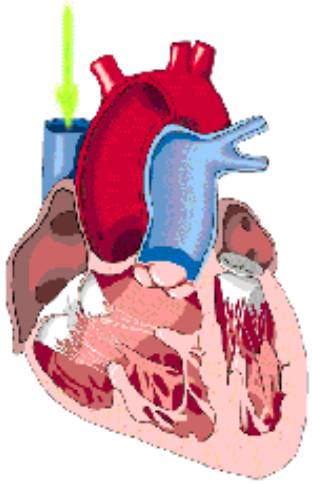
Design implications

- 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 or YouTube video to understand a given topic
- People find it hard to learn by following instructions in a manual
  - prefer to learn by doing

Design implications



- Right Atrium
- Tricuspid Valve
- Right Ventricle
- Pulmonic Valve
- Pulmonary Arteries
- Pulmonic Veins
- Left Atrium
- Mitral Valve
- Left Ventricle
- Aortic Valve
- Aorta

- Design interfaces that encourage exploration
- Design interfaces that constrain and guide learners
- Dynamically linking concepts and representations can 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

Applications

- Speech-recognition systems allow users to interact with them by asking questions
  - e.g. Google Voice, Siri
- 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

- Speech-based menus and instructions should be short
- Accentuate the intonation of artificially generated speech voices
  - they are harder to understand than human 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 artefacts
  - e.g. maps, books, pen and paper
- May involve working through different scenarios and deciding which is best option

Design implications

- 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

THEORETHICAL 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 versus shallow models
  - e.g. how to drive a car and how it works

Gulfs of execution and evaluation

- The ‘gulfs’ explicate the gaps that exist between the user and the interface
- 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

Norman, 1986; Hutchins *et al*, 1986

Bridging the gulfs

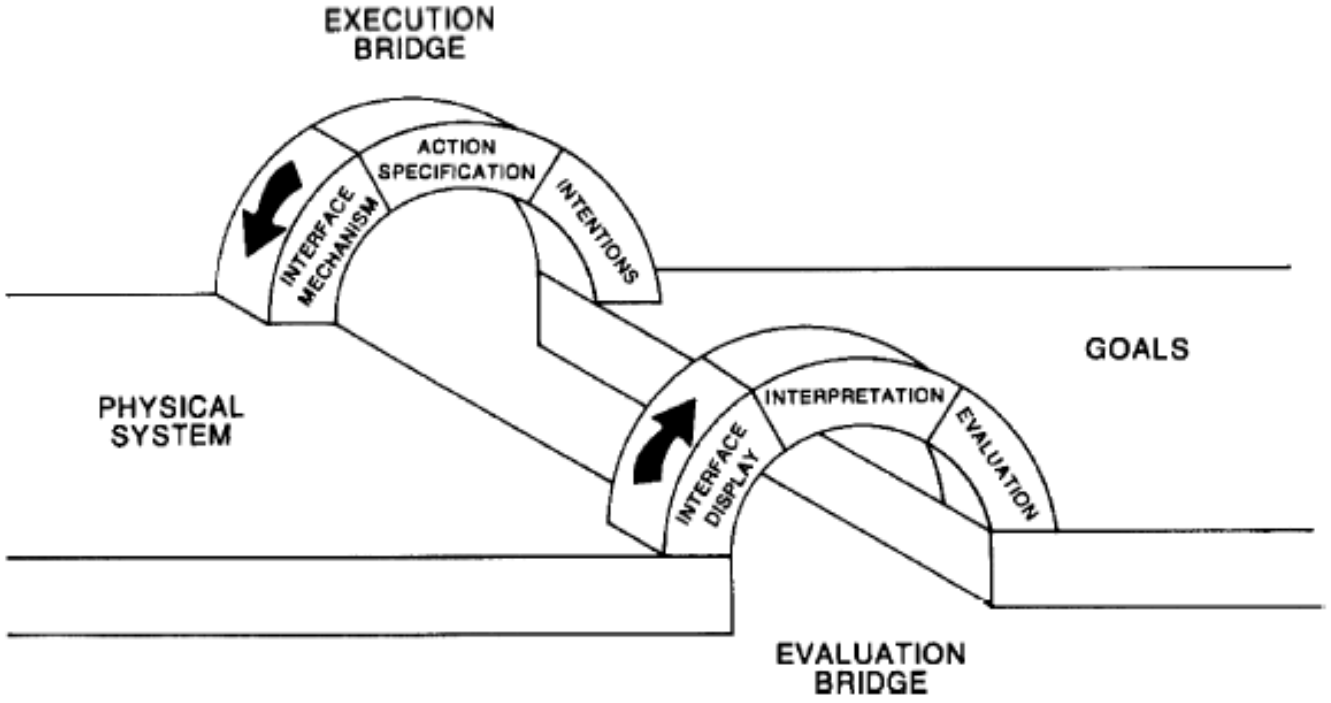


Figure 3.7 Bridging the gulfs of execution and evaluation

Source: User centered system design: new perspectives on human-computer interaction by D Norman. Copyright 1986 by Taylor & Francis Group LLC - Books. Reproduced with permission of Taylor & Francis Group LLC.

Information processing

- Conceptualizes human performance in metaphorical terms of information processing stages

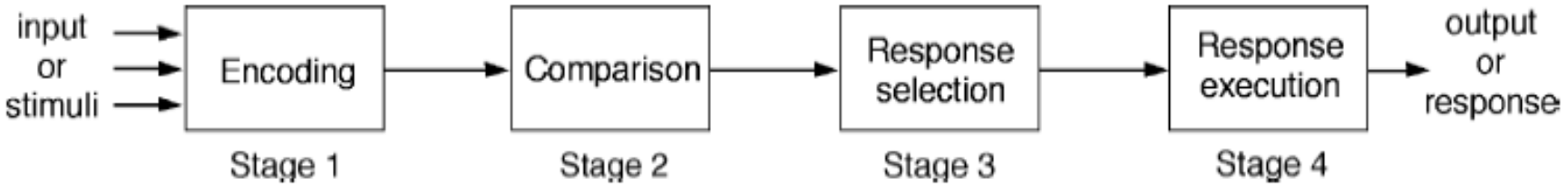


Figure 3.8 Human information processing model

Source: Reproduced with permission from P. Barber: *Applied Cognitive Psychology* 1998 Methuen, London.

Model Human processor (Card et al, 1983)

- Models the information processes of a user interacting with a computer
- 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

The human processor model

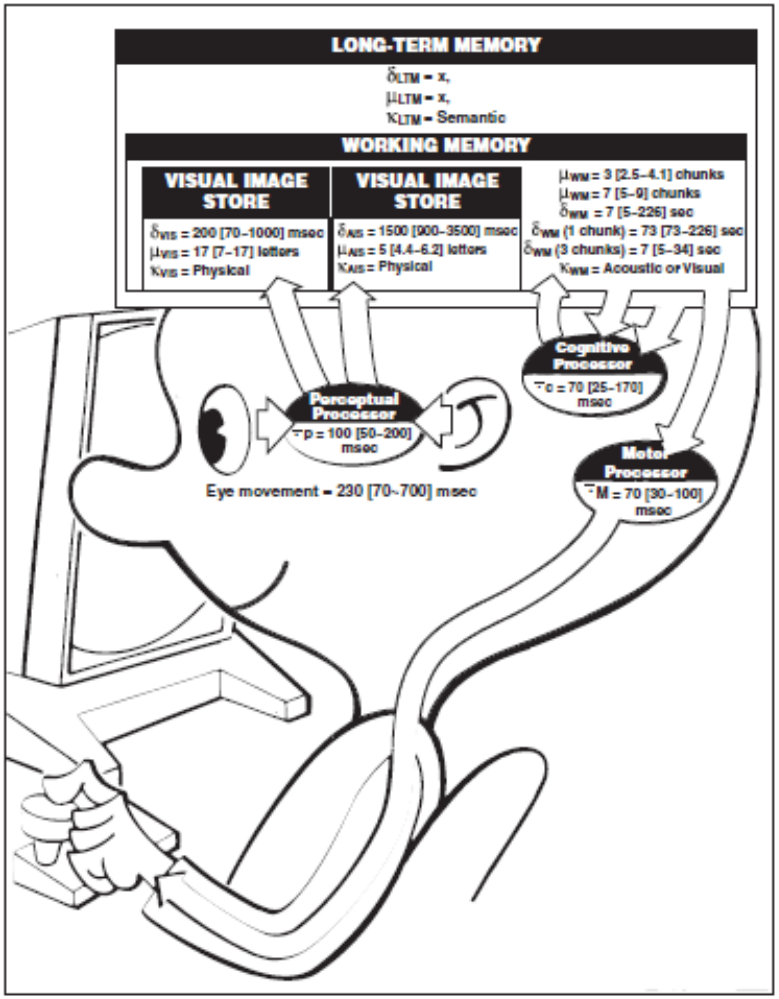


Figure 3.9 The human processor model

Source: The psychology of human-computer interaction by S. Card, T. Moran and A. Newell. Copyright 1983 by Taylor & Francis Group LLC - Books. Reproduced with permission of Taylor & Francis Group LLC.

Limitations

- Based on modelling mental activities that happen exclusively inside the head

- Do not adequately account for how people interact with computers and other devices in real world

Distributed cognition

- Concerned with the nature of cognitive phenomena across individuals, artefacts, 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)

How it differs from information processing

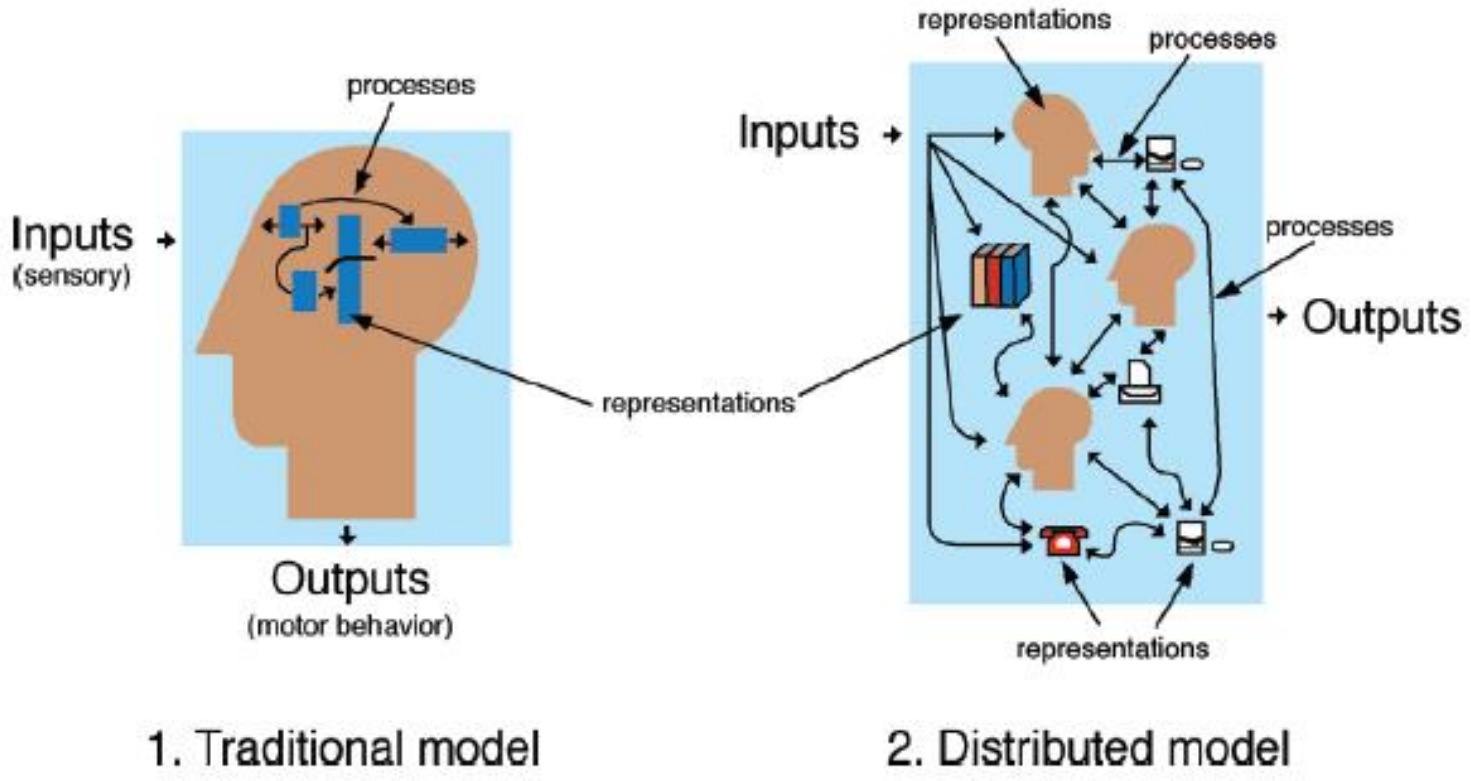
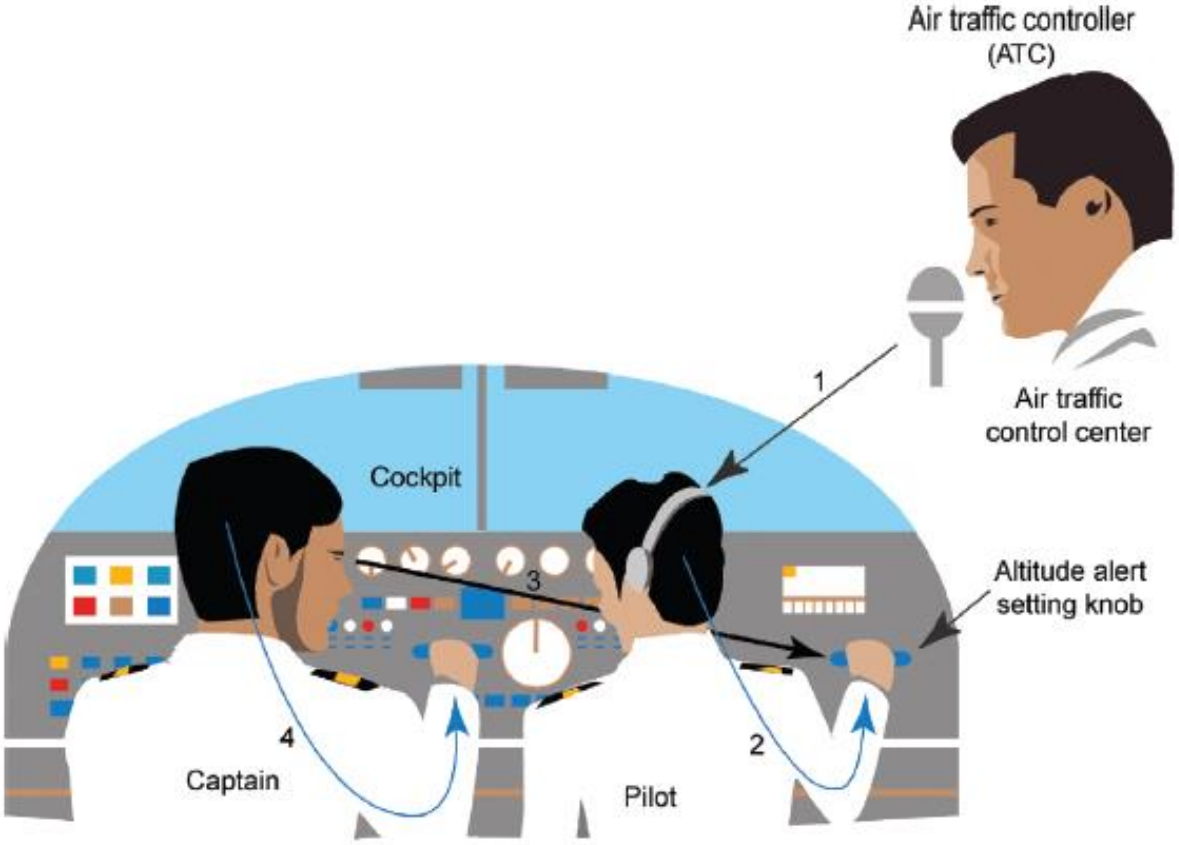


Figure 3.10 Comparison of traditional and distributed cognition approaches



Propagation of representational states:

1 ATC gives clearance to pilot to fly to higher altitude (verbal)

2 Pilot changes altitude meter (mental and physical)

3 Captain observes pilot (visual)

4 Captain flies to higher altitude (mental and physical)

Figure 3.11 A cognitive system in which information is propagated through different media

Source: Preece, J. and Keller, L. (1994) *Human-Computer Interaction*, Figure 3.5 (p. 70) Addison Wesley, 1994.

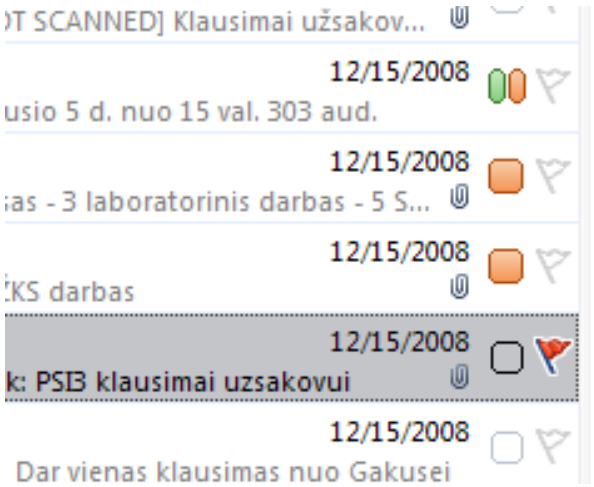
What's involved

- The distributed problem-solving that takes place
- The role of verbal and non-verbal behavior
- The various coordinating mechanisms that are used (e.g. rules, procedures)
- The communication that takes place as the collaborative activity progresses
- How knowledge is shared and accessed

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?

Externalizing to reduce memory load



- 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)

Computational offloading

- When a tool is used in conjunction with an external representation to carry out a computation (e.g. pen and paper)
- Try doing the two sums below (a) in your head, (b) on a piece of paper and c) with a calculator.
  - 234 x 456 =??
  - CCXXXIIII x CCCCXXXXXVI = ???
- Which is easiest and why? Both are identical sums

Annotation and cognitive tracing

- Annotation involves modifying existing representations through making marks
  - e.g. crossing off, ticking, underlining
- Cognitive tracing involves externally manipulating items into different orders or structures
  - e.g. playing Scrabble, playing cards

Design implication

- Provide external representations at the interface
  - that reduce memory load and
  - facilitate computational offloading

  - e.g. Information visualizations have been designed to allow people to make sense and rapid decisions about masses of data

Summary

- Cognition involves several processes including attention, memory, perception and learning
- The way an interface is designed can greatly affect how well users can perceive, attend, learn and remember how to do their tasks
- Theoretical frameworks, such as mental models and external cognition, provide ways of understanding how and why people interact with products
- This can lead to thinking about how to design better products

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- David Benyon, Phil Turner, Susan Turner. **Designing Interactive Systems: People, Activities, Contexts, Technologies,** Addison Wesley, 2014. Chapter 23, 24
- Andy Rutledge. Gestalt principles of perception, 2008