Week 4

The psychology of the user interface

Why UIs are like they are?

Human processor

sensory

organes

sensory

storage

long term

memory

perceptual

processor

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

feedback

working

memory

cognitive

processor

muscles

motor

processor



Human processor

Modeling humans as an information processing system



(Card, Moran & Newell 1983)

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

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



Visual perception

Visual perception

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

Text

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



Continuity

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



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

Proximity

We group objects first by their proximity between them

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000000	0 0	00	00
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000000	0 0	00	00



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





sitting.JPG standing.JPG video1.JPG video2.JPG

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

{ }[]()

 $\mathbf{O}\mathbf{O}$

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)



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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





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



Cognition

Reaction time



Reaction time



Hick-Hyman law

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

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

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

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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.



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 \rightarrow long term)

Interferences degrade short term memory faster



Chunking (grouping)

Perception and memory elements are grouped in \ll chunks \gg

Try to memorize this number:

456789067

Chunking (grouping)

Perception and memory elements are grouped in \ll chunks \gg

Try to memorize this number:

456789067

... and then this one:

456-789-067

Chunking (grouping)

Perception and memory elements are grouped in \ll chunks \gg

Try to memorize this number:

456789067

... and then this one:

456-789-067

The 7 \pm 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

Stroop effect

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

	Book
Test 1	Crayon
	Car
Identify the color of the following words in order,	Time
as fast as possible	Mouse

Stroop effect

Stroop effect

	Black
Test 2	Blue
	Red
Identify the color of the following words in order,	Green
as fast as possible	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: $T_m \approx 70 ms$

Closed-loop

Muscle movement is perceived and compared to desired result

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



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

Fitts' law (1954) movement target $T = a + b \cdot \log_2(\frac{D}{W} + 1)$ Size W Distance D

Fitts' law (1954)



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?

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Crossing rather than pointing?

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



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

Crossing rather than pointing?

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





(a) To trigger an action: on box, a goal can "store" two visual the left we push the button; on the right we cross the

states depending on the crossing direction.



(a) Pointing at targets

goal.

(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



Movement and menus



Movement and menus



Movement and menus



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)



Choice and visual search

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

Find Item 7 !

size of path >> W

Choice and visual search

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

lte	em 1
lte	em 2
lte	em 3
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lte	em 7
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lte	m 11

Find Item 7!

Choice and visual search

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

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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)

 \rightarrow 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)

 \rightarrow novice use

Frequency-based menus

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Minion Semibold	Minion Bold
Nonaco	Diotaloyta Dotasia chai
New Century Schlbk	Minion Semibold
New York	Monaco
Optima	New Century Schlbk
Palatino	New York
PC40	Optima
PC80	Palatino
San Franctico	PC40
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(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.

Alphabetical menu

Split menu

Frequency-based menus

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

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Short version

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Expanded version

Semantic grouping

Menus are usually organized into groups of semantically related items.

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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.

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es tot hit the target, repeat from (iii)			Universal

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