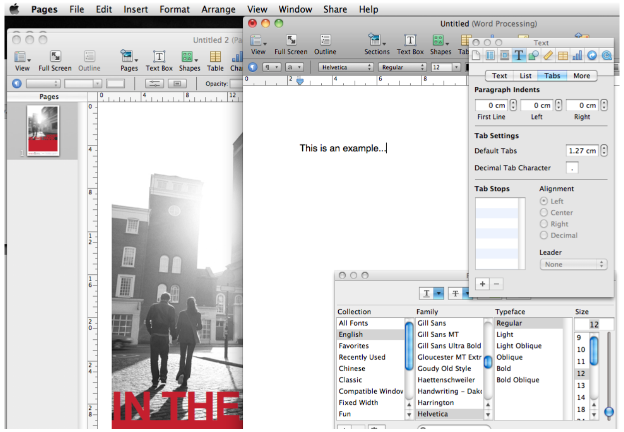
Week 4

The psychology of the user interface

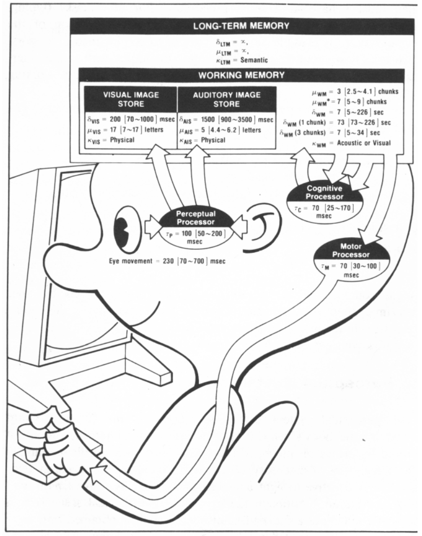
Why UIs are like they are?

Are there any laws or theory that tell us how to design a user interface?



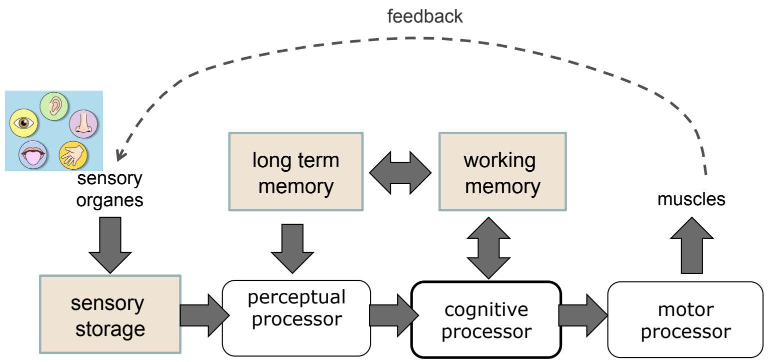
Human processor

Modeling humans as an information processing system

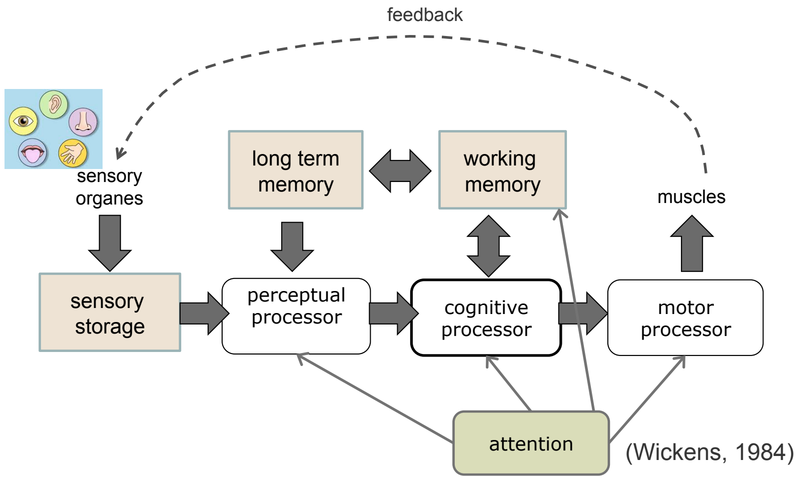


(Card, Moran & Newell 1983)

Human processor



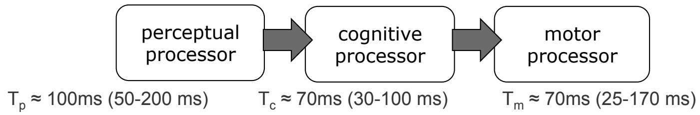
Human processor



Processors

Each processor has a processing cycle
  Necessary duration to treat an input and produce an output

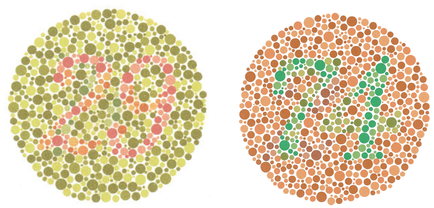
Speed of processing depends on individual humans and external conditions
  (e.g., intensity of the stimulus, noise, alcohol,...)
  The fastest speed can be 10 times faster than the slowest



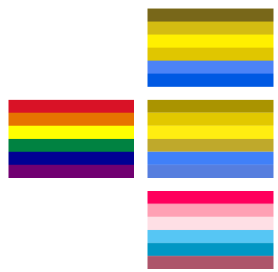
Visual perception

Visual perception

red-green color blindness (daltonism) is very common (8% of adult males)
  Don’t use only color to highlight differences, or use choose colors that are difficult to confuse



Ishihara Test for Colour Blindness



Visual perception

Colors of different wavelengths are hard to tell apart

Don’t use red text on blue background

With age, blue becomes harder to read

Change Blindness (Cécité au changement)

Difficult to see visual changes when our vision is interrupted

Avoid abrupt changes in the interface (show animations, highlight changes)

Visual perception

Visual perception

Gestaltism (psych. of the form)

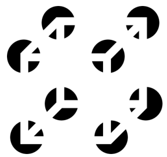
A theory claiming that the perception processing and the mental/cognitive representation of information, process spontaneously (« pre-attentively ») the surrounding phenomena as groups of structures (forms), and not as several discrete elements

Theory that has a psychological, philosophical and biological influences and implications, and is relevant to perception and cognition

Gestalt laws of perception

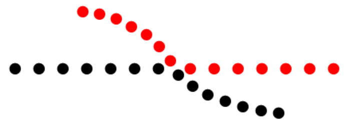
Continuity
Proximity
Similarity
Symmetry
Closure
Common fate
Past experience
Figure–ground

These laws act at the same time and can be occasionally contradictory



Continuity

Elements arranged on a line or curve are perceived as more related than elements not on the line or curve



http://www.smashingmagazine.com/2014/03/28/design-principles-visual-perception-and-the-principles-of-gestalt/

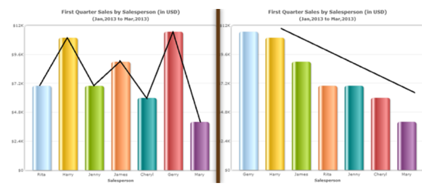
Continuity

Elements arranged on a line or curve are perceived as more related than elements not on the line or curve

eclipse splash screen

Continuity

We tend to perceive elements grouped together, and integrated into perceptual « wholes » if they are aligned



http://sixrevisions.com/usability/data-visualization-gestalt-laws/

Continuity

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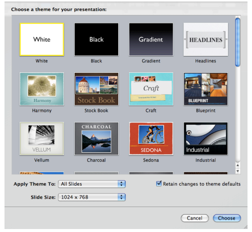
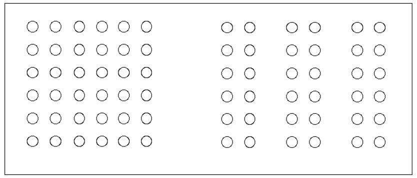
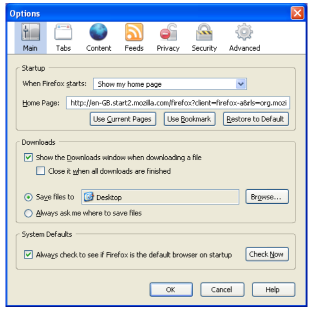


e.g., different style options in
a UI presented one after the other

Proximity

We group objects first by their proximity between them

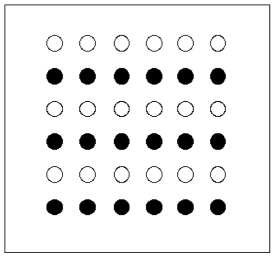


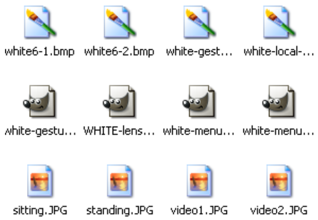


e.g., functions in a dialogue box

Similarity

If distance (proximity) does not allow grouping, we tend to group objects based on their perceived similarity in form





e.g., similar file icons to visually organize and
remember their applications (shape, size, color)

Symmetry

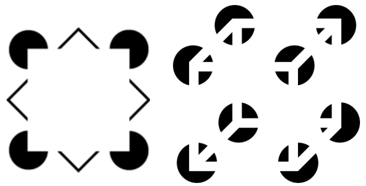
Symmetries are aesthetically pleasing, and we tend to group symmetrical objects as one group with a central point

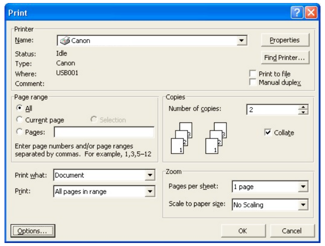
{ } [ ] ( )

e.g., symmetrical actions in the UI
have symmetrical icons and are seen as a group

Closure

We perceive objects such as shapes, letters, pictures, etc., as being whole even when they are not complete (we complete the missing parts)

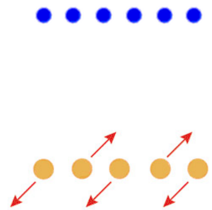


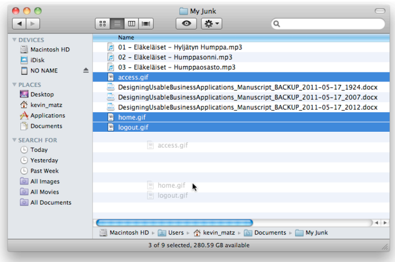


e.g., we can group items in a UI by explicit or implicit borders

Common fate

Elements moving in the same trajectory with the same speed are seen as a group





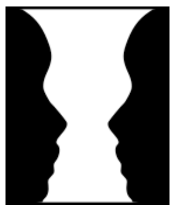
e.g., if you select and drag some icons, shadows of these items all move at the same direction and speed

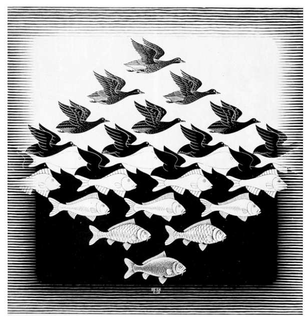
Past experience

Past experience and context affect the interpretation of elements in a group

Figure - Ground

Perception consists of a distinction between the graphical figure (target) and ground (context). It should always be clear in the UI





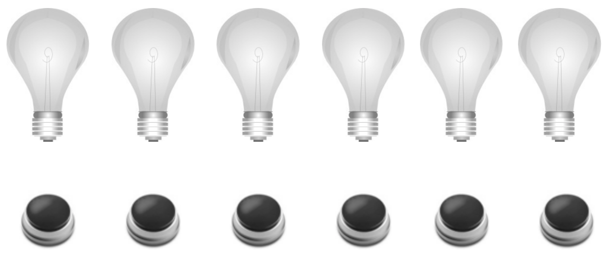
Cognition

Cognitive processes

Responsible for decisions
- Comparison and process of stimuli and selection of a response

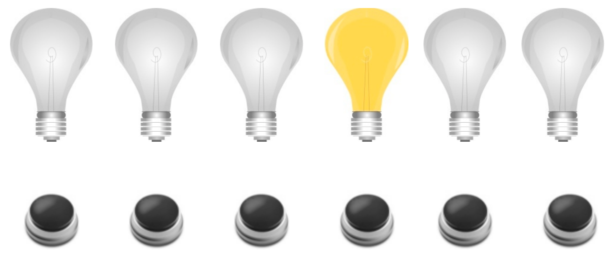
Types
- Mechanical, based on habits and repetition (e.g. walk, point, speak)
- Bases on rules (e.g. if there is an obstacle walk around it)
- Based on knowledge and experience (problem solving)

Reaction time

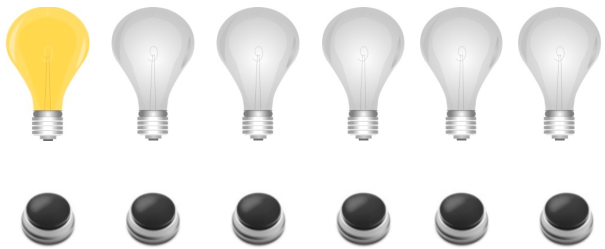


A lamp will be lit. Press on the associated button (in your head) as fast as possible

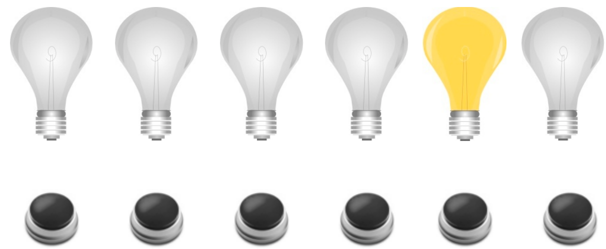
Reaction time



Reaction time



Reaction time



Hick-Hyman law

Describes the time it takes to make a simple decision given a number of choices

$$T = a+b \bullet log_2(n+1)$$

n : number of choices
a, b : constants

Humans divide the number of choices in categories: binary search

Attention

Capacity to focus on important things/objects
linked to visual and auditory perception

but ....
humans have limited cognitive resources

Attention

Attention resources

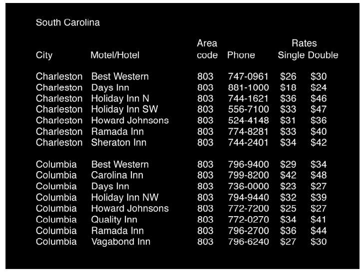
- divided attention: many stimuli, shallow level
- focused attention: few stimuli, deep level

practice reduces required attention

Attention

It is easier to pay attention to well structured information

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



South Carolina

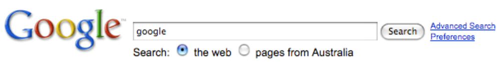
City	Motel/Hotel	Area code	Phone	Rates Single	Rates Double
Charleston	Best Western	803	747-0961	$26	$30
Charleston	Days Inn	803	881-1000	$18	$24
Charleston	Holiday Inn N	803	744-1621	$36	$46
Charleston	Holiday Inn SW	803	556-7100	$33	$47
Charleston	Howard Johnsons	803	524-4148	$31	$36
Charleston	Ramada 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

Attention

Make important information that needs attending salient (noticeable)

- colour, animation, underline, etc.
- but do not unnecessarily distract users

Structure information (ordering, spacing)
Avoid non-functional clutter



Memory and learning

Responsible for encoding, maintaining & retrieving information:

filtering (what)
context (when, where)

Memory and learning

To be shown for a few seconds. Try to memorize them.

http://faculty.washington.edu/chudler/puzmatch.html

Memory and learning

Write down as many as you can.

http://faculty.washington.edu/chudler/puzmatch.html

Memory and learning

Short term memory
- Working memory
- Small storage duration (10 – 30s)
- Small capacity: 7 ± 2 items (Miller, 56)
  - Later studies have shown that this range can be lower and depends on several factors, e.g., type & complexity of the item

Long term memory
- Infinite capacity
- Unlimited storage duration
- Associative access

Memory and learning

Learning and memorization by repetition
(short term ➔ long term)

Interferences degrade short term memory faster

Chunking (grouping)

Perception and memory elements are grouped in « chunks »

Try to memorize this number:

456789067

Chunking (grouping)

Perception and memory elements are grouped in « chunks »

Try to memorize this number:

456789067

… and then this one:

456-789-067

Chunking (grouping)

Perception and memory elements are grouped in « chunks »

Try to memorize this number:

456789067

… and then this one:

456-789-067

The 7± 2 rule for short term memory is applicable on the number of « chunks » rather than number of unique elements

The rule of 7 plus/minus 2

Some UI design guidelines suggest the the application of the rule to menus, toolbars, slides, etc.

Do you think that this is appropriate?

The rule of 7 plus/minus 2

Some UI design guidelines suggest the the application of the rule to menus, toolbars, slides, etc.

Do you think that this is appropriate?

Consider that such elements require us to recognize, not to recall! They have nothing to do with working memory.

Recall vs. Recognition

We are better at recognizing then remembering
- command line vs. GUI
- search box vs. list of options
- keyboard shortcut vs. actions in the menu

We are better at remembering images than words
- icons vs. items of a menu

Interferences: Stroop effect

Test 1

Identify the **color** of the following words in order, as fast as possible

Stroop effect

Book

Crayon

Car

Time

Mouse

Stroop effect

Test 2

Identify the **color** of the following words in order,
as fast as possible

Stroop effect

Black
Blue
Red
Green
Orange

Stroop effect

Interference between the main task (*identify the color*) and a cognitive process *(read a word)*

Affects reaction time and error rate

Some general guides

Avoid complex mappings (risk of interferences)
Support both recall and recognition
  but recognition is easier (e.g., menus, icons, lists)

Group/chunk related information
  e.g., tabs, sub-menus

Aid associative learning
  e.g., help, hints

Aid association by providing context
  e.g., colors, labeling, temporal metadata

Externalization of cognition

External representations and tools to support cognition

Externalizing to reduce cognitive load

- computational offloading
- annotating and cognitive tracing

Externalization of cognition

Externalization to reduce cognitive load (memory)

- agendas, calendars, notes, lists, …

External representations to remind us:

- that we need to do something (e.g., alarm)
- what to do (e.g., pay taxes)
- when to do them (e.g., the 15 of April)

Externalization of cognition

Computational offloading

- e.g., paper and pen, calculator, spreadsheet

Try to calculate 234 x 456 =?
(a) in your mind
(b) on paper
(c) with a calculator

Externalization of cognition

Annotation involves modifying existing representations through making marks to mark progression in tasks

- e.g., crossing off, ticking, underlining

Cognitive tracing involves externally manipulating items into different orders or structures that are easier to remember

- e.g., playing scrabble, playing cards, history

Motor system

Motor system

A movement is a series of micro-movements

Open-loop

The motor does an autonomous action without feedback

Cycle duration: $T_m \approx 70\text{ms}$

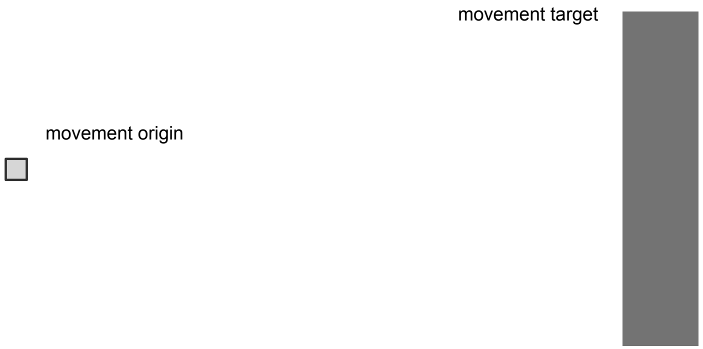
Closed-loop

Muscle movement is perceived and compared to desired result

$T_{total} = T_p + T_c + T_m \approx 240\text{ms}$

$T_p \approx 100\text{ms}$ (50-200 ms) $T_c \approx 70\text{ms}$ (30-100 ms) $T_m \approx 70\text{ms}$ (25-170 ms)

Movement time



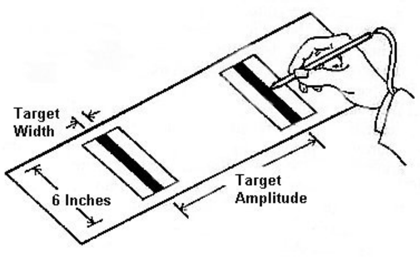
Task: Put your cursor on the origin and then point at the target as fast as possible. Try to avoid errors.

Fitts' law (1954)

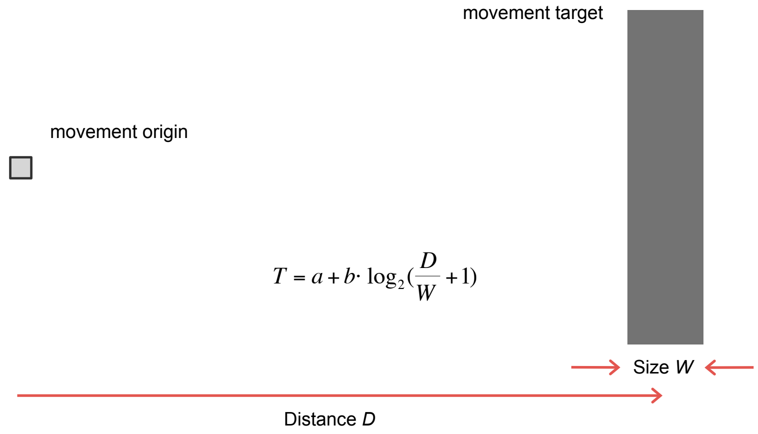
Describes the duration of movement as a function of the distance *D* and the target size *W*

$$T = a + b \cdot \log_2\left(\frac{D}{W} + 1\right)$$

a, b : constants, device-dependent

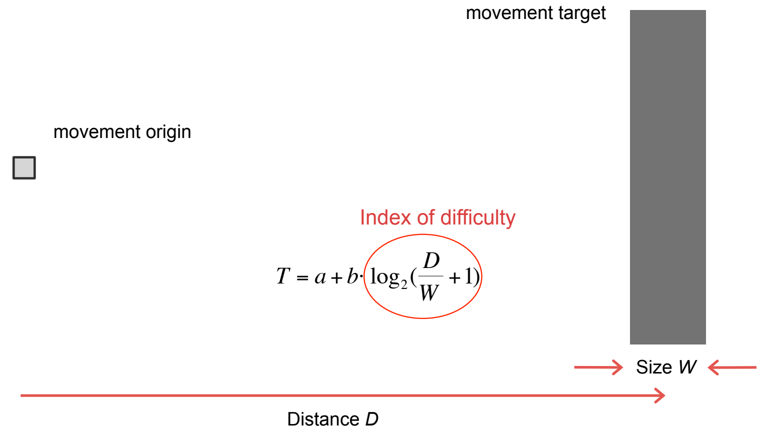


Fitts' law (1954)



$$T = a + b \cdot \log_2\left(\frac{D}{W} + 1\right)$$

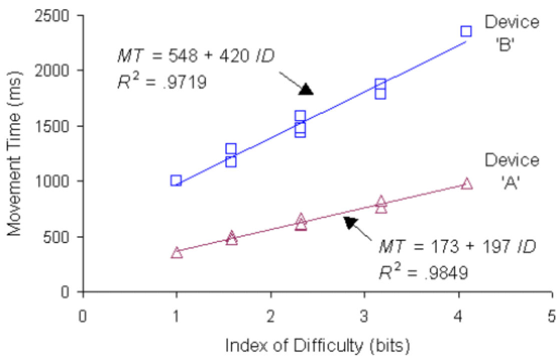
Fitts' law (1954)



$$T = a + b \cdot \log_2\left(\frac{D}{W} + 1\right)$$

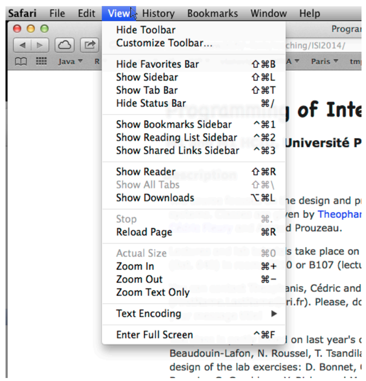
Fitts' law (1954)

Example of real data for two different input devices. The equation is a product of a linear regression on the means of user performance for a combination of D, W



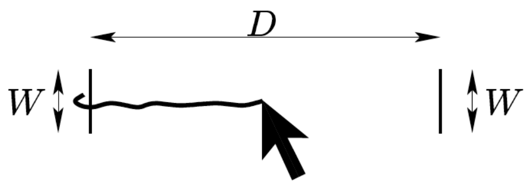
Mac OS vs Window Menu bars

Is the predicted time slower or faster to select a menu on Mac OS X?



Crossing rather than pointing?

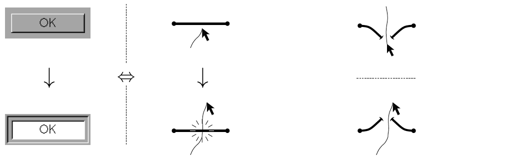
Again, Fitts' law equation is still valid (Accot & Zhai, 2002)



$$T = a + b \cdot \log_2\left(\frac{D}{W} + 1\right)$$

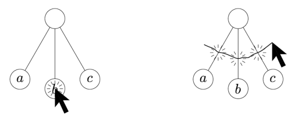
Crossing rather than pointing?

In certain situations, performance with crossing is superior (Accot & Zhai, 2002)



(a) To trigger an action: on the left we push the button; on the right we cross the goal.

(b) Unlike a traditional check box, a goal can "store" two visual states depending on the crossing direction.



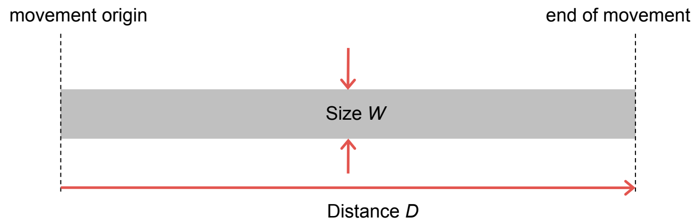
(a) Pointing at targets

(b) Crossing the arcs

Steering movements (Accot & Zhai, 97)

Task: Steer through the path with the cursor without exiting the path. Complete the task as fast as possible. Try to avoid errors.

Steering movements (Accot & Zhai, 97)

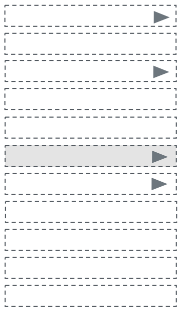


Steering law

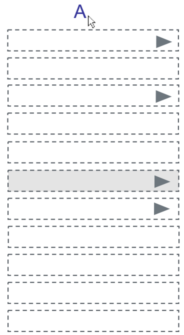
$$T = a + b\frac{D}{W}$$

α, *b* : constants

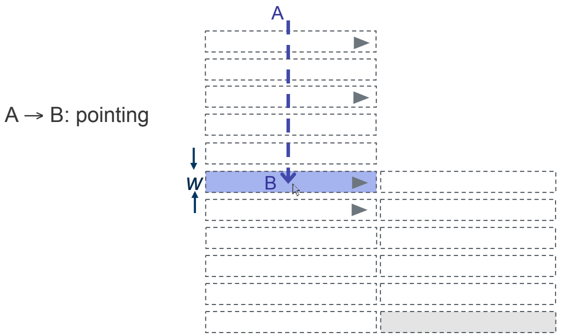
Movement and menus



Movement and menus



Movement and menus



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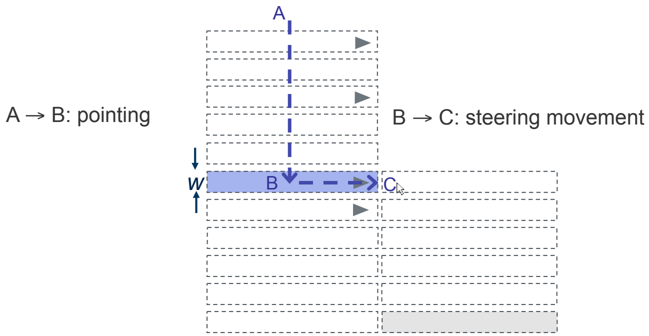
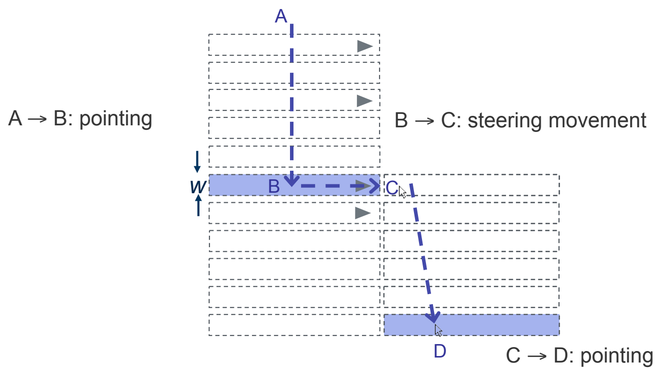
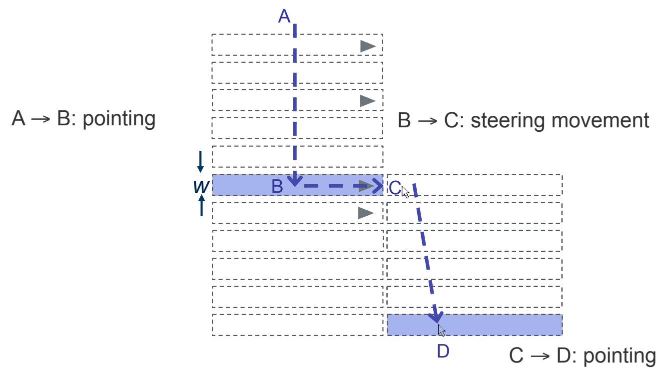


Movement and menus



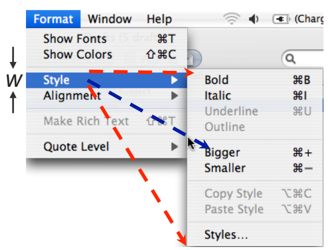
Movement and menus



$$T \approx a + b_1 \cdot \log_2\left(1 + \frac{|AB|}{W}\right) + b_2 \cdot \frac{|BC|}{W} + b_1 \cdot \log_2\left(1 + \frac{|CD|}{W}\right)$$

Menus in Mac OS X

The user can move the cursor towards the submenu, staying within a triangle and without exceeding a time threshold (~ 400 ms)



size of path >> *W*

Choice and visual search

and how long does it take to find the item in a menu?

Find Item 7 !

Choice and visual search

and how long does it take to find the item in a menu?

Item 1
Item 2
Item 3
Item 4
Item 5
Item 6
Item 7
Item 8
Item 9
Item 10
Item 11

Find Item 7 !

Choice and visual search

and how long does it take to find the item in a menu?

Item 9
Item 2
Item 3
Item 1
Item 8
Item 6
Item 11
Item 5
Item 7
Item 4
Item 10

Find Item 7 !

Choice and visual search

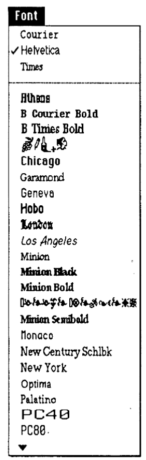
and how long does it take to find the item in a menu?

A. If the items are ordered (e.g., alphabetically), the choice time is approximated by Hick's law (logarithmic)
→ *expert use*

B. If the items are randomly ordered and the user does not know their position, they need to search for the target in a linear way (rather than logarithmic)
→ *novice use*

Frequency-based menus

Alphabetical menu



Split menu

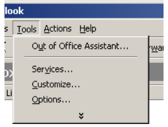
(Sears & Shneiderman, 1994)

Most frequent items. Sears & Shneiderman recommend up to four items in this area.

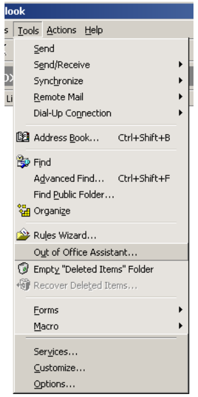
They showed that split menus can improve user performance when some items are more frequent than others.

Frequency-based menus

Adaptive pull-down menus in MS Office 2000. They were abandoned in more recent versions. What do you think went wrong?



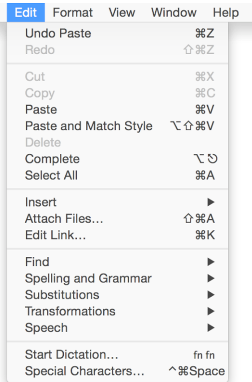
Short version



Expanded version

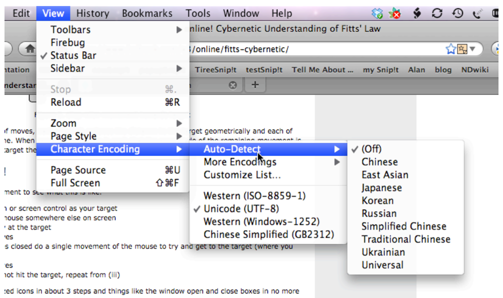
Semantic grouping

Menus are usually organized into groups of semantically related items.



Breadth vs. depth

Broader, shallower menu trees yield faster search than narrower, deeper ones (Landauer & Nachbar, 1985). In practice, more than two levels are rarely used.



Designing menus

Optimize for what?
- Visual search? (e.g., mostly novice use)
- Motor performance? (e.g., mostly expert use)
- Spatial stability?
- Consistency among applications?

MenuOptimizer (Bailly et al., 2013)
http://www.youtube.com/watch?v=OeLpOerrJ4M&feature=youtu.be