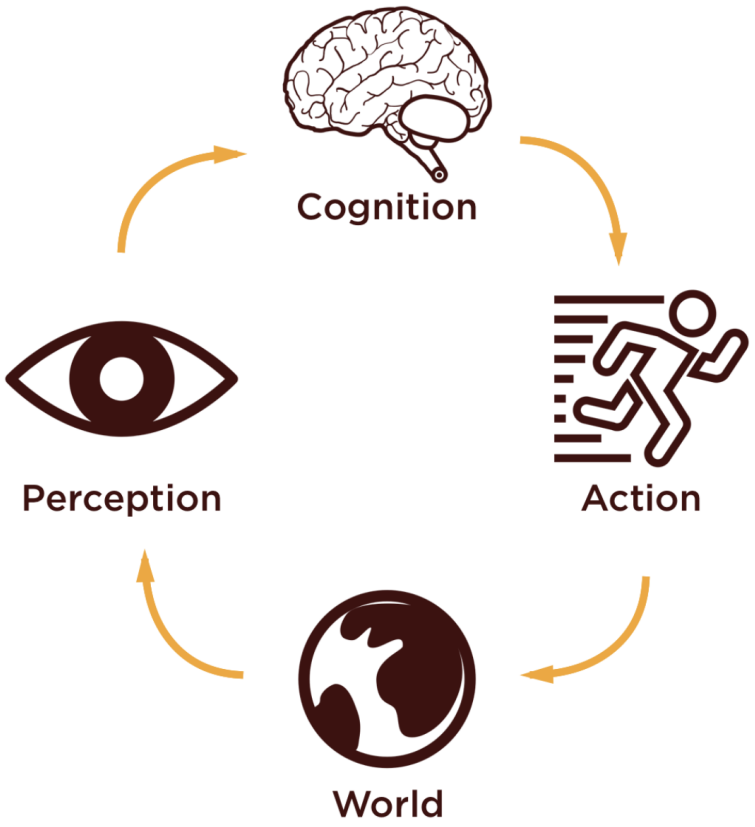
Understanding People: Cognition

CSU4051 Human Factors

Cognition

- Interacting with technology is cognitive.
- We need to take into account cognitive processes involved and cognitive limitations of users



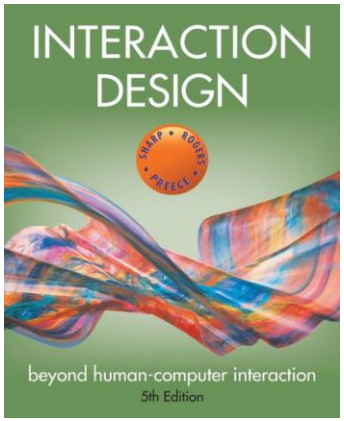
How can understanding cognition help HCI?

1. Provides knowledge about what people can and cannot be expected to do

2. Identifies and explains the nature and causes of problems people encounter when using technology

3. Provides theories, modelling tools, guidance, and methods that can lead to the design of better interactive products.

Cognition



Chapter 4: Cognitive Aspects

Cognitive Processes

1. Attention
2. Perception and Recognition
3. Memory
4. Learning
5. Reading, speaking and listening.
6. Problem-solving, planning, reasoning, decision making.

Cognitive Processes

1. **Attention**
2. Perception and Recognition
3. Memory
4. Learning
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Attention

Selecting things to concentrate on at a point in time from the mass of stimuli around us.

The difficulty of this process for a person depends on:

1. How clear their goal is
2. How salient in their environment the information they need is

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.

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

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

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

South Carolina

City	Motel/Hotel	Area code	Phone	Rates Single	Rates 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

Activity

- Tullis 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
  - 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

Distraction and interruption

- Users may be distracted or interrupted - “Cup of tea” problem.
- Users should know where they are in the system and what information is being displayed.
- This is particularly important in interfaces based around forms.
- Users should be able to pick up where they left off easily. Security mechanisms like auto-logoff can often disrupt this.
- A study with commercial pilots showed that abruptly delivered instructions in descent and approach flight phases resulted in ongoing procedures being 53% more likely to contain errors (Latorella).

Attention

"The *scarce* resource of the 21st century will not be technology; it will be *attention*."

Mark Weiser

Calm Technology:
Technology should require the smallest possible amount of attention.

Image: New York Times

Design Implications for Attention

1. Make information salient when it needs attending to at a given stage of a task.
2. Use techniques that make things stand out like colour, ordering, spacing, underlining, sequencing and animation
3. Avoid cluttering the interface with too much information.
4. Consider designing different ways to support effective switching and returning to an interface.

Cognitive Processes

1. ~~Attention~~

2. **Perception and Recognition**

3. Memory

4. Learning

5. Reading, speaking and listening.

6. Problem-solving, planning, reasoning, decision making.

Perception and recognition

How information is acquired from the world and transformed into experiences

Five senses for information acquisition: vision, hearing, taste, smell, touch

Q. How do we design representations that are readily accessible?

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

Find French

Webmaster	Curriculum	Student Life	Dance
Russian	Emergency (EMS)	Accountancy	Gerontology
Athletics	Statistics	McKnight Center	Marketing
Go Shockers	Award Documents	Council of Women	College Bylaws
Degree Options	Language Center	Commute	Why Wichita?
Newsletter	Future Shockers	Small Business	Tickets
Geology	Intercollegiate	Thinker & Movers	Career Services
Manufacturing	Bowling	Alumni	Doers & Shockers
Management	Wichita Gateway	Foundations	Core Values
UCATS	Transfer Day	Corbin Center	Grace Wilkie Hall
Alumni News	Job Openings	Jardine Hall	Strategic Plan
Saso	Live Radio	Hugo Wall School	Medical Tech
Educational Map	Beta Alpha Psi	Staff	Softball, Men's
Physical Plant	Liberal Arts	Aerospace	McKinley Hall
Graphic Design	Counseling	Choral Dept.	Email
Non Credit Class	Biological Science	Alberg Hall	Dental Hygiene
Media Relations	Duerksen Fine Art	French	Tenure
Advertising	EMT Program	Spanish	Personnel Policies
English	Religion	Parents	Instrumental
Graduate Complex	Art Composition	Wrestling	Nursing
Music Education	Physics	Philosophy	Opera
Advising Center	Entrepreneurship	Wichita Lyceum	Sports History
Medical School	Koch Arena	Fairmount Center	Athletic Dept.
Levitt Arena	Roster	Women's Museum	Health Plan

Which information structure was better?

Weller (2004) found people took less time to locate items for information that was grouped Using a border (2nd screen) compared with using colour contrast (1st screen)

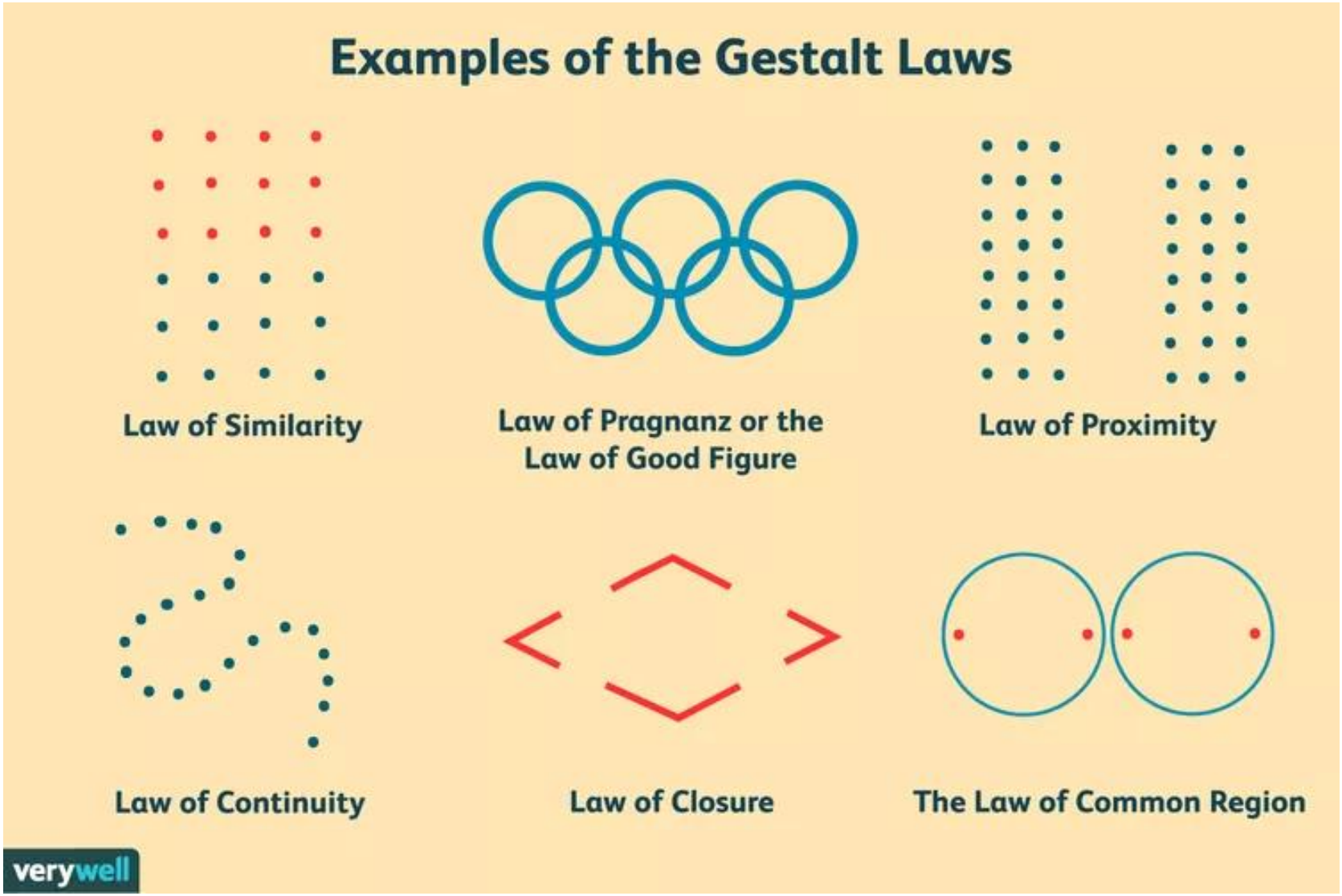
Layout

Layout is an important aspect of the design.

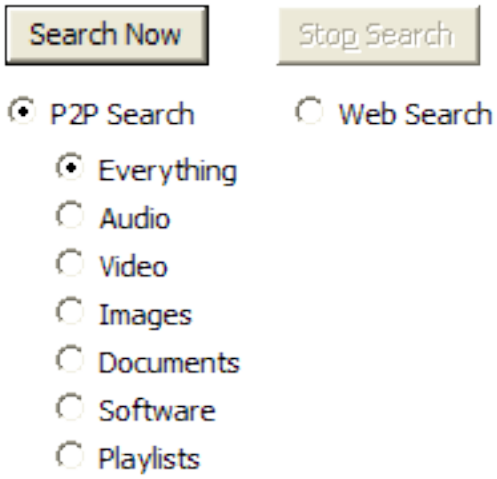
- Consistent layout
  - E.g., using different areas of the screen for different purposes can be helpful to the user.
- Grouping items
  - Grouping can be helpful to indicate that items are related in some fashion.
- Whitespace
  - Some argue that too much white space on web pages is detrimental to search process as it makes it hard to find information

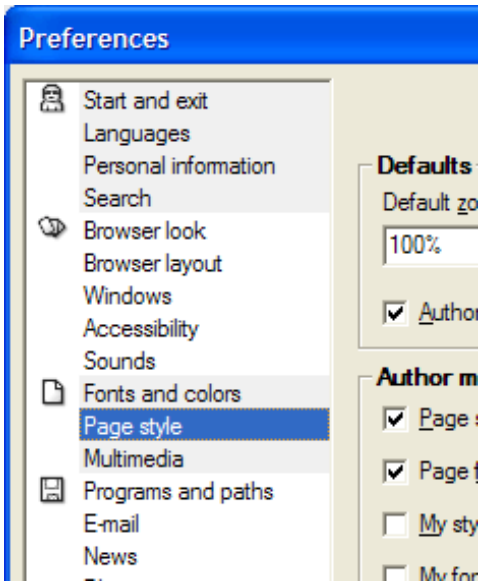
Laws of Gestalt

- **Proximity** – items are grouped according to the nearness of their respective parts
- **Similarity** – similar items tend to be grouped
- **Good Continuation** – e.g. straight lines appear to continue as straight lines, curves as curves.
- **Closure/Good Form** – completed items are grouped together
- **Membership character** – a single part of the whole is defined by the context in which it appears.



https://www.verywellmind.com/gestalt-laws-of-perceptual-organization-2795835





Examples from interaction-design.org

Poisoned Navalny discharged from Berlin hospital

The Putin-critic later described his slow recovery in Germany from poisoning with a nerve agent.

1h | Europe

- **Two hours that saved Navalny's life**
- **What are Novichok nerve agents?**
- **Russia's vociferous Putin critic**

LIVE

UK hospitality sector labels new rules 'devastating'

5m UK chancellor to update MPs on job protection plans

14m Belgium to reduce quarantine period

23m False claims about testing spreading online

Lukashenko shuts down capital for secret ceremony

The embattled president of Belarus is quietly sworn in for a sixth term despite weeks of protests.

3h | Europe

Harry urges US voters to 'reject hate speech'

His "non-partisan" plea has caused controversy, since royals are expected to stay politically neutral.

1h | UK

Health chief hails Africa's fight against Covid-19

Africa has had fewer cases than Europe, Asia or the Americas, with numbers continuing to decline.

3h | Africa

Assange fiancée 'dreaded making relationship public'

Stella Moris gave birth to the couple's two sons while he was in hiding in the Ecuadorean embassy.

8h | World

Over 300 whales die in Australia's worst stranding

4h | Australia

Schoolchildren killed in Nigeria tanker explosion

7m | Africa

Austrian government sued over Covid at ski resorts

4h | Europe

EU plans mandatory migrant pact to 'rebuild trust'

4h | Europe

The toughest workplace romance rules in the world?

3h | Business

New Zealand eases mask rule as Covid cases drop

1h | Asia

Four Seasons' Tommy DeVito dies aged 92

8h | US & Canada

Mexico investigating US immigrant 'sterilisations'

3h | Latin America & Caribbean

Must See

Graphic design example

In 1966, engineers and designers at Dow Chemical working for the National Cancer Institute set out to create an icon for biohazardous materials. They laid out six design criteria. The solution had to be:

1. Striking in form, in order to draw immediate attention
2. Unique and unambiguous to avoid confusion with other symbols
3. Quickly recognizable and easily recalled
4. Easily stencilled
5. Symmetrical, in order to appear identical from all angles
6. Acceptable to groups of varying ethnic backgrounds

Graphic design example

- Showed a set of 24 symbols to 300 people with various amounts of income and formal education from 25 American cities.
- Asked to guess the meaning of each, giving a "meaningfulness score." A week later, the same participants were shown the original 24 symbols with 36 more and asked to identify which symbols they remembered seeing before.

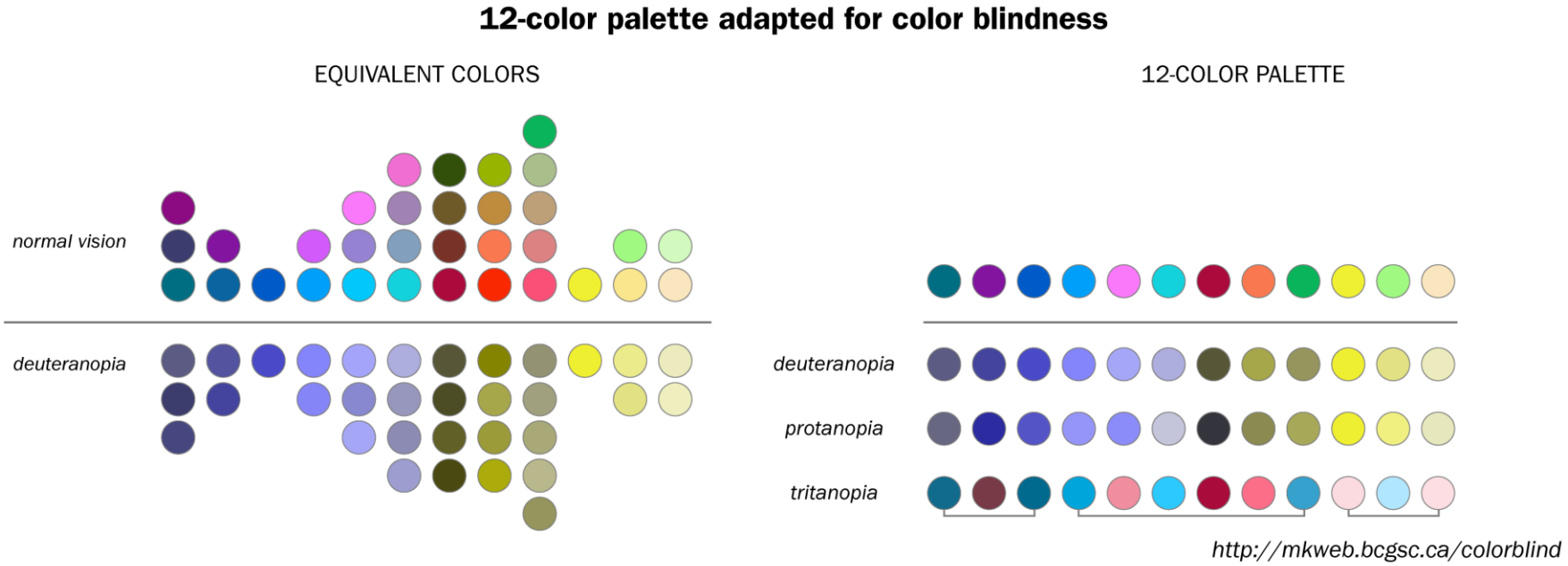
One scored joint highest in memorability, but the lowest in meaningfulness. So it was unforgettable, but also a had no conflicting interpretation.

Baldwin, C.L. and Runkle, R.S. *Science* 158: 264-265, 1967

Display readability

Colour

- Made up of hue, intensity, saturation
- About 8% of men have some form of colour vision deficiency, about 0.5% of women



Which is easiest to read and why?

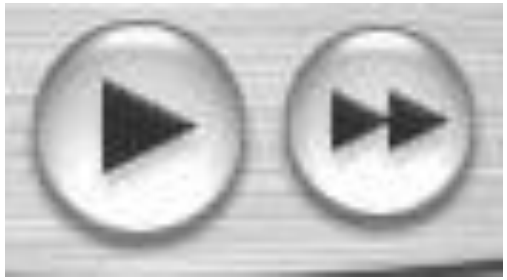
What is the time?

What is the time?

What is the time?

What is the time?

Readability



- Which is better?
- W3C recommends brightness difference and minimum colour difference

Touch

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

Haptic feedback

- Simple haptic feedback may be on/off.
- Responses to keypresses.
- Continuous cycling.
- Pulses.

Movement

- Time taken to respond to stimulus: reaction time + movement time
- Movement time - dependent on age, fitness etc.
- Reaction time - dependent on stimulus type:
  - visual ~ 200ms
  - auditory ~ 150 ms
  - pain ~ 700ms

Design Implications: Perception and Recognition

1. Icons and other graphical representations should enable users to readily *distinguish* their meaning
2. Bordering and spacing are effective visual ways of grouping information
3. Sounds should be audible and distinguishable
4. Text should be legible and distinguishable from the background
5. Haptic feedback should be used judiciously

Cognitive Processes

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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
- People with Dyslexia have difficulties understanding and recognising written words

Reading

- Several stages:
  - visual pattern perceived
  - decoded using internal representation of language
  - interpreted using knowledge of syntax, semantics, pragmatics
- Reading involves saccades and fixations
- Perception occurs during fixations
- Word shape is important to recognition
- Negative contrast (dark on light) improves reading from computer screen

Audio in Interfaces

- How might we make use of sound in an interface?
  - Getting the user's attention
  - Continuous status information
  - Confirmation
  - Hands-free eyes-free interaction

Design Implications: Reading, Speaking, and Listening

1. Speech-based menus and instructions should be short
2. Accentuate the intonation of artificially generated speech voices
   - They are harder to understand than human voice
3. Provide opportunities for making text large on a screen

Cognitive Processes

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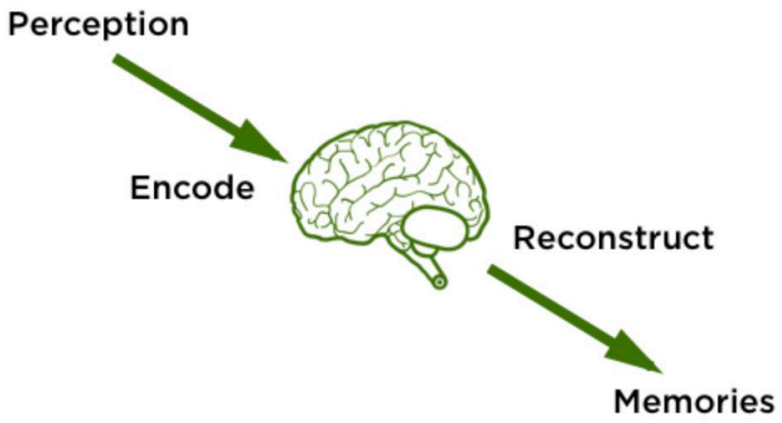
Memory

- Involves recalling various kinds of knowledge that allow people to act appropriately
  - For example, recognizing someone's face or remembering someone's name
- First encode and then retrieve knowledge
- We don't remember everything - involves filtering and processing what is attended to



Processing in memory

- Encoding is first stage of memory
  - determined by which information is attended to in the environment and how it is interpreted
- The more attention paid to something, and 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

  - *For example, 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 or listen to a lecture.*

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
  - e.g., You are on a train and someone comes up to you and says hello. You don't recognise him for a few moments but then realise it is one of your neighbours. You are only used to seeing your neighbour near where you live and seeing him out of context makes him difficult to recognise initially

Memory

There are three types of memory function:

1. Sensory memories (buffers for stimuli: visual → iconic, auditory → echoic, touch → haptic)
2. Short-term (STM)
3. Long-term (LTM)

Short-term memory (STM)

- Scratch-pad for temporary recall
  - rapid access ~ 70ms
  - rapid decay ~ 200ms
  - limited capacity - 7± 2 chunks

The problem with the classic '7±2'

- George Miller's theory of how much information people can remember
- People's immediate memory capacity is very limited
- Many designers have been led to believe that this is useful finding for interaction design

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?

Why?

- Inappropriate application of the theory
- People can scan lists of bullets, tabs, menu items till they see 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 design.
  - E.g. phone or smartwatch displays.
- Depends on task and available screen estate

Long-term memory (LTM)

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

- Two types
  - episodic - serial memory of events
  - semantic - structured memory of facts,concepts, skills
  - information in semantic LTM derived from episodic LTM.

LTM - Storage of information

- Rehearsal
  - information moves from STM to LTM
- Total time hypothesis
  - amount retained proportional to rehearsal time
- Distribution of practice effect
  - optimised by spreading learning over time
- Structure, meaning and familiarity
  - information easier to remember

LTM - Forgetting

- Decay
  - information is lost gradually but very slowly
- Interference
  - new information replaces old: retroactive interference (eg. phone number)
  - old may interfere with new: proactive inhibition
- May not forget at all: memory is selective…
- Affected by emotion - can subconsciously “choose” to forget

LTM - retrieval

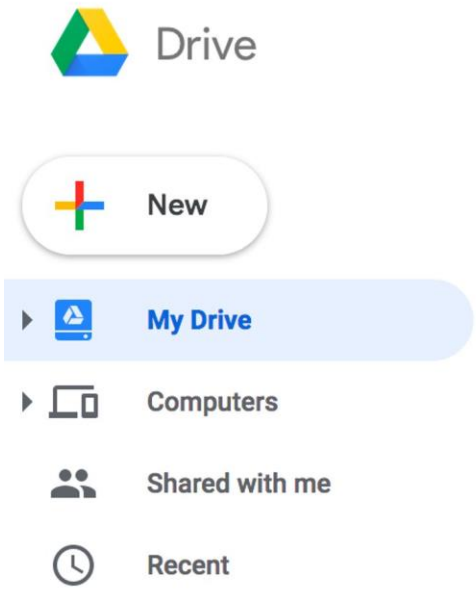
- Recall
  - information reproduced from memory
  - can be assisted by cues, e.g. categories, imagery
- Recognition
  - information gives knowledge that it has been seen before
  - less complex than recall - information is cue

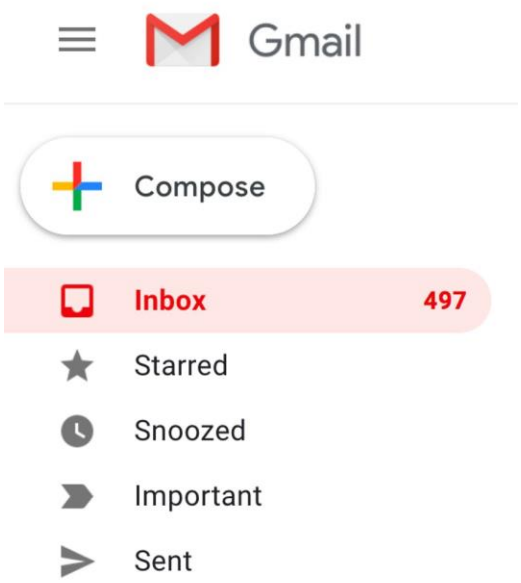
Recognition versus recall

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

Reducing memory load - consistency

- Consistency is useful as it can allow the user to predict what will happen when they carry out a certain action.
- Likewise they can have expectations on where certain information can be found.
- This can work across a given application, suite of applications, or an entire technology platform.





Personal information management

- Personal information management (PIM) is a growing problem for most users
  - Accumulate 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 you have 10,000s
  - How might such a process be facilitated taking into account people's memory abilities?

Personal information management

- Three interdependent processes model (Bergman and Whittaker 2016) to help people manage their stuff :
  1. How to decide what stuff to keep
  2. How to organize it when storing
  3. Which strategies to use to retrieve it later
- Retrieval involves 2 processes
  - recall-directed and recognition-based scanning
- Strong preference for scanning.

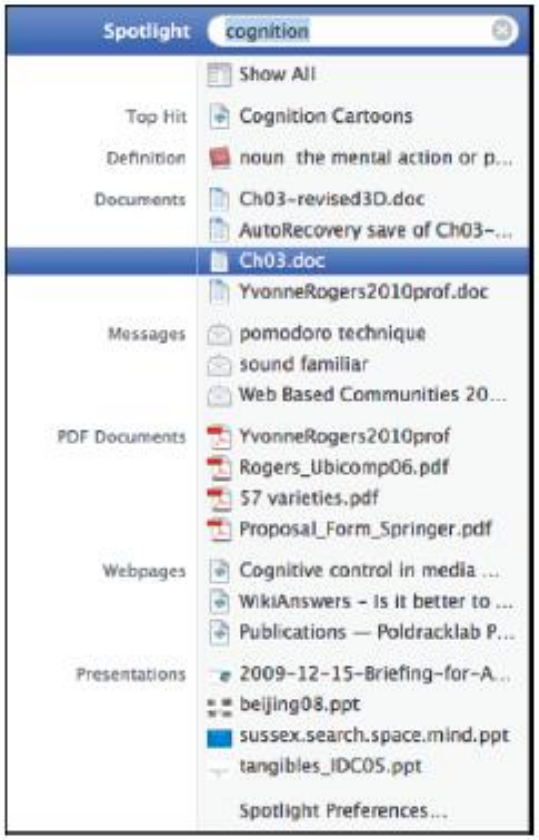
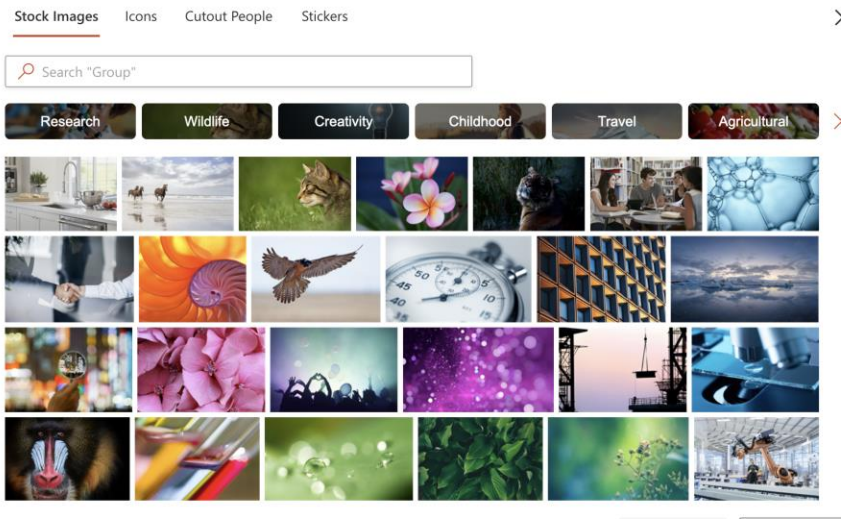


Figure 3.3 Apple's Spotlight search tool

Personal information management



- Optimise 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 load

- Online/mobile and phone banking now require users to provide multiple pieces of information to access their account
  - For instance, ZIP code, birthplace, a memorable date, first school attended
  - Known as multifactor authentication (MFA)
- Why?
  - Increased security concerns
- Password managers, such as LastPass, have been developed that require only one master password
  - reduces stress and memory load on users
- Passwords could become extinct with the widespread use of biometrics and computer vision algorithms

Digital Forgetting

- When might you wish to forget something that is online?
  - When you break up with a partner
  - Emotionally painful to be reminded of them through shared photos, social media, and so on.
- Sas and Whittaker (2013) suggest ways of harvesting and deleting digital content
  - For example, making photos of ex into an abstract collage
  - Helps with closure