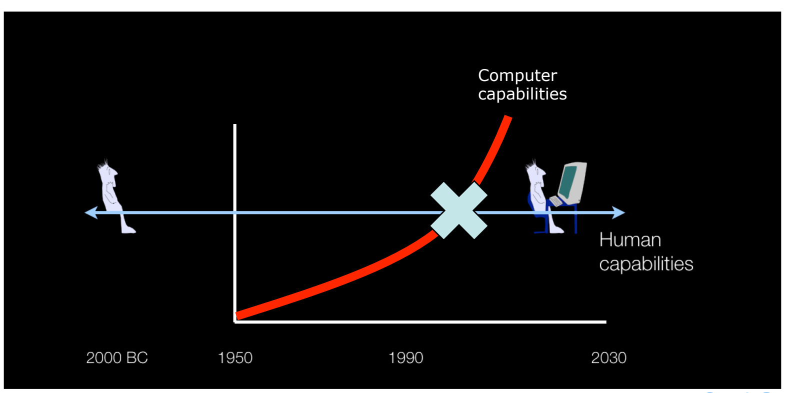
Week3.a
Psychology: (Perception, Cognition) & Motor control

Anastasia.Bezerianos@lri.fr

human capabilities

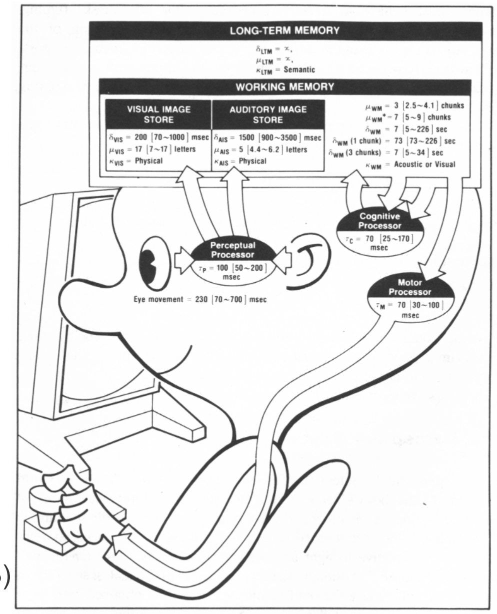
Moore's law
Human capabilities



Saul Greenberg

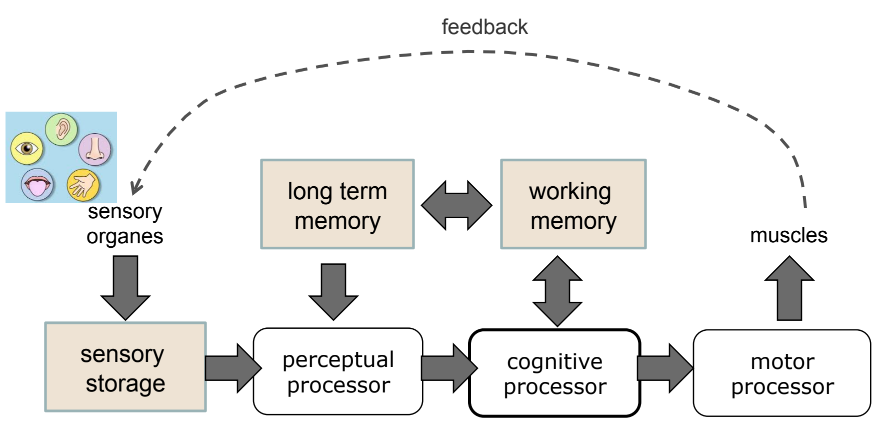
human processor

Modeling humans as an information processing system

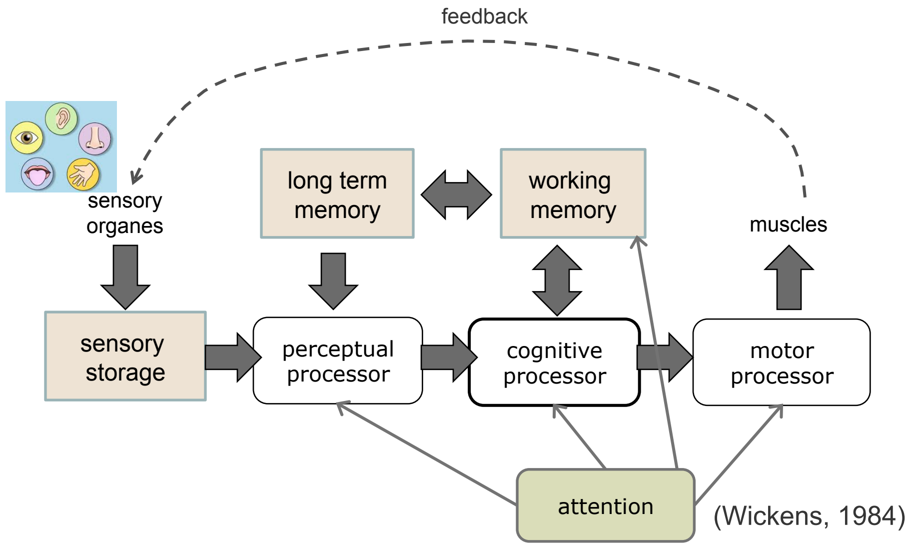


(Card, Moran & Newell 1983)

human processor



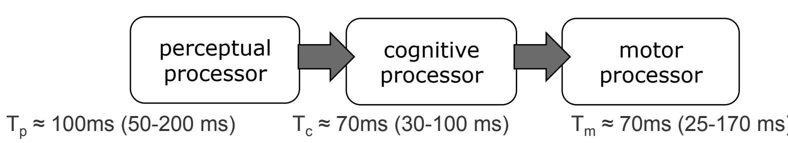
human processor



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 (ex. intensity of the stimulus, noise, alcohol,…)
- The fastest speed can be 10 times faster than the slowest



perception

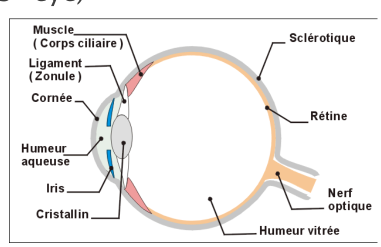
sensory organs: eye

Perception of color, movement, depth

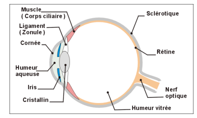
Visual field 180° (x 160°)

Focus of attention
- Visual acuity : 0,04mm to 50cm (13° eye)
- Fovea centralis (very high resolution) (3° eye)

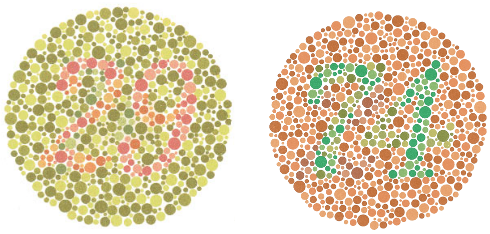
Peripheral Perception
- Less sensitive to colors
- More sensitive to movements



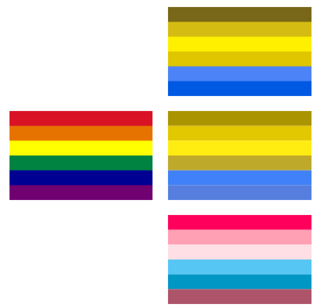
visual perception



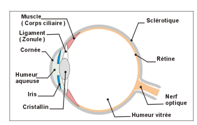
- red-green color blindness (daltonism) is very common (8% of adult males)
  - Don’t use only color to highlight differences, or use choose colors that are difficult to confuse



[Ishihara Test for Colour Blindness]



visual perception

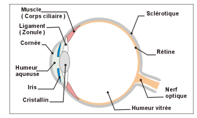


- Colors of different wavelengths are hard to tell apart
  - Don’t use red text on blue background

- With age, blue becomes harder to read

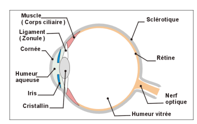
- Change Blindness (Cécité au changement)
  - Difficult to see visual changes when our vision is interrupted
  - Avoid abrupt changes in the interface (show animations, highlight changes)

visual perception



http://www.usd.edu/psyc301/ChangeBlindness.htm

visual perception



http://www.usd.edu/psyc301/ChangeBlindness.htm

Gestaltism (psych. of the forme)

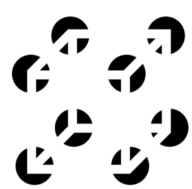
A theory claiming that the perception processing and the mental/cognitive representation of information, process spontaneously (« pre-attentively ») the surrounding phenomena as groups of structures (forms), and not as several discrete elements

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

Gestalt laws of perception

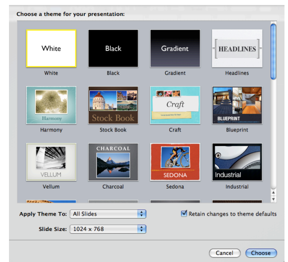
Continuity
Proximity
Similarity
Symmetry
Closure
Common fate
Past experience
Figure-ground

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



Continuity

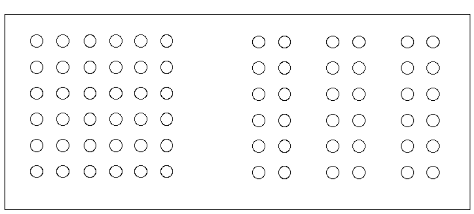
We tend to perceive elements grouped together, and integrated into perceptual « wholes » if they are aligned

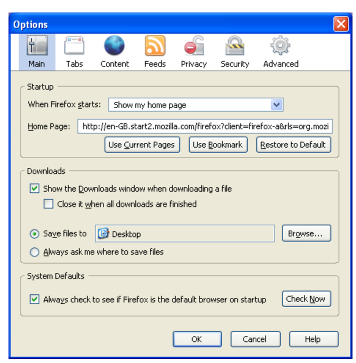


eg. different style options in a UI presented one after the other

Proximity

We group objects first by their proximity between them

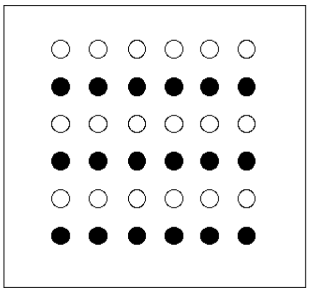


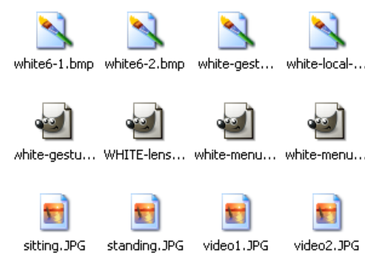


eg. functions in a dialogue box

Similarity

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



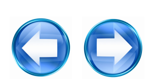


eg. similar file icons to visually organize and remember their applications (shape, size, color)

Symmetry

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

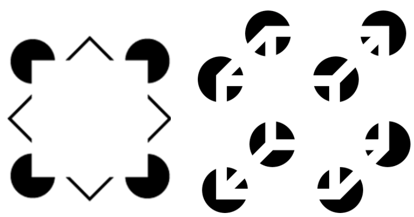
{ } [ ] ( )

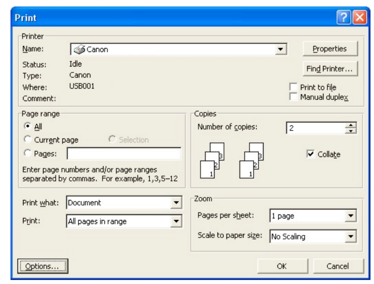


eg. symmetrical actions in the UI have symmetrical icons and are seen as a group

Closure

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

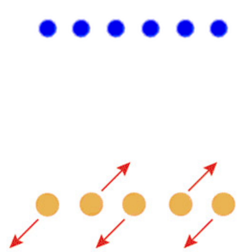


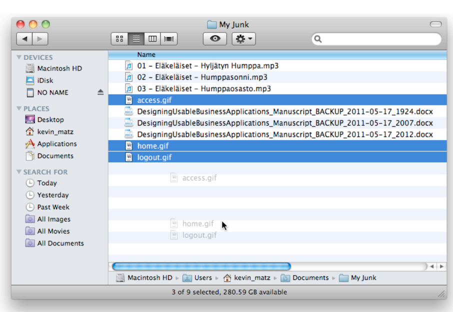


eg. we can group by explicit or implicit borders items in a UI

Common fate

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





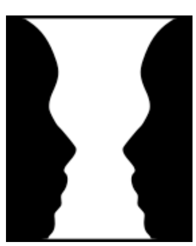
eg. if you select and drag some icons, shadows of these items all move at the same direction and speed

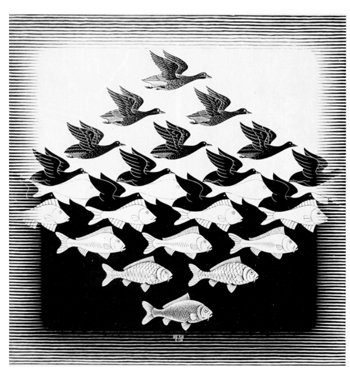
Past experience

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

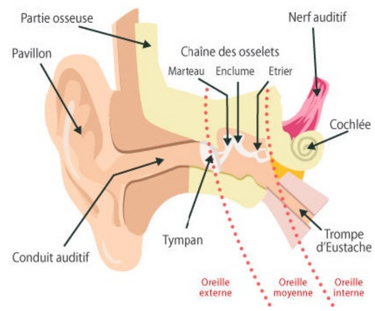
figure - ground

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





sensory organs: ear



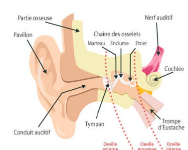
Frequencies : 20 Hz to 20KHz

Selective focus and perception
- Effect of « cocktail party »

Masking Effects
- We hear one sound source but not another
- Many factors affect it: frequency interval, intensity, distance

Localization of a source
- Correlation with visual localization

auditory perception



Listening needs less effort than reading
Reading is faster than listening
Written language is more permanent than audio
- audio menus should be brief

Individual differences and limitations
- individual preferences and capabilities
- (reading) difficult for dyslexics
- (listening) easy to forget
  - ➢ multimodal interfaces

touch perception

Tactile sense: receptor types
- temperature (hot, cold), hardness, pressure, touch.

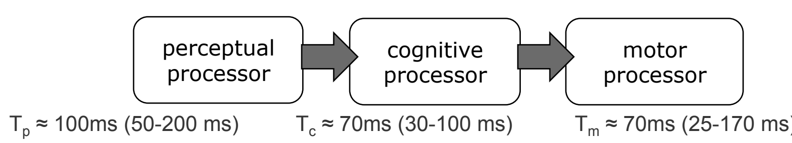
Sense that is also proprioceptive (vs. exteroceptive)
- Configuration of our own body in the space,
- feeling as objects/tools are extensions of our own body

Kinesthesia
- Perception of the effort of muscles, and so of resistance/weight of object

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 (ex. intensity of the stimulus, noise, alcohol,…)
- The fastest speed can be 10 times faster than the slowest



perceptual fusion

Two stimuli in the same cycle ($T_p \approx 100$ms) are combined

eg. two successive images that appear in the same cycle can be perceived as one event: animation.
a sound and a movement at the same time may be understood as the same event

perception

Guides:

- Visual presentation changes perception
- Pay attention to color choices
- Avoid abrupt changes
- Use borders, proximity, etc to group information
- Have brief audio instructions and menus

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)

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

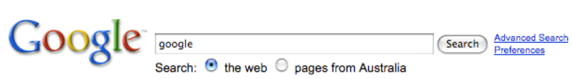
City	Motel/Hotel	Area code	Phone	Rates Single	Double
Charleston	Best Western	803	747-0961	$26	$30
Charleston	Days Inn	803	881-1000	$18	$24
Charleston	Holiday Inn N	803	744-1621	$36	$46
Charleston	Holiday Inn SW	803	556-7100	$33	$47
Charleston	Howard Johnsons	803	524-4148	$31	$36
Charleston	Ramada Inn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

Guides:

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

here are some objects,

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

memory and learning

here are some objects, which ones?

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

memory and learning

Short term memory

Working memory
Small capacity : 7 ± 2 items
Small storage duration (10 – 30s)

Long term memory

Infinite capacity
Unlimited storage duration
Associative access

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

7 groups

what some designers do:

7 options in a menu
7 bullets in slides
7 icons in toolbars
7 items in a tab

… is it recall or recognition?

Recall and Recognition

We are better at recognizing then remembering
e.g. 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
e.g. 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

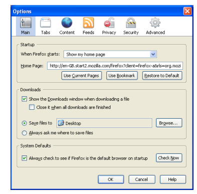
memory and learning

Guides:

Avoid complex procedures (risk of interferences)

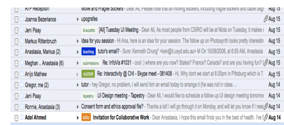
Recall and recognition (support both)

- but recognition is preferred
  - e.g. menus, icons, lists of selections
- consistent placement
  - e.g. buttons « OK » / « Cancel »



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)
e.g. 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

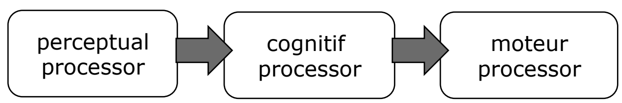
Open-loop

The motor does an autonomous action without feedback
Cycle duration: $T_m \approx 70ms$

Closed-loop

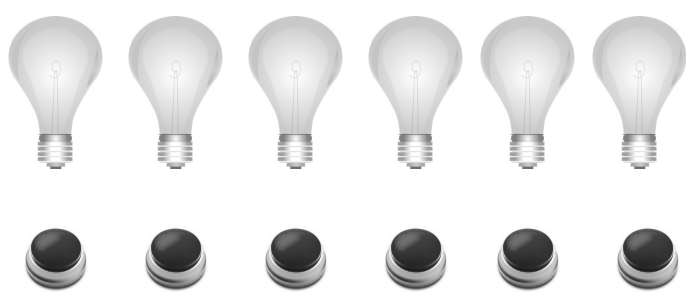
Muscle movement is perceived and compared to desired result

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



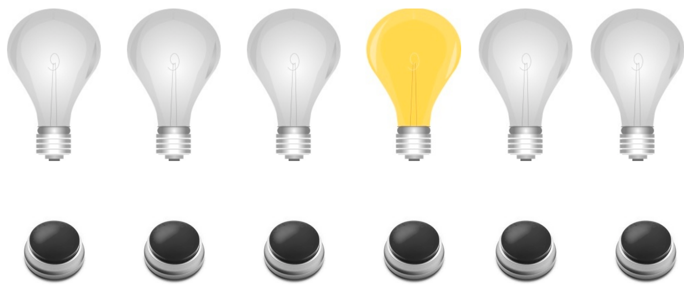
$T_p \approx 100ms$ (50-200 ms) $T_c \approx 70ms$ (30-100 ms) $T_m \approx 70ms$ (25-170 ms)

reaction time

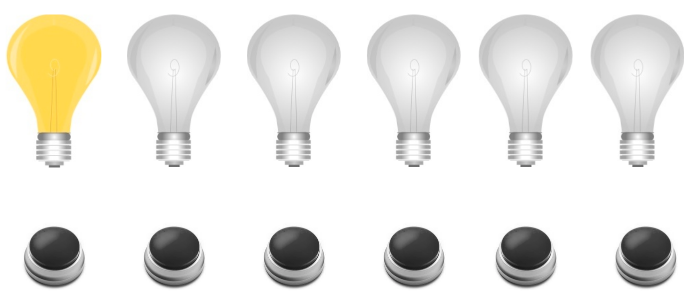


A lamp will be lit. Press on the associated button (in your mind) as fast as possible

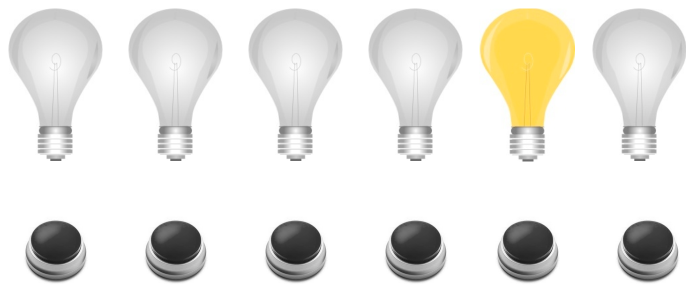
reaction time



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

movement time

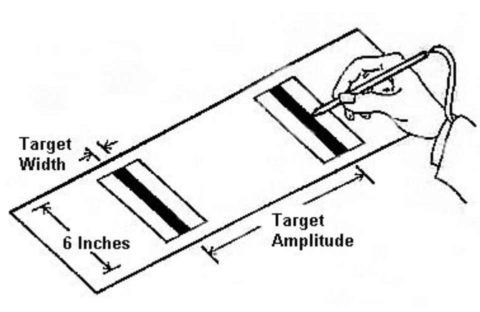
Task: Put your cursor on the origin and then point at the target as fast as possible. Try to minimize errors.

Fitts law

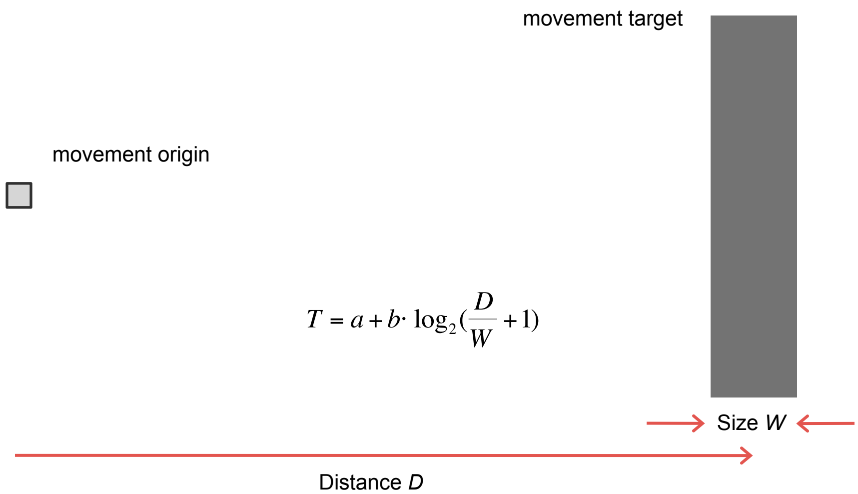
Describes the duration of movement as a function of the distance *D* and the target size *W*

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

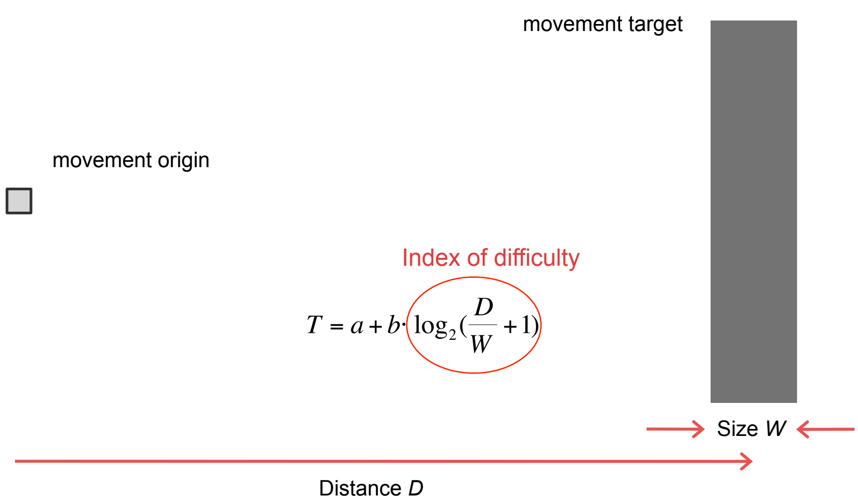
α, b : constants



Fitts law

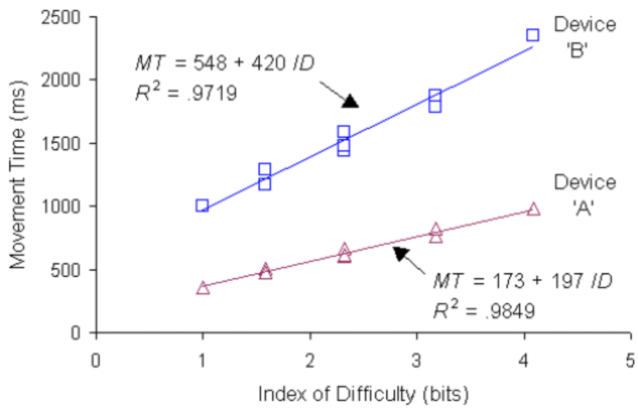


Fitts law



Fitts law

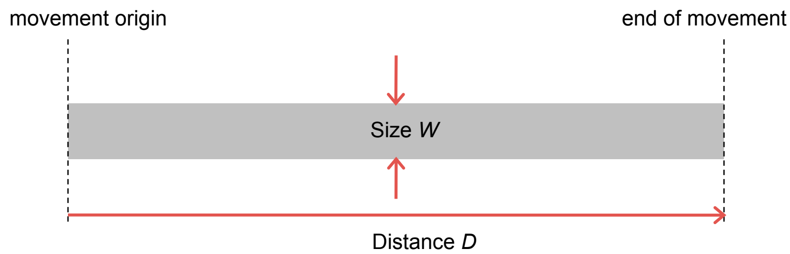
Example of real data for two different input devices. The equation is a product of a linear regression on the means of user performance for a combination of D, W



steering movements

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

steering movements

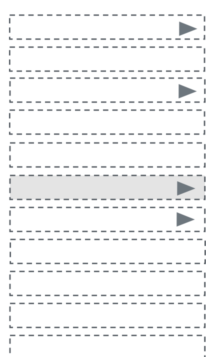


Steering law

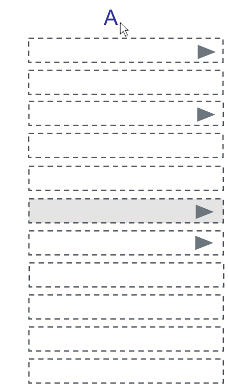
$$T = a + b\frac{D}{W}$$

a, b : constants

movement and menus

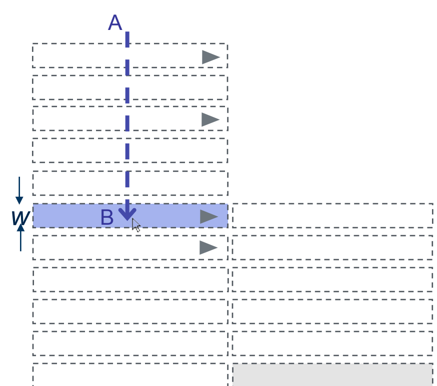


movement and menus

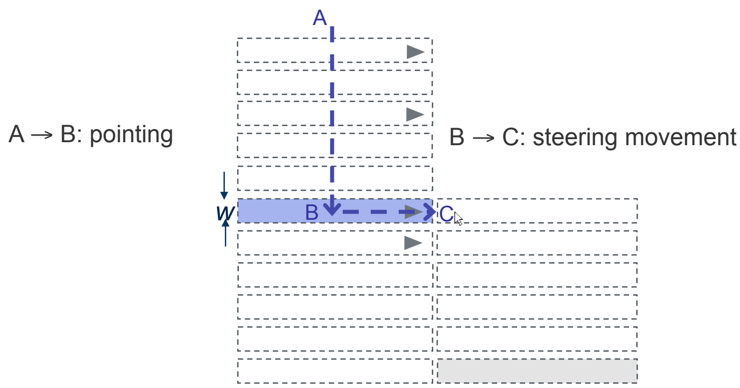


movement and menus

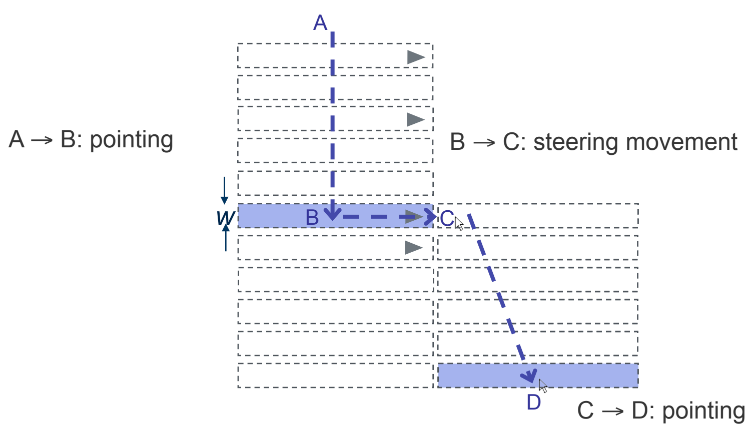
A → B: pointing



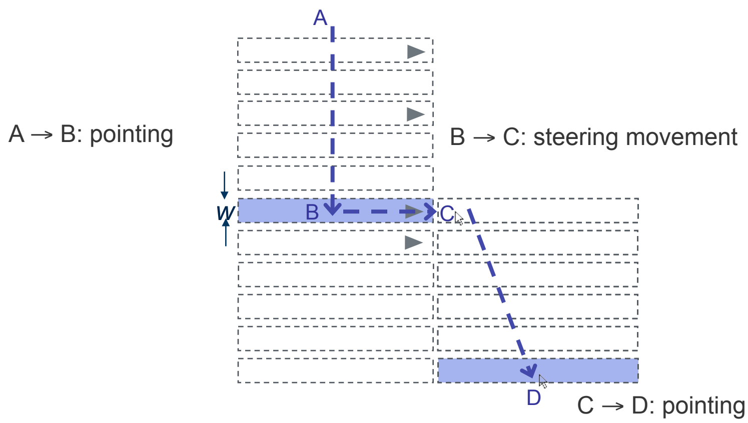
movement and menus



movement and menus

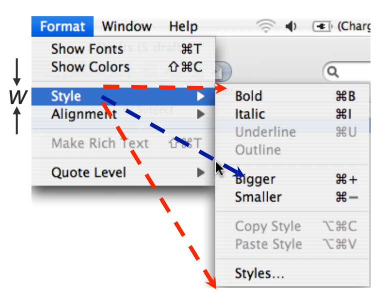


movement and menus



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

menus in Mac OS X



size of path >> *w*

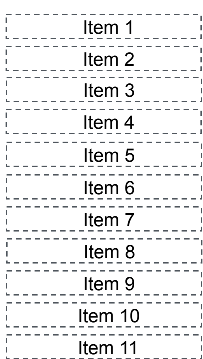
choice and visual search

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?



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 !

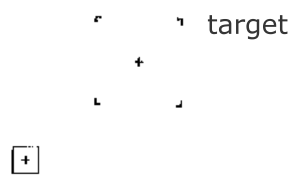
choice and visual search

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

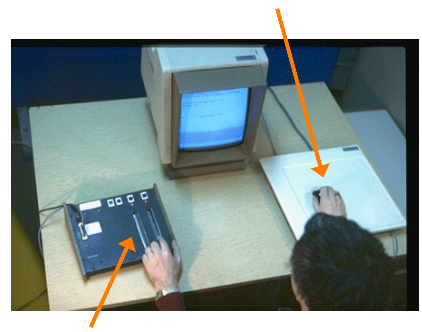
1. If the items are ordered (eg. alphabetically), the choice time is approximated by Hick's law (logarithmic)
   → *expert use*

2. 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*

bi-manual interaction



the cursor needs to be positioned on the target and clicked



Result: Parallel movements for up to 40.9% of time

(Buxton & Myers, 1986)

bi-manual interaction

A second experiment showed that bi-manual interaction is faster than uni-manual for a navigation and selection task

(Buxton & Myers, 1986)

kinematic chain model (Guiard, 1987)

The kinematic chain is a sequence of abstract motors

- e.g. shoulder -> elbow -> wrist -> finger

For each link in the sequence (e.g. wrist -> finger) the 2nd element (finger) defines its movement with respect to the movement of the 1st element (wrist)

kinematic chain model (Guiard, 1987)

The kinematic chain is a sequence of abstract motors

- e.g. shoulder -> elbow -> wrist -> finger

For each link in the sequence (e.g. wrist -> finger) the 2nd element (finger) defines its movement with respect to the movement of the 1st element (wrist)

➔ Hypothesis: bi-manual movement acts as a kinematic chain

non-dominante hand -> dominante hand

kinematic chain model (Guiard, 1987)

Principles :

1. The dominant hand moves in the reference frame established by the non-dominant hand
2. Asymmetry in the chain of actions. Movements of the dominant hand more precise
3. The non-dominant hand precedes the dominant hand. (eg. left hand positions a paper and the right hand starts writing)

verification of the model

Manipulation of physical objects (Hinckley, 1997)

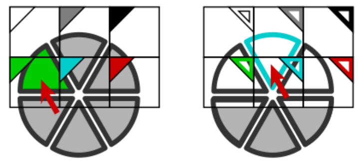
- Asymmetry between the two hands for difficult tasks
- … but the asymmetry disappears when tasks become easier

Other work has studied different aspects of the model

- Visual feedback and separation of input space (Balakrishanan & Hinckley, 1999)
- Symmetrical tasks (Balakrishanan & Hinckley, 2000)

toolglasses

Pallets of filters overlaid on objects of interest



Bi-manual interaction

- left hand positions the filters (toolglasses)
- right hand selects the filter on the object

bi-manual and tangible interaction