# Human-Computer Interaction

## Course Notes

Version of 27 May 2025

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https://courses.isds.tugraz.at/hci/hci.pdf

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# Preface

I first started teaching human-computer interaction at Graz University of Technology in 1993. These lecture notes have evolved since then, and have benefitted from my teaching courses on User Interface Design at FH Technikum Kärnten in Villach, Web Usability and Advanced User Interfaces at FH Joanneum in Graz, Human-Computer Interaction at FH Oberösterreich in Hagenberg, and numerous intensive courses at conferences and for industry.

I would like to thank my many tutors for their many helpful ideas and comments over the years. I would also like to thank all my students past and present for their many suggestions and corrections which have helped to massage these notes into their current form.

Thanks and happy reading,

Keith Andrews

Graz, Austria, 27 May 2025

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# Chapter 1

# Human-Computer Interaction

> *" Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them. "*
>
> [ ACM SIGCHI Curricula for Human-Computer Interaction [Hewett et al. 1992, page 5]. ]

### References

++ Sharp, Preece, and Rogers; *Interaction Design*; 6th Edition, Wiley, 04 Apr 2023. ISBN 111990109X (com, uk) [Rogers et al. 2023]

++ Nick de Voil; *User Experience Foundations*; BCS, 13 Jul 2020. ISBN 1780173490 (com, uk) [de Voil 2020]

\+ Ben Shneiderman and Catherine Plaisant; *Designing the User Interface*; 6th Edition, Pearson, 20 Apr 2016. ISBN 013438038X (com, uk) [Shneiderman et al. 2017]

++ Steve Krug; *Rocket Surgery Made Easy*; New Riders, 2009. ISBN 0321657292 (com, uk) [Krug 2009]

++ Steve Krug; *Don't Make Me Think!: A Common Sense Approach to Web Usability*; 3rd Edition, New Riders, 2013. ISBN 0321965515 (com, uk) [Krug 2013]

++ Alan Cooper, et al; *About Face: The Essentials of Interaction Design*; 4th Edition, Wiley, 02 Sep 2014. ISBN 1118766571 (com, uk) [Cooper et al. 2014]

\+ Alan Cooper; *The Inmates are Running the Asylum*; Sams, 1999. ISBN 0672316498 (com, uk) [Cooper 1999]

\+ Jeff Johnson; *Designing with the Mind in Mind*; 3rd Edition, Morgan Kaufmann, 06 Oct 2020 ISBN 0128182024 (com, uk) [J. Johnson 2020]

◦ Gavriel Salvendy and Waldemar Karwowski (Eds.); *Handbook of Human Factors and Ergonomics*; 5th Edition, Wiley, 13 Aug 2021, 1,600 pages. ISBN 1119636086 (com, uk) [Salvendy and Karwowski 2021]

◦ Julie Jacko (Ed.); *The Human-Computer Interaction Handbook*; 3rd Edition, CRC Press, 04 May 2012, 1,518 pages. ISBN 1439829438 (com, uk) [Jacko 2012]

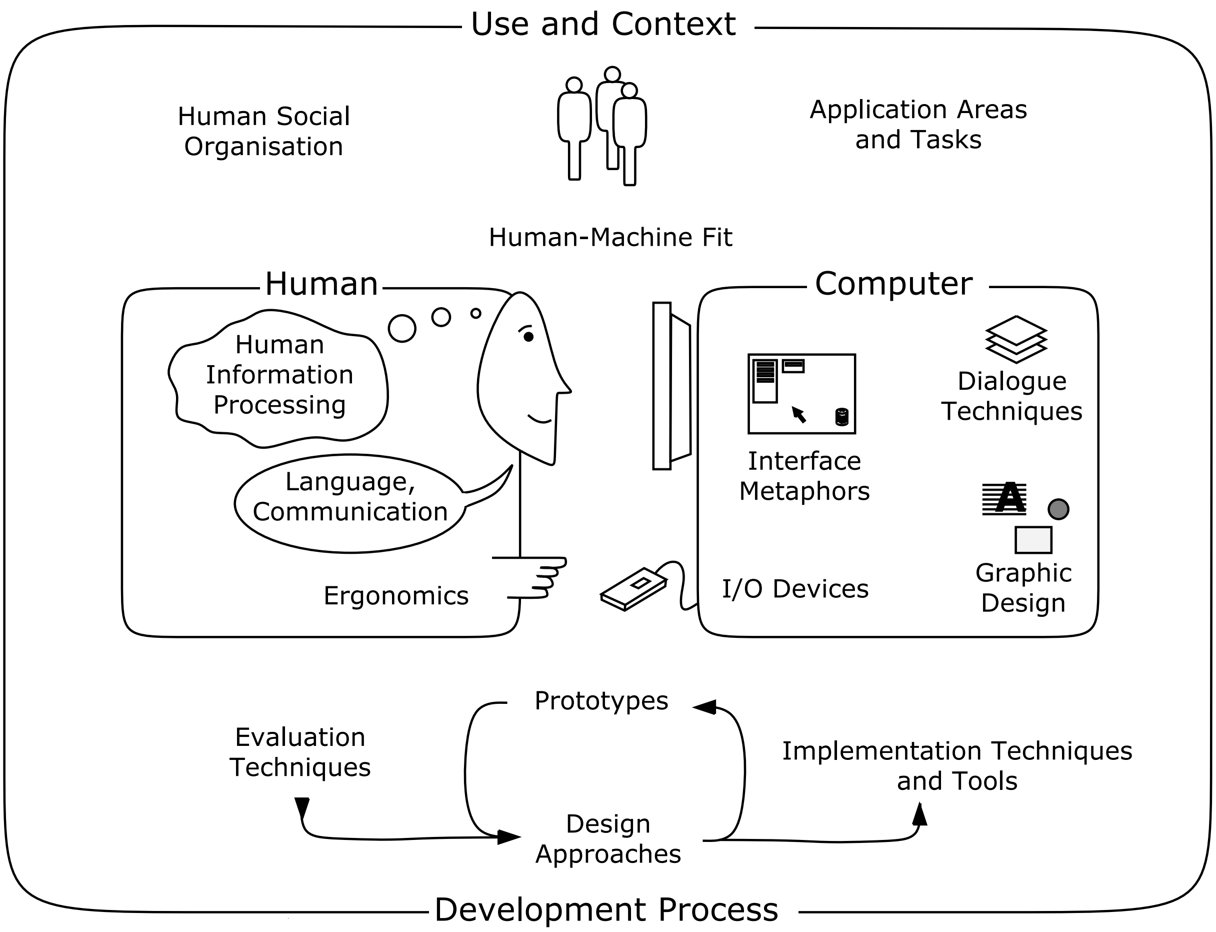


**Figure 1.1:** The nature of Human-Computer Interaction. Adapted from Figure 1 of the ACM SIGCHI Curricula for Human-Computer Interaction [Hewett et al. 1992].

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- Baecker et al; *Human-Computer Interaction: Toward the Year 2000*; Morgan Kaufmann, 1995. ISBN 1558602461 (com, uk) [Baecker et al. 1995]
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#### Standards

++ Nigel Bevan et al; *New ISO Standards for Usability, Usability Reports and Usability Measures*; HCI International 2016. [Bevan et al. 2016]

++ David Travis; *Bluffers' Guide to ISO 9241*; Userfocus, 01 Oct 2014 . [Travis 2014]

+ ISO 9241; *Ergonomics of Human-System Interaction*; revised new family of standards. `iso.org`
+ Wikipedia; *ISO 9241*; [Wikipedia 2020a]
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+ David Travis; *New Standards in Usability*; Userfocus, 13 Jan 2009. [Travis 2009]

#### Online Resources

◦ Wikipedia; *Human-Computer Interaction*; `https://wikipedia.org/wiki/Human-computer_interaction`

+ Interaction Design Foundation; `interaction-design.org`

◦ UXmatters; `uxmatters.com`

◦ Usability.gov; `usability.gov`

◦ HCI Bibliography; `hcibib.org`

++ ACM Digital Library; `dl.acm.org`
[Free access from IP addresses within TU Graz]

++ IEEE Computer Society Digital Library;
[Free access from IP addresses within TU Graz through IEEE Explore `ieeexplore.ieee.org`]

#### Journals

- *interactions*; ACM; ISSN 1072-5520; `interactions.acm.org`
- *Transactions on Computer-Human Interaction (TOCHI)*; ACM; ISSN 1073-0516; `tochi.acm.org`
- *International Journal of Human-Computer Interaction (IJHCI)*; Taylor & Francis; ISSN 1044-7318; `https://tandfonline.com/toc/hihc20/current`

- *International Journal of Human-Computer Studies (IJHCS)*; Elsevier; ISSN 1071-5819; https://sciencedirect.com/science/journal/10715819
- *Behaviour & Information Technology (BIT)*; Taylor & Francis; ISSN 0144-929X; https://tandfonline.com/toc/tbit20/current
- *Journal of Usability Studies (JUS)*; User Experience Professionals Association; ISSN 1931-3357; uxpajournal.org
- *User Experience Magazine*; User Experience Professionals Association; uxpamagazine.org

#### Conferences

- Conferences sponsored by or in cooperation with ACM SIGCHI https://sigchi.org/conferences/
- UIUX Trend; *Top UX Events & UX Conferences* https://uiuxtrend.com/events/
- CHI; Annual SIGCHI Conference: *Human Factors in Computing Systems*; chi2025.acm.org
- AVI; *Advanced Visual Interfaces*; avi2024.dibris.unige.it
- UIST; *User Interface Software and Technology*; uist.acm.org
- UXPA; *User Experience Professionals Association*; uxpa2025.org
- HCII; *Human-Computer Interaction International* 2025.hci.international
- World Usability Congress; Every Oct in Graz. worldusabilitycongress.com

### Professional Organisations

+ ACM SIGCHI; sigchi.org
+ User Experience Professionals Association; uxpa.org
+ Interaction Design Association; ixda.org
+ Human Factors and Ergonomics Society; hfes.org

### Local Communities

++ UX Graz; https://meetup.com/uxgraz/, https://x.com/uxgraz/, uxgraz.at,

+ UX Vienna; uxvienna.at
+ UX Linz; https://meetup.com/UX-Linz/
+ UXPA Austria; uxpa-austria.org
+ UXpro Austria; uxpro.at

#### Professional Usability Qualifications

- UXQB; *Certified Professional for Usability and User Experience (CPUX)*; https://uxqb.org/en/certification/

- UXQCC; *Certified Professional for Usability Engineering and User Experience Design*; https://uxqcc.com/personal-certifications/
- NN/g; *UX Certification* https://nngroup.com/ux-certification/

### Video: Saving Lives by Design

- Harold Thimbleby; *Saving Lives by Design*; Swansea University, 2011. [Thimbleby 2011] [Video: https://youtu.be/3LiGsPR34w8]

# Chapter 2

# The Psychology of Usable Things

*“ When simple things need pictures, labels, or instructions, the design has failed. ”*

[ Don Norman, The Psychology of Everyday Things, 1988 [Norman 1988, page 9] ]

This chapter is based around Don Norman’s classic book, The Psychology of Everyday Things [Norman 1988].

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- Jaye Hannah; *10 Classic UX Design Fails That Teach Us How Not To Do UX*; Career Foundry, 09 May 2023 `https://careerfoundry.com/en/blog/ux-design/10-classic-ux-design-fails/`
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- Computer Stupidities; `http://rinkworks.com/stupid/` [Last updated 2013.]
- Teo Siang; Bad Design vs. Good Design: 5 Examples We can Learn From; 31 Oct 2021 `https://interaction-design.org/literature/article/bad-design-vs-good-design-5-examples-we-can-learn-frombad-design-vs-good-design-5-examples-we-can-learn-from-130706`
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- Wikipedia; *Natural Mapping*; `https://wikipedia.org/wiki/Natural_mapping`

## 2.1 The Psychopathology of Everyday Things

Examples of where the design of everyday things went wrong.

### Opening a Milk Carton

- Classic example from Austrian TV [ORF 1989]. [Video: `https://youtu.be/2-p8YpR7rJc`]
- Glass bottles were being replaced by new cartons.


**Figure 2.1:** The most basic functionality of a video recorder, playing a tape, is easy to use. However, anything more advanced, such as programming a recording, can become rather difficult.

- On live TV, a manager demonstrates how easy it is to open the new cartons. . .
- . . . but everything goes rather wrong!
- The original was broadcast live on the program "wir", but was later rebroadcast in the outtake show "Hoppala" (hence the laughter over the original soundtrack).

### Early Tractors

- Early tractors had a high centre of gravity and narrow wheel base.
- On rough, hilly surface → disaster!
- Used to be called "driver error".
- More probably "design error", since tractors today are designed with a low centre of gravity and wide wheel base.

### The Frustrations of Everyday Life

Can you use all the functions of your:

- digital watch?
- mobile phone?
- washing machine?
- video recorder?

### Zeiss Slide Projector

- Only one button to control the slide advance, see Figure 2.3.
- During lectures, sometimes the slides go forwards, sometimes they go backwards . . .


**Figure 2.2:** Some of the buttons on a VCR remote control are easy to understand, but others are unfathomable without the instruction manual.

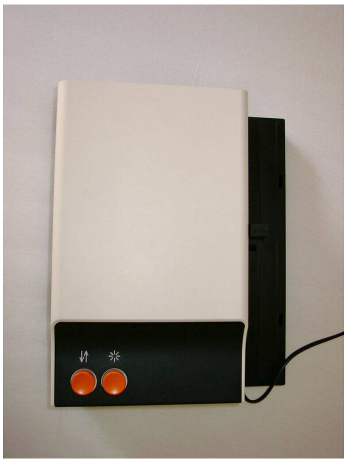

**Figure 2.3:** The Zeiss Ikon Perkeo 511 slide projector. A short press advances to the next slide, a long press moves back one slide, but how should first-time users know this? [Thanks to Horst Ortmann for providing the photograph.]

- If you can find an instruction manual:
  Short press = forward, long press = backward.
- What an elegant design, two functions with just one button!
- But how should first-time users know what to do?

### The Louis-Laird Amphitheatre in the Sorbonne

- Magnificent murals on the ceiling.
  - But only the right way up for the lecturer.
- Electric projection screen.
  - Has to be lowered from a back room up a short flight of stairs, out of sight.

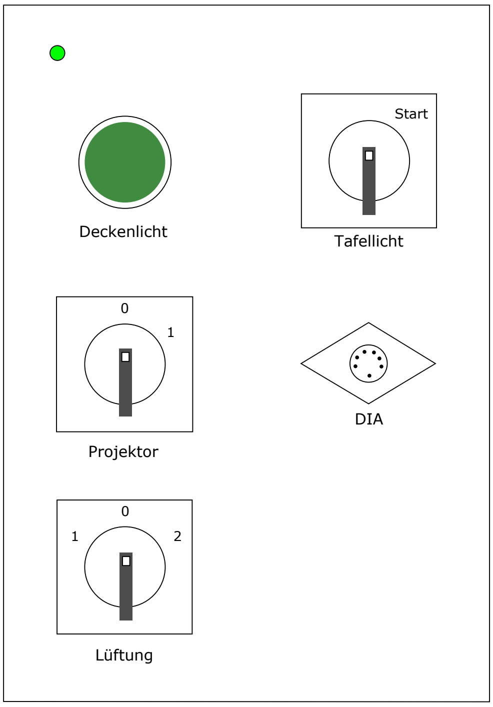


**Figure 2.4:** The control panel for the lecturer in the old lecture theatre HS EDV of Graz University of Technology.

### Could Someone Please Turn the Lights Down

- Figure 2.4 shows the control panel for the lecturer at the front of the old lecture theatre HS EDV.
- I often had to assist guest speakers in turning the lights down (but not completely off).
- The problem is that four (!) separate controls are mapped to the single green button (Deckenlicht):
  - Depressing and releasing the green button either turns the lights completely on or completely off, depending on whether they are currently on or off.
  - Holding the green button down either dims or increases lighting, depending on whether it was last dimmed or increased.
- The air conditioning control (Lüftung) is also problematic: 0 is off, 1 is on, and 2 is off (!).

### Clunky Connector

- The audiovisual control trolley (see Figure 2.5) at the front of lecture theatre HS EDV also caused me a major problem.
- Intending to hook up my laptop to the ceiling mounted projector, I unwittingly unscrewed the monitor cable connector from the outside of the trolley.
- This resulted in a dull clunking sound from inside the trolley.
- Unfortunately, the internal connector had only been secured by virtue of its being attached to the external connector!

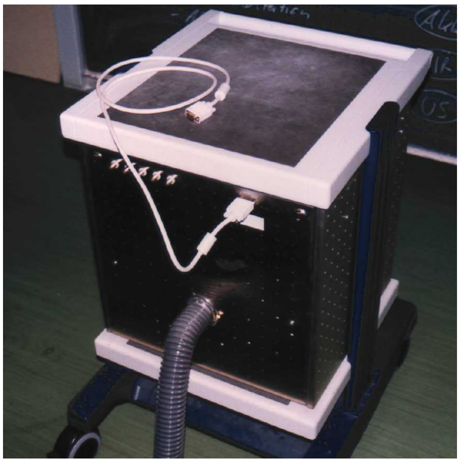

**Figure 2.5:** The audiovisual trolley in lecture theatre HS EDV has input connectors at the rear. Unfortunately, unscrewing the external connector causes the internal connector to fall with a clunk somewhere inside the trolley!

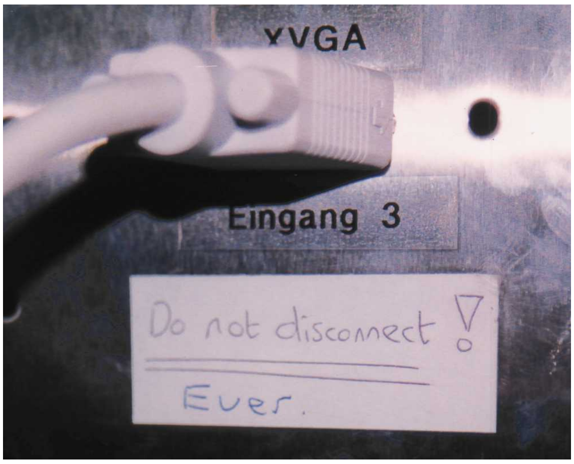


**Figure 2.6:** I provided this label as a warning to myself and others.

- It took three days for a technician to arrive, disassemble the trolley, and reconnect everything.
- To remind myself and to warn others, I resorted to the last ditch technique of providing the label shown in Figure 2.6.

### Where is the Toilet Paper?

- Fancy hotel, nice bathrooms, see Figure 2.7.
- Having sat down and done the business, where the heck is the toilet paper?
- Ah, there it is! Well-hidden, see Figure 2.8.
- At least it was still in reaching distance, see Figure 2.9.

**Figure 2.7:** Can you see where the toilet paper is in this hotel bathroom?

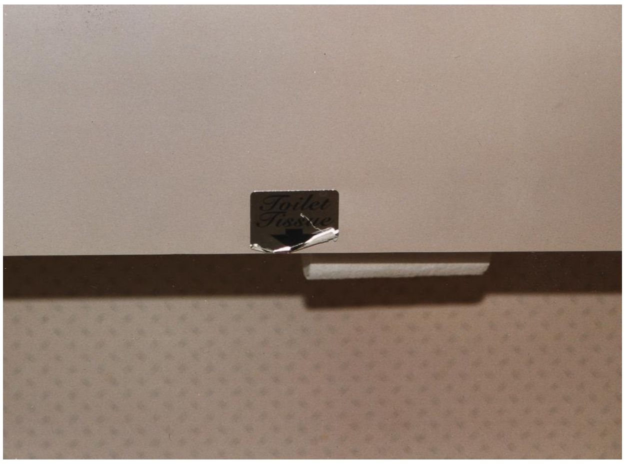


**Figure 2.8:** The toilet paper is well-hidden under the ledge, and is impossible to find without the sign.

**Figure 2.9:** The toilet paper here is easy to see, but a little too far away. . . [Image placed in the public domain by my former student.]

**Figure 2.10:** The men's toilet in a restaurant in Santa Barbara. The fixture in the corner affords a certain activity. It is, however, not a urinal but a mop sink. [Photograph courtesy of Baddesigns.Com [Darnell 2010].]


**Figure 2.11:** A close-up of the label. It reads "This is a Mop Sink". [Photograph courtesy of Baddesigns.Com [Darnell 2010].]

### This is a Mop Sink

- A picture from the men's toilet of a restaurant in Santa Barbara, see Figure 2.10.
- There is no urinal in the toilet.
- Where do you think most men relieve themselves?
- The label says "This is a Mop Sink", see Figure 2.11.
- The mop sink looks enough like a urinal to be used as one.
- This example is from Baddesigns.Com [Darnell 2010] `http://baddesigns.com/mopsnk.html`

### This is a Measuring Device

- A photo from the restroom of a doctor's surgery in Graz, Austria, see Figure 2.12.
- Are there two toilets?
- The "toilet" on the left has a label on it and a sign above it. The label reads "Measuring device, not toilet", see Figure 2.13.
- I guess experience showed the label was necessary. . .

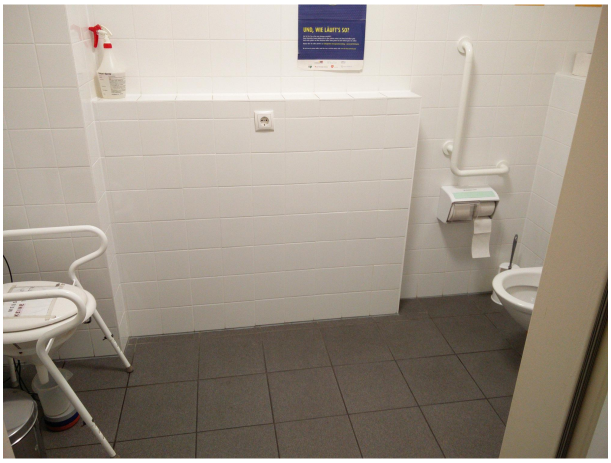


**Figure 2.12:** The restroom of a doctor's surgery in Graz. Are there two toilets in the room?


**Figure 2.13:** The "toilet" on the left has a label and a sign above it. The label reads "Measuring device, not toilet".

### Shower Control

- Shower control: water either goes into the bath out of the faucet or comes out of the shower. See Figure 2.14.
- Sticker with instructions on the faucet.
- How do you make the water come out of the shower instead of the faucet? <
- You have to reach *under* the faucet and pull the knob down!
- This example is from Baddesigns.Com [Darnell 2010] `http://baddesigns.com/shower1.html`

### Car Seat

- A seat in a mini-van (people carrier), see Figure 2.15.
- What do you think happens when you pull the lever under the seat?

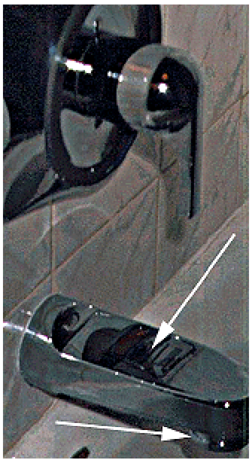

**Figure 2.14:** Hidden shower control. To divert water to the shower, you have to pull down on the knob beneath the faucet. [Photograph courtesy of Baddesigns.Com [Darnell 2010].]

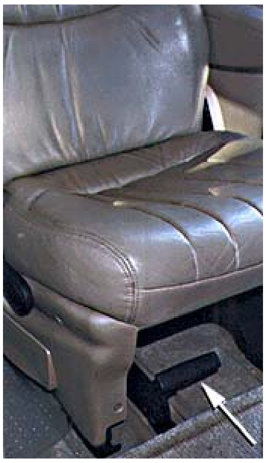

**Figure 2.15:** The lever beneath this mini-van seat does not work as expected. Instead of allowing the seat to slide backward or forward, pulling the lever detaches the seat from the floor to make room for cargo! [Photograph courtesy of Baddesigns.Com [Darnell 2010].]

- Most normal-thinking people would expect the seat to slide backward or forward.
- Not in this mini-van. Pulling the lever detaches the seat from the floor to make room for cargo!
- This example is from Baddesigns.Com [Darnell 2010] `http://baddesigns.com/carseat.html`

## 2.2 The Psychology of Everyday Things

### Perceived and Real Affordances

*Affordances* are the range of possible physical actions by a user on an artefact:

- *Perceived Affordances* are the physical actions a user perceives to be possible.
- *Real Affordances* are the physical actions which are actually possible.

See [Norman 1999] for a discussion of affordances and perceived affordances.

### Real World Affordances

For physical objects, there can be both real and perceived affordances (and the two sets are not necessarily the same):

- Appearance indicates how to use something:
  - A chair affords (suggests) sitting.
  - Knobs are for turning.
  - Slots are for inserting things.
  - A button affords pushing.
- When perceived affordances are taken advantage of, the user knows what to do just by looking.
- Figure 2.16 illustrates good affordances of rubbish bins. The shape of the slot suggests the type of rubbish which should be inserted.

### Norman Doors

- Badly designed doors are sometimes called "Norman doors" after Don Norman.
- "A door where the design tells you to do the opposite of what you're actually supposed to do." [Posner 2016, 01:39].
- Figures 2.17, 2.18, 2.19, and 2.20 illustrate the perceived affordances of door handles.

### Video: Norman Doors

- Norman Doors video [Posner 2016] [Video: `https://youtu.be/yY96hTb8WgI`]

### Labels

- "When simple things need pictures, labels, or instructions, the design has failed!" Norman [1992, page 9]
- See Figure 2.22.


**Figure 2.16:** Good use of affordances for rubbish bins. [Photograph taken at Hyatt Regency, Bellevue, WA, in Feb 2012. Used with kind permission of Karl Voit.]

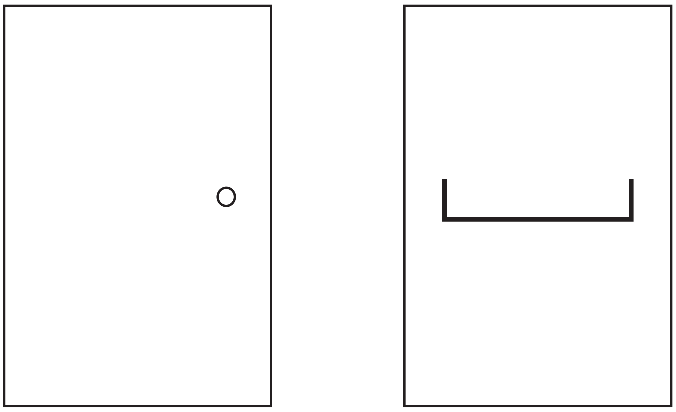

**Figure 2.17:** Ambiguous door designs. A knob affords turning, but do you push or pull? A horizontal bar affords pushing, but which side do you push on?

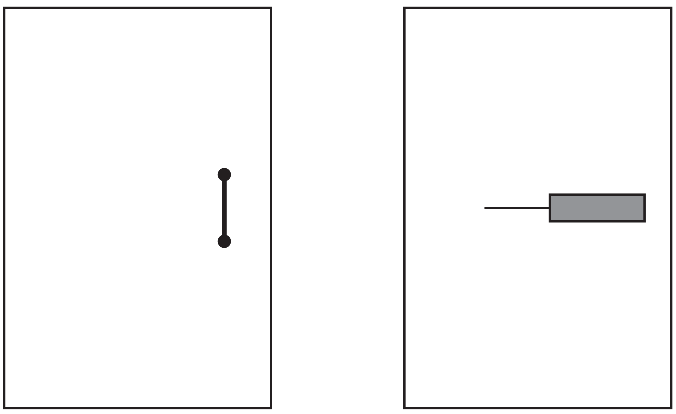

**Figure 2.18:** Good use of affordances in door designs. A vertical handle affords grasping and pulling. A flat panel affords pushing and the broadness indicates which side to push.

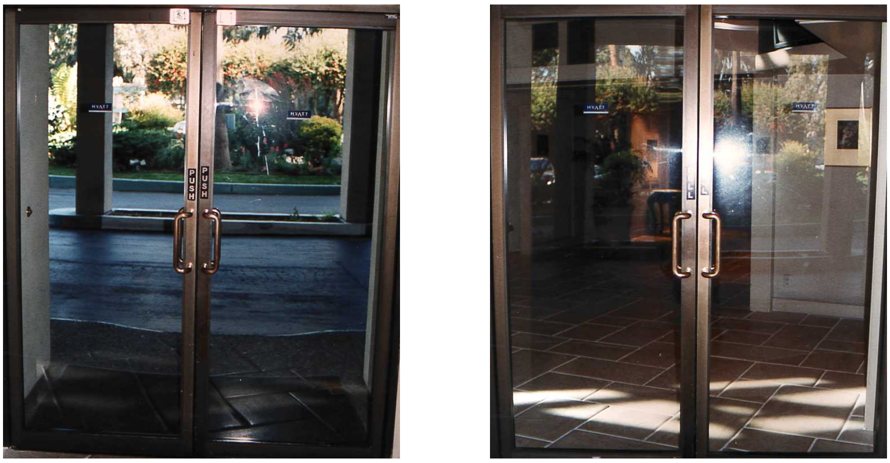


**Figure 2.19:** An example of ambiguous affordances in door design. The vertical handles mounted on both sides of the door suggest grasping and pulling. Unfortunately, from one side, the door has to be pushed! Note the signs above the handles.

**Figure 2.20:** Good use of affordances in the same hotel. This door is well designed. The vertical handle correctly suggests pulling, the flat bar correctly suggests pushing.

**Figure 2.21:** The affordances for this door seem reasonable within themselves. Context is everything. Hopefully, the door is kept locked!

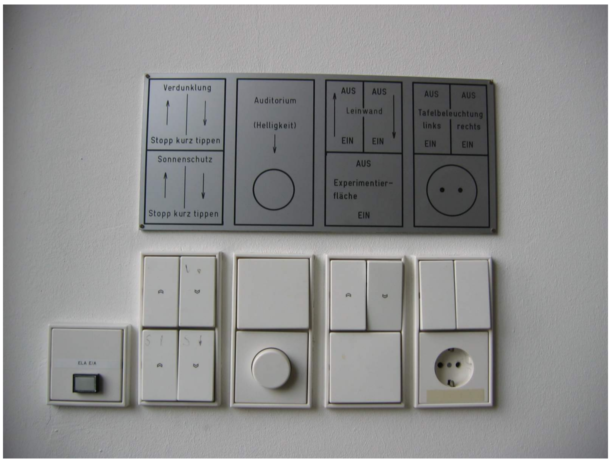


**Figure 2.22:** A label as big as the control panel. [Photograph taken at TU Chemnitz, Germany in March 2008. Used with kind permission of Karl Voit.]

### GUI Affordances

For screen-based interfaces, the computer hardware already has built-in physical affordances:

- Screen affords touching.
- Mouse affords pointing.
- Mouse buttons afford clicking.
- Keyboard affords typing.

Changing the shape of the cursor to indicate a clickable link is visual feedback, not a physical affordance (you can still click anywhere).

### Mappings

*Mappings* are the relationships between controls and their effects on a system.

*Natural mappings* take advantage of physical analogies and cultural standards.

Examples:

- Turn steering wheel clockwise to turn a car right. Actually, there are two mappings here:
  - which control affects steering,
  - which direction to turn it.
- Move a control up to move an object up.
- Use a louder sound to mean a greater amount.

#### Mapping of Cooker Controls

How should one arrange the hot plate controls on a cooker?

Like the Glem gas hob shown in Figure 2.23?


**Figure 2.23:** A Glem gas hob with an arbitrary mapping of controls to the four burners. [Photo taken by Keith Andrews.]

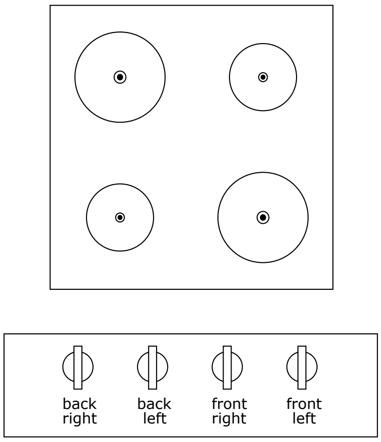


**Figure 2.24:** Arbitrary mapping of controls to hot plates. There are 24 possible arrangements, requiring the use of labels and memory.

Three possibilities:

- Arbitrary Mapping (see Figure 2.24).
- Paired Mapping (see Figure 2.25).
- Full Natural Mapping (see Figure 2.26).

[Adapted from Norman, *The Design of Everyday Things*, Figures 3.3, 3.4, and 3.5 [Norman 1988].]

### Constraints

The difficulty of dealing with a novel situation is directly related to the number of possibilities.

*Constraints* are physical, semantic, cultural, and logical limits on the number of possibilities:

- *Physical* constraints such as pegs and holes limit possible operations.
- *Semantic* constraints rely upon our knowledge of the situation and of the world.

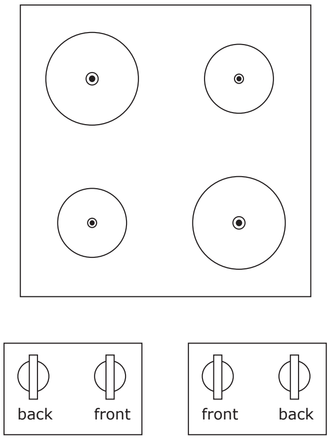


**Figure 2.25:** Paired cooker controls. Now there are only four possible arrangements, two on each side, but confusion can still occur.

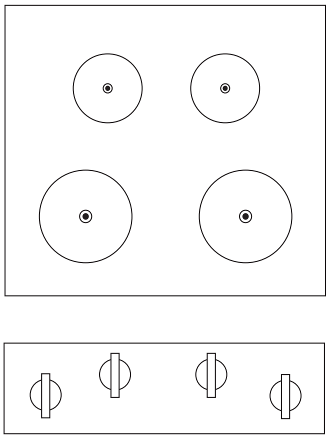

**Figure 2.26:** A full, natural mapping of cooker controls. There is no ambiguity, no need for learning or remembering, and no need for labels.

- *Cultural* constraints rely upon accepted cultural conventions.
- *Logical* constraints exploit logical relationships. For example, a natural mapping between the spatial layout of components and their controls.

Where affordances suggest the range of possibilities, constraints limit the number of alternatives.

### Constraints in Lego Motorbike

Motorbike toy with 12 parts. Constraints make its construction simple, even for adults!

- *Physical:* Front wheel only fits in one place.
- *Semantic:* The rider sits on the seat facing forward.
- *Cultural:* Red is a rear light, yellow a front light.
- *Logical:* Two blue lights, two white pieces, probably go together.

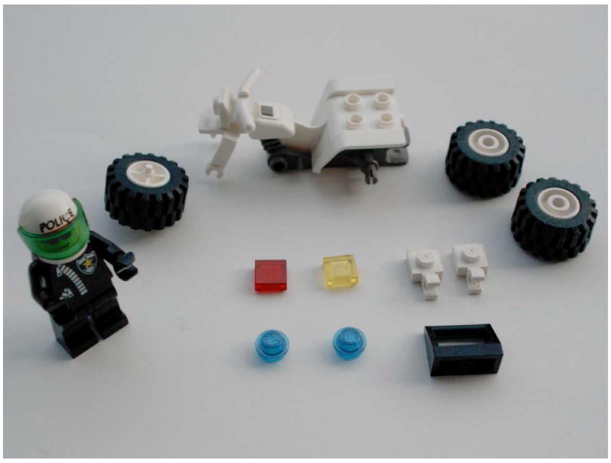


**Figure 2.27:** The design takes advantage of constraints to make its construction simple.

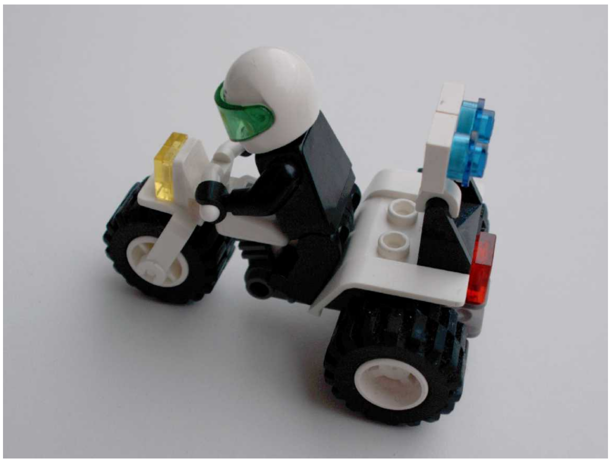

**Figure 2.28:** The assembled lego motorbike.

See Figures 2.27 and 2.28.

### Conventions

Conventions are cultural constraints. They are initially arbitrary, but evolve and become accepted over time.

They can however still vary enormously across different cultures, for example:

- Light switches:
  America down is off
  Britain down is on

- Water taps:
  America anti-clockwise is on
  Britain anti-clockwise is off

- The colour red:

| | |
|---|---|
| America | danger |
| Egypt | death |
| India | life |
| China | happiness |

### The Principle of Causality

*Causality* is the relation between two events, cause and effect, where the second occurs as a consequence of the first.

*Apparent causality* is when something which happens immediately after an action, *appears* to have been caused by that action. We associate the effect with the *apparent* cause.

There are two kinds of *false* causality:

- Coincidental effects lead to superstition:
  - Touch a computer terminal just before it fails, and you are apt to believe you caused the failure.
  - Start an unfamiliar application, just before the computer crashes.
- Invisible effects lead to confusion:
  - When an action has no apparent result, you may conclude it was ineffective (and repeat it).
  - For example, repeatedly clicking the "Stop" button when the system is unresponsive.

  → There is a need for feedback!

### The Structure of Human Memory

#### Short-Term Memory (STM)

Short-term memory is the memory of the present, used as working or temporary memory:

- Information is retained in STM automatically and can be retrieved without effort.
- However, the amount of information in STM is extremely limited: 7 ± 2 items [Miller 1956]
- STM is extremely fragile – the slightest distraction and its contents are gone.

For example, STM can hold a seven digit phone number from the time you look it up until the time you use it, as long as no distractions occur.

#### Long Term Memory (LTM)

Long-term memory is the memory of the past:

- It takes time to put stuff into LTM and time and effort to get stuff out.
- Capacity of LTM is estimated at about $10^9$ bits or around 100 million items, according to Norman [1988, page 67] referring to Landauer [1986].

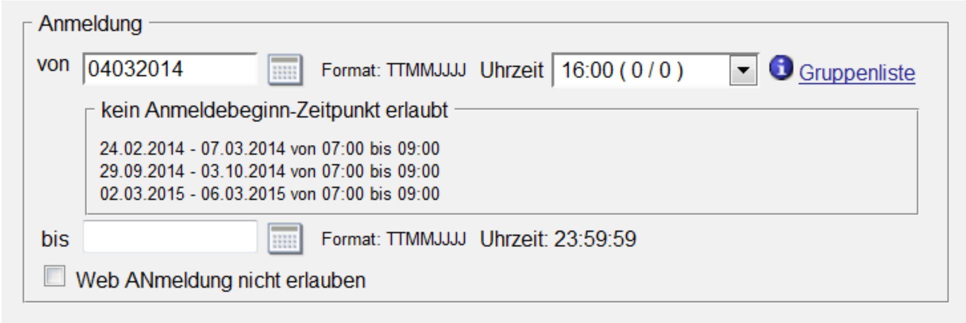


**Figure 2.29:** TUGRAZonline, the intranet server at Graz University of Technology, provides an example of the expected date format (TTMMJJJJ) in the interface next to the input field. Users do not have to remember the required format.

### Knowledge in the Head and in the World

Not all of the knowledge required for precise behaviour has to be in the head. It can be distributed:

- partly in the head
- partly in the world
- and partly in the constraints of the world.

#### Placing Knowledge in the World

Having knowledge in the world reduces the load on human memory:

- An example of the input format can be provided in the interface:

  *Please enter the date (yyyy/mm/dd):*

  See Figure 2.29 for an example.
  [But keep it consistent, not like in another part of the same system, shown in Figure 2.30!]

- Previously entered values can be used as defaults, so users do not have to remember items between screens.
- It is better if the designers of an interface place knowledge in the world.
- However, sometimes, users have to place knowledge in the world themselves to fix a broken interface.

Wherever possible, also allow expert users to internalise knowledge for faster and more efficient performance (say by learning to type a date in a particular format, rather than having to use the provided calendar widget).

#### Superimposing Knowledge onto Control Panels

Control-room operators at nuclear power plants felt it necessary to adapt and superimpose knowledge onto their control panels in various ways [Seminara et al. 1976]:

- Using sticky labels to label controls.
- Using tape to visually group related elements.

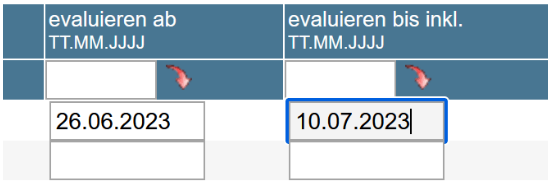


**Figure 2.30:** Unfortunately, in another part of the same system, dates are required in a *different* format (TT.MM.JJJJ)!

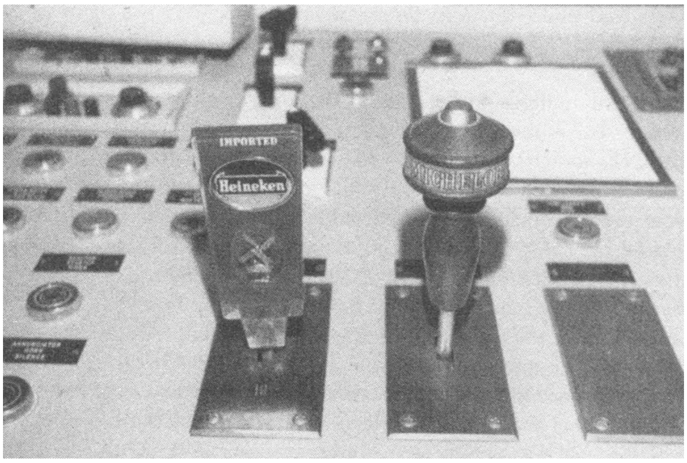


**Figure 2.31:** Beer tap handles mounted atop similar-looking knobs in the control room of a nuclear power plant to help operators distinguish between them. [Original photograph by Joseph Seminara [Seminara et al. 1976, page 8-4], scanned from Norman [1988, page 95] with kind permission from Don Norman.]

- Fixing beer-tap handles to similar-looking knobs, so as to better distinguish between them. See Figure 2.31.

### Video: Nuclear Power Plant Controls

- Douglas H. Harris; *Human Factors Success Stories*; Human Factors and Ergonomics Society (HFES), 1987, DVD. [Harris 1987, 08:58-09:40]

#### Shape Coding for Aircraft Control Knobs

- During the first years of World War 2, there were dozens of gear-up accidents when landing B-17, B-25, and P-47 aircraft [Koonce 2002, page 95].
- Pilots frequently retracted the landing gear instead of the flaps after landing. See Figure 2.32.
- In 1943, Lt. Alphonse Chapanis was ordered to investigate and noticed that C-47 transport (DC3 Dakota) pilots suffered no such accidents [Roscoe 1997, page 3].
- In the B-17, the control knobs for flaps and landing gear were identical and located close to one another, as shown in Figures 2.33, 2.34, and 2.35.
- In the C-47, the flaps control was totally separate and was activated like a modern car handbrake.
- Chapanis realised that so-called “pilot errors” were really “designer errors” [Chapanis 1999, page 16].

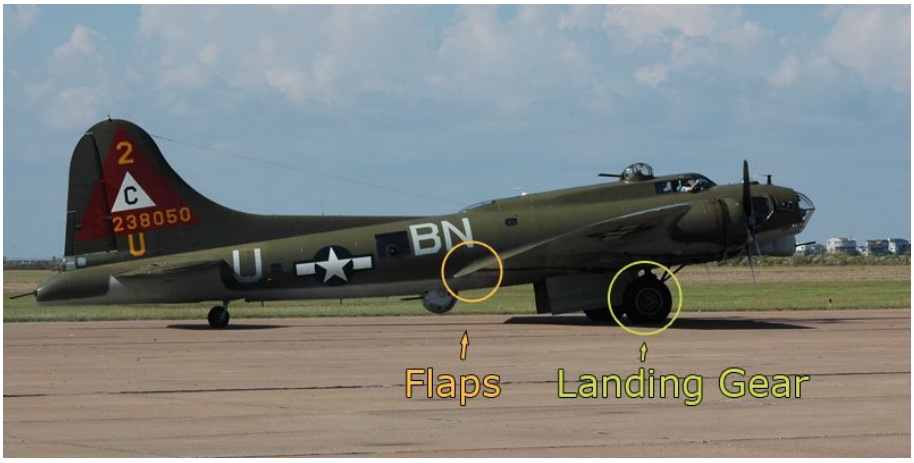


**Figure 2.32:** The B17 Flying Fortress. [From Emgonzalez [2005], the image was placed in the public domain by the photographer.]

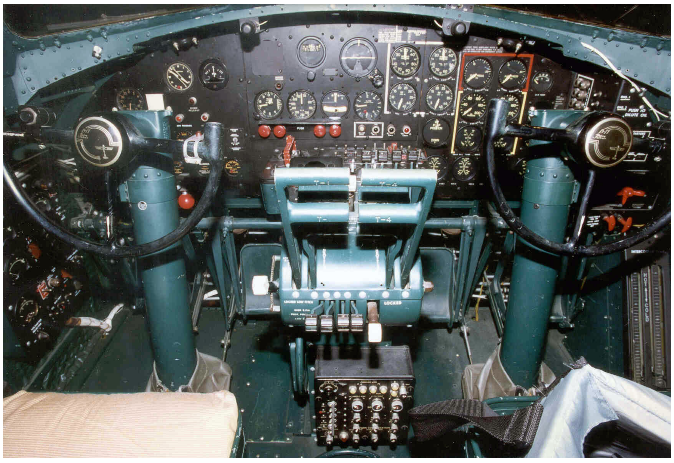

**Figure 2.33:** The cockpit of a B17G Flying Fortress. The landing gear and flaps control knobs are identical and are very close to one another. [From USAF [2006], image believed to be in the public domain.]

- As a quick fix, a small rubber wheel was attached to the end of the landing gear control and a wedge shape to the flap control.
- The gear-up landings ceased.
- After the war, the shape-coded wheel and flap controls were standardised and are still used today [CFR 2008, pages 253–254], as shown in Figure 2.36.

### To Err is Human

- People make errors routinely, you must design for error.
- Assume that any error, that can be made, will be made!
- You can never anticipate all the ways which users will (attempt to) use your interface.
- People sometimes use(d) the mouse is many unexpected ways [Mantei 1990].


**Figure 2.34:** Close-up of the cockpit control knobs of a B17G Flying Fortress. The landing gear and flaps control knobs are identical and are very close to one another. [From USAF [2006], image believed to be in the public domain.]

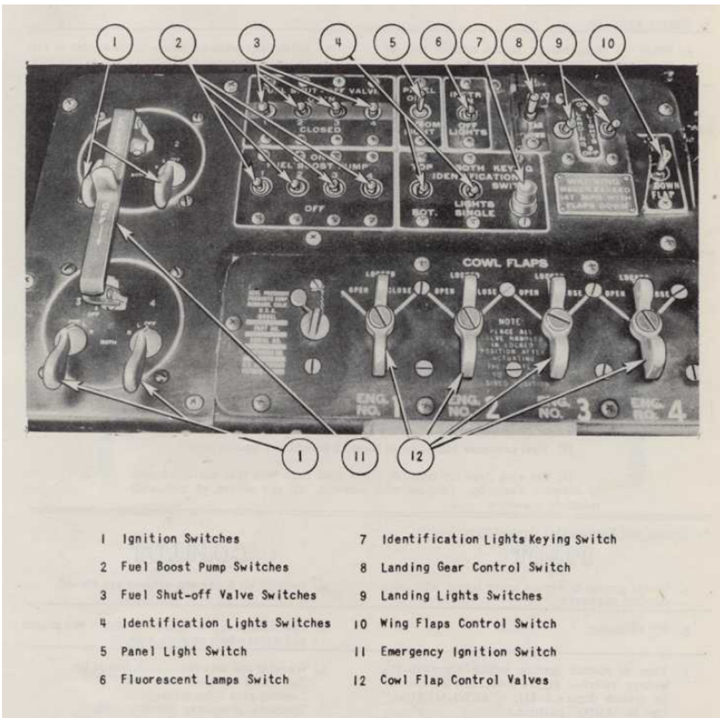


**Figure 2.35:** Page 53 from the B-17F Airplane Pilot's Flight Operating Instructions. Item 8 is the landing gear control switch and item 10 is the flap control. [From USAF [1942].]

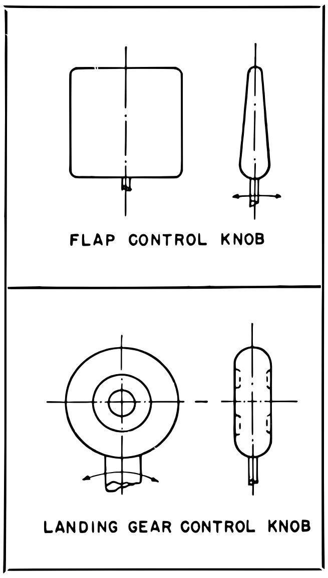


**Figure 2.36:** After WW2, the shape coding for landing gear and flaps control knobs was standardised. The landing gear control resembles a wheel and the flaps control resembles a flap. [From CFR [2008, page 254].]

**Figure 2.37:** An old-style mouse with a ball, being used upside down. [Photo taken by Keith Andrews.]

For example, users unfamiliar with the old-style ball mouse sometimes grabbed it and used it upside down [Raskin 1994; freem 2000]: rolling the ball with the thumb and clicking underneath, as illustrated in Figure 2.37.

- Design explorable systems, where operations are easy to reverse.

### Video: Upside-Down Running Hamster

- Ben Bever; *Upside-Down Running Hamster*; 18 Mar 2013 [Video: `https://youtu.be/1gIH94st0mY`]

#### Categories of Error

Two fundamental categories of error:

- *Slips* result from automatic behaviour, when subconscious actions toward a correct goal go wrong.
- *Mistakes* result from conscious deliberations, which formed an inappropriate goal.

## Conceptual Models

A *conceptual model* is a mental model of how something works, which is formed inside a person's head.

A user's conceptual model is built up and influenced by numerous factors, including:

- familiarity with similar devices (transfer of previous experience)
- affordances
- mapping
- constraints
- causality
- instructions
- interacting with the device.

Conceptual models may be wrong, particularly if the above factors are misleading.

### A Conceptual Model of a Fridge Freezer

A fridge-freezer with two compartments: the fridge for fresh food at the bottom and the freezer for frozen goods at the top, as shown in Figure 2.38:

- The two control dials (Figure 2.39) suggest a particular conceptual model (Figure 2.40) for operating the fridge freezer.
- Unfortunately, the apparent conceptual model does not match the way the fridge freezer actually works (Figure 2.41).

Adapted from [Norman 1988], pages 17–18.

### Projecting a Correct Conceptual Model

- Designers have their own conceptual model of a system, the *design model*.
- The *system image* is the actual implementation or embodiment of the design (including documentation, instructions, and labels).
- The *user's model* is built through interaction with the system.

The designer expects the user's model to be the same as the design model, however all communication takes place through the system image.

→ The system image should make the design model clear and consistent.

### A Pair of Scissors Projects a Good Conceptual Model

- *Affordances*: holes for putting fingers in.


**Figure 2.38:** The fridge freezer.

| | | | |
|---|---|---|---|
| NORMAL SETTINGS | C | AND | 5 |
| COLDER FRESH FOOD | C | AND | 6-7 |
| COLDEST FRESH FOOD | B | AND | 8-9 |
| COLDER FREEZER | D | AND | 7-8 |
| WARMER FRESH FOOD | C | AND | 4-1 |
| OFF (FRESH FD & FRZ) | | | 0 |

1 SET BOTH CONTROLS
2 ALLOW 24 HOURS TO STABILIZE

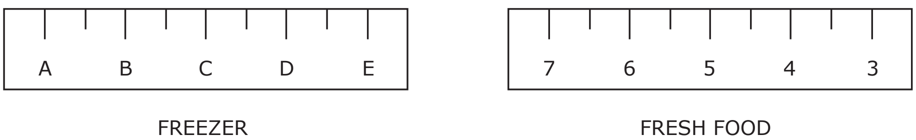


**Figure 2.39:** The fridge freezer controls and instructions.

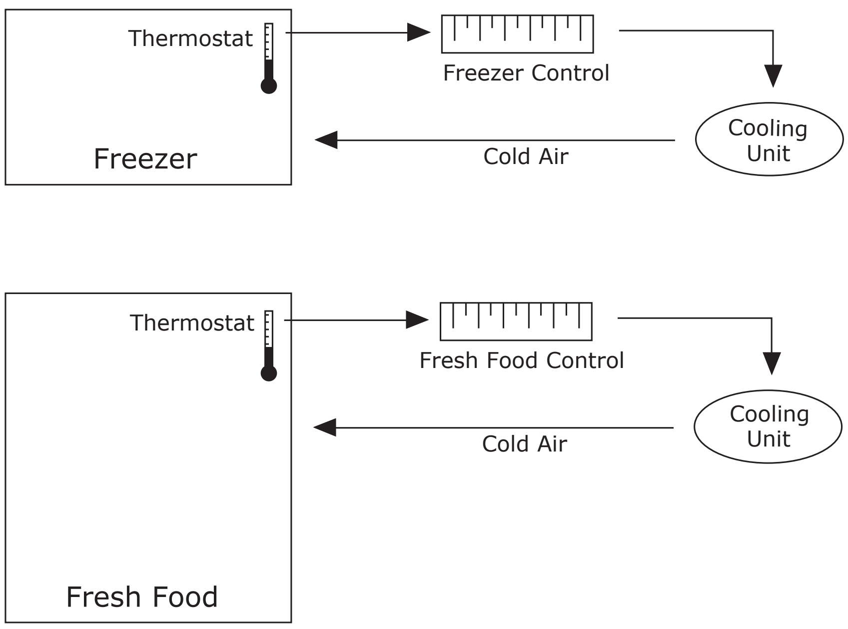


**Figure 2.40:** The apparent conceptual model for the fridge freezer, gleaned from the controls and instructions, is that each control is responsible for the temperature of the corresponding compartment.

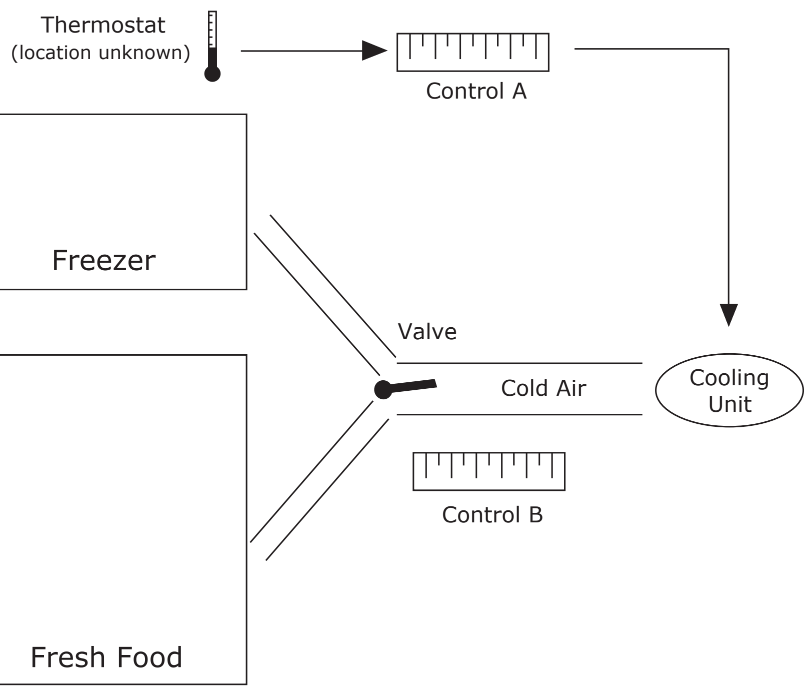


**Figure 2.41:** The actual conceptual model for the fridge freezer. In fact, there is only one thermostat and only one cooling unit. One control adjusts the thermostat setting, the other controls the relative proportion of cold air!

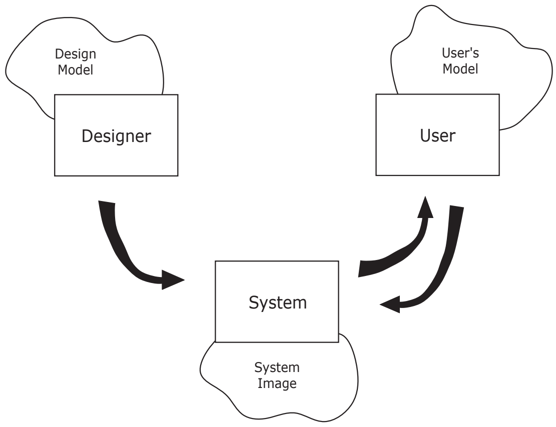


**Figure 2.42:** Projecting a correct conceptual model. Designers should take care to project an accurate conceptual model through the system image.

**Figure 2.43:** Scissors project a good conceptual model.

- *Constraints*: small hole for thumb, big hole for several fingers.
- *Mapping*: between holes and fingers suggested and constrained by appearance.
- *Conceptual Model*: operating parts are visible and their implications are clear.

### A Digital Watch Projects No Visible Conceptual Model

- *Affordances*: four buttons to push – but what do they do?
- *Mapping*: no clear relationship between buttons and possible actions.
- *Transfer of Prior Knowledge*: little similarity to analog watches.
- *Conceptual Model*: must be learnt from instructions.

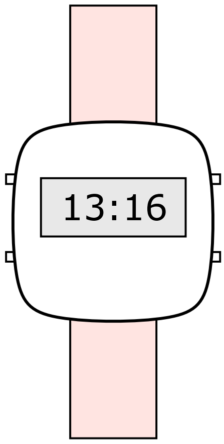


**Figure 2.44:** A digital watch projects no obvious conceptual model.

## 2.3 The Psychopathology of Computers

Usability "war stories" concerning computers . . .

### The PC Cup Holder

A supposedly true story from a Novell NetWire SysOp:

| | |
|---|---|
| *Caller*: | *"Hello, is this Tech Support?"* |
| Tech Rep: | "Yes, it is. How may I help you?" |
| *Caller*: | *"The cup holder on my PC is broken and I am within my warranty period. How do I go about getting that fixed?"* |
| Tech Rep: | "I'm sorry, but did you say a cup holder?" |
| *Caller*: | *"Yes, it's attached to the front of my computer."* |
| Tech Rep: | "Please excuse me if I seem a bit stumped, it's because I am. Did you receive this as part of a promotional, at a trade show? How did you get this cup holder? Does it have any trademark on it?" |
| *Caller*: | *"It came with my computer, I don't know anything about a promotional. It just has '4X' on it."* |

At this point the Tech Rep had to mute the caller, because he couldn't stand it. The caller had been using the load drawer of the CD-ROM drive as a cup holder, and snapped it off the drive.

This story was found at Greenberg 1997 and is attributed there to George Wagner `g.wagner@sylvania.sev.org`.

### Dangerous Command Names

A widely used text editor (ed) used the character '.' to select the current line of text, and ',' to select the entire document for an operation.

- These two keys are adjacent on the keyboard → highly likely they will sometimes be mistaken.
- Intending to change one line

  "A heavy poll is expected . . . "

  to

> “A heavy turnout is expected . . . ”

can easily change ’poll’ to ’turnout’ throughout the entire document.

- Such a case was reported in the British press: all the election documents of a candidate named Pollack were printed with the name Turnoutack.
- A “computer failure” was blamed.

This story is taken from [Newman and Lamming 1995], pages 8–9.

### Beware Unix Commands

- Intend to type: `rm *~` to remove Emacs backup files.
- Actually type: `rm * ~` which removes everything!
- And there is no undo . . .

### The Terminal is Dead

Reported in the *Human Factors Society Bulletin*, 1981:

- The manager of a system installation for police departments reported that one day he received the call “your terminal is dead. Come and get it.”
- He suggested that the repair service should be contacted, but the caller insisted.
- The terminal had two bullet holes in it.
- Apparently, an officer got a “Do not understand” message on the screen once too often.

### Phobos 1 Never Made it to Mars

From *Science* magazine, 1989, and reported by Norman in *CACM*, Jan. 1990 [Norman 1990]:

> *“not long after the launch, a ground controller omitted a single letter in a series of digital commands sent to the spacecraft. And by malignant bad luck, that omission caused the code to be mistranslated in such a way as to trigger the test sequence”*

- The test sequence, stored in ROM, was intended to be used only when checking the spacecraft on the ground.
- Phobos 1 went into a tumble from which it never recovered.
- The controller was moved to other duties.

### Iran Air 655

Reported in [L. Lee 1992]:

- In 1988, the USS *Vincennes* shot down an Iran Air A-300 Airbus with 290 people aboard.

- The Aegis weapons system aboard the *Vincennes* had sophisticated software for identifying and tracking potential targets.
- However, the large-screen display did not show altitude information – altitude had to be read from separate consoles.
- The Airbus which had levelled off at 12 500 feet, was taken to be an F-14 fighter descending from 9 000 feet.
- Ironically, an escort ship with older equipment was able to read the plane's altitude quite correctly, but could not intervene in time.

### Lessons

- Most failures of human-machine systems are due to poor designs which do not take account of peoples' capabilities and fallibilities.
- These are often labelled as "computer failure" or "human error" rather than design failure.

## 2.4 Interface Hall of Shame

Examples of interface design mistakes.

- Many are taken from the Interface Hall of Shame, which used to be available at `http://www.iarchitect.com/shame.htm` but went offline in 2002.
- A partial mirror is available at the Internet Archive: `https://web.archive.org/web/20021105045514/http://www.iarchitect.com/shame.htm`
- Thanks to Brian Hayes from Isys Information Architects Inc. for permission to use them here.

### Smallest Setting is 1%

- The Internet Explorer 4.0 cache size can only be set in increments of 1% of the size of the hard disk, as shown in Figure 2.45.
- To quote from user Ross Cormier:

  > *"The smallest setting is 1%. I have a 4 Gig drive, and don't need 40 MB of cache thank you."*

### Horizontal Scrolling

- Humans can scan written material faster from top to bottom rather than left to right.
- Vertically scrolling lists support single-item scrolling.
- The Internet Explorer 4.0 certificate authority selection panel uses horizontal scrolling, as shown in Figure 2.46.

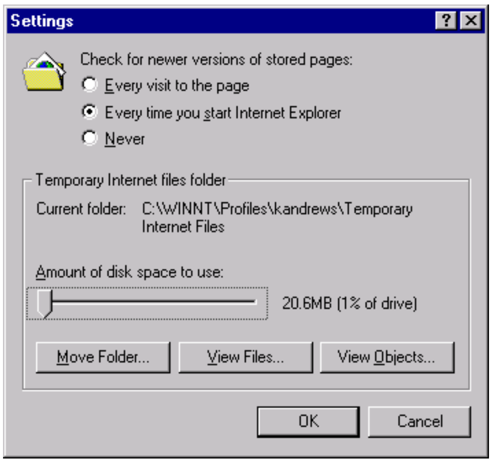


**Figure 2.45:** Internet Explorer 4.0 cache settings panel.


**Figure 2.46:** Internet Explorer 4.0 certificate authority selection panel.

### Two Item List Box

- Visual Basic 5.0 uses a two (!) item list box, as shown in Figure 2.47.
- A drop down list or radio buttons would be much better.

### Two Thousand Item List Box

- Do *not* put hundreds or thousands of items into a list box, either, like in Figure 2.48.
- The following message, posted in a Visual Basic programmers forum on 11th December 1996, is typical:

  > *"I want to fill a list box with 2000 items ... This takes incredibly long ... over 20 minutes. Any ideas?"*


**Figure 2.47:** A two-item list box in Visual Basic 5.0.

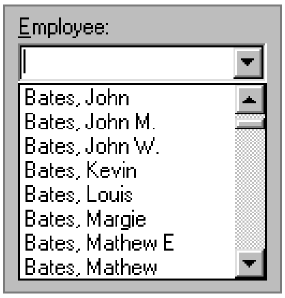


**Figure 2.48:** A two thousand item list box. Putting too many items into a list box is bad.

### Multi-Row Property Sheets

- Single-row property sheets (tab controls) are among the best user interface elements ever devised.
- Multi-row tab controls are perhaps one of the worst interface elements ever!
- Clicking one of the tabs other than from the bottom row, causes a major reorganisation of the complete set of tabs.

Figure 2.49 shows an example from Zoc, a communications program.

### Stupid Error Messages

- Roy Child writes: "I came across this message when trying to delete files from a nearly-full hard drive in Windows 95.", as shown in Figure 2.50.

### Avoid Breaking a Metaphor

- Originally introduced in the Xerox Star, the trashcan icon was later used on the Apple Mac in combination with drag-and-drop to provide a very intuitive way for users to delete files and folders.
- Unfortunately, the Mac designers then extended the trashcan metaphor to include the completely counterintuitive function of ejecting diskettes.
- To eject a diskette, the user had to drag the diskette icon and drop it into the trash! See Figure 2.51.
- Later versions of the Mac keyboard have a dedicated eject button. See Figure 2.52.
- The interface was finally fixed in Mac OS X. When the user drags a diskette icon, the trash icon morphs into an eject icon. See Figure 2.53.

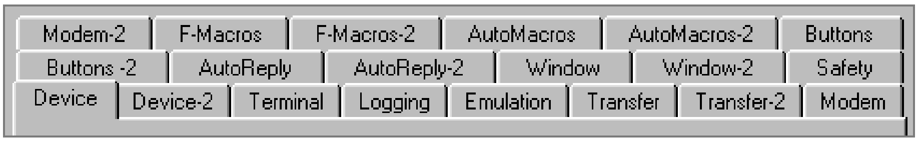


**Figure 2.49:** Zoc uses multi-row tab controls.


**Figure 2.50:** Deleting files from an almost full hard disk in Windows 95. OK, now I know what to do!

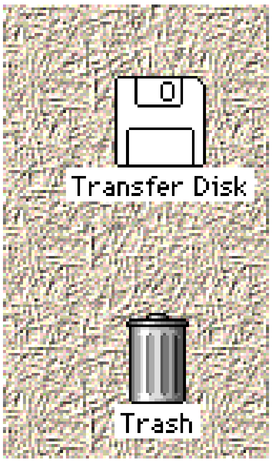


**Figure 2.51:** Ejecting a diskette on the Mac by throwing it into the trash unfortunately breaks the trash can metaphor.

**Figure 2.52:** Later versions of the Mac keyboard have a dedicated eject button.


**Figure 2.53:** Mac OS X retains the trash can metaphor, but when the user drags a diskette icon, the trash can morphs into an eject icon. [Thanks to Tanja Kolrus for the screen shots.]

## 2.5 User-Centered Design

| | |
|---|---|
| *Science Finds, Industry Applies, Man Conforms.* | [Motto of 1933 Chicago World's Fair] |
| *People Propose, Science Studies, Technology Conforms.* | [Don Norman's person-centered motto for 21st century] |

### System-Centered Design

- What can be built easily on this platform?
- What can I create from the tools available?
- What do I as a developer find interesting to work on?
- What do I as a developer think users need?

### User-Centered Design

User-Centered Design = Human-Centered Design.

The design is based upon a user's:

- abilities and needs
- context
- work
- tasks

### Video: Simplicity Sells

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# Chapter 3

# Usability Engineering

> *" When the cook tastes the soup it is formative evaluation and when the guest tastes the soup it is summative. "*
>
> [ Robert E. Stake, 1976. [Stake 1976, page 19] ]

Usability Engineering . . . *iterative process* to improve usability of a system.

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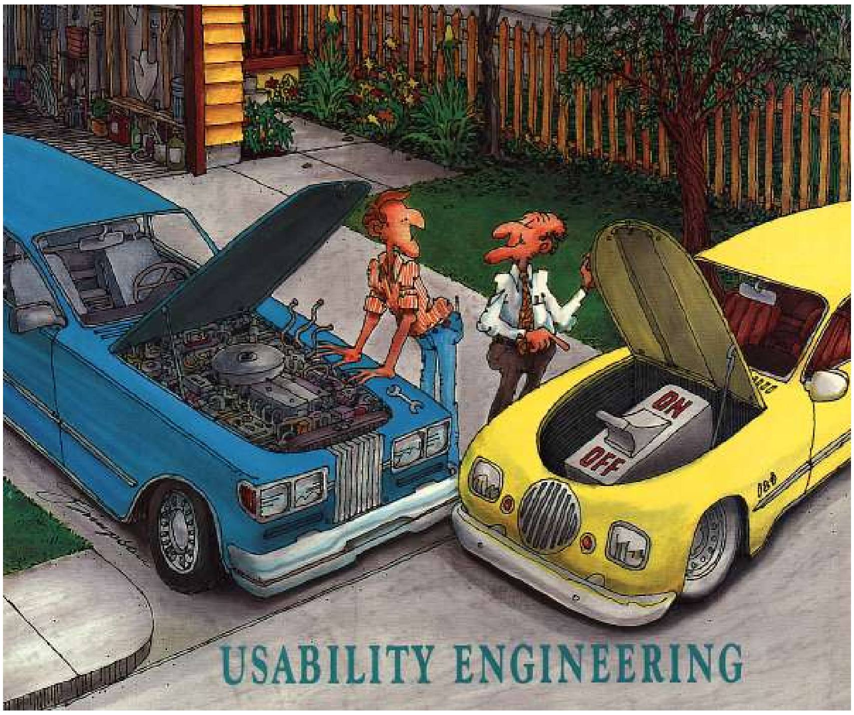


**Figure 3.1:** Usability engineering. By Jay Simpson, from the cover of IEEE Computer, March 1992.

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## 3.1 Defining Usability

The ISO defines usability as "the extent to which a product can be used by *specified users* to achieve *specified goals* with *effectiveness*, *efficiency* and *satisfaction* in a *specified context of use*." [ISO 1998].

[The emphasis is mine, not part of the original definition.]

The three measurable usability attributes defined by ISO [1998] are:

- *Effectiveness*: accuracy and completeness with which users achieve specified goals.

- *Efficiency*: resources expended in relation to the accuracy and completeness with which users achieve goals.

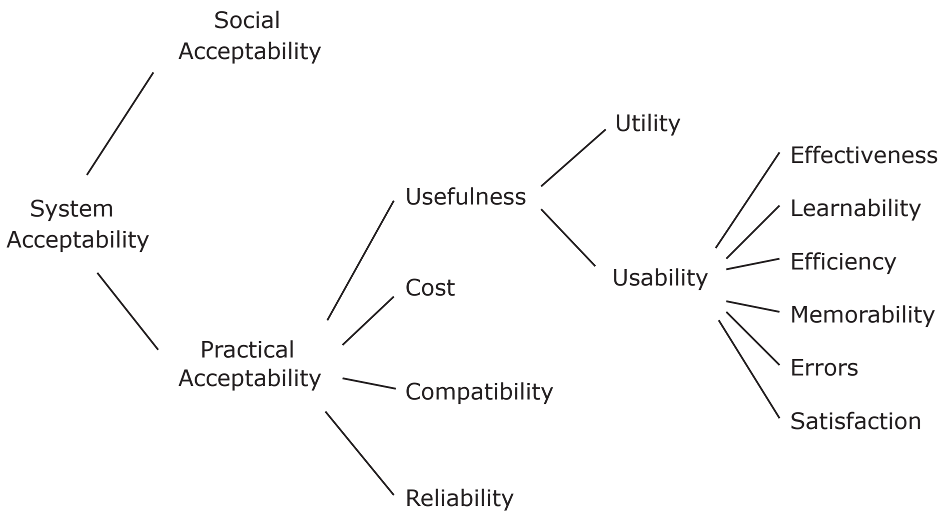


**Figure 3.2:** A model of the attributes of system acceptability, based on Figure 1 of J. Nielsen [1993b, page 25].

- *Satisfaction*: freedom from discomfort, and positive attitudes towards the use of the product.

### Usability in Context

J. Nielsen [1993b, pages 24–25] defines usability in the context of overall system acceptability, as shown in Figure 3.2.

### Six Usability Attributes

Combining the three ISO usability attributes with Nielsen's five usability attributes, leads to the following six usability attributes:

1. *Effectiveness*: completeness with which users achieve their goal.
2. *Learnability*: ease of learning for *novice* users.
3. *Efficiency*: steady-state performance of *expert* users.
4. *Memorability*: ease of using system intermittently for *casual* users.
5. *Errors*: error rate for minor and catastrophic errors.
6. *Satisfaction*: how satisfying a system is to use, from user's point of view.

### Measuring Usability Attributes

- *Effectiveness*: decide on definition of success. For example, number of substitution words spotted in a text, or binary measure of success (order completed or not).
- *Learnability*: pick novice users of system, measure time to perform certain tasks. Distinguish between no/some general computer experience.

- *Efficiency*: decide definition of expertise, get sample expert users (difficult), measure time to perform typical tasks.
- *Memorability*: get sample casual users (away from system for certain time), measure time to perform typical tasks.
- *Errors*: count minor and catastrophic errors made by users while performing some specified task. For example, number of deviations from optimal click path.
- *Satisfaction*: ask users' subjective opinion (questionnaire), *after* trying system for real task.

## 3.2 Usability Evaluation

There are four types of evaluation, according to the purpose of the evaluation:

- *Exploratory* - how is it (or will it be) used?
- *Predictive* - estimating how good it will be.
- *Formative* - how can it be made better?
- *Summative* - how good is it?

My definitions [Andrews 2008] are adapted from those of several authors [Stone et al. 2005; Rubin 1994; Lockee et al. 2002; Ellis and Dix 2006].

### Exploratory Evaluation

Explores current usage and the potential design space for new designs:

- Done *before* interface development.
- Learn *which* software is used, *how often*, and *what for*.
- Collect *usage data* – statistical summaries and observations of usage.

### Predictive Evaluation

Estimates the overall quality of an interface:

- Done once a design has been done, but before implementation proceeds.
- Like a summative evaluation, but a prediction made in advance.

### Formative Evaluation

Informs the design process and helps improve an interface during design;

- Done *during* interface development.
- Learn *why* something went wrong, not just that it went wrong.
- Collect *process data* – qualitative *observations* of what happened and why.

Formative evaluation methods are "find and fix" methods, and typically produce a list of problems found as output.

### Summative Evaluation

Assesses the overall quality of an interface:

- Done once an interface is (more or less) *finished*.
- Either compare alternative designs, or test specific performance requirements.
- Collect *bottom-line data* – quantitative *measurements* of performance: how long did users take, were they successful, how many errors did they make.

### Modified Soup Analogy

Extending Robert Stake's soup analogy [Stake 1976, page 19] to usability evaluation gives:

> "When the cook tastes other cooks' soups, that's *exploratory*.
> When the cook assesses a certain recipe, that's *predictive*.
> When the cook tastes the soup while making it, that's *formative*.
> When the guests (or food critics) taste the soup, that's *summative*."

### Usability Evaluation Methods

The methods of usability evaluation can also be classified according to who performs them:

- *Usability Inspection Methods*
  Inspection of interface design by usability specialists using *heuristics* and *judgement* (no test users).
- *Usability Testing Methods*
  *Empirical* testing of interface design with real users.

Figure 3.3 illustrates some of the different inspection and testing methods, grouped by purpose and by who performs them.

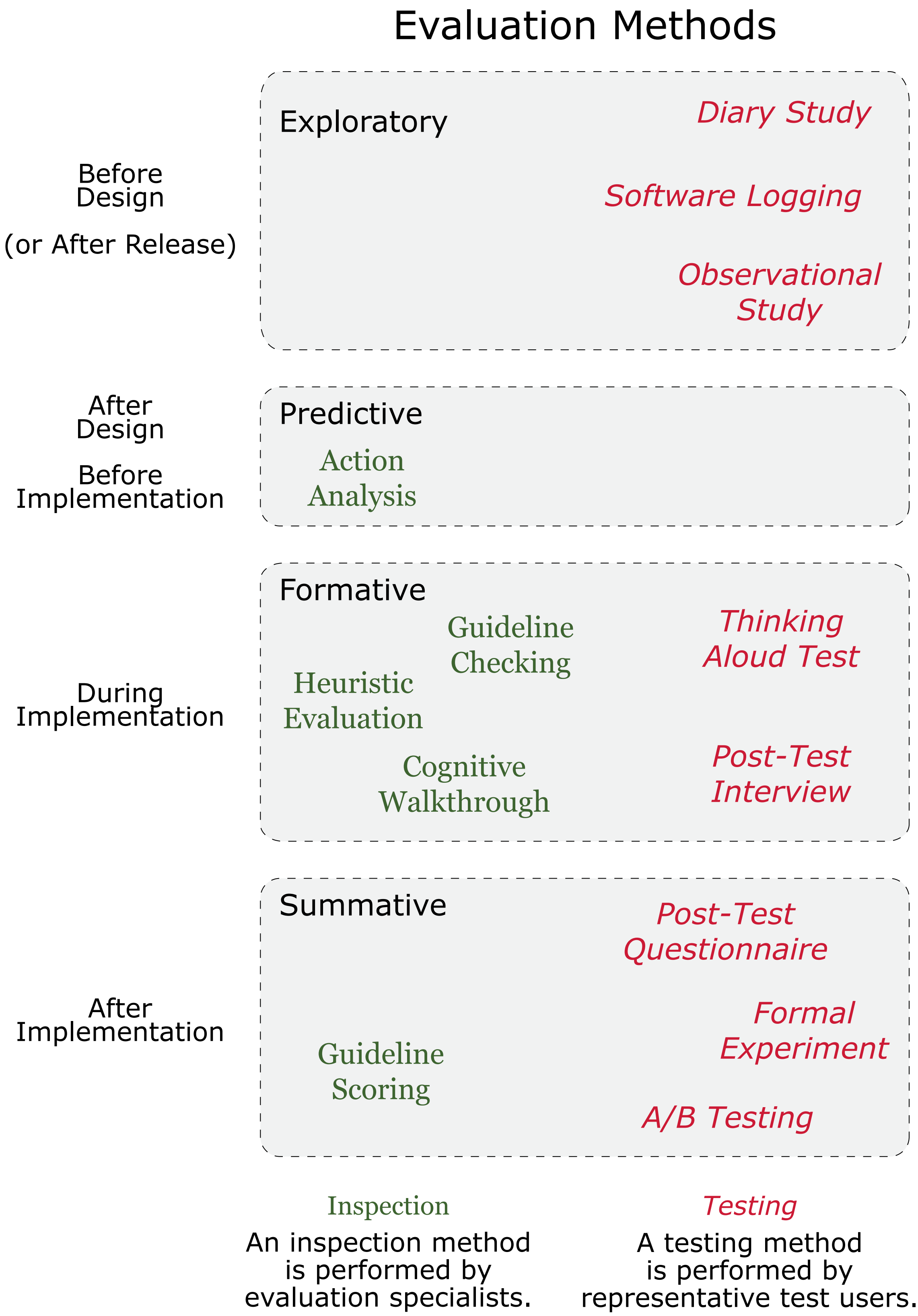


**Figure 3.3:** Twelve common evaluation methods grouped by purpose and by who performs them.

## 3.3 The Usability Engineering Lifecycle

1. Exploratory Evaluation
2. User Research
3. Usability Benchmarking
4. Interaction Design
5. Iterative Design Cycle:
   (a) Prototyping
   (b) Formative Evaluation (Inspection and/or Testing)
6. Summative Evaluation
7. Follow-up Studies

The usability engineering lifecycle above is based on the discussion in J. Nielsen [1993b, Chapter 4]. It is illustrated in Figure 3.4.

### 3.3.1 User Research

Get to know the target user group:

- Qualitative research: observation of users and interviews.
- Classify users according to their characteristics.
- Draw up a *user profile* for each (potential) class of user, based on behavioural and demographic variables.
- Identify user goals and attitudes.
- Analyse workflow and context of work.
- Exploratory evaluation: which software is used, how is it used, and what is it used for.
- Draw up a set of typical *user scenarios*.

See Chapter 4.

### 3.3.2 Usability Benchmarking

- Analyse competing products or interfaces heuristically and empirically.
- Set measurable usability targets for your own interface.

See Chapter 5.

### 3.3.3 Interaction Design

Goal-oriented initial design of interface.

See Chapter 6.

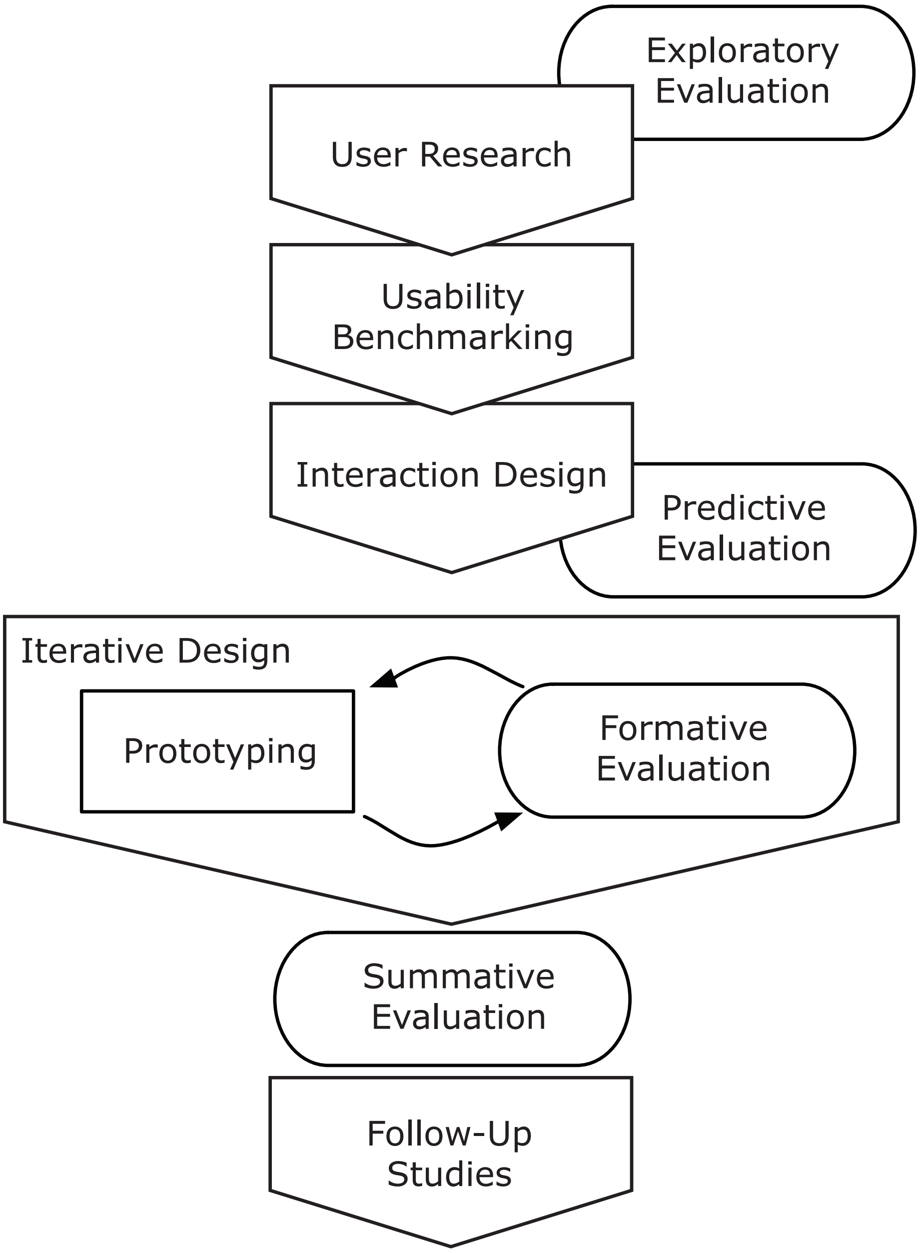


**Figure 3.4:** The usability engineering lifecycle. Adapted from a figure kindly provided by Martin Loitzl.

### 3.3.4 Iterative Design

"Design, Test, Redesign."

Build and evaluate prototype interface, then:

- *Severity ratings* of usability problems discovered.
- Fix problems → new version of interface.
- Capture *design rationale*: record reasons why changes were made.
- Evaluate new version of interface.

until time and/or money runs out.

A cycle of continuous improvement.

#### Building Prototypes

- Verbal description.
- Paper prototype.
- Interactive prototype.
- Working prototype.
- Implementation of final design.

See Chapter 7.

#### Formative and Summative Usability Evaluation

The usability evaluation methods are grouped according to who performs them:

- *Usability Inspection Methods*: Chapter 8.
- *Usability Testing Methods*: Chapter 9.

Both chapters include both formative and summative methods.

### 3.3.5 Follow-Up Studies

Important usability data can be gathered after the release of a product for the next version:

- Specific field studies (interviews, questionnaires, observation).
- Standard marketing studies (what people are saying in the newsgroups and mailing lists, reviews and tests in magazines, etc.).
- Analyse user complaints to hotline, modification requests, bug reports.
- Usage studies of longer-term use of product (see Section 9.11):
  - Diary studies.
  - Software logging: instrumented versions of software → log data.

– Observational studies.

## 3.4 Planning Usability Activities

1. Prioritise activities.
2. Write down explicit plan for each activity.
3. Subject plan to independent review (e.g. colleague from different project).
4. Perform pilot activity with about 10% of total resources, then revise plan for remaining 90%. [*Always* perform a pilot study!]

Chapter 4

# User Research

> *" I'm a very selfish designer: when I design sofware, I design it for me. And so my first task is to become you. "*
>
> [ Bruce Tognazzini, The Front Desk, BBC Video, 1996. [BBC 1996, 00:21:28] ]

Qualitative research is used to determine user characteristics, goals, and context of use.

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## 4.1 Classifying Users

Users can be classified according to their:

- experience
- educational level
- age
- amount of prior training, etc.

### Categories of User Experience

User experience can be thought of along three dimensions, as shown in Figure 4.1.

### Learning Curves

- Some systems are designed to focus on learnability.
- Others emphasise efficiency for proficient users.
- Some support both ease of learning and an “expert mode” (for example rich menus and dialogues plus a command/scripting language), and thus attempt to ride the top of the curves in Figure 4.2.

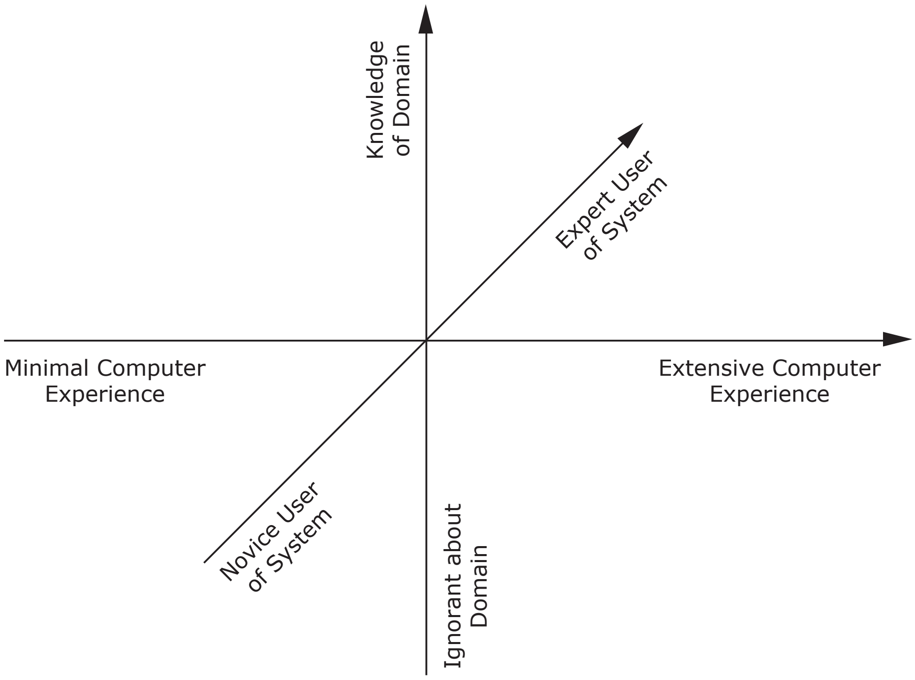


**Figure 4.1:** The three main dimensions on which user experience varies: experience of computers in general, understanding of the task domain, and expertise in using the specific system. Redrawn from Figure 3 of J. Nielsen [1993b, page 44].

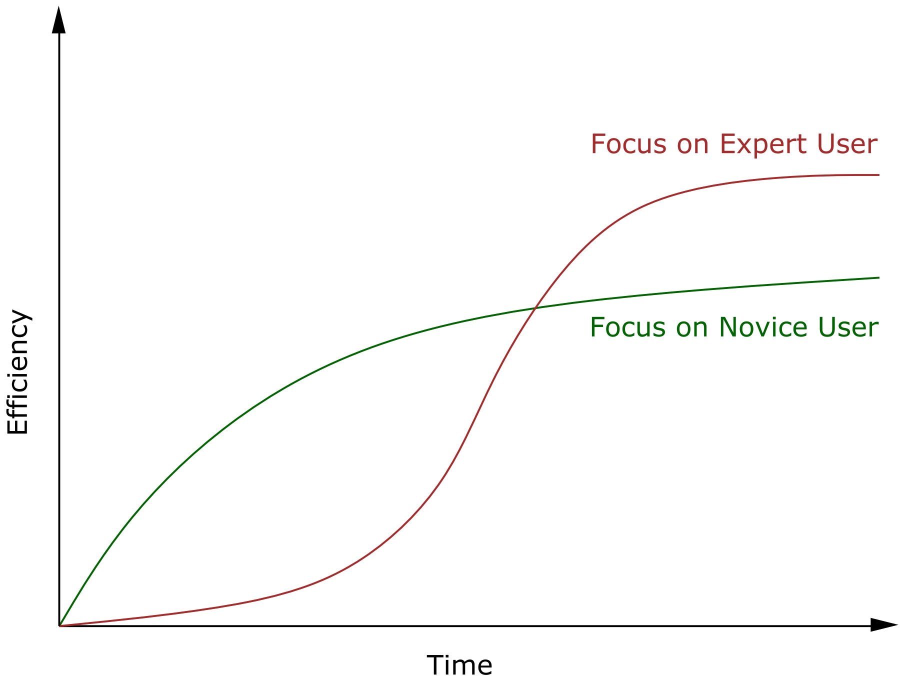


**Figure 4.2:** Learning curves for hypothetical systems focusing on the novice user (easy to learn, but less efficient to use) and the expert user (harder to learn, but then highly efficient). Redrawn from Figure 2 of J. Nielsen [1993b, page 28].

## 4.2 Research the Frames of Reference

Conduct interviews with:

- Project staff (managers, programmers, marketing people) who are in charge of developing the software.
- Subject matter and domain experts.
- Customers (the purchaser of the product, not necessarily the same as the end user).

to determine values, expectations, issues, and constraints.

#### Interviewing Project Staff

- One-on-one interviews.
- Try to discover:
  - vision of the product.
  - budget and schedule.
  - technical constraints.
  - perceptions of who users might be.

#### Interviewing Subject Matter Experts (SMEs)

- Often hired externally by project manager.
- Provide knowledge of complex domains, regulations, industry best practice.
- Often lean towards expert user perspective (rather than intermediate).

#### Interviewing Customers

- Customers are the people who make the decision to purchase.
- For consumer products, customers are often the same as users.
- For business settings, customers are rarely actually the users of a product.
- Try to discover the customer's:
  - goals in purchasing the product
  - frustrations with current solutions
  - decision process for purchasing
  - role in installation and maintenance

## 4.3 Focus on Researching the End User

The actual *users* of a product should always be the main focus of the design effort:

- Most people are incapable of accurately assessing their own behaviour [Pinker 1999].
- Rather than talk to users about how they think they behave, it is better to observe their behaviour first-hand.
- And then ask clarifying questions in the context of use.

### Ethnographic Interviews

A combination of immersive observation and directed interview techniques:

- Observe the user using their current tools in their normal environment.
- Interviewer assumes the role of an apprentice learning from the master craftsman (user).
- Alternate between observation of work and discussion of its structure and details.

### Identifying Candidate Users

Designers must capture the range of user behaviours regarding a product:

- What sorts of people might use this product?
- How might their needs vary?
- What ranges of behaviour might be involved?
- Which kinds of environment might be involved?

Try to interview some people from each different group.

### Examples

Whom would you interview if you were designing:

- An in-flight entertainment system?
- A corporate help desk?
- A complete hospital management system?
- A mobile phone with email capability?

### Conducting an Ethnographic Interview

- In actual workplace/environment.
- 45-60 minutes.
- No third parties (supervisors or clients).
- Focus on understanding:
  - Overall goals
  - Current tasks

  - Constraints and exceptions
  - Problems needing solution (where does it hurt?)
  - Broader context
  - Domain issues
  - Vocabulary
- Ask permission to take a few photographs of the user and their workplace (for creating personas).

#### Patterns of Use

When interviewing users, we are trying to discover patterns of use:

- Business products: Patterns of use are generally based on job responsibilities.
- Consumer products: Patterns of use are generally based on lifestyle (age, gender, occupation, etc).

#### Being an Active Listener

A good interviewer is an active listener:

- Use open body language: lean forward, hand under chin, arms open, eye contact.
- Use minimal encouragers: brief verbal cues (hmmm, uh-huh, oh?), nodding, tilting head sideways.
- Ask open-ended questions (how, when, what, why) to encourage elaboration.
- Use closed questions (can you, will you, do you) with yes/no or simple fact answer to clarify your understanding.
- Summarise to check you understand the important points: "So it sounds like the key points are...".

#### General Flow of Interview for Business Product

- Introductions.
- Why we're here: We've been asked to design/improve X.
- What we'll ask: your day, your background, your frustrations.
- Tell us about your responsibilities and your typical workday.
- Drill into specific tasks.
- How is existing product (if any) involved in those tasks.
- Relationships with other people and processes.
- Goals.
- Follow up on interesting points.
- Wrap-up.

### Good General Questions

- What do you spend most of your time on? [task priority]
- What things waste your time? [opportunity]
- Where does it hurt? [opportunity]
- What makes a good work day? A bad one? [goals]
- What kind of training do you have? [support to provide]
- What are the most important things you do? [priorities, goals]
- What information helps you make decisions? [info to provide]

### Video: Steve Portigal on User Research

- Clips from Steve Portigal's talk at Mind the Product 2019 [Portigal 2019, 07:24-]. (≈ 9 mins.) [Video: `https://youtu.be/zysjg457r6I?t=07m24s`]

# Chapter 5

# Usability Benchmarking

Usability benchmarking:

- How usable is the competition?
- How much better should your interface be?
- What is your likely return on investment (ROI)?
- Is your interface more usable than one year ago?

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## 5.1 Competitive Analysis

Competitive analysis of competing systems:

- Determine the current state of the art and decide how far to raise the bar.
- Analyse competing products or interfaces heuristically (run a heuristic evaluation) or empirically (run a thinking aloud test or formal experiment).
- "Intelligent borrowing" of ideas from other systems.

## 5.2 Set Usability Targets

Usability targets should be *concrete* and *measurable*:

- Decide in advance which usability metrics should be used and the desired target level of usability.

For example:

- The current system exhibits 4.5 errors per hour on average for an experienced user. The target for the new version is less than 3 errors per hour.
- From competitive analysis, on the main competing web site, novice users take 8 mins. and 21 secs. on average to book a flight. The target for our new web site is 6 mins.

## 5.3 Return on Investment

Estimate *return on investment* (ROI) by performing a financial impact analysis:

- Compare potential savings based on *loaded cost* of users to to the estimated cost of the usability effort.

# Chapter 6

# Interaction Design

> *" What should be in the designer's mind at the start of an interface project? That's simple. Nothing. "*

[ Don Norman, The Front Desk, BBC Video, 1996. [BBC 1996, 00:21:20] ]

Many of the ideas in this chapter are adapted from Alan Cooper's groundbreaking books "The Inmates are Running the Asylum" [Cooper 1999] and four editions of "About Face" [Cooper et al. 2014].

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| *Computers* | *Humans* |
|---|---|
| Incredibly fast | Incredibly slow |
| Error free | Error prone |
| Deterministic | Irrational |
| Apathetic | Emotional |
| Literal | Inferential |
| Sequential | Random |
| Predictable | Unpredictable |
| Amoral | Ethical |
| Stupid | Intelligent |

**Table 6.1:** There are incredible differences between computers and the humans who have to use them. [From Cooper [1999, page 87].]

| *Programmer* | *User* |
|---|---|
| Wants control,<br>will accept some complexity. | Wants simplicity,<br>will accept less control. |
| Wants to understand,<br>will accept some failure. | Wants success,<br>will accept less understanding. |
| Concerned with all possible cases,<br>will accept advance preparation. | Concerned with probable cases,<br>will accept occasional setbacks. |

**Table 6.2:** Programmers ("homo logicus") think and behave differently from normal humans (homo sapiens). They are more in tune with the needs of computers. [From Cooper [1999, pages 97–100].]

Always first assume that images are covered by copyright! Then check the exact licence terms, to see if you can use them.

Or, of course, you could generate realistic-looking imagery with generative AI tools.

### Computers Versus Humans

Computers do not work like humans (see Table 6.1).

- One part of software, the inside, must clearly be written in harmony with the demands of silicon.
- Equally, the other side of software, the outside, must be written in harmony with the demands of human nature.

### Programmers are Different

Programmers ("homo logicus") think and behave differently from normal humans (homo sapiens) and most users. See Table 6.2.

Programmers are good at designing the inside of software, interaction designers should design the outside.

### Goal-Oriented Interaction Design

Designing software based on an understanding of human goals.

| *Personal Goals* | *Corporate Goals* |
|---|---|
| Do not look stupid.<br>Not make mistakes.<br>Get adequate amount of work done.<br>Have fun. | Increase profit.<br>Increase market share.<br>Defeat competition.<br>Hire more people.<br>Go public. |

**Table 6.3:** Personal and corporate goals are different. Both must be taken into account for software to succeed, but personal goals will always dominate. [From Cooper [1999, pages 157–158].]

What is a goal?

- A *goal* is a final purpose or aim, an objective.
- *Tasks* are particular ways of accomplishing a goal.

There may be multiple ways of achieving a goal.

### Tasks are not Goals

- *Goal*: Satisfy hunger.
- *Task*: Go to the restaurant around the corner. Or
- *Task*: Call the pizza delivery service. Or
- *Task*: Go to the supermarket, buy ingredients, and cook for myself.

Too often, software designers focus on simplifying a task, rather than accomplishing a goal.

Tasks are a means to an end, not an end in themselves.

### Personal and Corporate Goals

Personal and corporate goals are different (See Table 6.3).

- Both are important for their respective owners (so both must be taken into account).
- However, people are using the interface, and their personal goals will always take precedence.

### The Interaction Design Process

1. Interview users.
2. Create personas.
3. Define their goals.
4. Create concrete scenarios.
5. Move to a design solution.

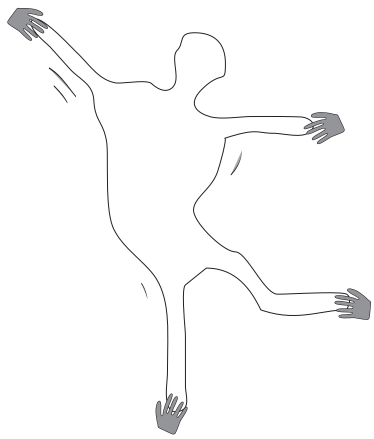


**Figure 6.1:** The term "user" is elastic and is liable to be bent and stretched by the programmer to the needs of the moment. [Redrawn from Cooper [1999, page 127].]

### The Design Team

Two designers in core team:

- Designer: generates ideas, leads the process.
- Design Communicator: articulates half-formed ideas, writes design spec.

## 6.1 Creating Personas

From the insight you gained in your interviews, you now invent user archetypes to represent the main user groups of your product.

In other words, you make up pretend users and design for them.

### The Elastic User

All too often, the term "user" is bent and stretched by the programmer to adapt to the needs of the moment (see Figure 6.1):

- When a developer finds it convenient to open a file browser, the user is presumed to be an experienced, computer-literate user.
- When a developer finds it convenient to use a step-by-step wizard, the user is redefined to be an obliging first-time novice.

Never refer to "the user", instead refer to a very specific individual, a persona.

### Do Not Design for the Average User

- Designing for the "average" user produces a design to please no-one, like the jumble car in Figure 6.2.
- Differentiate primary kinds of user and design for them, like the cars in Figure 6.3.

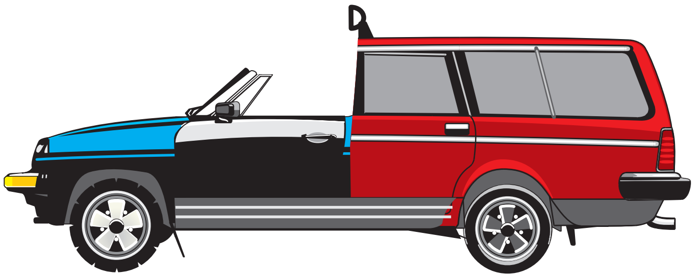


**Figure 6.2:** The jumble car was designed for the "average" driver.

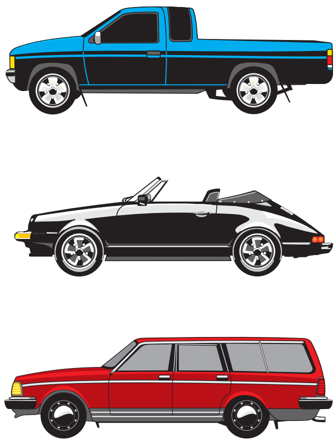


**Figure 6.3:** Cars are designed to appeal to different kinds of drivers with different needs and goals.

### What is a Persona

A *persona* is a prototypical user:

- An imaginary, but very specific, example of a particular type of user.
- Not "real", but hypothetical.

A persona is used to role-play through an interface design and check if the design would meet the needs of such a user.

### Define the Persona Precisely

- Specify a name, age, face, and quirky, believable detail.
- For faces, use stock photos from the internet, photographs taken during user interviews, or realistic AI-generated images.
- It is more important to define the persona in great and specific detail, so that it cannot wiggle under the pressure of development, than that the persona be exactly the right one.

### Finding Primary and Secondary Personas

- Start off with a larger set of personas.

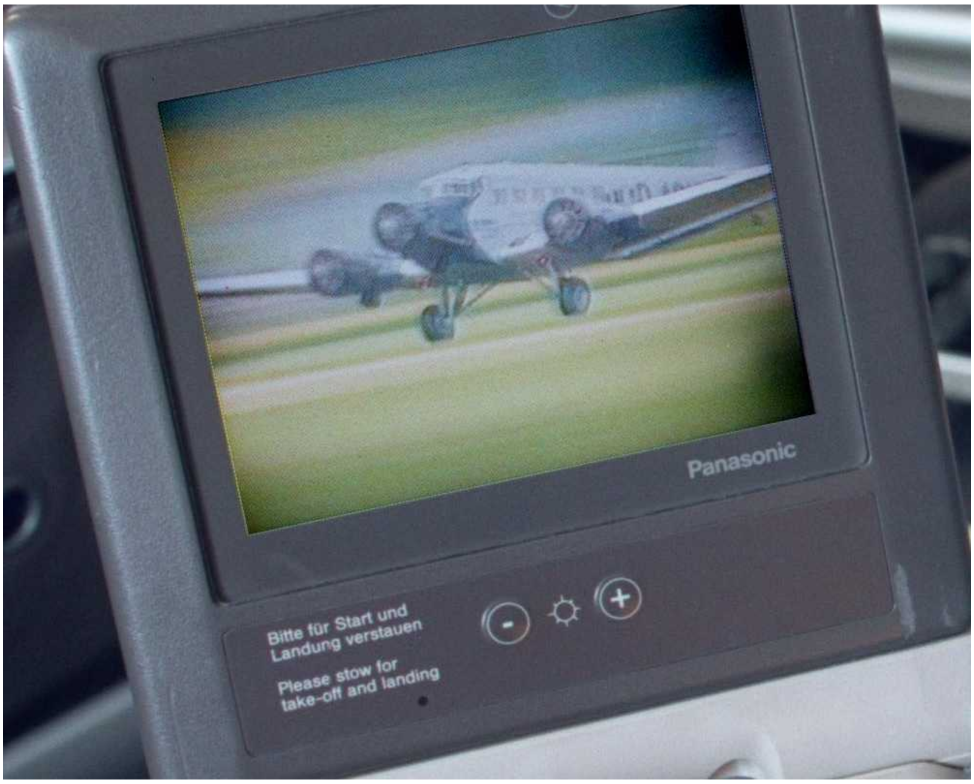



**Figure 6.4:** The InFlight seat console.

- Combine or throw out redundant personas.
- A *primary* persona will not be satisfied with a design for someone else.
  - If there are multiple personas with radically different needs, there are multiple primaries.
  - Each primary gets their own interface.
- A *secondary* persona is mostly satisfied with a primary's interface, but has a specific additional need.

### Case Study: In-Flight Entertainment System

Fictional example based on Cooper [1999], an inflight entertainment system called InFlight for Zoom Airways.

At each seat a touch-screen video console (see Figure 6.4):

- 36 films in five categories, 36 music channels, news, childrens shows, games, shopping.
- computers + large hard disks in front of the plane.
- true video on demand – each passenger can start, pause, and rewind programmes independently.

### Case Study: Two Separate Interfaces

- One for the passengers in the seat console. The four main passenger personas are shown in Table 6.4.
- A different one for employees in the attendant's station.

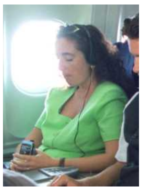
| | |
|---|---|
|  | **Name:** Clevis McQuinn<br>**Age:** 63<br>**Class:** Economy<br>Clevis was born and still lives in a small town in Texas. He only flys once or twice a year to visit his daughter who lives in Boston.<br>Clevis might be old, but he is still spry. He is slightly embarassed about the touch of arthritis in his hands, but his mind is still very sharp.<br>Clevis does not own a computer and does not know how to use one. He is firmly of the opinion that you can get by without one.<br>Clevis had to start wearing glasses about 5 years ago, because his eyesight was starting to fail him. |
|  | **Name:** Marie Dupart<br>**Age:** 31<br>**Class:** Business<br>Marie was born in France, but has been living and working in the USA for 6 years. She is bilingual, but English is her second language.<br>Marie travels on business several times times a year. She is a self-confident young woman, who is not afraid of modern gadgetry. She owns the latest iPhone.<br>Marie does much of her shopping online. She is also very interested in the latest show business gossip in the entertainment media. |
|  | **Name:** Chuck Burgstein<br>**Age:** 52<br>**Class:** First<br>Chuck is a resident of New York who flies almost every week. He is a member of the 100,000-mile club. He has an extremely hectic lifestyle and spends more than 100 nights a year in hotel rooms.<br>Chuck expects service here and now and has little tolerance for condescending or time-consuming activities.<br>Chuck has strong opinions, which he is not shy to express. Even if he is usually right, other people do find his in-your-face manner somewhat irritating. |
|  | **Name:** Erin Scott<br>**Age:** 9<br>**Class:** Economy<br>Erin lives Austin, Texas and is going to stay with her aunt and uncle in upstate New York for two weeks.<br>She is a little bit nervous, but also excited about travelling unacompanied for the first time.<br>Erin likes drinking fizzy orange pop. At home she will often spend hours on her computer playing games. |

**Table 6.4:** The four main passenger personas.

### Case Study: Who are the Primary Passenger Personas?

The seat console interface has to satisfy Chuck, Erin, Marie, and Clevis, while at the same time not making any of them unhappy.

- Erin knows wanting to play games is something special, so she does not mind pressing a few extra buttons to get them.
- Chuck knows his vast flying experience has earned him some shortcuts, but he does not mind investing a little effort into remembering those special commands.
- Marie is similar to Chuck, and both would be annoyed by time-consuming training screens for new users.
- Clevis is the golden nugget, the primary persona. A menu bar or dialogue box would instantly lose Clevis. With arthritis, any complex manipulation is out of the question. An interface designed for Clevis will be acceptable to all the others, as long as their special needs are accommodated somewhere in the interface.

### Case Study: Designing for Clevis

Clevis can not and will not “navigate”, so there can be only one screen:

- Horizontal scrolling panoply of film posters and album covers.
- A large rotating knob (a “data wheel”) physically below the screen, which can be spun like a radio wheel.
- Clevis views the posters as if strolling past, no need to even think in terms of film categories.
- Navigation bar across bottom of screen, feedback where we are and with jump scrolling for Chuck.

See Figure 6.5.

### A Good Persona

- A good persona is not “average”, but typical and believable.
- If the set of users interviewed were somehow plotted according to their characteristics as a cloud of points, the best ones to base personas on would be the ones around the edges. See Figures 6.6, 6.7, and 6.8.
- If our design satisfies the hard cases around the edges, the ones in the middle should be able to use the interface as well.

### Video: Illustrating the Persona Design Process

- A 3d animation to illustrate the persona design process, created by Keith Andrews and Ines Legnar in 2012.
- A set of 14 blue spheres represent real users, whose characteristics are known from user research, as shown in Figure 6.6.


**Figure 6.5:** The InFlight final design.

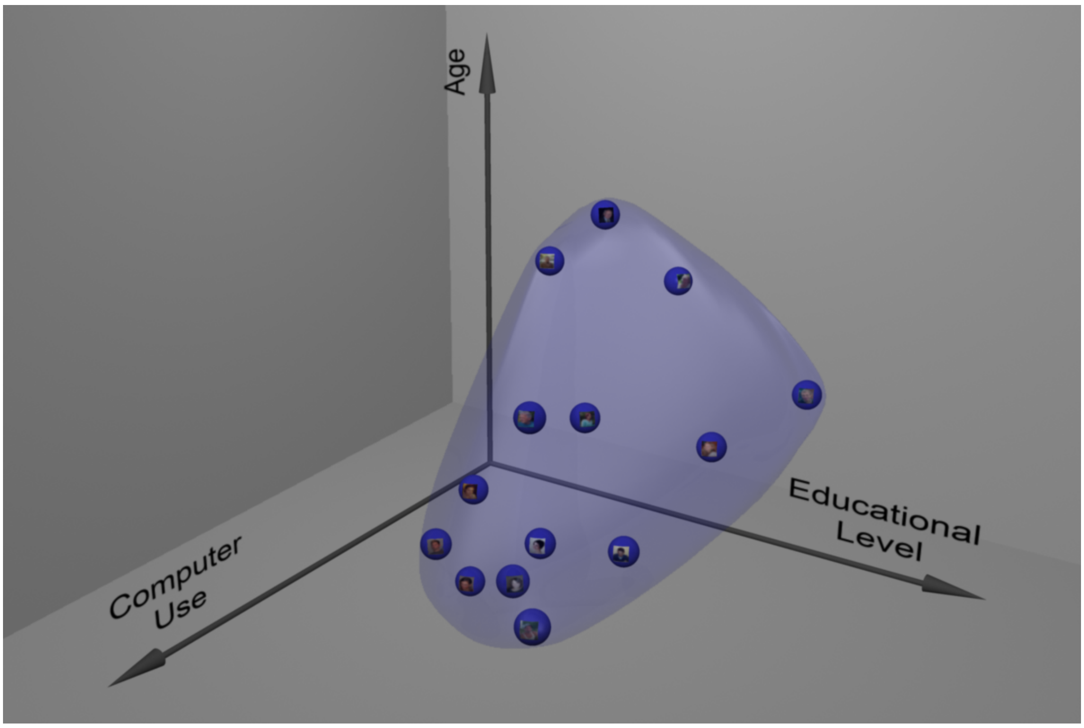



**Figure 6.6:** Users form a point cloud based on their characteristics.

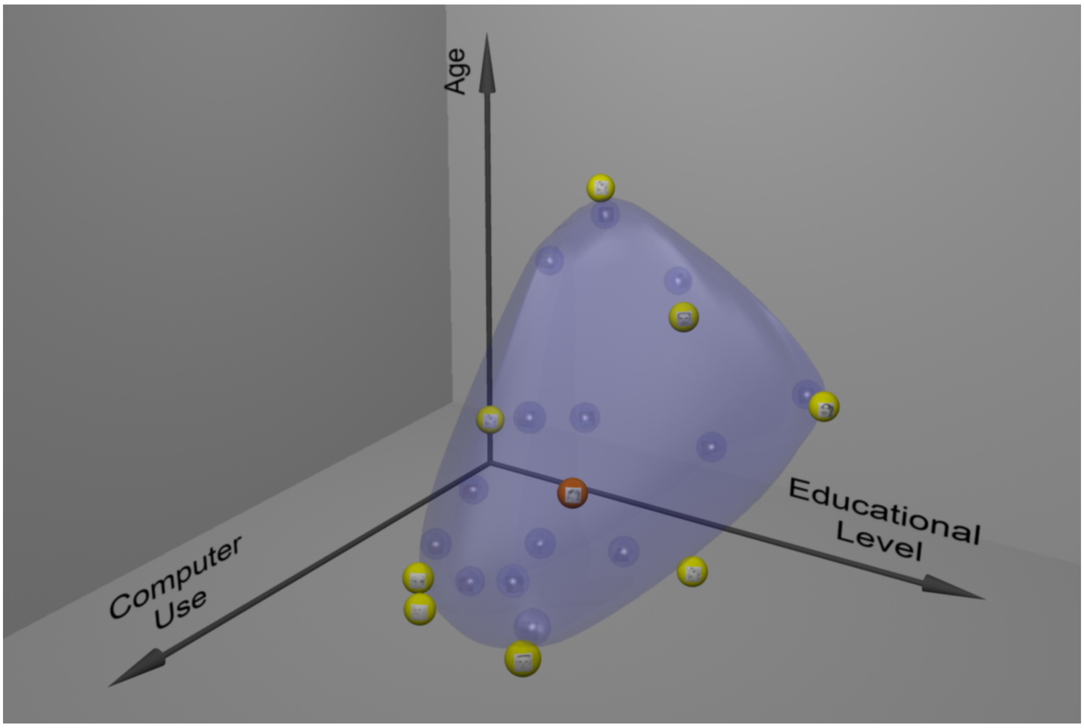



**Figure 6.7:** Good candidate personas (yellow) often lie around the edges of the point cloud. The "average" user (orange) does not make a good design target.

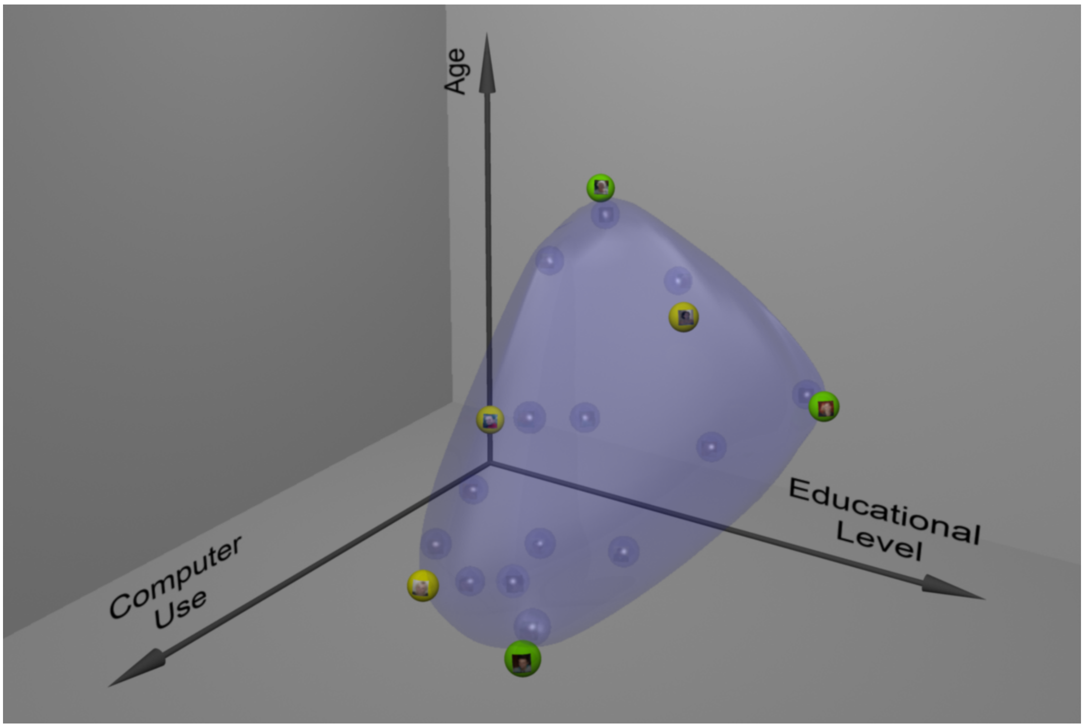



**Figure 6.8:** Some candidate personas have been eliminated or merged. In this example, three personas have been determined to be primary personas (green). The personas have been given names and photographs to make them more believable.

- They are placed within three (exemplary) dimensions, according to the characteristics age, educational level, and computer experience.
- The users form a “point cloud”.
- Good candidate personas (yellow) tend to represent the edge cases of user characteristics around the edges of the point cloud, as shown in Figure 6.7.
- A persona in the middle of the point cloud would represent the “average” user (orange) and does not generally make a good design target.
- Personas are given names and photographs to make them more believable.
- Finally, personas are divided into primary and secondary personas (by analysing who will not be satisfied with a design made for someone else). In Figure 6.8, three primary personas were identified.

## 6.2 Defining Goals for each Persona

Goals and personas co-exist:

- A persona exists to achieve his or her goals.
- A goal exists to give meaning to a persona.

  Define the goals of each persona.

## 6.3 Defining Scenarios for each Persona

A scenario is a precise description of a persona using an interface to achieve a goal:

- *Daily Use Scenarios*: The actions users perform regularly and frequently. These need the most robust design.
- *Necessary Use Scenarios*: More occasional, infrequent actions, but which are necessary from time to time.
- *Edge Case Scenarios*: Loved by programmers, these can usually be ignored during the design process.

As the design progresses, play act the personas through the scenarios to test the validity of the design.

## 6.4 Moving to a Design Solution

### Parallel Design

- If time and resources allow, explore design alternatives.
- Have several design teams work *independently*, then compare draft designs (see Figure 6.9).

### Brainstorm

- Meet away from usual workplace (different building, hut in the mountains).

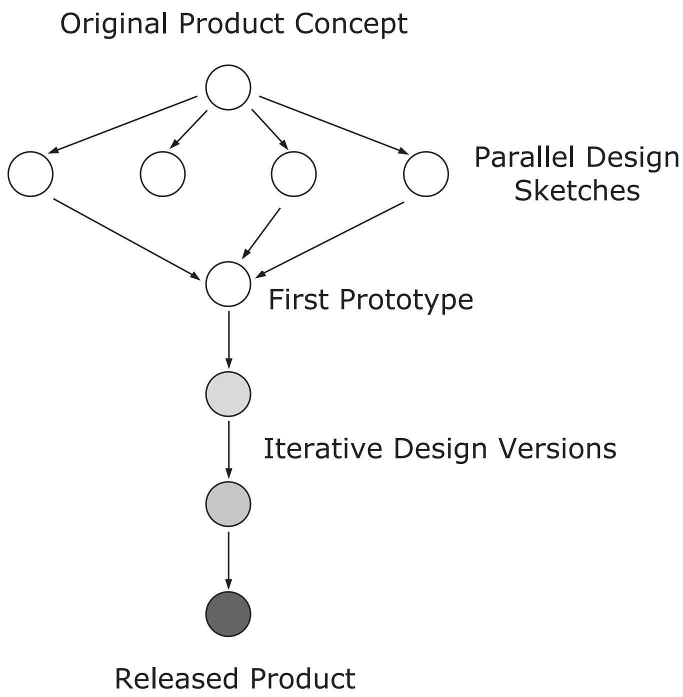



**Figure 6.9:** The relationship between parallel and iterative design. The first prototype is based on ideas from parallel design sketches. [Redrawn from Figure 8 of J. Nielsen [1993b, page 86].]

- Brainstorm with mixed team (engineers, graphic designer, writer, marketing types, usability specialist, one or two representative users).
- Use plenty of paper. Cover the walls with it!
- Draw. Scribble. Use lots of coloured pens.
- Be stupid.
- Go crazy, build on the insane, think laterally (see Figure 6.10).
- Three rules during brainstorming:
  1. No one is allowed to criticise another's ideas.
  2. Programmers must not say it can't be implemented.
  3. Graphic designers must not laugh at programmers' drawings.
- Only *after* brainstorming, organise ideas and consider their practicality and viability.

Adapted from Tognazzini [1992, page 67].

### Four Techniques for Getting Unstuck

- *Pretend It's Magic*: If it were magic, it would do X. If we can not do X, how close can we get?
- *Pretend It's Human*: What response would the persona expect from a human?
- *Getting Another Brain*: 15-minute rule. If a team is stuck for more than 15 minutes, ask another

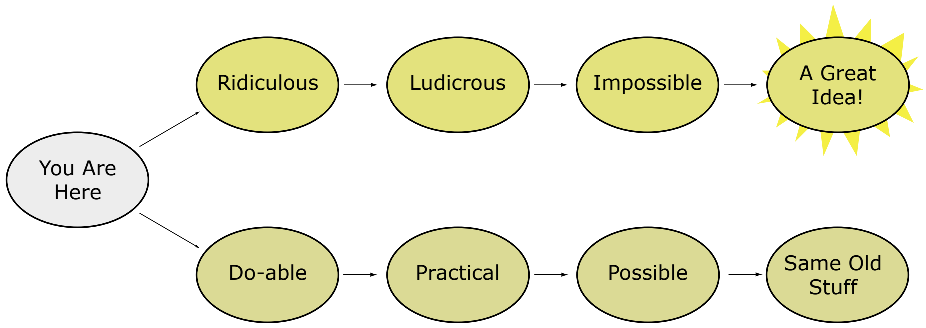



**Figure 6.10:** Lateral thinking. Build on the crazy to generate new ideas. [Redrawn from Cooper [1999, page 188], based on the ideas of de Bono [1970]] .

designer for help.

- *Renaming*: Sometimes, a lack of common vocabulary is the problem. In this case, give elements new names in a silly theme (types of cheese, mountain ranges), define what they mean, and give them real names later.

### Pretend It's Magic

What would these things do if they were magic?

- TV/VCR entertainment system
- Telephone/voicemail
- Calendar software
- Microsoft Windows

## 6.5 Getting Ideas from Your Users

### Quick Surveys for Menu Organisation

A simple user survey can quickly tell you where users would expect to find certain functionality.

Figure 6.11 shows a survey to place word processing functions.

[This is, in fact, a quick and dirty version of a closed card sorting test.]

Under which pull-down menu would you most expect to find each of the word processing tasks below?

*File Edit View Insert Format Utilities Macro Window*

1. Search for a word: __________
2. Create a header: __________
3. Create an index entry: __________
4. Set up your document preferences: __________
5. Repeat an annotation: __________
6. Paste another file into your current file: __________
7. Use italics: __________
8. Show summary stats about your document: __________
9. Switch to another document: __________
10. Show all annotations in the document: __________
11. Repaginate the document: __________
12. Set up your printer: __________

**Figure 6.11:** A quick user survey on menu organisation.

## 6.6 Follow Conventions

Following the standard way of doing things is generally good:

- Users can then *transfer knowledge* as they move between applications.
- Only break the convention for good reason.

### Link Styles

- Users should not have to guess where they can click (or have to scan the screen with the mouse to see what is clickable).
- For textual links, use coloured and underlined text (and do *not* underline non-link text).
- Distinguish between visited and unvisited links.
- By convention, unvisited links are blue underlined, visited links are purple underlined. This is is a good default choice. See Figure 6.12.
- If you do choose to use a different link style, at least use it *consistently* across your site. See Figure 6.13.

### An Asterisk Means a Required Field

- In the context of a web form, a field marked with an asterisk (*) has come to mean a *required* field.
- Do not change this meaning arbitrarily, as Avis did on their web site in 2005, shown in Figure 6.14.

useit.com → Alertbox → Oct. 2005 Top Ten Web Design Mistakes of 2005 Search

Jakob Nielsen's Alertbox, October 3, 2005:

**Top Ten Web Design Mistakes of 2005**

**Summary:**
The oldies continue to be goodies — or rather, baddies — in the list of design stupidities that irked users the most in 2005.

For this year's list of worst design mistakes, I decided to try something new: I asked readers of my newsletter to nominate the usability problems they found the most irritating.

I assumed that asking for reader input would highlight many issues that I hadn't noticed in my own user testing. This was not the case. Instead, all of the top thirty problems were covered in existing usability guidelines. Thus, when you read this year's top ten list, you'll probably say, "Yes, I've heard about this before." That's okay.

There's value in reminding ourselves of past findings and raising their priority on the agenda of things to be fixed. Because these mistakes continue to be so common, it makes sense that people continue to complain about them the most.

**1. Legibility Problems**

Bad fonts won the vote by a landslide, getting almost twice as many votes as the #2 mistake. About two-thirds of the voters complained about **small font sizes** or frozen font sizes; about one-third complained about **low contrast** between text and background.

For more info on resizable text and readability, see my 2002 column, "Let Users Control Font Size."

**2. Non-Standard Links**

Following are the five main guidelines for links:

- Make obvious what's clickable: for text links, use colored, underlined text (and don't underline non-link text).
- Differentiate visited and unvisited links.
- Explain what users will find at the other end of the link, and include some of the key information-carrying terms in the anchor text itself to enhance scannability and search engine optimization (SEO). Don't use "click here" or other non-descriptive link text.
- Avoid JavaScript or other fancy techniques that break standard interaction techniques for dealing with links.
- In particular, don't open pages in new windows (except for PDF files and such).

Links are the Web's number one interaction element. Violating common expectations for how links work is a sure way to confuse and delay users, and might prevent them from being able to use your site.

**Figure 6.12:** Jakob Nielsen's web site `useit.com` used the conventional link sytle of blue underlined for unvisited links and purple underlined for visited links [J. Nielsen 2005].

**Ausland** Zehntausende bei Demo gegen Mafia in Süditalien

Hamas feuert Granaten auf Israel

**Weitere Proteste trotz Notstands in Jemen**

Trotz eines am Vortag verhängten Ausnahmezustands sind heute die Proteste gegen die Herrschaft von Präsident Ali Abdullah Saleh im Jemen weitergegangen. Zehntausende Menschen versammelten sich im Zentrum von Sanaa, um den Rücktritt des Staatschefs zu fordern.

**Erster Minister verlässt Regierung**

Derweil trat, wie die „Yemen Post" heute berichtete, der jemenitische Tourismusminister Nabil al-Fakih von seinem Amt zurück. Er ist das erste Regierungsmitglied, das aus Protest gegen die massive Gewaltanwendung des Regimes den Hut nahm.

Am Vortag hatten Scharfschützen in Zivil von Dächern aus auf die Massendemonstrationen geschossen. 44 Menschen waren nach offiziellen Angaben getötet worden, 240 weitere erlitten Verletzungen.

**Mehr** dazu in **Ausnahmezustand verhängt**

Wieder Hunderte Flüchtlinge auf Lampedusa gelandet

Ex-US-Außenminister Warren Christopher tot

**Figure 6.13:** Non-Standard and inconsistent link styles at `orf.at`. There are three different styles for links: white, bold black, and bold blue-grey. Furthermore, bold black is used inconsistently: the first bold black text (Ausland) is not clickable, the second (Weitere Proteste...) is, the third (Erster Minister...) is not. Users can no longer predict what is a link and what is not.

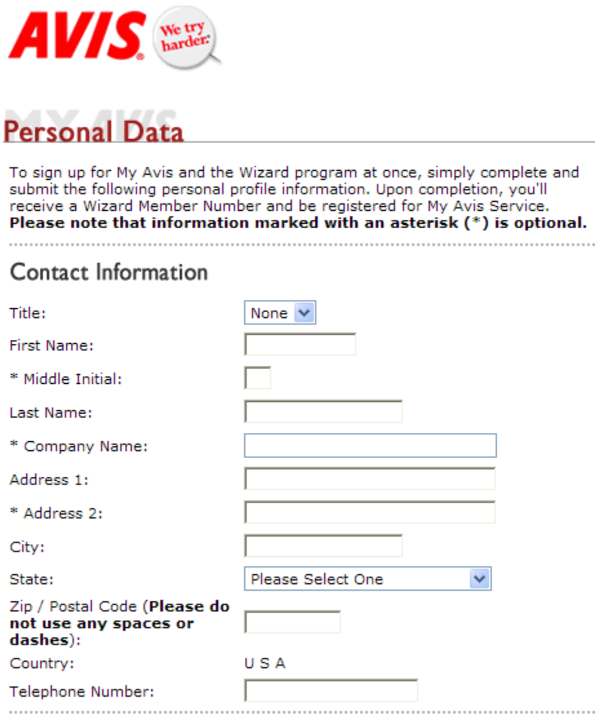



**Figure 6.14:** In 2005 the Avis web site used an asterisk to indicate an *optional* field, breaking the convention that an asterisk means *required*. This caused confusion to their users. [Image used with kind permission of Jared Spool [Spool 2005]]

- These three fields were the only three optional fields on their site.
- Rather than place asterisks meaning *required* next to dozens of other fields (a terrible waste of asterisks), Avis' web designers thought it reasonable to redefine the meaning of an asterisk to indicate an *optional* field.
- Breaking the convention caused unnecessary confusion to their users.
- Avis redesigned the site to follow the conventional meaning where an asterisk indicates a *required* field, as shown in Figure 6.15.
- See Jared Spool's article [Spool 2005] and talk video [Spool 2010, 01:50–03:52]. [Video: `https://youtu.be/ucVeyVgt6Rg?t=01m50s`]

### Platform Conventions

Platform conventions are the accepted way of doing things on a particular platform:

- Apple; Human Interface Guidelines, 1987 [Apple 1987]
- Apple; Human Interface Guidelines, 2025. `https://developer.apple.com/design/human-interface-guidelines/`
- Microsoft Windows User Experience, Microsoft Press, September 1999. [Microsoft 1999].
- Microsoft; Design for Windows Apps, 11 May 2024. `https://learn.microsoft.com/en-us/windows/apps/design/`

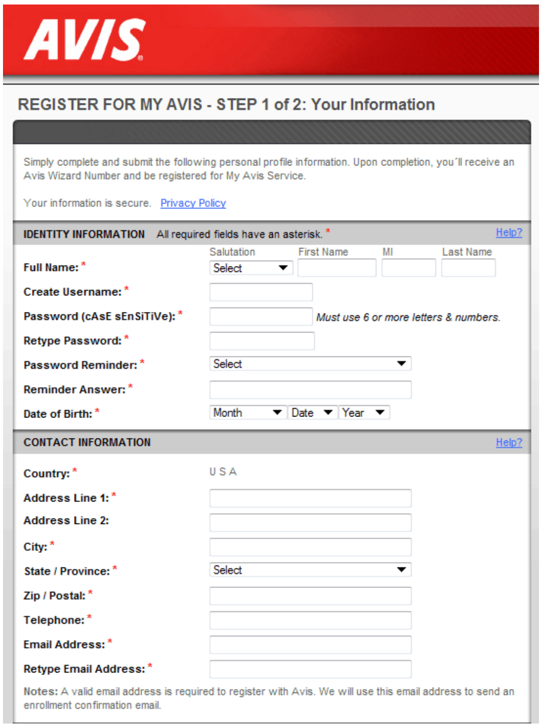



**Figure 6.15:** Avis redesigned the site to follow the conventional meaning where an asterisk indicates a *required* field. Here, the same form in 2011.

- Java Look and Feel Design Guidelines, Sun Microsystems, July 1999. [Sun 1999]
- Material Design; 2025. `material.io`

They are often supported by *widget libraries* of shared code.

## 6.7 User Interface Patterns

- *Design Pattern*: a best-practice solution to a particular design problem.
- *Anti-Pattern*: an example of bad practice.
- *Dark Pattern*: an example of a carefully crafted solution designed to mislead users.

### Design Patterns

A design pattern descibes a best-practice solution to a particular design problem.

Look for *design patterns* for your particular situation: platform-independent tried-and-tested solutions to common design problems (for example, the shopping cart design pattern for an e-commerce web site).

### References

+ Tidwell, Brewer, and Valencia; *Designing Interfaces: Patterns for Effective Interaction Design*; 3rd Edition, O'Reilly, 30 Jan 2020. ISBN 1492051969 (com, uk) [Tidwell et al. 2020]

+ Christopher Alexander et al; *A Pattern Language*; Oxford University Press, 1977. ISBN 0195019199 (com, uk) [Alexander et al. 1977]

◦ van Duyne, Landay, and Hong; *The Design of Sites: Patterns, Principles, and Processes for Crafting a Customer-Centered Web Experience*; 2nd Edition, Prentice Hall, Dec 2006. ISBN 0131345559 (com, uk) [van Duyne et al. 2006]

◦ Bill Scott and Theresa Neil; *Designing Web Interfaces: Principles and Patterns for Rich Interactions*; O'Reilly, 26 Jan 2009. ISBN 0596516258 (com, uk) [Scott and Neil 2009]

◦ Martijn van Welie and Gerrit van der Veer; *Pattern Languages in Interaction Design*; Proc. Interact 2003. [van Welie and van der Veer 2003]

+ Harry Brignull; *Deceptive Patterns*; Testimonium, 30 Jul 2023. ISBN 1739454405 (com, uk) [Brignull 2023]

### Online Resources

+ *UI Patterns*; `https://ui-patterns.com/patterns`

◦ Martijn van Welie; *Interaction Design Pattern Library*; `https://web.archive.org/web/20230824034030/http://welie.com/patterns/`

◦ Nick Babich; *Basic Patterns For Mobile Navigation: Pros And Cons*; Smashing Magazine, 10 May 2017. `https://smashingmagazine.com/2017/05/basic-patterns-mobile-navigation/`

◦ Harry Brignull; *Dark Patterns*; `deceptive.design` (was `darkpatterns.org`)

### Hierarchy of Patterns (from Architecture)

Design patterns are sample design solutions based on good practice (Musterlösungen):

- Knobs
- Doors
- Walls
- Rooms
- Buildings
- Communities
- Regions

Different patterns are available at each level of abstraction.

### Hierarchy of Patterns (from Web Design)

A heuristically-derived system of pluggable interface components:

- Radio Buttons
- Forms

- Search Interface
- Page Layout
- Navigation System
- Site Architecture
- Site Genre

Different patterns are available at each level of abstraction.

### Video: Dark Patterns

- Harry Brignull; *Dark Patterns*; UX Brighton Conference 2010, 29-minute video [Brignull 2010, 05:22–12:09]. [Video: `https://youtu.be/1KVyFio8gw4?t=05m22s`]

### Style Guides and Design Systems

In contrast to design patterns, style guides and design systems document the patterns (to be) used on one particular suite of interfaces.

### Video: Inventing on Principle

- Bret Victor; *Inventing on Principle*; 54-minute video [Victor 2012, 01:54–09:30]. [Video: `https://youtu.be/PUv66718DII?t=01m54s`]
- Bret describes a principle he calls *immediate feedback*, but which is more generally known as *direct manipulation* [Shneiderman 1983].
- That kind of editing is sometimes known as *live coding* or *live programming*: `https://liveprog.org/all-programs.html`
- There are many live coding projects inspired by Bret's talk: `http://stackoverflow.com/questions/9448215/tools-to-support-live-coding-as-in-bret-victors-inventing-on-principle-talk`
- I have not been able to locate Bret's original editor anywhere.
- Bret blogs at `worrydream.com`.

# Chapter 7

# Prototyping

> *“ There’s a mantra at IDEO:* “Never go to a meeting without a prototype.” *At whatever stage of development, one week, one month, or 6 months. ”*
>
> [ Tim Brown, President of IDEO, speaking at CHI 2004 in Vienna. ]

Perform usability evaluation and obtain feedback as *early* as possible in the design cycle by building and evaluating prototypes.

### References

++ Carolyn Snyder; *Paper Prototyping*; Morgan Kaufmann, 2003. ISBN 1558608702 (com, uk) [Snyder 2003]

\+ Bill Buxton; *Sketching User Experiences*; Morgan Kaufmann, 2007. ISBN 0123740371 (com, uk) [Buxton 2007]

◦ Marc Rettig; *Prototyping for Tiny Fingers*; CACM, 37(4), 1994. [Rettig 1994].

◦ Carolyn Snyder; *Using Paper Prototypes to Manage Risk*; Software Design and Publisher Magazine, 1996. `https://articles.uie.com/prototyping_risk/`

◦ Snyder and Lahti; *Paper Prototyping Tricks*; 12 min. videotape. User Interface Engineering, 1995. `uie.com`

◦ Jakob Nielsen; *Paper Prototyping: A How-To Training Video*; 32 min. video (DVD). Nielsen Norman Group, 2003. `https://nngroup.com/videos/paper-prototyping-tutorial/` `https://youtu.be/OlbdIXLunt4`

### Online Resources

◦ Google; *Rapid Prototyping*; Google for Entrepreneurs; 08 Aug 2016. Three-part short video series; `https://youtu.be/JMjozqJS44M`

◦ Patrick Thornton; *How to do Paper Prototyping*; 23 Mar 2019. `https://uxdesign.cc/how-to-do-paper-prototyping-719173215a7e`

◦ Nick Babich; *The Magic of Paper Prototyping*; UX Planet; 02 Sep 2018. `https://uxplanet.org/the-magic-of-paper-prototyping-51693eac6bc3`

- ◦ Shawn Medero; *Paper Prototyping*; A List Apart; 23 Jan 2007. https://alistapart.com/article/paperprototyping
- ◦ Carolyn Snyder; *Streamlining the Design Process with Paper Prototyping: An Interview with Carolyn Snyder*; User Interface Engineering, 30 Jan 2007. https://articles.uie.com/snyder_interview/
- ◦ Jared Spool; *Looking Back on 16 Years of Paper Prototyping* ; User Interface Engineering, 27 Jul 2005. https://articles.uie.com/looking_back_on_paper_prototyping/
- ◦ Tara Scanlon; *Paper Prototypes: Still Our Favorite*; User Interface Engineering, 01 May 1998. https://articles.uie.com/paper_prototyping/
- ◦ Matthew Klee; *Five Paper Prototyping Tips*; User Interface Engineering, 01 Mar 2000. https://articles.uie.com/prototyping_tips/
- ◦ Prototypr.io; Prototyping news, stories, tool reviews, etc. prototypr.io
- + UX Design Tools Survey; https://uxtools.co/survey/2023/

#### The Prototype Becomes the Product

- Historically, best practice was to throw the prototype away and implement the final design (efficiently) from scratch.
- With the advent of agile development and designing in the web browser, that practice is changing.
- It is now quite common to incremetally develop a prototype until it becomes the product.

## 7.1 Types of Prototype

In increasing order of complexity:

- *Verbal Prototypes*: textual description of choices and results.
- *Paper Prototypes*:
  - *Low-Fidelity*: hand-drawn paper sketches.
  - *High-Fidelity*: more elaborate paper printouts.
- *Interactive Prototypes*: interactive prototypes for testing purposes only.
- *Working Prototypes*: interactive, skeleton implementations in code.

## 7.2 Verbal Prototypes

- Simple textual description of choices and results.
- Write the user guide first, before anything is implemented. Have it reviewed by someone else.

## 7.3 Low-Fidelity Paper Prototypes

- Paper prototypes simulate screen and dialogue elements on paper.

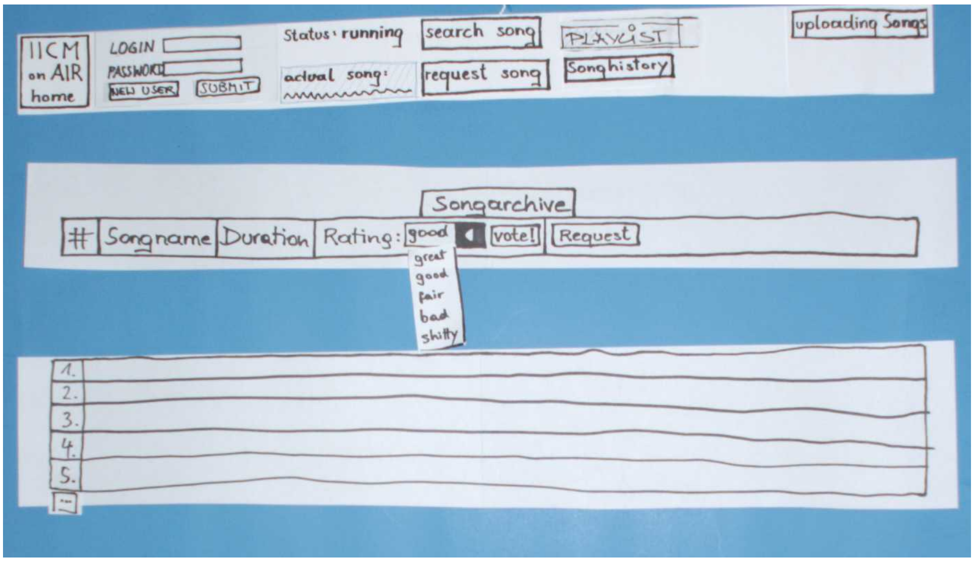



**Figure 7.1:** Paper prototype of IICM on Air.

- First hand-drawn sketches (lo-fi), later perhaps more elaborate printouts (hi-fi).
- Early usability feedback with throwaway designs: *maximum feedback for minimum effort!*
- Greeking (drawing squiggly lines) is used to represent text which would otherwise be a distraction.
- Figures 7.1 and 7.2 show paper and working prototypes for an online radio station.
- Excalidraw is an open-source editor for sketching hand-drawn style diagrams and prototypes [Excalidraw 2025].

### Paper Prototype of Customer Information Terminal

- Design interface for customer information terminal to be placed in branches of the (fictional) Northumberland Bank.
- Specifically prototype the loans section: tasks include information about loans and calculation of loan repayments.
- Figures 7.3, 7.4, and 7.5 show three of the paper prototypes developed.
  [Thanks to Cliff Brown, Northumbria University, for permission to use these images.]

### Testing with Low-Fidelity Paper Prototypes

Some examples:

- *Blood Testing Kiosk*; UCID Paper Prototyping Project, 2009. [Video: `https://youtu.be/_g4GGtJ8NCY`]
- *T-shirt Vending*; UCID Paper Prototyping Project, 2009. [Video: `https://youtu.be/-PZmX1Lt3Ro`]
- Paul Wilshaw; *Low Fidelity Prototype Testing of the YouTube Website*; UX Playground, 2015. [Video: `https://youtu.be/aDqbMOI13o4`]
- Chakib Labidi; *Paper-Based Prototype Testing (National Rail Enquiries App and snozoneuk.com)*; UX Playground, 2015. [Video: `https://youtu.be/Car4IlhY3_0`]

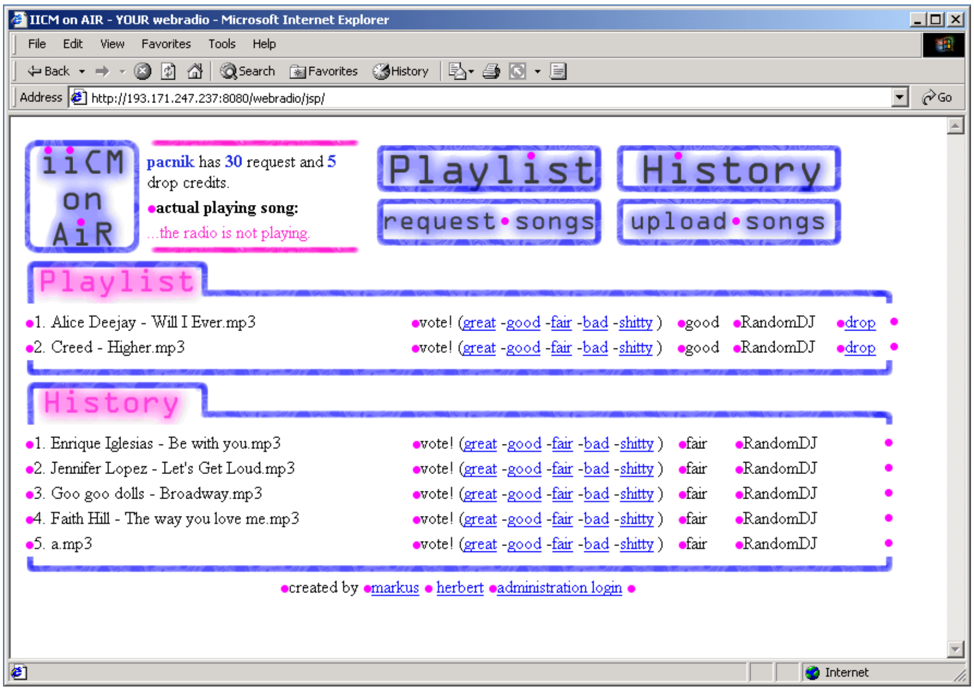



**Figure 7.2:** Working prototype of IICM on Air.

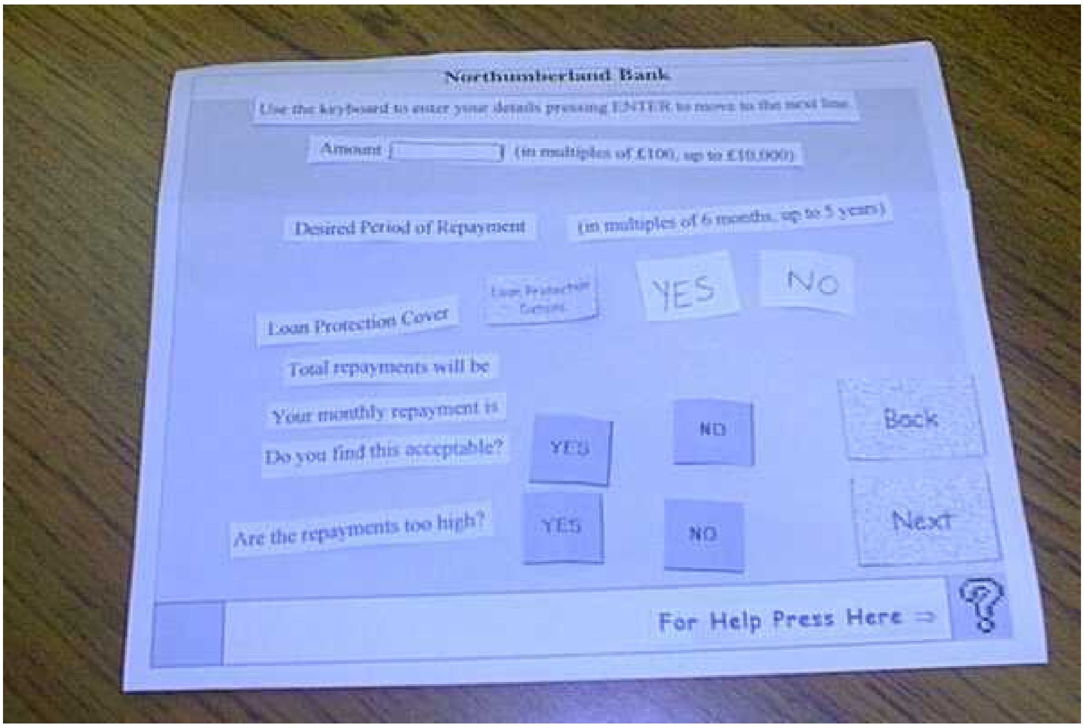



**Figure 7.3:** Paper prototype 1 for a customer information terminal. [Image used with kind permission of Cliff Brown, Northumbria University.]

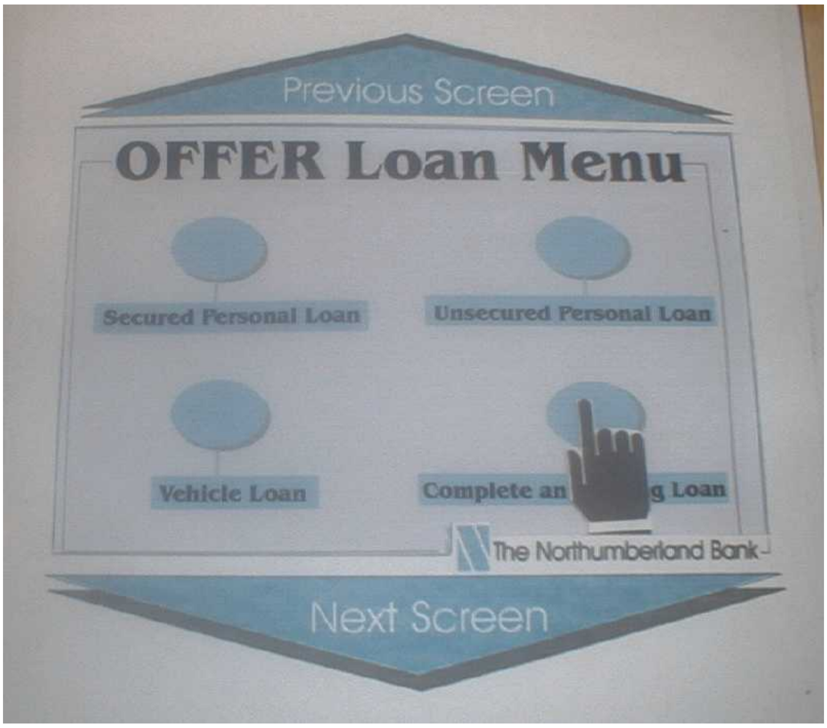



**Figure 7.4:** Paper prototype 2 for a customer information terminal. [Image used with kind permission of Cliff Brown, Northumbria University.]

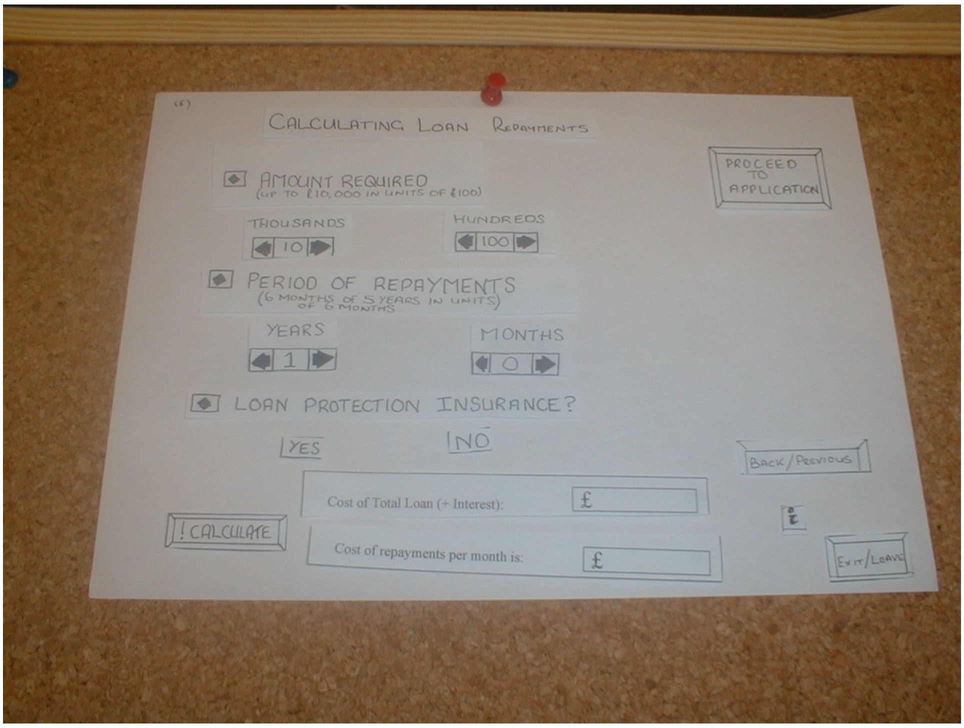



**Figure 7.5:** Paper prototype 3 for a customer information terminal. [Image used with kind permission of Cliff Brown, Northumbria University.]

## 7.4 High-Fidelity Paper Prototypes

- Elaborate screen designs created with drawing editors such as Adobe Illustrator, Inkscape, or Corel Draw.
- Printed out in colour.
- The often look too much like a finished design, and not enough like a prototype.
- Users tend to comment on the choice of fonts and colours, rather than the flow through the application.

## 7.5 Interactive Prototypes

Building an interactive prototype for testing:

- Hand-drawn sketches, scanned, and linked together for interactive use.
- Electronic sketching interfaces.
- Prototyping tools (some of which can switch between a hand-drawn and a clean look).

The prototype is then thrown away, and the system is implemented in code.

### Hand-Drawn Interactive Sketches

- Scan in hand-drawn interface sketches.
- Assemble interactive prototype with clickable elements (say as web pages with image maps linking between them).
- Retains throwaway, casual look to encourage criticism and discussion, as shown in Figure 7.6.
- For example, Chris Edwards' Sketchy Thing [Edwards 1999] and Marc Rettig's Interactive Sketch [Rettig 1999].
- And more recently, the Marvel App (formerly called the PoP App) `https://marvelapp.com/apps`. [Video: `https://youtu.be/JCEhCSDcj_I`].

### Electronic Sketching Interfaces

- DENIM; James Lin, tablet-based research prototype [Lin et al. 2002a; Lin et al. 2000a] See Figures 7.7 and 7.8. Videos at CHI 2002 [Lin et al. 2002b] and CHI 2000 [Lin et al. 2000b]. [Video: `https://youtu.be/0ZA0TgmCMgI`]

### Prototyping Tools

See the UX Design Tools Survey `https://uxtools.co/survey/2023/`.

Examples include:

- Balsamiq Mockups; `balsamiq.com`. Can switch between hand-drawn and clean look. See Figure 7.9. [Video: `https://youtu.be/70hfU7_95Gw`]

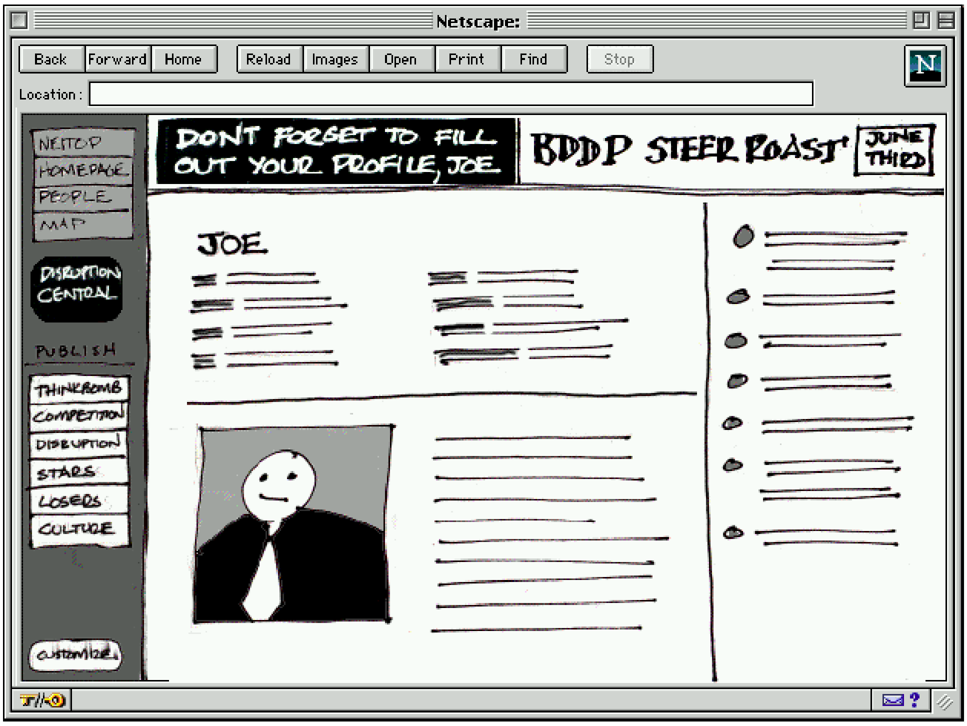



**Figure 7.6:** An interactive sketch made in Shockwave. Screen designs sketches are scanned and assembled into an interactive prototype with Macromedia Director. Screenshot taken from Chris Edwards' Sketchy Thing [Edwards 1999].

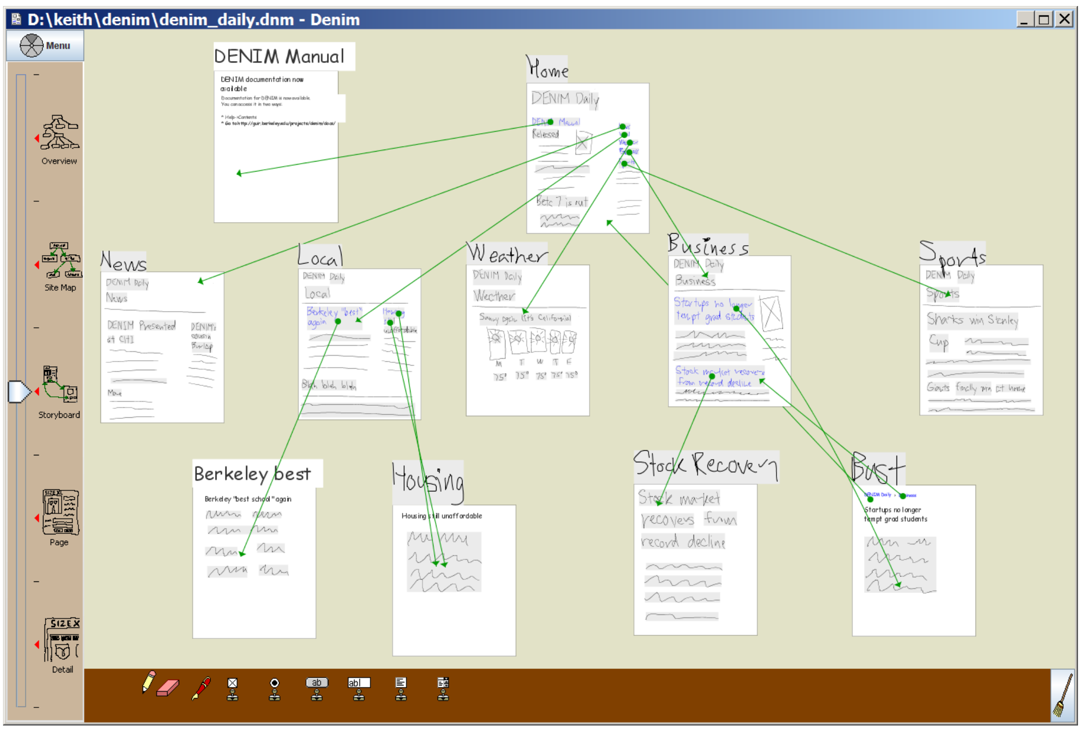



**Figure 7.7:** A storyboard of individual page wireframes modeled using DENIM.

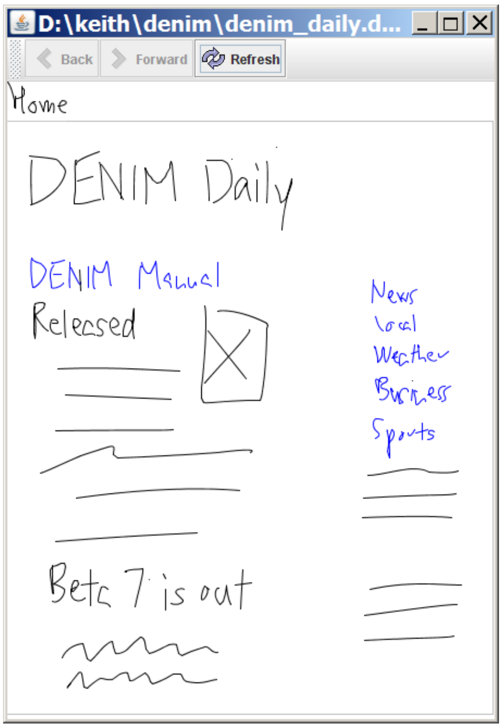



**Figure 7.8:** Running through a DENIM prototype.

- Figma; `figma.com`
- Adobe XD; `https://adobe.com/products/xd.html`. [No longer being developed.]
- Axure; `axure.com`.
- UXPin; `uxpin.com`.
- HotGloo; `hotgloo.io`.
- Framer; `framer.com`.

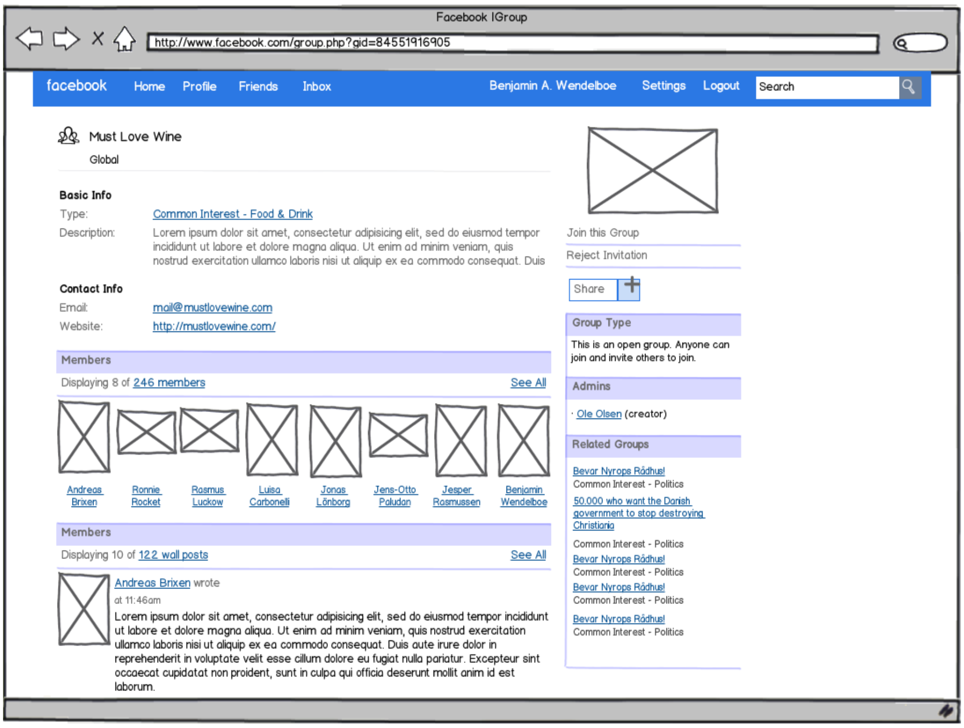



**Figure 7.9:** A wireframe of a Facebook Group page, modeled using Balsamiq Mockups. [Mockup contributed to `mockupstogo.net` by Benjamin A. Wendelboe. Image created by Keith Andrews.]

## 7.6 Working Prototypes

Implemented in code, but cut down to a bare minimum:

- *Simple algorithms*: ignore special cases.
- *Fake data*: similar data, images instead of video, etc.
- *Wizard of Oz*: human expert operating behind the scenes to simulate interface responses.

  [For example, Minister Busek's visit to Graz in 1990 and the Hotact demo. [Video: `https://much.isds.tugraz.at/social_events/films/_data/098.mpg`]]

### Dimensions of Working Prototypes

Working prototypes cut down on either the number of interface features, or the depth of functionality of features:

- *Vertical Prototype*: in-depth functionality for a few selected interface features.
- *Horizontal Prototype*: full interface features, but no underlying functionality.
- *Scenario Prototype*: only interface features and functionality along the specific scenarios or paths through the interface which are to be evaluated.

These varieties of prototype are illustrated in Figure 7.10.

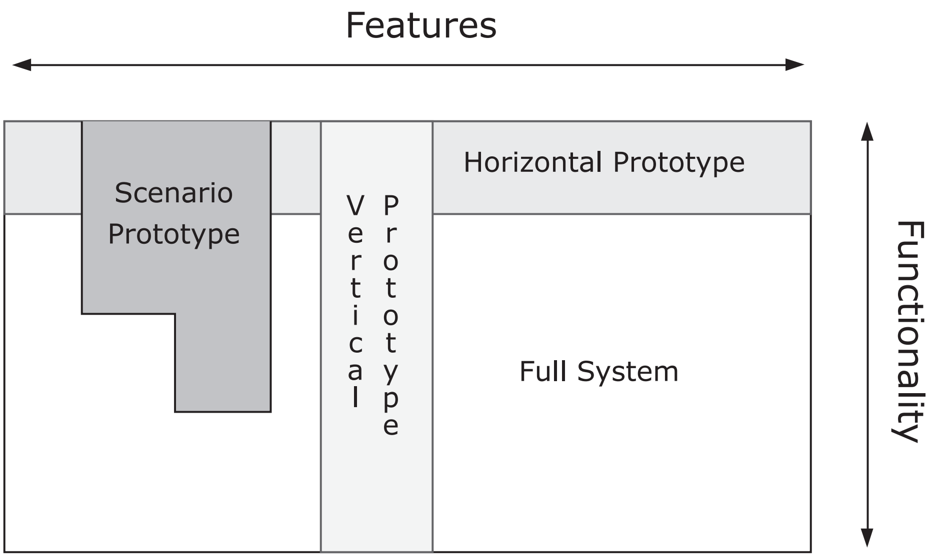



**Figure 7.10:** Working prototypes vary according to the breadth or depth of features and functionality implemented. Adapted from Figure 9 of J. Nielsen [1993b, page 94].

## 7.7 Implementation

Implement final design.

Competitive analysis of software components:

- Use existing interface framework as far as possible (Motif, MS-Windows, Java Swing) – saves a *lot* of work.
- Use existing components and applications rather than re-inventing the wheel.

# Chapter 8

# Usability Inspection Methods

Inspection of interface design using *heuristic* methods (based on analysis and judgement rather than experiment).

1. *Heuristic Evaluation*: A small team of evaluators inspects an interface using a small checklist of general principles and produces an aggregate list of potential problems.

2. *Guideline Checking*: An evaluator checks an interface against a detailed list of specific guidelines and produces a list of deviations from the guidelines.

3. *Cognitive Walkthrough*: A small team walks through a typical task in the mind set of a novice user and produces a success or failure story at each step along the correct path. [analyses learnability]

4. *Guideline Scoring*: An evaluator scores an interface against a detailed list of specific guidelines and produces a total score representing the degree to which an interface follows the guidelines.

5. *Action Analysis*: An evaluator produces an estimate of the time an expert user will take to complete a given task, by breaking the task down into ever smaller steps and then summing up the atomic action times. [analyses efficiency]

### Would You Use Untested Software?

Would you knowingly use untested software?

- How many of you have written programs that are *used* by other people?

- How many of you have watched or observed users using your software?

- How many of you actually evaluated or tested your interface before it was used?

- In practice, most software developers do not actually conduct *any* kind of usability evaluation [due to perceived expense, lack of time, lack of expertise, lack of inclination, or lack of tradition].

### References

+ Jakob Nielsen and Robert L. Mack (Eds.); *Usability Inspection Methods*; John Wiley, 1994. ISBN 0471018775 (com, uk) [J. Nielsen and Mack 1994]

+ Chauncey Wilson; *User Interface Inspection Methods*; Morgan Kaufmann, 2013. ISBN 012410391X (com, uk) [C. Wilson 2013]

### Online Resources

+ Jeff Sauro; *What's the difference between a Heuristic Evaluation and a Cognitive Walkthrough?*; 02 Aug 2011. https://measuringu.com/he-cw/

## 8.1 Heuristic Evaluation

Heuristic evaluation is a formative usability inspection method.

First described by J. Nielsen and Molich [1990]:

- Small team of evaluators (usually usability specialists) systematically checks interface design against small set of recognised usability principles (the "heuristics").
- Often called an *expert review*.

### References

+ Jakob Nielsen and Rolf Molich; *Heuristic Evaluation of User Interfaces*; Proc. CHI'90, 01 May 1990 . [J. Nielsen and Molich 1990]

◦ Jakob Nielsen; *Finding Usability Problems Through Heuristic Evaluation*; Proc. CHI'92, 01 May 1992 . [J. Nielsen 1992]

◦ Jakob Nielsen; *Enhancing the Exploratory Power of Usability Heuristics*; Proc. CHI'94, 01 Apr 1994 . [J. Nielsen 1994]

### Online Resources

+ Kate Moran and Kelley Gordon; *How to Conduct a Heuristic Evaluation*; Nielsen Norman Group, 25 Jun 2023. https://nngroup.com/articles/how-to-conduct-a-heuristic-evaluation/ [Moran and Gordon 2023]

+ Jakob Nielsen; *10 Usability Heuristics for User Interface Design*; Nielsen Norman Group, 30 Jan 2024. https://nngroup.com/articles/ten-usability-heuristics/ [J. Nielsen 2024]

+ Kelley Gordon, Kate Moran, and Feifei Liu; *10 Heuristics Posters*; Nielsen Norman Group, 30 Jan 2024. 10 free PDF posters, each explaining one heuristic. https://nngroup.com/articles/ten-usability-heuristics/#free-10-heuristics-poster

◦ Jakob Nielsen; *Heuristic Evaluation*; Nielsen Norman Group. https://nngroup.com/topic/heuristic-evaluation/ [J. Nielsen 2022]

+ Luke Chambers; *How to Run an Heuristic Evaluation*; https://uxmastery.com/how-to-run-an-heuristic-evaluation/ [Chambers 2016] [Caveat: This article is somewhat problematic, because it conflates Cognitive Walkthrough (CW) with Heuristic Evaluation (HE). It is not a perfect description of how I advocate doing a HE.]

+ Enzinger et al; *Heuristic Evaluation of Enigmail*; https://projects.isds.tugraz.at/enigusab/he/he.html [Enzinger et al. 2017]

### Usability Heuristics

The first nine heuristics were defined in J. Nielsen and Molich [1990]. Some of the heuristics were renamed and the tenth heuristic was added in J. Nielsen [1994]. The category names in square brackets are the new names of the corresponding heuristics, in those cases where they are different.

1. **Feedback** [Visibility of System Status]

   The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

   For example: busy cursor [1–10s], progress indicator [>10s].

2. **Speak the Users' Language** [Match Between System and the Real World]

   The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

   Match users' mental model. Beware of misleading metaphors.

3. **Clearly Marked Exits** [User Control and Freedom]

   Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.

4. **Consistency** [Consistency and Standards]

   Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.

5. **Error Prevention**

   Even better than good error messages is a careful design which prevents a problem from occurring in the first place.

   For example: select file from menu rather than typing in name, confirmation before dangerous actions, beware of modes, avoid similar command names, warning if Caps Lock is activated when entering a password, etc.

6. **Recognition rather than Recall**

   Make objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

   Users' short-term memory is limited. Provide examples, default values, easily retrievable instructions.

7. **Accelerators** [Flexibility and Efficiency of Use]

   Accelerators – unseen by the novice user – may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.

   For example: abbreviations, command keys, type-ahead, edit and reissue previous commands, menu of most recently used files, macros.

8. **Minimalist Design** [Aesthetic and Minimalist Design]

   Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility. "Less is more"

9. **Good Error Messages** [Help Users Recognise, Diagnose, and Recover from Errors]

Error messages should be expressed in *plain language* (no codes or jargon), *precisely* indicate the problem, and *constructively* suggest a solution.

Phrase error messages *defensively*, never blame the user. Multilevel messages. Link to help system.

10. **Help and Documentation**

    Help and documentation should be easy to search, focused on the user's tasks, list concrete steps to be carried out (recipes), and make liberal use of examples.

#### Limits on Response Times

- **0.1 sec.**: is the limit so that the system appears to react instantaneously.
  Important for direct manipulation, virtual world navigation.
- **1 sec.**: is the limit so that the user's flow of thought stays uninterrupted.
  Display a busy cursor if things will take longer than 1 sec.
- **10 secs.**: is the limit for keeping the user's attention on the task at hand.
  Display a progress indicator if things will take longer than 10 secs.

From Section 5.5 of [J. Nielsen 1993b] and [J. Nielsen 1993a].

### Performing a Heuristic Evaluation

Step-by-step recipe for performing a heuristic evaluation, in five phases:

1. Preparation
2. Individual Evaluations
3. Aggregation
4. Severity Ratings
5. Debriefing and Report

#### 1. Preparation

- The design may be verbal description, paper mock-up, working prototype, or running system. [when evaluating paper mock-ups, pay special attention to missing dialogue elements!]
- Provide evaluators with checklist of usability heuristics.
- Optionally provide evaluators with some domain-specific training.

#### 2. Individual Evaluations

- Each evaluator works *alone* (≈ 1–2 hours).
- Interface is often examined in two passes: first pass focuses on general flow, second on particular elements in detail.
- Notes taken either by evaluator or evaluation manager.

- Make a list of (potential) problems and a list of positive findings. [Not all problems fall under a heuristic. It is OK to include problems which are not covered by any heuristic.]
- Use screen video capture software such as OBS Studio, Camtasia, or AZ Screen Recorder to record each evaluation session (including the evaluator's voice if possible), since some problems may not be reproducible later on.
- Re-create a short video clip to illustrate each finding, concisely describing the finding in the audio track.

  Where a finding cannot be recreated, extract a video clip from your evaluation recording. If the existing audio commentary does not describe the finding adequately, record a new audio commentary to describe the issue.

  In some cases, a static image (still frame) may suffice to illustrate a finding. [But not in the practicals for this course!]

#### 3. Aggregation

- Independent findings are now aggregated into one large list (by the evaluation manager) using a spreadsheet:
  - Start by copying the longest individual list of problems over into the spreadsheet. Then look through the other individual lists and compare each problem to see if it is already in the aggregated list.
  - If two or more evaluators find the same (or very similar) problem, combine them into one.
  - List many small related problems (such as 27 individual typos) as one problem (rather than 27).
- Proceed analogously to create an aggregated list of positive findings.

#### 4. Severity Ratings

- The aggregated list of potential problems (with associated video clips) is distributed to each evaluator.
- Each evaluator now assigns severity ratings *individually* to each problem in the large list, unseen by the other evaluators. [For example, on a simple 0 (not a problem) to 4 (catastrophic problem) scale.]
- The individual severity ratings are averaged to obtain the final mean severity rating for each problem.
- The aggregated list is sorted in decreasing order of average severity.
- Proceed analogously for the positive findings and positivity ratings.

#### 5. Debriefing and Report

- If possible, organise a group debriefing session to recommend possible solutions.
- Write up all of your results into a report.

### How Many Problems are Found?

J. Nielsen and Molich [1990] ran four heuristic evaluations using "usability novices" as evaluators.

| *Evaluation Name* | *Number of Evaluators* | *Total Known Problems* | *Average No. Problems Found per Evaluator* |
|---|---|---|---|
| Teledata | 37 | 52 | 51% |
| Mantel | 77 | 30 | 38% |
| Savings | 34 | 48 | 26% |
| Transport | 34 | 34 | 20% |

**Table 8.1:** The average number of problems found by individual novice evaluators in each of four heuristic evaluations. [Data extracted from J. Nielsen and Molich [1990, Table 2].]

| *Aggregate:* | *1* | *2* | *3* | *5* | *10* |
|---|---|---|---|---|---|
| Teledata | 51% | 71% | 81% | 90% | 97% |
| Mantel | 38% | 52% | 60% | 70% | 83% |
| Savings | 26% | 41% | 50% | 63% | 78% |
| Transport | 20% | 33% | 42% | 55% | 71% |

**Table 8.2:** The average proportion of usability problems found by various sized aggregates of novice evaluators in each of the four heuristic evaluations. [Data extracted from J. Nielsen and Molich [1990, Table 4].]

They compared the average number of problems found by each evaluator with the total number of known problems in each system, as shown in Table 8.1.

#### Aggregated Evaluations

- Individual evaluators found relatively few problems.
- Aggregating the evaluations (merging the problem lists) of several individuals produced much better results.
- See Table 8.2 and Figure 8.1.
- Group debriefing session to suggest possible redesigns.

### Experience of Evaluators

The experience of evaluators influences how many problems they find [J. Nielsen 1992].

Study of one interface, the Banking System, a touch tone "voice response" telephone banking system, by 3 groups of evaluators:

- 31 "novice" evaluators: computer science students with no formal knowledge of UI or usability (no usability expertise).
- 19 "regular" specialists: people with UI and usability experience, but no expertise in voice-response systems (usability expertise).
- 14 "double" specialists: people with expertise both in usability and in telephone-operated interfaces (usability and domain expertise).

Task: transfer $1000 from savings account to check account.

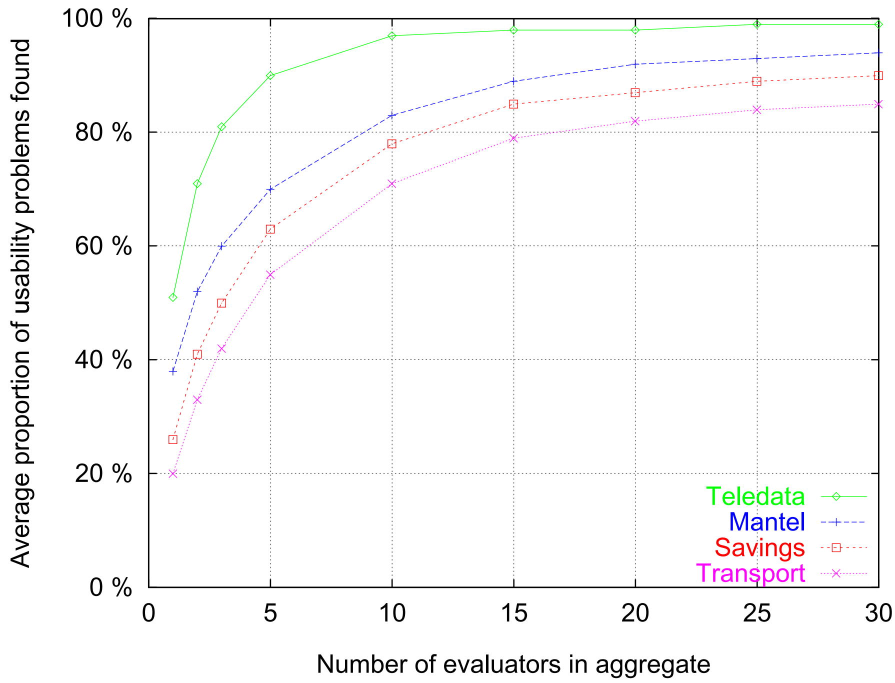



**Figure 8.1:** Average proportion of usability problems found by aggregates of size 1 to 30. [Results from J. Nielsen and Molich [1990, Figure 4].]

### Sample Banking System Dialogue

Figure 8.2 shows the sample dialogue given to evaluators in the study.

- This dialogue actually took place!
- The problem was that the user did not have authority to make phone transfers.
- The results are summarised in Table 8.3.
- Aggregating the results of individual evaluators gives the plots shown in Figure 8.3.

## Conclusions from Studies

From these two studies, we can conclude that:

- Single evaluator finds only small subset of potential problems.
- Several evaluators should work *independently*, then aggregate results.
- Evaluators pay more attention to major problems without neglecting minor ones.
- In the second study [J. Nielsen 1992], for the Banking System interface, finding around 80% of usability problems required 2–3 double specialists, 3–5 regular usability specialists, and around 15 novice usability evaluators.
- This result does *not* generalise to all interfaces in all situations.

[First there is a short dialogue in which the user is identified by entering an identification number and access code – this is not part of the evaluation exercise]

1. S: *Enter one for account information, three for transfers between your own accounts, . . .*
2. U: 3# {the user interrupts the system}
3. S: *Enter account to transfer from.*
4. U: 1234567890# {savings account number}
5. S: *Enter account to transfer to.*
6. U: # {an abbreviation for the checking account}
7. S: *Enter amount in cents.*
8. U: 100000#
9. S: *From account number twelve thirtyfour fiftysix seventyeight ninety to account number primary account, a transfer of one thousand dollars is to be made. Press one to confirm, zero to cancel.*
10. U: 1#
11. S: *You do not have access to this function.*

**Figure 8.2:** The sample Banking System dialogue used for the study. [Extracted from J. Nielsen [1992, Figure 1].]

| *No.* | *Problem* | *Novice* | *Regular* | *Double* |
|---|---|---|---|---|
| ***Major Usability Problems*** | | | | |
| 1. | Error message appears too late. | 68% | 84% | 100% |
| 2. | Do not require dollar amount to be entered in cents. | 68% | 74% | 79% |
| 3. | The error message is not precise. | 55% | 63% | 64% |
| 4. | The error message is not constructive. | 6% | 11% | 21% |
| 5. | Replace term “primary account” with “checking account”. | 10% | 47% | 43% |
| 6. | Let users choose account from a menu. | 16% | 32% | 43% |
| 7. | Only require a # where it is necessary. | 3% | 32% | 71% |
| 8. | Give feedback as name of chosen account. | 6% | 26% | 64% |
| | **Average for Major Problems** | **29%** | **46%** | **61%** |
| ***Minor Usability Problems*** | | | | |
| 9. | Read menu item description before action number. | 3% | 11% | 71% |
| 10. | Avoid gap in menu numbers between 1 and 3. | 42% | 42% | 79% |
| 11. | Provide earlier feedback. | 42% | 63% | 71% |
| 12. | Replace use of 1 and 0 for accept and reject with # and *. | 6% | 21% | 43% |
| 13. | Remove the field label “number” when no number is given. | 10% | 32% | 36% |
| 14. | Change prompt “account” to “account number”. | 6% | 37% | 36% |
| 15. | Read numbers one digit at a time. | 6% | 47% | 79% |
| 16. | Use “press” consistently and avoid “enter”. | 0% | 32% | 57% |
| | **Average for Minor Problems** | **15%** | **36%** | **59%** |
| | **Average for All Problems** | **22%** | **41%** | **60%** |

**Table 8.3:** Proportion of novice, specialist, and double specialist usability evaluators finding problems in the Banking System. [Results from J. Nielsen [1992, Table 1].]

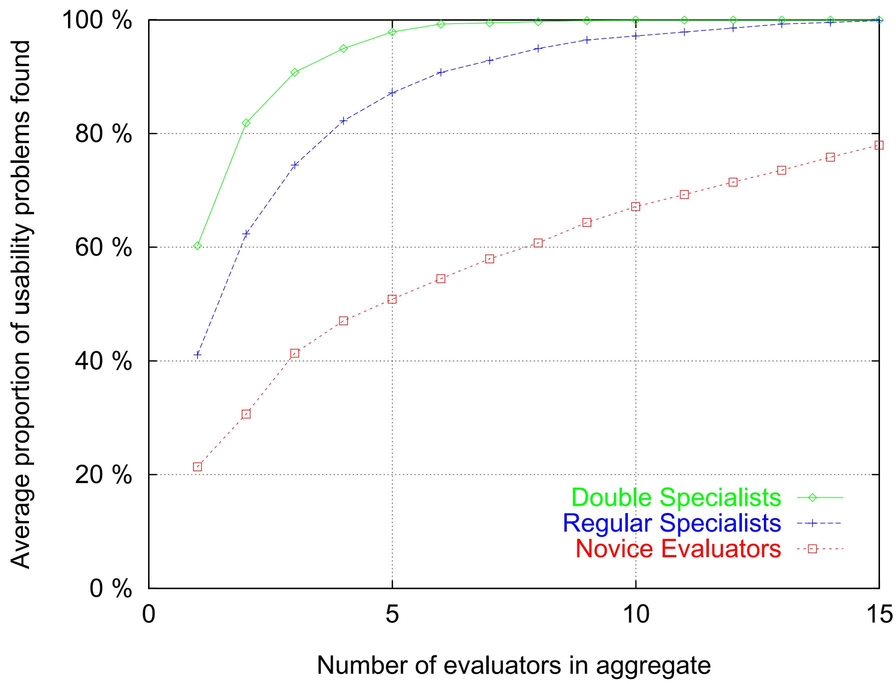



**Figure 8.3:** Average proportion of usability problems found by aggregates of novice evaluators, regular specialists, and double specialists. [Results from J. Nielsen [1992, Figure 2].]

### Heuristic Evaluation in Practice

When heuristic evaluation is used in standard industry practice today:

- It is often called an *expert review*.
- It is typically performed by 3–4 usability specialists.

### Tools for Heuristic Evaluation

A number of tools have been developed to help conduct a heuristic evaluation:

- Heuristic Evaluation Manager (HEM); A php-based online tool, developed in 2006. [Loitzl 2006]
- heurio; `heurio.co`
- Heurix; `heurix.io`
- Capian; `capian.co`

### Pros and Cons of Heuristic Evaluation

++ cheap

+ intuitive

+ usable early in development process

+ finds many problems

+ finds both major and minor problems

- may miss domain-specific problems

## 8.2 Severity Ratings

Severity ratings can help prioritise the fixing of usability problems.

- After evaluation sessions, a complete aggregate list of usability problems is given/sent to each evaluator.
- Working independently, evaluators assign severity rating [on scale of 0–4] to each problem (≈ 30 mins.).
- Severity rating of single evaluator is unreliable, mean of 3–5 evaluators is satisfactory.

  See the discussion of severity ratings in [J. Nielsen and Mack 1994], pages 47–55.

### Five-Point Severity Scale

| *Score* | *Severity* | *Fix Priority* |
|---|---|---|
| **4** | catastrophic problem | imperative |
| **3** | major problem | high |
| **2** | minor problem | low |
| **1** | cosmetic problem only | |
| **0** | not a problem at all | |

### Order of Criticality

To explicitly take problem frequency into account, assign *criticality* ratings.

Criticality = Severity Ranking + Frequency Ranking

| *Severity* | | *Frequency* | |
|---|---|---|---|
| 4 | catastrophic | 4 | >90% |
| 3 | major | 3 | 51–89% |
| 2 | minor | 2 | 11–50% |
| 1 | cosmetic | 1 | 1–10% |
| 0 | none | 0 | <1% |

## 8.3 Guideline Checking

Guideline checking is a formative usability inspection method.

*Guidelines* . . . specific advice about usability characteristics of an interface.

- An evaluator checks an interface against a detailed list of specific guidelines and produces a list of deviations from the guidelines.
- Whereas heuristic evaluation employs 10 broad principles, guideline checking often involves dozens (or hundreds) of more specific individual items on a checklist.

## 1.3 DATA ENTRY: Text

### 1.3/1 Adequate Display Capacity

Ensure that display capacity, i.e., number of lines and line length, is adequate to support efficient performance of text entry/editing tasks.

*Example*: For text editing where the page format of subsequent printed output is critical, the user's terminal should be able to display full pages of text in final output form, which might require a display capacity of 50-60 lines or more.

*Example*: For general text editing where a user might need to make large changes in text, i.e., sometimes moving paragraphs and sections, a display capacity of at least 20 lines should be provided.

*Example*: Where text editing will be limited to local changes, i.e., correcting typos and minor rewording, as few as seven lines of text might be displayed.

*Comment*: A single line of displayed text should not be used for text editing. During text editing, a user will need to see some displayed context in order to locate and change various text entries. Displaying only a small portion of text will make a user spend more time moving forward and back in a displayed document to see other parts, will increase load on the user's memory, and will cause users to make more errors.

*Reference*:
Elkerton Williges Pittman Roach 1982
Neal Darnell 1984

*See also*: 1.3/27

**Table 8.4:** One of the 944 guidelines by S. L. Smith and Mosier [1986].

### Example Sets of Guidelines

- Sidney Smith and Jane Mosier; *Design Guidelines for Designing User Interface Software*; The MITRE Corp., 1986. [944 guidelines] [S. L. Smith and Mosier 1986].

  Table 8.4 shows one of the 944 guidelines from Smith and Mosier.

- C. Marlin Brown; *Human-Computer Interface Design Guidelines*; Ablex, NJ, 1988. [302 guidelines] [C. M. Brown 1998].

- Deborah Mayhew; *Principles and Guidelines in Software User Interface Design*; Pearson, 2008. [288 guidelines] [D. Mayhew 2008].

- David Travis, Userfocus; Web Usability Guidelines; [247 guidelines in 9 categories] [Travis 2016]. `https://userfocus.co.uk/resources/guidelines.html`

- teamsuccess; Usability Checklist for web sites; [56 guidelines in 8 categories] [teamsuccess 2020]. `https://teamsuccess.io/UX`

### Testpad: Online Guideline Checking Tool

- Testpad `testpad.com` provides an environment for creating and managing online checklists (called scripts) [Butlin 2025].

- Checklists can be filled out by evaluator via a web app.

- Only binary criteria are supported, no point-based criteria.

- The project manager can view and aggregate the results and download them as a CSV file for offline analysis.

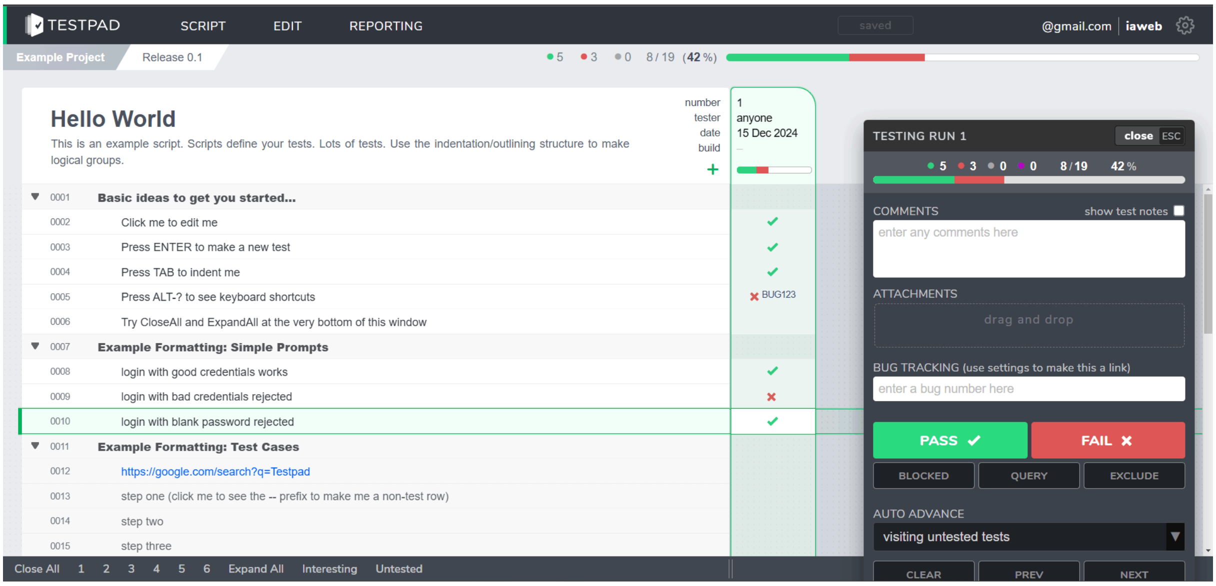



**Figure 8.4:** Testpad: An online tool for guideline checking. [Screenshot taken by Nico Gabriel. Used under the terms of a Creative Commons Attribution 4.0 International (CC BY 4.0) licence.]

- See Figure 8.4 and video clips [Video: `https://vimeo.com/271880156`] and [Video: `https://youtu.be/8j--urI1Be4`].

### Pros and Cons of Guideline Checking

+ cheap
+ intuitive
+ usable early in development process

- time-consuming
- can be intimidating – often hundreds or thousands of specific guidelines.

## 8.4 Guideline Scoring

Guideline scoring is a summative usability inspection method.

- The interface is scored according to its conformance against a weighted list of specific guidelines.
- A total score is produced, representing the degree to which an interface follows the guidelines.

An example checklist for the evaluation of a web site is shown in Figure 8.5.

### Pros and Cons of Guideline Scoring

+ cheap
+ intuitive

## Web Technologies - Checklist Homepage Design / Usability

| | | | | | |
|---|---|---|---|---|---|
| Homepage (URL) | | Date | | Nr. | |
| Tester | | Size | kB | Score | % |

| Nr | Topic | Recommended Design | Strength | Points | You |
|---|---|---|---|---|---|
| **1** | Download time | 50 kB (<10 sec for your customer) | *** | 3 | |
| **2** | Window title | Start with Company Name | *** | 3 | |
| **3** | Title tag line | What about, Slogan | *** | 3 | |
| **4** | Readable URL | Hackable URL, URL is a UI part | ** | 2 | |
| **5** | Error page | Catch errors/dead links, to search | ** | 2 | |
| **6** | Meta tags | For search engines (trafficattack.de) | *** | 3 | |
| **7** | Alt Information | Images, accessibility, Lynx | ** | 2 | |
| **8** | Page width | 770 pixel (620-1024) | ** | 2 | |
| **9** | • Liquid vs. frozen layout | Liquid is better | ** | 2 | |
| **10** | • Page length | <2 pages (1000-1600 px) | ** | 2 | |
| **11** | Frames | No, Don't use (search, bookmarks) | *** | 3 | |
| **12** | Logo placement | Upper left | *** | 3 | |
| **13** | • Logo size | Around 80x68 Pixel | ** | 2 | |
| **14** | **Search** | Yes, in a box, always | *** | 3 | |
| **15** | • Search placement | Upper part, right or left corner | ** | 2 | |
| **16** | • Search box color | White | *** | 3 | |
| **17** | • Search button | Call it "Search" or "Go" | ** | 2 | |
| **18** | • Width of search box | >=25 characters (30 best) | ** | 2 | |
| **19** | • Type of search | Simple search (Link to advanced) | ** | 2 | |
| **20** | **Navigation** | 4 types: left, tabs, top, categories | ** | 2 | |
| **21** | • Footer navigation links | Max. 7 links, single line | * | 1 | |
| **22** | • Sitemap link | Name "Site Map", Content | ** | 2 | |
| **23** | Routing page | No (www.logitech.com) | ** | 2 | |
| **24** | Splash page | No | *** | 3 | |
| **25** | Sign-In | "Account" or "Sign In" | * | 1 | |
| **26** | **About** the company | Always include it | *** | 3 | |
| **27** | • About link | Call it "About <company>" | ** | 2 | |
| **28** | • Contact information | Call it "Contact us" | ** | 2 | |
| **29** | • Privacy policy | If you collect data | *** | 3 | |
| **30** | Home Button | Is there a home button visible | *** | 3 | |
| **31** | Job opening | Call it "Jobs" if you have it | ** | 2 | |
| **32** | **Help** | If it is a complex site (eBay, etc.) | * | 1 | |
| **33** | • Help placement | Upper right | ** | 2 | |
| **34** | Auto-playing music | No | *** | 3 | |
| **35** | Animation | No | ** | 2 | |
| **36** | Graphics/illustration | 5-15% | * | 1 | |
| **37** | Advertising | <= 3 ads | ** | 2 | |
| **38** | **Body** text color | Black | ** | 2 | |
| **39** | • Body text size | 12 points | * | 1 | |
| **40** | • Body text size frozen | No (www.wired.com) | *** | 3 | |
| **41** | • Body text typeface | Sans-serif | * | 1 | |
| **42** | • Background color | White | ** | 2 | |
| **43** | • Link color (unvisited) | Blue | ** | 2 | |
| **44** | • Link color (visited) | Purple | * | 1 | |
| **45** | • Link color different | Yes (not light gray) | *** | 3 | |
| **46** | • Link underlining | Yes (except in navigation bar) | ** | 2 | |
| | **Score of URL:** | | | 100 | |

| | |
|---|---|
| * | Default Recommendation |
| ** | Strong Recommendation |
| *** | Essential Recommendation |

from Nielsen, Homepage Usability
adapted by Alexander Nischelwitzer V1.7
last update 10/2005 by NIS www.nischelwitzer.com

**Figure 8.5:** The Web Usability Checklist. The checklist covers 46 individual guidelines, each with a weighting of between one and three points, for 100 points total. [Adapted from [J. Nielsen and Tahir 2001] by Alexander Nischelwitzer, used with permission.]

- must select and weight guidelines
- guidelines or weightings often domain-dependent

## 8.5 Cognitive Walkthrough

Cognitive walkthrough is a formative usability inspection method.

*Task-oriented* walkthrough of interface, imagining novice users' thoughts and actions. Focuses explicitly on learnability.

- Design may be mock-up or working prototype.
- Analogous to structured walkthrough in software engineering.
- Based on *cognitive model* (CE+) of human exploratory learning.

First described in C. Lewis et al. [1990].

### References

- ∘ Clayton Lewis et al; *Testing a Walkthrough Methodology for Theory-Based Design of Walk-Up-and-Use Interfaces*; Proc. CHI'90, Apr 1990. [C. Lewis et al. 1990]
- ∘ Cathleen Wharton et al; *The Cognitive Walkthrough Method: A Practitioner's Guide*; Chapter 5 of Usability Inspection Methods, Wiley 1994. [Wharton et al. 1994].
- ∘ Clayton Lewis and John Rieman; *Task-Centered User Interface Design: A Practical Introduction*; 1993. `https://hcibib.org/tcuid/`
- \+ Kim Flaherty; *Evaluate Interface Learnability with Cognitive Walkthroughs*; NN Group, 13 Feb 2022. `https://nngroup.com/articles/cognitive-walkthroughs/`
- ∘ Peter G. Polson et al; *Cognitive Walkthroughs: A Method for Theory-Based Evaluation of User Interfaces* International Journal of Man-Machine Studies, Vol. 36, No. 5, May 1992. [Polson et al. 1992]
- ∘ Bonnie John and Hilary Packer; *Learning and Using the Cognitive Walkthrough Method: A Case Study Approach*; Proc. CHI'95, May 1995. [John and Packer 1995]
- ∘ Rick Spencer; *The Streamlined Cognitive Walkthrough Method*; Proc. CHI 2000, Apr 2000. [Spencer 2000]

### Exploratory Learning

Rather than read manual or attend course, users often prefer to learn new system by "trial and error" → *exploratory learning* [Carroll and Rosson 1987]:

1. Start with rough idea of task to be accomplished.
2. Explore interface and select most appropriate action.
3. Monitor interface reactions.
4. Determine what action to take next.

### The CE+ Model of Exploratory Learning

Based on psychological studies, the CE+ model describes exploratory learning behaviour in terms of 3 components:

- **Problem-Solving Component**

  User chooses among alternative actions based on similarity between the expected consequences of an action and the current goal.

  After executing selected action, user evaluates system response and decides whether progress is being made toward the goal. A mismatch results in an undo → "hill-climbing".

- **Learning Component**

  When above evaluation process leads to positive decision, the action taken is stored in long-term memory as a rule.

- **Execution Component**

  User first attempts to fire applicable rule matching current context. If none found, problem-solving component is invoked.

### Cognitive Walkthrough Preparation

i) *Users*: Identify user population.

ii) *Task(s)*: Define suite of *representative* tasks.

iii) *Interface*: Describe or implement interface or prototype.

iv) *Correct Action Sequence*: Specify correct action sequence(s) for each task.

### Cognitive Walkthrough Steps

For each action in solution path, construct *credible* "success" or "failure" story about why user would or would not select correct action.

Critique the story to make sure it is believable, according to four criteria:

a) *Will the user be trying to achieve the right effect?*

   What is users' goal – will they *want* to select this action?

b) *Will the user know that the correct action is available?*

   Is control (button, menu, switch, triple-click, etc.) for action *apparent* (visible)?

c) *Will the user know that the correct action will achieve the desired effect?*

   Once users find control, will they *recognise* that it is the correct control to produce the desired effect?

d) *If the correct action is taken, will the user see that things are going ok?*

   After correct action, will users realise progress has been made towards the goal (feedback)?

Note that CW always tracks the *correct* action sequence. Once the user deviates from the correct path, their further progress is no longer considered.

### Group Walkthrough

- Performed by mixed team of analysts (designers, engineers, usability specialist).
- Capture critical information on three group displays (flip charts, overheads):
  1. User knowledge (prior to and after action).
  2. Credible success or failure story.
  3. Side issues and design changes.
- Perhaps also video record the entire walkthrough.

### Detailed Cognitive Walkthrough Example

Forwarding calls on a campus telephone system, from the perspective of a first time user; from [Wharton et al. 1994], pages 118–123.

i) *Users*: New faculty, staff, guests, and visitors. For this evaluation assume that the user is a new university professor.

ii) *Task*: Cancel current forwarding and forward calls instead to a colleague with the extension 1234.

iii) *Interface*: Standard-size, touch-tone phone on desk. Overlay template includes the following information:
FWD *2
CNCL #2
SEND ALL *3

iv) *Correct Action Sequence*: The seven correct actions for accomplishing this task are:

1. Pick up the receiver.
   Phone: *dial tone*
2. Press #2. {command to cancel forwarding}
   Phone: *bip bip bip*
3. Hang up the receiver.
4. Pick up the receiver.
   Phone: *dial tone*
5. Press *2. {command to forward calls}
   Phone: *dial tone*
6. Press 1234.
   Phone: *bip bip bip*
7. Hang up the receiver.

### Example Walkthrough Steps

1. Pick up the receiver.
   Phone: *dial tone*

Success story:

Seems ok based on prior experience with phones.

2. Press #2.
   Phone: *bip bip bip*

   Failure story:

   a) *Will the user be trying to achieve the right effect?*

      How does the user even know that forwarding is in effect?

   b) *Will the user know that the correct action is available?*

      Probably yes, if forwarding is active, one must be able to cancel it. CNCL is visible on the template.

   c) *Will the user know that the correct action will achieve the desired effect?*

      Might not recognise CNCL as the control to cancel forwarding. Might think that just pressing '2' is sufficient, instead of '#2'. Might try to press the buttons simultaneously, rather than sequentially.

   d) *If the correct action is taken, will the user see that things are going ok?*

      How do first-time users know they have succeeded? After some experience, they will recognise the *bips* as confirmation, but will they at first?

3. Hang up the receiver.

   Failure story:

   a) *Will the user be trying to achieve the right effect?*

      Big trouble. How do you know you have to hang up before reestablishing forwarding?

4. etc.

#### Video: Cognitive Walkthrough

- Clayton Lewis; *Cognitive Walkthrough*; Human Factors Engineering course, University of Michigan, 03 Aug 2016. [C. Lewis 2016] [Video: `https://youtu.be/FR7sKP_p1v0`]

#### Pros and Cons of Cognitive Walkthrough

++ finds task-oriented problems

\+ helps define users' goals and assumptions

\+ usable early in development process

\- some training required

\- needs task definition methodology

\- applies only to ease of learning problems

\- - time-consuming

## 8.6 Action Analysis

Action analysis is a predictive usability inspection method:

- Quantitative analysis of actions to predict the time an expert user requires to complete a task.
- The analysis is done on one or more interface designs, before the designs have been implemented.
- A task is broken down hierarchically into ever smaller subtasks.
- Assumes that expert users know how to perform the task correctly (without errors or deviations).
- Time estimates are based on known (published) timings for typical interface actions.
- Focuses on the performance of expert users (efficiency).

#### Flavours of Action Analysis

Two flavours (levels of detail) of action analysis:

a) Formal or “Keystroke-Level”

b) Informal or “Back-of-the-Envelope”

There are good examples in C. Lewis and Rieman [1993] and Raskin [2000].

### 8.6.1 Keystroke-Level Analysis

Described by Card et al. [1983].

- Developed from GOMS (Goals, Operators, Methods, Selection) modeling.
- Extremely detailed, may often predict task duration to within 20%, but very tedious to carry out.
- Used to estimate performance of *high-use* systems (e.g. telephone operator workstations).

#### Procedure for Keystroke-Level Analysis

- Break down tasks hierarchically into subtasks until reach fraction of second level of detail.
- Use average values for action times (determined through extensive published research) to predict expected performance for particular task. See Table 8.5.
- The analysts do not measure action times themselves, but refer to published tables.

### 8.6.2 Back-of-the-Envelope Action Analysis

From [C. Lewis and Rieman 1993]. “Back-of-the-Envelope” uses the analogy of sketching out a rough analysis on the back side of an envelope while somewhere away from your desk (“Milchmädchenrechnung” in German).

- List actions required to complete a task (as before), but in much less detail – at level of explaining to a user:

| | *Action* | *Time* |
|---|---|---|
| *Physical Movements* | One keystroke | 0.28 |
| | Point with mouse | 1.50 |
| | Move hand to mouse or function key | 0.30 |
| *Visual Perception* | Respond to brief light | 0.10 |
| | Recognise 6-letter word | 0.34 |
| | Move eyes to new location on screen | 0.23 |
| *Mental Actions* | Retrieve one item from long-term memory | 1.20 |
| | Learn one step of a procedure | 25.00 |
| | Execute a mental step | 0.075 |
| | Choose among methods | 1.20 |

**Table 8.5:** Average Times for typical keystroke-level actions, in seconds. From [J. Olson and G. M. Olson 1990], and cited by [C. Lewis and Rieman 1993].

"Select Save from the File menu"
"Edit the file name"
"Confirm by pressing OK"

- At this level of analysis, assume every action takes (say) 3 seconds (video record a few users doing random tasks if you do not believe it takes this long!).
- Allows quick estimation of expected performance of interface for particular task.

### Video: GOMS and the Keystroke-Level Model

- Paul Green; *Cognitive Walkthrough*; Human Factors Engineering course, University of Michigan, 02 Aug 2016. [Green 2016] [Video: `https://youtu.be/eFlSpAs1lbY`]

### Pros and Cons of Action Analysis

\+ predicts efficiency of interface before building it

\- some training required

\-- time-consuming

# Chapter 9

# Usability Testing Methods

> *“ Would you fly in an airplane that hasn’t been flight tested? Of course not. So you shouldn’t be using software that hasn’t been usability tested. ”*
>
> [ Ben Shneiderman, The Front Desk, BBC Video, 1995. ]

*Empirical* testing of interface design with *representative users*.

### Seven Testing Methods

Usability testing methods include:

- *Thinking Aloud Tests*: Test users verbalise thoughts while performing test tasks.
- *Co-Discovery Tests*: Two test users explore an interface together. Insight is gained from their conversation while performing test tasks.
- *Formal Experiments*: Controlled experiment, face-to-face with test users, measurements and statistical analysis.
- *A/B Testing*: Controlled experiment on (part of) actual user population, typically (remote) web site users, with measurements and statistical analysis.
- *Post-Test Interviews*: Qualitative feedback after a test.
- *Post-Test Questionnaires*: Quantitative feedback after a test.
- *Usage Studies*: Usage data is collected from a small number of users working on their own tasks in their natural environment over a longer period.

### References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◦ Thomas Landauer; *Research Methods in Human-Computer Interaction*; In *Handbook of HCI*, Helander (Ed.), North-Holland, 1988. ISBN 0444705368 (com, uk) [Landauer 1988]

◦ Ericsson and Simon; *Protocol Analysis: Verbal Reports As Data*; MIT Press, May 1993. ISBN 0262550237 (com, uk) [Ericsson and Simon 1993]

◦ van Someren, Barnard, and Sandberg; *The Think Aloud Method*; Academic Press, 1994. ISBN 0127142703 (com, uk) [van Someren et al. 1994]

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+ Andy Field; *Discovering Statistics Using IBM SPSS Statistics*; Sage Publications, 6th Edition, 06 Mar 2024. ISBN 1529630002 (com, uk) [Field 2024]

+ Andy Field and Graham Hole; *How to Design and Report Experiments*; Sage Publications, 2002. ISBN 0761973834 (com, uk) [Field and Hole 2003]

◦ Shaughnessy et al; *Research Methods In Psychology*; 10th Edition, McGraw-Hill, 18 Feb 2014 ISBN 0077825365 (com, uk) [Shaughnessy et al. 2014]


### Experience Changes Perception

- Experience changes one's perception of the world.
- It is almost impossible to "forget" an experience and put oneself in the position of someone not having had the same experience [Landauer 1988, pages 907–911].
- For example:
  - Karl Dallenbach's famous photo [Dallenbach 1951; Landauer 1988, page 909].
  - Hearing a clear version of a garbled voice recording [NatGeo 2011, 00:31:32-00:32:32]. [Video: `https://dailymotion.com/video/xq1rfl?start=1883`]

### Why do Usability Testing?

- More often than not, intuitions are wrong!
- People often believe they understand the behaviour of others based on their own experiences.
- Designers often believe they understand the behaviour of their users.
- Observation and measurement (→ usability tests) can dispel such false beliefs.

### Keyboard vs Mouse

From studies at Apple [Tognazzini 1992]:

- Test users consistently report that keyboarding is faster than mousing.
- The stopwatch consistently proves that mousing is faster than keyboarding, an average of 50% faster.

“In one study of this phenomenon (Tognazzini, Tog on Interface, 1992.), users were asked to do the same task using the keyboard and the mouse. The keyboard was powerfully engaging, in the manner of many videogames, requiring the user to make many small decisions. The mouse version of the task was far less engaging, requiring no decisions and only low-level cognitive engagement.

Each and every user was able to perform the task using the mouse significantly faster, an average of 50% faster.

Interestingly, each and every user reported that they did the task much faster using the keyboard, exactly contrary to the objective evidence of the stopwatch.

The most obvious take-away message from this is that people’s subjective beliefs as to what is or is not quick are highly-suspect. No matter how heart-felt the belief, until a stopwatch shows it is true, do not accept personal opinion about speed and efficiency as fact. Instead, user-test.” [Tognazzini 1999]

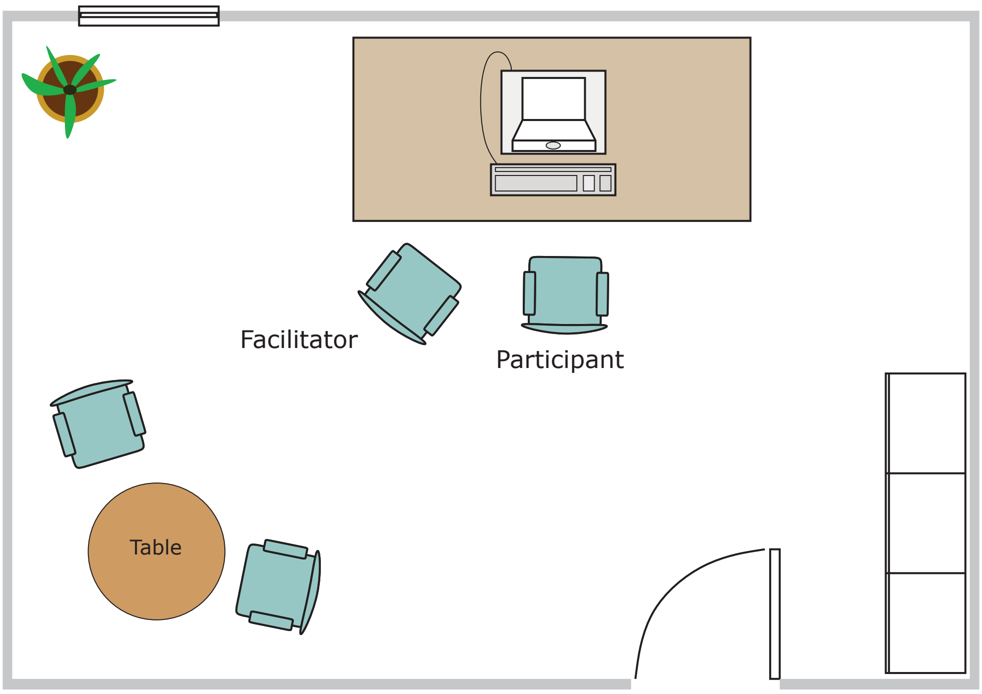


**Figure 9.1:** A simple usability test setup. This and the following test setup diagrams were inspired by those of Rubin [1994].

## 9.1 Preparing for Usability Testing

### Test Environment

Ensure comfortable test environment:

- Organise *quiet* room.
- Put up sign "Usability Test in Progress – Do not Disturb".
- Disable telephones (fixed line and mobile).
- Ensure good lighting [K. Wilson 2017].
- Provide (non-alcoholic) refreshments.

  Or use dedicated usability lab . . .

### Test Equipment

- Digital video camera.
- Video tripod.
- Good microphone (table, lapel, or headset). A singer's microphone is no good, because it must be held right next to the mouth.
- Headphones (to monitor sound).

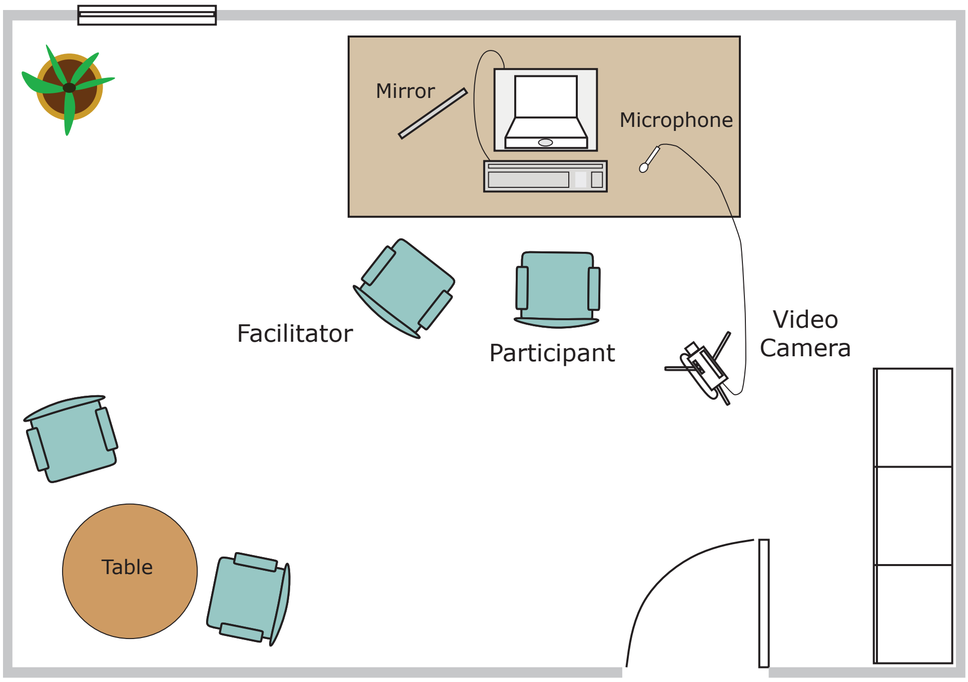


**Figure 9.2:** A typical single room, single camera usability test setup.

**Figure 9.3:** Simple usability test setup in 2002 with a single video camera. A mirror is used to capture the user's facial expressions. Video is recorded onto a VHS cassette.

**Figure 9.4:** Simple usability test setup in 2019. An external camera, mirror, and table microphone are being used, in addition to screen video capture and webcam capture on the laptop. [Image used with kind permission of Angelika Droisner and Ana Korotaj.]

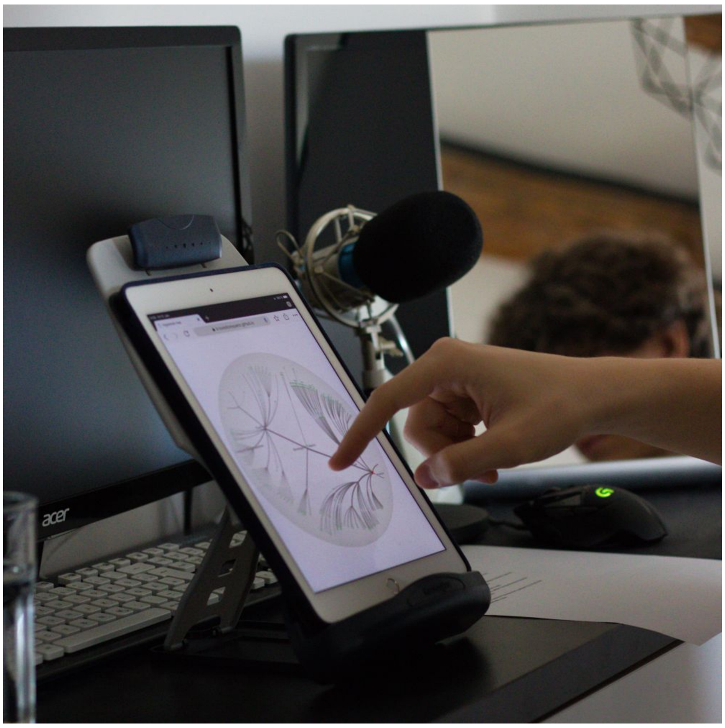

**Figure 9.5:** Testing on a tablet using a book stand. An external camera, mirror, and table microphone are being used, in addition to screen video capture and audio capture on the tablet. [Image used with kind permission of Chris Oser.]

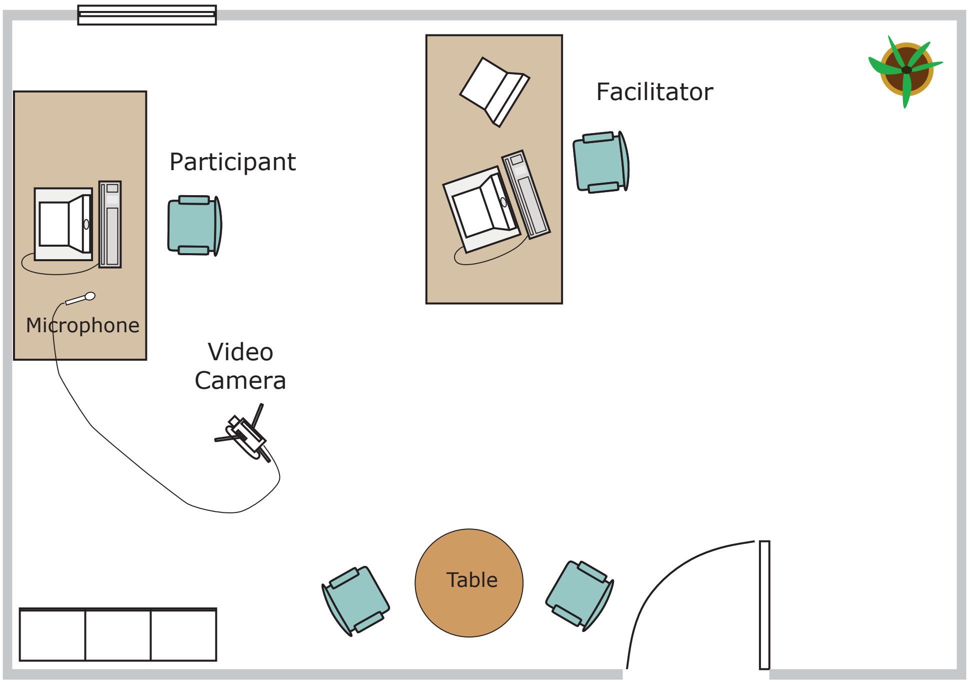


**Figure 9.6:** Single room test setup. Facilitator sits behind test participant monitoring video output and using logging software.

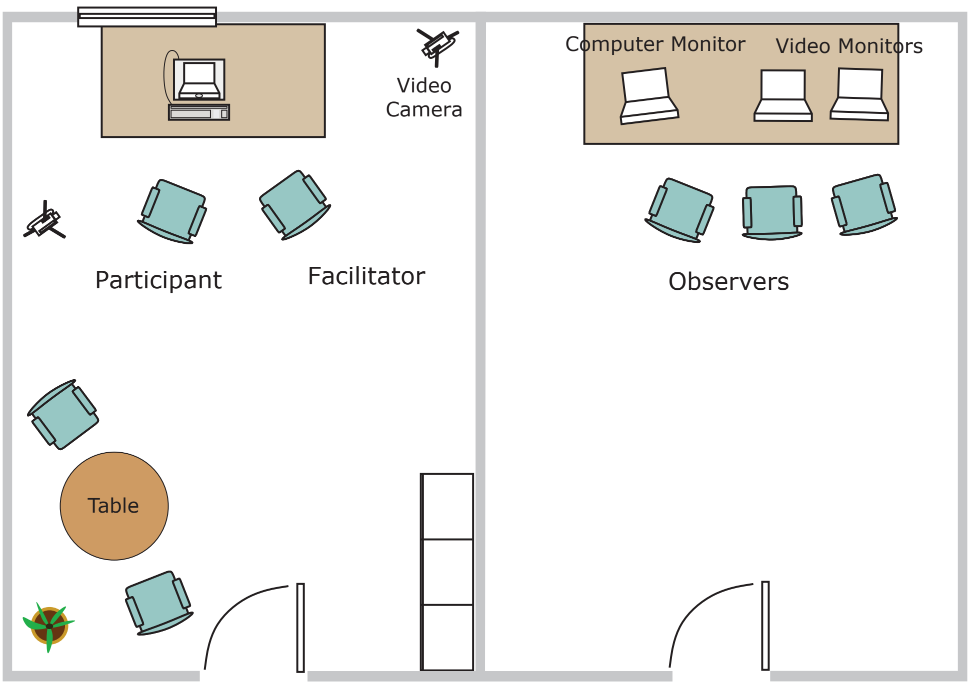


**Figure 9.7:** Observation room with electronic monitoring.

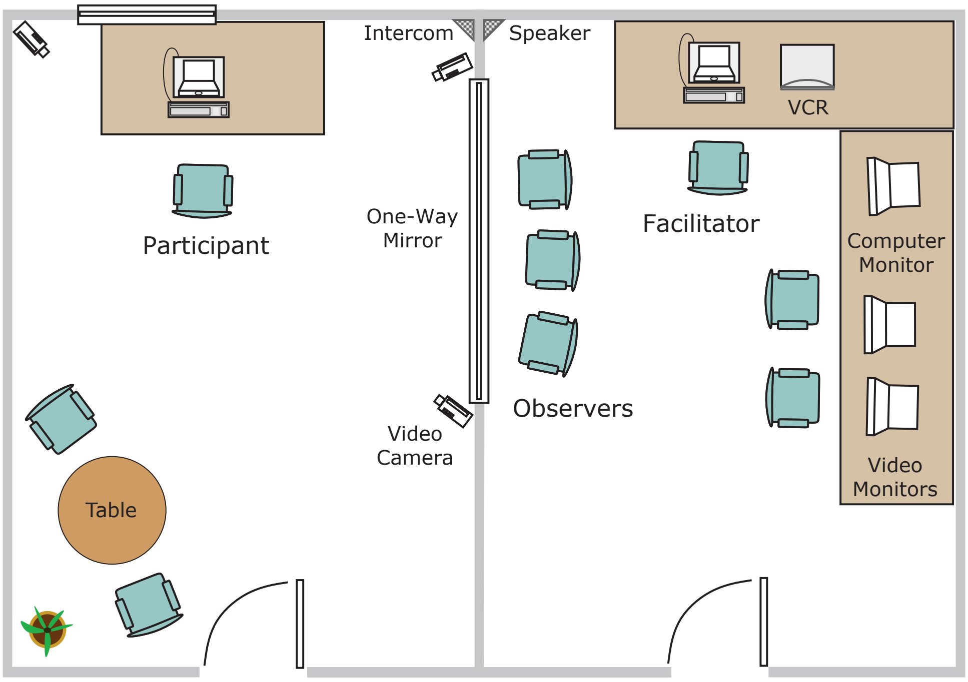


**Figure 9.8:** A classical usability lab, including an observation room with a one-way mirror.

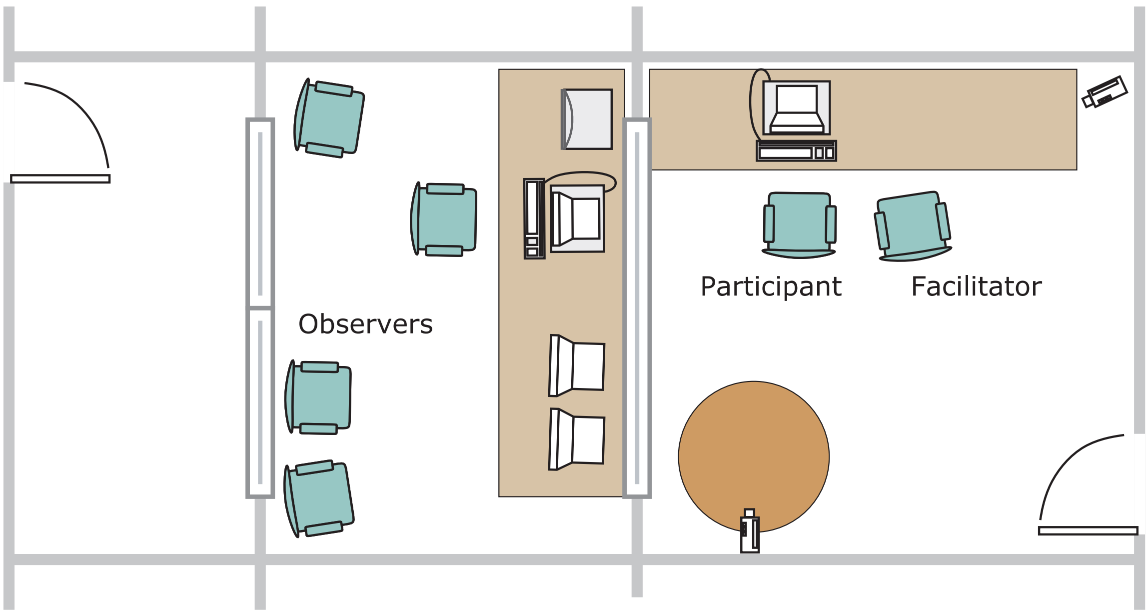


**Figure 9.9:** The standard usability lab at Microsoft headquarters in Seattle. There are 25 such labs on two floors, side to side. Users enter from the right, developers enter from the left. [Adapted from diagram at [Microsoft 2005].]

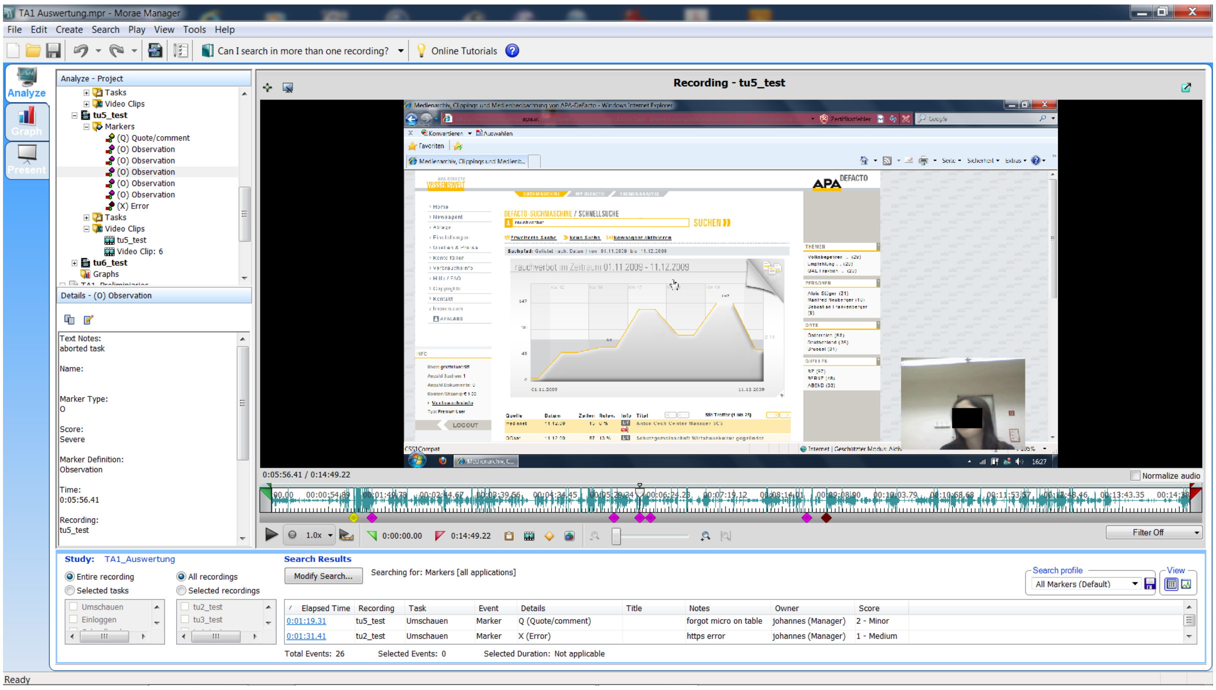

**Figure 9.10:** In Morae Manager, noteworthy events could be marked, and clips of findings easily assembled and exported. Morae was discontinued on 31 Dec 2019.

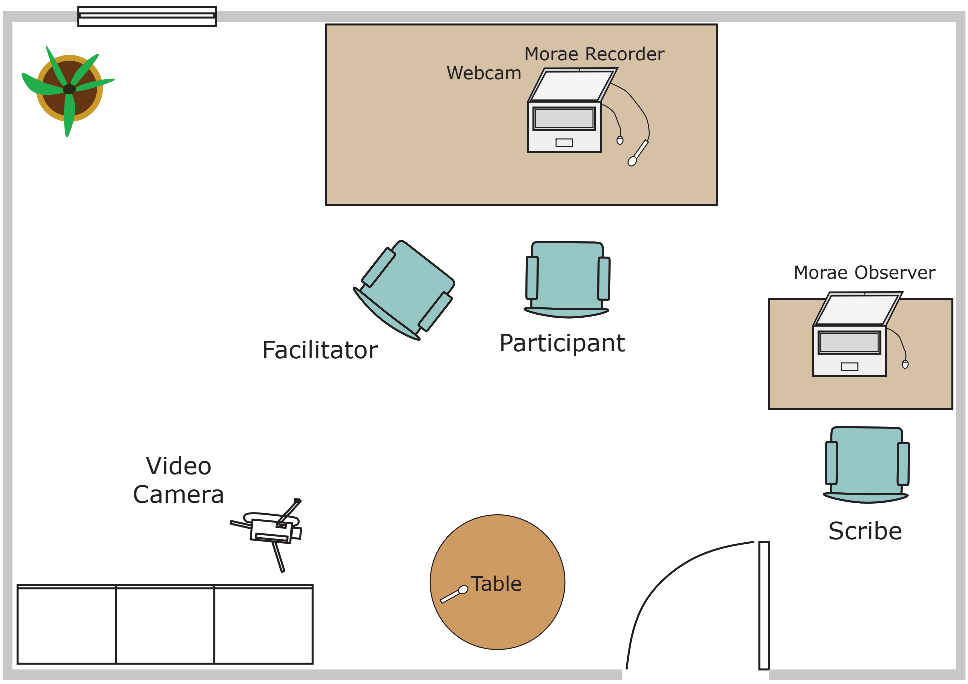


**Figure 9.11:** Morae Recorder software [TechSmith 2018] installed on the test laptop captured screen video, webcam video, and audio in snychronised streams. Morae Observer software on a second laptop could be used for live, synchronised note-taking. Morae was discontinued on 31 Dec 2019.

Usability Kit Inventory List

1. Tripod Hama Profil 74
2. Rucksack LowePro
3. Headphones
4. Headphones extension cable
5. Microphone stand
6. Microphone DeLOCK 66640
7. Microphone cable
8. Video camera manual
9. Microphone adapter cable
10. Headphone adapter
11. Microphone extension cable
12. Inventory list
13. Video camera remote control
14. Beikell SD-Card Reader
15. Lexar SDHC Card 32 GB
16. Sanyo Xacti HD1010 video camera
17. Video camera power supply
18. Video camera bag

**Figure 9.12:** The portable usability kit used at Graz University of Technology. The inventory shows all of the components of the kit.

- Mirror (to capture user's facial expressions).
- Light (desk lamp or video lighting).
- Colour video monitor (to monitor camera image).
- Powerstrip, extension cables.
- Transportation cart, or rucksack.
- "Do not Disturb" sign.
- Refreshments.
- Logging software or forms.

Figures 9.12 and 9.13 show the portable usability kits used at Graz University of Technology.

### Roles in the Test Team

- *Facilitator* (Administrator, Moderator, Manager, Monitor)
  In overall charge of test, responsible for *all* interaction with test user (introduction, test, debriefing).
- *Data Logger* (Scribe)
  Records activities and events of interest on paper, incl. time of occurrence. [Assign shorthand codes to expected activities *before* test.]
- *Video Operator*
  Responsible for recording *entire* test proceedings, incl. initial instructions and debriefing interview:

**Figure 9.13:** The portable usability kit used at Graz University of Technology. On the left, the kit has been set up ready for use. On the right, the kit packed up.

  - Check camera angles so user and interface both clearly visible.
  - Use *manual* focus (can't autofocus on computer screen).
  - Turn off any data fields (date, time, etc.) superimposed onto the video stream.
  - Ensure audio recording level is high enough.
  - Label, copy, and edit recordings.
- *Computer Operator*
  - Play the role of computer in a paper prototype.
  - Reset the interface to a clean state for each new test user (clear the cache, history, cookies, etc.).
  - Do *not* set the Home button to a web site under test, ask the user to type the URL.
  - Restart after system crash, unexpected hang-ups, etc.

### Test Users

The users taking part in the test:

- Refer to them as *test participants* or *test users*.
- Never ever call them *test subjects* or *probands*. And certainly not so they can hear!

## 9.2 Six Stages of Conducting a Test

1. Develop the Test Plan
2. Select and Recruit Participants
3. Prepare Test Materials
4. Run a Pilot Test
5. Conduct the Real Test
6. Analysis and Final Report

Note: *Always* do a pilot test!

### 9.2.1 The Test Plan

Main section headings:

- Purpose
- Problem Statement
- User Profile
- Method (Test Design)
- Task List
- Test Environment
- Data to be Collected
- Content of Report

#### Task List

- Prioritise tasks by frequency and criticality.
- Choose those most frequent and critical to test.
- Make a task list for test team internal use only.
- For each task:
  - Define any prerequisites.
  - Define successful completion criteria.
  - Specify maximum time to complete each task, after which help may be given.
  - Define what constitutes an error.
- Do *not* instruct the test user to return to the initial screen (home page) at the beginning of each task. If they do so of their own accord, that fine.

See Figure 9.14.

| *Task* | *Description* | *Prerequisites* | *Completion Criteria* | *Max. Time* | *Possible Solution Path* |
|---|---|---|---|---|---|
| 1 | Please go to the website `tugraz.at` and spend a few minutes looking around the site. | Browser is open at `google.com`. | The user indicates that they have finished looking around. | 3 minutes. | |
| 2 | When is the general admission period for next winter semester? | Browser is open somewhere on `tugraz.at`. | The user identifies the general admission period. | 4 minutes. | Main Menu → Studying and Teaching: Academic Calendar → Academic Year. |
| 3 | Find and look through the curriculum of your degree programme. | Browser is open somewhere on `tugraz.at`. | The user has opened the PDF file of the curriculum. | 4 minutes. | Main Menu → Studying and Teaching → Select a degree programme → Curriculum. |
| 4 | etc. | | | | |

**Figure 9.14:** An example internal task list for a usability test of of a university website.

### 9.2.2 Selecting and Recruiting Participants

- Users are typically divided into different user groups, based on their characteristics and needs.
- Test each user group *separately*.
- Test at least 5 test users per user group.
- Choose *representative* test users who span the chosen user group.
- Recruit test users via employment agency, students, existing customers, internal personnel.
- Maintain a database of potential test users.
- Screening questionnaire (ensure users fit profile).

### 9.2.3 Test Materials

- Orientation Script
- Background Questionnaire
- Nondisclosure and Consent Form
- Training Script (if any)
- Task Scenarios
- Data Collection Forms
- Debriefing Interview Guide

"Hi, my name is Keith. I'll be working with you in today's session. [Frank and Thomas here will be assisting me].

We're here to test a new product, the Harmony 3D Information Landscape, and we'd like your help.

I will ask you to perform some typical tasks with the system. Do your best, but don't be overly concerned with results – the system is being tested, and not your performance.

Since the system is a prototype, there are certainly numerous rough edges and bugs and things may not work exactly as you expect.

[I am an independent researcher hired to conduct this study, and have no affiliation with the system whatsoever]. My only role here today is to discover the flaws and advantages of this new system from your perspective. Don't act or say things based on what you think I might want to see or hear, I need to know what you really think.

Please do ask questions at any time, but I may only answer them at the end of the session.

While you are working, I will be taking some notes. We will also be recording the session for the benefit of people who couldn't be here today.

If you feel uncomfortable, you may stop the test at any time.

Do you have any questions?

If not, then let's begin by filling out a short background questionnaire and having you sign the nondisclosure agreement and consent to tape form."

**Figure 9.15:** An orientation script for testing the Harmony 3D Information Landscape.

- Feedback Questionnaire
- Checklist

### Orientation Script

- Introduce yourself and any observers by first name (no titles or job descriptions!).
- Explain that the purpose of the test is to collect input to help produce a better interface.
- Emphasise that system is being tested *not* user.
- Acknowledge software is new and may have problems.
- Do not mention any association you have with product (do mention if you are *not* associated with product).
- Explain any recording (reassure confidentiality).
- Say user may stop at any time.
- Say user may ask questions at any time, but they may not be answered until after the test is completed.
- Invite questions.

See Figure 9.15.

### Background Questionnaire (Pre-Test Questionnaire)

For better understanding of the user's background:

- Admin. data: date, test number, user number or id.
- General data: age (range), gender, occupation, educational level, etc.

- Computer experience: total time, frequency of use, types of software, have used a GUI before, ...
- Application experience: total time, frequency of use, brand.

See Figure 9.16.

The facilitator should ask the test user the questions on the background questionnaire and fill it in (it is more efficient than handing the pen and questionnaire to the user).

#### Training Script

Exact written description of prior training:

- Demonstration of GUI.
- Demonstration of special interaction styles: mouse keys, drag-and-drop, etc.
- Walk-through of sample task.
- Demo of how to think aloud (for Thinking Aloud style tests).

#### Task Scenarios

The task descriptions given to the test users:

- Simple introductory first task (early success).
- Realistic scenarios in typical order.
- If sequential ordering not crucial, randomise presentation order (→ counterbalances learning effect).
- Each task scenario on a separate sheet.
  [Do *not* hand the user all the tasks at once, but one at a time!]
- Do not guide participants through the task!
  [Describe the goal rather than individual steps.]

#### An Example Task Scenario

| | |
|---|---|
| Task 2. | Find the number of the telephone hotline. |

#### Data Collection Forms

- Define abbreviations for expected events → coding scheme. See Table 9.1.
- Use a probe mark like ? to signal an event worth probing during debriefing interview.
- Paper or electronic data collection forms (or instrumented software). See Figure 9.18.

#### Debriefing Interview Guide

- How was it?
- Structured interview questions (things to discuss with user in any case).

**Background Questionnaire**

Date: __________ Time: _______ Test User ID: _______

**1. General Information**

Gender: ☐ Man ☐ Woman ☐ Prefer not to disclose ☐ Prefer to self-describe: ___________

Age: _______ Occupation: ____________________

**2. Education**

1. Highest educational grade you have attained:
   ☐ Vocational Training ☐ A Levels ☐ Bachelor ☐ Master ☐ Doctorate
2. If you are a student or graduate, please state your main area of study.
   ____________________________________

**3. Personal Computer Use**

1. Which kind of personal computer do you use most?
   ☐ MS Windows ☐ Apple Mac ☐ Unix ☐ Other _______
2. How long have you been using personal computers (years)? _______
3. In a typical week, how many hours do you use a computer? _______

**4. Smartphone Use**

1. Which kind of smartphone do use most?
   ☐ None ☐ Android ☐ Apple (iOS) ☐ Other _______
2. How long have you been using a smartphone (years)? _______
3. In a typical week, how many hours do you use a smartphone? _______

**5. Web Use**

1. Which kind of device do you most often use to access the World Wide Web?
   ☐ Desktop ☐ Laptop ☐ Tablet ☐ Smartphone
2. Which kind of internet connection do you normally use?
   ☐ xDSL ☐ Cable ☐ Fibre Optic ☐ 3G
   ☐ 4G ☐ Other _______
3. Which web browser do you normally use?
   ☐ Chrome ☐ Firefox ☐ Safari ☐ Edge
   ☐ Other _______
4. How many hours per week do you use the World Wide Web? _______

**Figure 9.16:** A typical background questionnaire for a web site test.

Thank you for participating in our product research. Please be aware that confidential information will be disclosed to you and that it is imperative that you do not reveal information that you may learn during the course of your participation. In addition, your session will be recorded, to allow staff members who are not present to observe your session and benefit from your feedback.

Please read the statements below and sign where indicated. Thank you.

*I agree that I will disclose no information about the product research conducted by ABC Company Inc. or about the specifications, drawings, models, or operations of any machine, devices, or systems encountered.*

*I understand that video and audio recordings will be made of my session. I grant ABC Company Inc. permission to use these recordings for the purposes mentioned above, and waive my right to review or inspect the recordings prior to their dissemination and distribution.*

Please print name: ________________

Signature: ________________

Date: ________________

**Figure 9.17:** A combined nondisclosure and consent form.

| *Code* | *Event* |
|---|---|
| S | Start of task. |
| E | End of task. |
| N | Negative observation (problem). |
| P | Positive observation. |
| Q | Quote or comment from user. |
| X | Error or unexpected action. |
| F | Facilitator prompts user. |
| H | Facilitator helps user. |
| T | Timeout, exceeded maximum time. |
| ? | Probe during interview (probe mark). |
| C | Comment by facilitator. |
| * | Very important action. |

**Table 9.1:** A simple coding scheme for logging events during a test.

| Test: | | User No.: |
|---|---|---|
| Date: | Time: | Page: of |
| *Task* | *Elapsed Time* | *Observations* |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

**Figure 9.18:** A generic data collection form.

| Test: Edit HTML Document | | User No.: 3 |
|---|---|---|
| Date: 23 Apr 97 | Time: 11:50 | Page: 1 of 3 |

| *Task* | *Elapsed Time* | *Observations* |
|---|---|---|
| 1 | 04:25 | X Opened wrong file. Found mistake.<br>X Opened wrong file again.<br>Self-corrected due to error message. |
| | 06:00 | P |
| | 07:00 | T |
| 2 | 11:30 | Q "I wish it were always that easy!" |
| | 15:20 | ? Very long hesitation, then correct action. |
| | 16:15 | E |

**Figure 9.19:** A completed data collection form with a probe mark during task 2.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Getting to the right part of the site. | Very easy | 3 | 2 | 1 | 0 | 1 | 2 | 3 | Very hard |
| 2. | Quality of information. | Very good | 3 | 2 | 1 | 0 | 1 | 2 | 3 | Very poor |
| 3. | It is easy to read the text. | Very easy | 3 | 2 | 1 | 0 | 1 | 2 | 3 | Very hard |
| 4. | The site's local search facility (if available and used). | Very good | 3 | 2 | 1 | 0 | 1 | 2 | 3 | Very poor |
| 5. | Appearance of site, including colours and graphics. | Very good | 3 | 2 | 1 | 0 | 1 | 2 | 3 | Very poor |
| 6. | Consistency of site. | Very consistent | 3 | 2 | 1 | 0 | 1 | 2 | 3 | Very inconsistent |
| 7. | Speed of pages displaying. | Very fast | 3 | 2 | 1 | 0 | 1 | 2 | 3 | Very slow |

**Figure 9.20:** An example feedback questionnaire using 7-point semantic differentials for a usability test of of a university website.

### Feedback Questionnaire (Post-Test Questionnaire)

Collect ratings, opinions, suggestions (hard to observe in other ways), for example:

- Interface organisation matches real-world tasks?
- Too much or too little information on screens?
- Similar information consistently placed?
- Problems with navigation?
- Computer jargon?
- Appropriate use of colour?

See Figure 9.20.

### Checklist

- Make chronological checklist of things to do, as shown in Figure 9.21.

## Test Checklist

1. Preparation:
   - ☐ Reset interface for new user.
   - ☐ Check that everything is ready in test room.
2. Opening:
   - ☐ Greet the participant.
   - ☐ Go through orientation script and set the stage.
   - ☐ Ask user to read and sign consent and non-disclosure forms.
   - ☐ Background questionnaire: facilitator asks and fills out form.
3. Test Session:
   - ☐ Move over to testing area (computer).
   - ☐ Start session recording.
   - ☐ Provide any prior training.
   - ☐ Provide training of thinking aloud.
   - ☐ User begins with tasks.
   - ☐ User finishes last task.
4. Closing:
   - ☐ Interview: how was it?
   - ☐ Structured interview questions.
   - ☐ Individual interview questions arising from test.
   - ☐ Stop session recording.
   - ☐ Feedback questionnaire: user fills out form.
   - ☐ Thank participant, provide any remuneration, show participant out.
5. Clean-Up:
   - ☐ Summarise thoughts about this test.
   - ☐ Organise data sheets and notes.
   - ☐ Check and archive session recordings.

**Figure 9.21:** A example test checklist.

### 9.2.4 Pilot Test

*Always* perform pilot tests of the *entire* test procedure.

You always find something you need to fix, such as:

- ambiguous instructions.
- unrealistic time estimates.
- ambiguous task completion criteria.
- misleading questionnaire questions.
- dead battery in microphone.

If you do not catch these things in a pilot test and one of these problems occurs with user number 1 of 10 scheduled at hourly intervals, it can ruin the whole test.

Maybe even run two pilot tests: once with colleagues, once with one or two real test users.

### 9.2.5 Conducting the Real Test

- Test facilitator handles *all* interaction with participant (other team members and observers remain completely quiet).
- Use screen capture software to record the entire test session, including the user's voice and (possibly) face. Later on, extract video clips to illustrate findings.
- Do not prompt or bias user during test (beware of non-verbal signals).
- Only assist if user in severe difficulty (make note of when and what help given).
- Conduct debriefing interview and/or feedback questionnaire.
- Test users who are waiting should wait *outside* the testing room. They should *not* observe a current test in progress!

#### Debriefing Interview

1. Let user speak thoughts first: "So, how was it?".
2. Let them talk and talk, until they stop talking of their own accord.
3. Top-down: probe high-level issues from topic guide first, then more detailed questions about each task.
4. Probe specific issues arising from test notes ? . See Figure 9.19.
5. Ask any questions passed to the facilitator from the observers (they should be written onto index cards by the observers).

See also Section 9.8.

### 9.2.6 Analysis and Final Report

- Compile and summarise data, for example:

- Mean, median, range, and standard deviation of completion times.
- Percentage of users performing successfully.
- Bar chart of preference scores.
- etc.

- Analyse data:
  - Identify errors and difficulties which arose.
  - Diagnose the source of each error.
  - Prioritise problems by their severity or criticality.

### Final Report

- Title Page
- Description of Test Environment
  - Hardware, software version, test room, dates when tests were performed.
- Executive Summary
  - Concise summary of major findings, no more than a few pages.
- Description of Test
  - Updated test plan, method, training, and tasks.
- Test Person Data
  - Tabular summary of age, occupation, experience.
- Results
  - Tabular and graphical summaries of times taken, number of errors made, questionnaire responses, etc.
  - Discussion and analysis, amusing quotations.
- List of Positive Findings
- List of Recommendations List of problems discovered, in descending order of severity, and recommended improvements. For each recommendation:
  - diagnose why the problem occurred
  - illustrate it with a screen shot
  - rate its severity (0. . . 4 scale)
  - indicate exactly how many test users experienced the problem
  - include a reference to timestamp(s) on the video tape
  - possibly include an appropriate user quotation
  - describe your suggested improvements
- Appendices (raw data and tables).

– Background questionnaires, consent forms, orientation script, data collection forms, video and audio tapes, transcripts, etc.

#### Example Recommendation

R12. **Sort Order Panel** (Severity 3.2)

- *Problem*: Users had problems understanding the sort order panel. In particular, the plus and minus icons used for increasing and decreasing order are non-intuitive.
- *Reference*: TP1, 00:08:15
  "What does this plus mean?"
- *Recommendation*: redesign the icons, for example as sloping ramps.

## 9.3 Thinking Aloud Tests

A thinking aloud test is a formative usability testing method:

- Test users are asked to verbalise their thoughts ("think aloud") while performing tasks.
- In other words, to provide a running commentary on what they are seeing, thinking, and doing.
- Provides insight into their thought processes and why things go wrong (process data).
- Relatively small number of test users (say 3 to 5).
- Many vivid and colourful quotes.

#### Detecting Vocabulary Problems with Thinking Aloud

Example from C. Lewis and Rieman [1993, Section 5.5]:

- Menu-based administrative system for law offices.
- System messages extensively refered to "parameter".
- Test users persistently misread "parameter" as "perimeter".
- Hard to detect such problems just by watching people's mistakes, much easier when they are thinking aloud.

#### The Thinking Aloud Method

Ask users to tell you:

- what they are trying to do
- things they read
- questions that arise in their mind
- things they find confusing
- decisions they make

### Preparing the User

- Demonstrate thinking aloud for an unrelated task, e.g. looking up the films on tonight in the local cinemas (newspaper or online).
- Show user short video clip of a previous thinking aloud test.
- Have the user practice the technique using a different interface and unrelated task.
- Request questions be asked as they arise, but explain that you won't answer them until after the test.

### Test Facilitator's Role

The facilitator must encourage the user to keep up a flowing commentary:

- Minimal encouragers:
  - non-committal "uh huh", "mmm", "yeah".
  - head-nodding.
  - body language.
- Neutral, unbiased prompts:
  - "Tell me more."
  - "Keep talking to me."
  - "Please tell me what you are doing now?"
  - "I can't hear what you are saying"
  - "What are you thinking right now?"

### Video: Demo Usability Test

- Steve Krug's book Rocket Surgery Made Easy [Krug 2009] has an accompanying demo video [Krug 2010a]. [Video: `https://youtu.be/1UCDUOB_aS8`]
- Watch the video and make a note of any usability problems you observe.
- Pause the video at 21:05.
- At this point, decide which were the top three usability problems you observed.
- Now watch the rest of the video.
- The video shows an example of a simple thinking aloud test.
- Facilitator (Steve Krug) sitting next to test user (his wife).
- Just screen and audio recording (no usercam).

  [I generally prefer to have a usercam where possible, so the user's reactions and facial expressions are captured. Of course, such videos should only ever be published or shared with the user's consent, and usually after the user's face has been pixelated or blurred.]

### Spontaneous Comments are Best

Do *not* direct the user with specific questions like:

- "Why did you do that?"
- "Why didn't you click here?"
- "What are you trying to decide between?"

Spontaneous comments from the user are best.

### Do Not Ask Why Questions

Specific "why" questions encourage plausible, but often unreliable, answers [Higgins 2007], as shown in many classic studies:

- Maier [1931]. Problem: tie together two cords hanging from ceiling, too far apart to be grabbed. Solution: tie weight to one cord, set it swinging, grab other cord, wait for swinging cord to come within reach. When Maier "accidentally" brushed against one cord, 16 participants solved the problem. However, when asked how solution was arrived at, only one mentioned that seeing the cord swaying had prompted him. The others gave explanations such as: "It just dawned on me."
- Nisbett and T. D. Wilson [1977, pages 243–244] and T. D. Wilson [2002, pages 102–103]. Four *identical* pairs of nylon stockings were placed from left to right (labeled A to D) on a display table outside a busy supermarket. 52 participants were asked to say which of the stockings were the best quality. The preferences were 12% for A, 17% for B, 31% for C, and 40% for D, indicating a statistically significant position effect. When asked why they chose a particular item, participants made up plausible (but wrong) reasons, such as "superior knit, sheerness, or elasticity". In fact, there is a natural bias towards last of a number of closely matched alternatives.
- Johansson et al. [2005], Johansson and Hall [2008] and Simons [2010, 14:04-15:38] [Video: `https://youtu.be/eb4TM19DYDY?t=14m04s`]. 118 participants were shown 15 pairs of photos of women and asked which woman in each pair was most attractive. The chosen photo was pushed toward the participant for further comment and the non-chosen photo removed. The participant was then asked why they had chosen that photo. Three of the pairs were manipulated (through sleight of hand), such that the non-chosen photo was presented for comment. Most participants failed to notice any manipulation and made up plausible (but obviously wrong) reasons to justify their choice.

Asking people to explain the reasons for their behaviour (introspection or self-reporting) is unreliable!

### Pros and Cons of Thinking Aloud

++ Finds many usability problems.

++ Finds *why* problems occur (process data).

\+ Small number of test users (3 to 5).

\+ Usable early in development process.

\+ Requires little facilitator expertise.

\+ Generates colourful quotes.

- - Users typically only find issues associated with the tasks they are asked to perform.

- - Thinking aloud slows users down by about 17% [Ericsson and Simon 1993, page 105].

- Depending on the instructions given to the user, having to think aloud can change the user's problem-solving behaviour (they might think more before acting).

- Cannot provide performance data (bottom-line data).

It does not make sense to take timings or analyse task completion times in a thinking aloud test!
[For that, do a formal experiment, without thinking out loud.]

## 9.4 Listening Labs

A listening lab is a variant of a thinking aloud test:

- Facilitator with single user who thinks aloud.
- No predefined tasks.
- The user explores the interface and sets their own tasks.
  ["What do you think you might want to do on this web site?"]
- Environment simulates real-use setting.
- Predefined tasks often neglect what individual users want to accomplish and sometimes miss larger strategic findings.

See Rehman [2000] and Hurst [2015, Chapter 7].

## 9.5 Co-Discovery Tests

A co-discovery test is a variant of a thinking aloud test with two users instead of one:

- Two test users explore an interface *together*.
- There is natural interaction and communication between the test users.
- Marissa Mayer used a co-discovery test for the first ever user test of Google (search engine) in Jan 2000, 16 students at Stanford, in 8 pairs [Mayer 2009, 01:00-04:14]. [Video: `https://aiga.org/inspiration/talks/marissa-mayer-2009-make-think-design-conference`]

### Pros and Cons of Co-Discovery

++ No unnatural thinking aloud.

- Need twice as many test users.

- - Validity issue: would the interface be used by two people working together in real life?

## 9.6 Formal Experiments

A formal experiment is a summative usability testing method:

- Controlled experiment with representative test users.
- Measurement and collection of quantitative data.
- Both objective measures (performance, success, ... ) and subjective measures (ratings, overall preference).
- *Never* ask users to think aloud during a formal experiment (thinking aloud slows users down and can change their behaviour).
- Summative evaluation: performed on (fully) implemented design(s).
- Followed by more or less rigorous statistical analysis.
- Two main uses:
  - assessing the absolute performance of an interface.
  - objectively comparing two (or more) alternative interface designs.

Formal experiments provide bottom-line data (measurements), but require larger numbers of test users for statistical accuracy (sometimes around 16 to 20, but often 50 or 100 or more).

### Objective Measures

Collect objective, quantitative data by measuring or counting things such as:

- Time to complete specific task(s).
- Number of tasks completed within given time.
- Number of errors.
- Number of deviations (extra clicks) from optimal path.
- Accuracy (answer to question true or false).
- Ratio successful interactions : errors.
- Time spent recovering from errors.
- Number of commands/features used.
- Number of features user can remember after test.
- How often help system used.
- Time spent using help.
- Ratio positive : negative user comments.
- Number of times user sidetracked from real task.

### Subjective Measures

Collect subjective, quantitative data, by asking users to give ratings and/or to express a preference (usually via a questionnaire), such as:

- The interface was easy to use (for example, on a scale of 0..6).
- The interface was cluttered (for example, on a scale of 0..6).
- Of the four interfaces, which was your favourite?

### Validity

*Validity*: is measured data relevant to the usability of the real system in real world conditions?

Typical validity problems include:

- *Testing with the wrong kind of user*: For example, testing business students instead of managers for a management information system. However, testing business students will generally lead to better results than testing, say, mathematics students.
- *Testing the wrong tasks*: The results from testing a toy task in a prototype of a few dozen hypermedia documents may not be relevant to a planned system for managing tens of thousands of documents.
- *Not including time constraints and social influences*: Queues of people waiting in line, noise levels in the working environment, etc.

## 9.6.1 Testing Absolute Performance of One Interface

- One interface.
- Run an experiment to objectively determine whether the interface satisfies specific requirements.
- For example: measure how long it takes 20 expert users to perform task X.
- Result: an expert user can on average perform task X in 2 minutes 10 seconds ± 6 seconds.

## 9.6.2 Comparing Two Alternative Interfaces

- Two interfaces, A and B.
- Run an experiment to objectively determine which interface is better, according to some criterion (efficiency, error rate, etc.).
- Two different ways of designing an experiment: *independent measures* (also called *between-groups* or *unrelated*) and *repeated measures* (also called *within-groups* or *related*).

#### Independent Measures (or Between-Groups) Experimental Design

- Two equally-sized groups of test users.
- *Randomly* assign users to two groups.
- Group 1 uses only system A, group 2 only system B.

- Identical tasks for both groups.

### Pros and Cons of Independent Measures Experimental Design

\+ no problems with learning effect.

\- cannot ask users which they preferred.

\- generally needs twice as many users.

\- large individual variation in user skills (std. dev. $\approx$ 50%).

#### Repeated Measures (or Within-Groups) Experimental Design

- One group of test users.
- *Randomly* assign users to two equally-sized pools.
- Users work with both systems.
- Pool 1 uses system A first, pool 2 system B first.
- Two sets of different but equivalent (equally difficult) tasks.

### Pros and Cons of Repeated Measures Experimental Design

\+ automatically controls for individual variability.

\+ can ask users which they preferred.

\+ generally needs fewer test users in total.

\- transfer of skill between systems (learning effect).

#### Example Experimental Designs

| **Independent Measures** | |
|---|---|
| *System A* | *System B* |
| John | Dave |
| James | Mariel |
| Mary | Ann |
| Stuart | Phil |
| Keith | Tony |
| Gary | Gordon |
| Jeff | Ted |
| ... | ... |
| Bill | Edward |
| Charles | Thomas |
| Celine | Doug |

| **Repeated Measures** | |
|---|---|
| *Participant* | *Sequence* |
| Elisabeth | A, B |
| Sven | A, B |
| Amanda | A, B |
| Claudia | A, B |
| Terry | A, B |
| Nigel | A, B |
| Barry | A, B |
| ... | ... |
| Ben | B, A |
| Michael | B, A |
| Richard | B, A |

### Statistical Analysis

Answers questions such as:

- Is there a statistically significant difference between system A and B? [hypothesis testing]
- How large is the difference? [point estimation, averages]
- How accurate are the results? [standard deviation, confidence intervals]

with statements such as:

- We are 95% certain that the time to perform task X is $4.5 \pm 0.2$ minutes.
- System A is faster than system B at the level $p < 0.2$.
  [20% chance that B is faster, but still choose A since odds are 4:1.]

### Sample Size (How Many Test Users?)

- Depends on desired confidence level and confidence interval.
- Confidence level of 95% often used for research, 80% ok for practical development.
- Nielsen: survey of 36 published usability studies [J. Nielsen 1993b, pages 166–169]. Rule of thumb: 16-20 test users.
- If the differences are small, you might need 50 or 100 or more users to detect a statistically significant difference.

### Case Study: Touchscreen Toggle Design

Study by Catherine Plaisant, University of Maryland:

- Home automation system with touchscreen display.
- Toggles (on/off switches) for lighting, climate control, security, etc.
- Six toggle designs: 1-Button, Rocker, 2-Button, Words, Slider, and Lever.
- Formal experiment with 15 novice users (undergrad students).
- Measures:
  - Objective: error rate.
  - Subjective: user satisfaction.

  [Performance (time) was apparently not measured.]
- Tech report [Plaisant and Wallace 1990] and short paper [Plaisant and Wallace 1992a]
- Video made in 1991, also shown at CHI'92 [Plaisant and Wallace 1992b]. [Video: `https://youtu.be/wFWbdxicvK0`]
- The video was successfully cited as prior art when Apple lost their law suits against HTC [Mueller 2012] and Samsung [Beem 2016] for infringement of the slide-to-unlock patent. [Video: `https://channel4.com/news/apple-touch-screen-patent-war-comes-to-the-uk`] [00:39-02:11]

See Plaisant [2016] for more on the work at HCIL. See Joyce [2018] and Kuric [2022] for more discussion and examples around toggle design.

#### Pros and Cons of Formal Experiment

++ collects quantitative measurement data (bottom-line data)

++ collects both objective and subjective measures

++ allows comparison of alternative designs

- usable only later in development process

- requires facilitator expertise

- cannot provide why-information (process data)

-- needs significant number of test users (20 or more)

## 9.7 A/B Testing

An A/B test is a summative usability testing method:

- Controlled experiment on a live web site with its real live users.
- A proportion of visitors are randomly assigned to a variant (B) of the web site (they have a slightly different experience), the others see the standard web site (A, the control).
- A cookie is usually assigned, so that individual users always see the same variant.
- A metric (the *overall evaluation criterion*, or OEC) such as click-through rate is measured for each variant.
- The difference in OEC is examined for statistical significance.
- Originally used in marketing [Hopkins 1923], where direct mail with variants of brochures elicited varying response rates (go with the best one).
- Online A/B testing was pioneered at Amazon.com.
- Also called *split testing*, *bucket testing*, and *multivariant testing*.

  See Figure 9.22.

#### References

++ Ronny Kohavi, Diane Tang, and Ya Xu; *Trustworthy Online Controlled Experiments: A Practical Guide to A/B Testing*; Cambridge University Press, 02 Apr 2020 [Kohavi et al. 2020].

++ Ronny Kohavi et al; *Controlled Experiments on the Web: Survey and Practical Guide*; Data Mining and Knowledge Discovery, Vol. 18, No. 1, Kluwer, 01 Feb 2009 , pages 140–181. doi:10.1007/s10618-008-0114-1 [Kohavi et al. 2009].

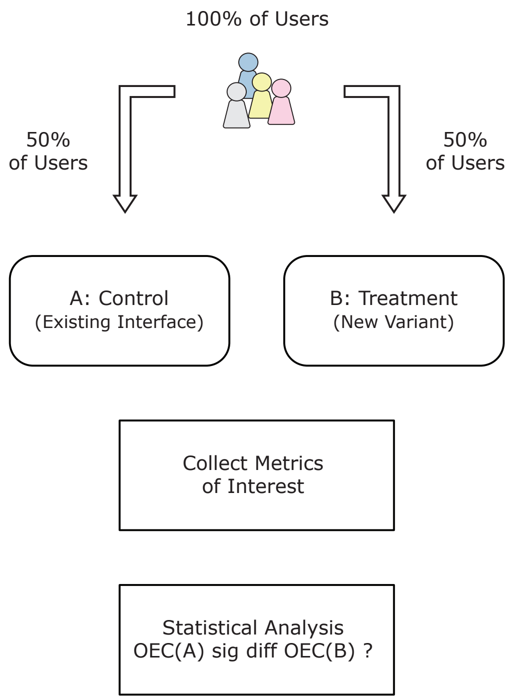


**Figure 9.22:** An A/B test is a controlled experiment on a web site involving its real live users. A proportion of users see a modified version and are then compared to a control group.


++ Ronny Kohavi and Stefan Thomke; *The Surprising Power of Online Experiments*; Harvard Business Review, Sep 2017. `https://hbr.org/2017/09/the-surprising-power-of-online-experiments` `https://optimizely.com/resources/hbr-online-experiments/`

++ Ronny Kohavi et al; *Seven Rules of Thumb for Web Site Experimenters*; doi:10.1145/2623330.2623341 `http://exp-platform.com/Documents/2014%20experimentersRulesOfThumb.pdf`

++ Erin Weigel; *Design for Impact: Your Guide to Designing Effective Product Experiments*; Rosenfeld, 11 Jun 2024 [Weigel 2024].

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+ Ronny Kohavi and Roger Longbotham; *Online Experiments: Lessons Learned*; IEEE Computer, Vol. 40, No. 9, 01 Sep 2007 , pages 103–105. doi:10.1109/MC.2007.328 [Kohavi and Longbotham 2007]

+ Ronny Kohavi et al; *Practical Guide to Controlled Experiments on the web: Listen to Your Customers not to the HiPPO*; Proc. KDD 2007, San Jose, California, 01 Aug 2007 , pages 959–967. doi:10.1145/1281192.1281295 [Kohavi et al. 2007]

◦ Bryan Eisenberg and John Quarto-vonTivadar; *Always Be Testing: The Complete Guide to Google Website Optimizer*; Sybex, 01 Aug 2008 . ISBN 0470290633 (com, uk) [Eisenberg and Quarto-vonTivadar 2008]

◦ Claude Hopkins; *Scientific Advertising*; Lord & Thomas, 1923. Copyright expired. Freely available in PDF. [Hopkins 1923]

### Online Resources

\+ Shanelle Mullin; *The Complete Guide to A/B Testing*; https://shopify.com/blog/the-complete-guide-to-ab-testing

\+ Wikipedia; *A/B testing*; https://wikipedia.org/wiki/A/B_testing

\+ Microsoft; *ExP Platform*; https://exp-platform.com/talks/

\+ Sergey Gitlin et al.; *Supercharging A/B Testing at Uber*; 21 Jul 2022 https://uber.com/blog/supercharging-a-b-testing-at-uber/

\+ Erin Weigel; *Erin Does Things: Resources*; https://erindoesthings.com/resources/

◦ G2 Crowd; *Best A/B Testing Software*; https://g2crowd.com/categories/a-b-testing

◦ Visual Website Optimizer; https://vwo.com/resources/case-studies/

++ abtests.com at Internet Archive; https://web.archive.org/web/20120225010041/http://www.abtests.com:80/browse

\+ wishpond; *50 A/B Split Test Conversion Optimization Case Studies*; https://blog.wishpond.com/post/98235786280/50-a-b-split-test-conversion-optimization-case-studies

### Videos: Ron Kohavi on A/B Testing

- Ronny Kohavi's talk at CIKM 2008 [Kohavi 2008, 00:00-14:40] is a great introduction. [Video: https://videolectures.net/cikm08_kohavi_pgtce/]
- Ronny Kohavi's talk at Decisions 2018 [Kohavi 2018] is a great update [33 mins.] [Video: https://youtu.be/kTAFOCynWIg]

### Running an A/B Test

- The interface variants should be equivalently well implemented. Before a design makes it as far as an A/B test, it usually undergoes several iterations of formative usability testing.
- Multiple variants can be tested simultaneously (sometimes called A/B/N or A/B/Z tests).
- The test users are normal visitors to the site and usually unknowingly take part in an A/B test.
- It is good practice to start with a small fraction of users (say 1%) assigned to the test.
- After a few hours, compute a small number of "guardrail" metrics, to ensure that the new feature is not harming overall system integrity [Kohavi 2018, 11:40-12:30].
- Then gradually ramp up over several days to 10%, 20%, or 100% (=50% in each condition).
- After a day, compute a swathe of (a 1,000 or more) metrics, with email alerts for significant differences, to guard against any surprise effects in other parts of the system [Kohavi 2018, 12:30-13:16].
- An experiment typically runs for several weeks, so as to balance out any cyclical or calendar effects (more purchases at weekends, more visits by children during school holidays, etc.).
- The user base must be large enough (many thousands of users per week), so that there is a reasonable chance of reaching statistical significance.

- Problems and biases in the design or statistical analysis can be detected by running an A/A test (the same interface against itself). The result should be no statistically significant differences in all metrics.

### Lessons Learned in Running A/B Tests

Based on Ronny Kohavi's insights [Kohavi 2018]:

1. *Choosing a good metric as the OEC is really hard*: Ideally, look for short-term metric which predicts long-term benefit [Kohavi 2018, 13:21-22:38].

2. *Most ideas fail*: At Microsoft, around ⅓ ideas are positive, ⅓ are flat (no sig. diff.), and ⅓ are negative [Kohavi 2018, 22:38-24:59]. If a new feature shows no statistically significant improvement (flat), probably better not to ship it (unnecessary extra code).

3. *Small changes can have a big impact, but these are rare*: When a small change makes a big difference, they become the subject of a keynote talk! [Kohavi 2018, 24:59-26:40].

4. *Most progress is made incrementally by small changes*: Extremely rare for an experiment to improve OEC by > 2%. Ship once a month rather than every three years. [Kohavi 2018, 26:40-28:02].

5. *Validate the experimentation system*: Carefully check the stats, filter out bot traffic, run A/A tests [Kohavi 2018, 28:02-31:58].

   Remember Twyman's Law: "Any figure that looks interesting or different is usually wrong."

### Examples of A/B Testing

- Microsoft runs around 2,000 A/B tests a month [Kohavi 2018, 06:00-06:09]. Every new feature goes through an A/B test before it ships.

- Google puts every design change through an A/B test [Holson 2009; Walker 2009]. "Let data decide.", as Marissa Mayer out it [Mayer 2009, 06:33-07:39]. [Video: `https://aiga.org/inspiration/talks/marissa-mayer-2009-make-think-design-conference`]

  Google famously tested 41 shades of blue to find the best colour for links. Adding a little red to the blue link colour increased the click rate [Mayer 2009, 07:39-11:08].

  Google's former Lead Visual Designer, Douglas Bowman, resigned over the issue [Shankland 2009; Bowman 2009].

- Amazon has run many experiments to optimise its shopping cart [Eisenberg 2008].

- The BBC uses A/B testing for different design elements on its web sites [Hampson 2010].

- Many Facebook ad campaigns rely on A/B testing. Ad agency TBG typically tries out 27,000 versions of an ad [BBC 2011, 30:40-32:28]. [Video: `https://dailymotion.com/video/xmso1d?start=1840`]

- Luis von Ahn at Duolingo runs many A/B tests, including to discover the best ordering for teaching modules [von Ahn 2014, 22:45-24:08] and the best way to get users to come back [von Ahn 2014, 19:15-19:40]. [Video: `https://youtu.be/FU47HMHPQRs?t=22m45s`] [Video: `https://youtu.be/FU47HMHPQRs?t=19m15s`]

- Mark Pincus at Zynga is very enthusiastic about A/B testing [Pincus 2009, 46:36-47:50]. [Video: `https://vimeo.com/412860029#t=46m36s`]

- Amazon (and others) have experimented with random price tests: setting different prices for the same product to determine the optimal price (so-called *differential pricing*) [Martinez 2000; Ramasastry

2005; Useem 2017]. Amazon CEO Jeff Bezos said it was "a mistake" to have done so and they would not do it again [PSBJ 2000].

## 9.8 Post-Test Interviews

A post-test interview is a formative usability testing method:

- Ask test users questions *after* they have used the system to perform representative tasks.
- Useful supplement after a thinking aloud test.
- Provides *subjective* qualitative feedback about users' view of system: preferences, impressions, attitudes.

#### Post-Test Interview Procedure

- Let user speak thoughts first: "So, how was it?".
- Top-down: probe high-level issues from topic guide first, then more detailed questions about each task.
- Probe specific issues arising from test notes.
- Accept questions from any observers (should be written on a slip of paper for the facilitator to ask).
- Interviews should be transcribed into words for later reference and for full-text search.

#### Pros and Cons of Post-Test Interview

++ flexible: facilitator can probe interesting issues

\+ collect subjective user feedback about system

\+ simple

\+ cheap

\- hard to analyse and compare

## 9.9 Post-Test Questionnaires

A post-test questionnaire is a summative usability testing method:

- Written, structured form is given to users to fill out, after they have used the system(s) being evaluated.
- Collects quantitative data (ratings and preferences) which can be analysed statistically.
- Can also collect some additional qualitative feedback.
- Note, however, that designing truly unbiased questionnaires and surveys is a discipline of its own (see Section 9.10).

#### Styles of Question

1. **General**: age (range), gender, occupation, educational level, etc.

2. **Open-Ended**: suggestions, comments.

   I found the following aspects particularly easy to use (please list 0–3 aspects):

   ____________________________
   ____________________________
   ____________________________

   Open-ended questions collect qualitative responses for formative feedback, but which cannot be analysed statistically.

3. **Likert Scale**: Quantitative ratings to judge user's agreement with specific statement (5, 6, or 7 point scale best).

   Overall, I found the widget easy to use.

   | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |
   |---|---|---|---|---|
   | ☐ | ☐ | ☐ | ☐ | ☐ |

   5 and 7 point scales offer the user a midpoint (a fence to sit on). Use a 6 point scale to force users to jump one way or the other. More than 7 point scales provide too little distinction between neighbouring points.

4. **Semantic Differentials**: Quantitative ratings with sliding scale between opposing pairs of adjectives (5 or 7 point scale best).

   Circle the number most closely matching your feelings about the interface.

   | | | | | | | | | |
   |---|---|---|---|---|---|---|---|---|
   | Simple | 3 | 2 | 1 | 0 | 1 | 2 | 3 | Complex |
   | Professional | 3 | 2 | 1 | 0 | 1 | 2 | 3 | Unprofessional |
   | Reliable | 3 | 2 | 1 | 0 | 1 | 2 | 3 | Unreliable |
   | Attractive | 3 | 2 | 1 | 0 | 1 | 2 | 3 | Unattractive |

   Externally, on the questionnaire, the user sees unbiased ratings from 3 down to 0 and back up to 3. Internally, for statistical analysis, these ratings are converted to scores between 0 points (the worst rating) and 6 points (the best rating).

5. **Overall Preference**: A vote for one item from a set of choices.

   Overall, which hierarchy browser did you prefer?

   | | |
   |---|---|
   | Tree View (Windows explorer) | ☐ |
   | Hyperbolic browser | ☐ |
   | Treemap | ☐ |
   | Information pyramids | ☐ |

6. **Multi-Choice**: boxes to tick. [Tick just one box, tick multiple boxes, yes and no boxes]

   Which methods do you use to get help (tick any that apply)?

| | |
|---|---|
| Context-sensitive help | ☐ |
| On-line manual | ☐ |
| Printed manual | ☐ |
| Google search | ☐ |
| Ask a colleague | ☐ |

7. **Ranked**: place items in order.

Please rank the usefulness of these methods (1 most useful, 2 next, 0 if unused)?

| | |
|---|---|
| Menu-selection | ☐ |
| Button | ☐ |
| Accelerator Key | ☐ |
| Command line | ☐ |

### Standardised Usability Questionnaires

There are numerous standardised post-test (after a user has used the system) usability questionnaires:

- SUS (System Usability Scale); free; 10 ratings on 5-point Likert scale [Brooke 1996; Brooke 2013; Sauro 2011]. An example SUS questionnaire can be seen in Figure 9.23.

  Odd-numbered ratings are scored from 0 (left=worst) to 4 (right=best) points. Even-numbered ratings are scored from 4 (left=best) to 0 (right=worst) points. The points total is then multiplied by 2.5 to give a score between 0 and 100.

  Then convert score into a percentile, see `https://measuringu.com/sus/`.

- UEQ (User Experience Questionnaire); free; 26 ratings as 7-point semantic differentials [UEQ 2020]. An example UEQ questionnaire can be seen in Figure 9.24.

- QUIS (Questionnaire for User Interaction Satisfaction); commercial; 41 (upto 122) ratings as semantic differentials on 9-point scale [HCIL 2020].

- SUMI (Software Usability Measurement Inventory); commercial; 50 ratings on 3-point Likert scale [SUMI 2020].

- WAMMI (Website Analysis and MeasureMent Inventory); commercial; 20 ratings on 5-point Likert scale [WAMMI 2020]. See `http://wammi.com/samples/` and `http://wammi.com/demo/`.

- SUPR-Q (Standardized User Experience Percentile Rank Questionnaire); commercial; 8 ratings, 7 on 5-point Likert scale, 1 on 11-point NPS scale [SUPR-Q 2020].

The commercial providers usually offer the possibility to compare your own ratings with benchmark ratings across similar products or industries.

### Net Promoter Score (NPS)

- Single rating of customer loyalty, based on *likelihood to recommend* (LTR).
- invented by Frederick Reichheld [Reichheld 2003; Reichheld and Markey 2011].
- Used by vast numbers of companies and organisations [Colvin 2020; Sauro 2012].
- 11-point Likert scale, as shown in Figure 9.25.
- Score: 9 or 10 → Promoter, 7 or 8 → Passive, 0 to 6 → Detractor.

PARTICIPANT NAME: DATE:

System Usability Scale

For each of the following statements, please mark one box that best describes your reactions to TreeTest today.

| | Statement | Strongly disagree 1 | 2 | 3 | 4 | Strongly agree 5 |
|---|---|---|---|---|---|---|
| 1. | I think that I would like to use TreeTest frequently. | 1 | 2 | 3 | 4 | 5 |
| 2. | I found TreeTest unnecessarily complex. | 1 | 2 | 3 | 4 | 5 |
| 3. | I thought TreeTest was easy to use. | 1 | 2 | 3 | 4 | 5 |
| 4. | I think that I would need the support of a technical person to be able to use TreeTest. | 1 | 2 | 3 | 4 | 5 |
| 5. | I found the various functions in TreeTest were well integrated. | 1 | 2 | 3 | 4 | 5 |
| 6. | I thought there was too much inconsistency in TreeTest. | 1 | 2 | 3 | 4 | 5 |
| 7. | I would imagine that most people would learn to use TreeTest very quickly. | 1 | 2 | 3 | 4 | 5 |
| 8. | I found TreeTest very cumbersome (awkward) to use. | 1 | 2 | 3 | 4 | 5 |
| 9. | I felt very confident using TreeTest. | 1 | 2 | 3 | 4 | 5 |
| 10. | I needed to learn a lot of things before I could get going with TreeTest. | 1 | 2 | 3 | 4 | 5 |

Comments (optional):

**Figure 9.23:** An SUS questionnaire for a system called TreeTest, generated by usabiliTEST's free SUS PDF Generator [usabiliTEST 2020].

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | annoying | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | enjoyable |
| 2 | not understandable | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | understandable |
| 3 | creative | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | dull |
| 4 | easy to learn | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | difficult to learn |
| 5 | valuable | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | inferior |
| 6 | boring | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | exciting |
| 7 | not interesting | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | interesting |
| 8 | unpredictable | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | predictable |
| 9 | fast | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | slow |
| 10 | inventive | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | conventional |
| 11 | obstructive | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | supportive |
| 12 | good | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | bad |
| 13 | complicated | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | easy |
| 14 | unlikable | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | pleasing |
| 15 | usual | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | leading edge |
| 16 | unpleasant | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | pleasant |
| 17 | secure | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | not secure |
| 18 | motivating | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | demotivating |
| 19 | meets expectations | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | does not meet expectations |
| 20 | inefficient | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | efficient |
| 21 | clear | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | confusing |
| 22 | impractical | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | practical |
| 23 | organised | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | cluttered |
| 24 | attractive | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | unattractive |
| 25 | friendly | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | unfriendly |
| 26 | conservative | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | innovative |

**Figure 9.24:** An example UEQ questionnaire, recreated by Keith Andrews from the example at UEQ [2020].


**Figure 9.25:** The Net Promoter Score (NPS) is based on a single rating, using an 11-point Likert scale.

- NPS = % of Promoters - % of Detractors [ranging from -100 to 100]
- NPS of 10 means 10% more Promoters than Detractors.

### Pros and Cons of Post-Test Questionnaire

++ can provide quantitative data (easy to analyse and compare)

+ easy to repeat (recognise trends)

+ simple

+ cheap

- less flexible than interview

## 9.10 Surveys

Planning, conducting, and analysing large-sale surveys.

### References

++ Jeff Sauro and Jim Lewis; *Surveying the User Experience*; MeasuringU Press, 22 Jan 2024. ISBN 1733339213 (com, uk) [Sauro and J. Lewis 2024]

++ Caroline Jarrett; *Surveys That Work*; Rosenfeld, 17 Aug 2021. ISBN 1933820535 (com, uk) [Jarrett 2021]

+ Louis Rea and Richard Parker; *Designing and Conducting Survey Research*; 4th Edition, Jossey-Bass, 29 Aug 2014. ISBN 1118767039 (com, uk) [Rea and R. A. Parker 2014]

+ Dillman, Smyth, and Christian; *Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method*; 4th Edition, Wiley, 18 Aug 2014. ISBN 1118456149 (com, uk) [Dillman et al. 2014]

◦ William Foddy; *Constructing Questions for Interviews and Questionnaires*; Cambridge University Press, 18 Mar 1993. ISBN 0521420091 (com, uk) [Foddy 1993]

## 9.11 Usage Studies

Usage studies are exploratory usability testing methods:

- Users' actual activity is estimated or recorded and then analysed.
- Three kinds:
  - Diary Studies
  - Software Logging
  - Observational Studies

### Purpose of a Usage Study

- Insight into how long users spend on each activity.
- Insight into which software is used for what purpose.
- Insight into which features of software packages are most used or unused.

### 9.11.1 Diary Studies

- Users are asked to keep a diary (or logbook) of their usage of a system over several days or weeks (self-reporting).
- Repeat for several users.
- The diary entries are converted into estimates of the amount of time spent on various activities.
- Statistically analyse the resulting data.

### Pros and Cons of Diary Studies

\+ anecdotal evidence (better than nothing?)

\- subjective estimates made by users

\- - self-reporting is highly unreliable

### 9.11.2 Software Logging

- An instrumented version of the software logs all user interactions.
- Users must give their informed consent.
- Can recruit a larger sample of test users (20–50+).
- Gather and aggregate the various log files.
- Statistically analyse the resulting data.

### Pros and Cons of Software Logging

\+ objective log file data

- all the software of interest must be instrumented
- hard (impossible) to infer the user's intentions and motivations

### 9.11.3 Observational Studies

- Record one or more typical days of use of a system (screen capture and user video).
- Users must give their informed consent.
- Repeat for several users.
- Manually analyse the recordings and encode the activities (begin and end) in a timeline.
- Statistically analyse the resulting data.

#### References

- Byrne et al; *A Day in the Life of Ten WWW Users*; unpublished paper, 2000. [Byrne et al. 2000]
- Byrne et al; *The Tangled Web We Wove: A Taskonomy of WWW Use*; [Byrne et al. 1999]

#### Finding Willing Users

Users are often reluctant to participate in a usage study, because they feel it is an invasion of their privacy.

Over several meetings and many hours, explain to potential test users:

- Exactly what will be recorded.
- That they can turn off the recording at any time.
- Exactly how the data will be analysed.
- That statistics will be aggregated on activities and software usage over several users.
- That statistics of individual user performance will not be aggregated.
- That individual users will not be identifiable in any reports or publications.
- That you will seek specific permission before showing or publishing and video, photographs, or screenshots.

#### Pros and Cons of Observational Studies

++ objective analysis of usage (not self-reporting)

\- often difficult to find willing users

-- video analysis is extremely time-consuming

## 9.12 Remote Usability Testing

As well as testing with users face-to-face in the same physical location, it is possible to run usability tests remotely:

- *Moderated*: The facilitator moderates the test remotely.
- *Unmoderated*: The test user works alone without a facilitator.

### References


+ Inge De Bleecker and Rebecca Okoroji; *Remote Usability Testing*; Packt Publishing, 23 Aug 2018 ISBN 1788999045 (com, uk) [Bleecker and Okoroji 2018]

◦ Nate Bolt and Tony Tulathimutte; *Remote Research: Real Users, Real Time, Real Research*; Rosenfeld, 01 Feb 2010 ISBN 1933820446 (com, uk) [Bolt and Tulathimutte 2010]

◦ William Albert, Tom Tullis, and Donna Tedesco; *Beyond the Usability Lab: Conducting Large-scale Online User Experience Studies*; Morgan Kaufmann, 01 Feb 2010 ISBN 0123748925 (com, uk) [Albert et al. 2010]


### Online Resources


+ Kate Moran and Kara Pernice; *Remote Moderated Usability Tests: Why to Do Them*; NNGroup, 12 Apr 2020 `https://nngroup.com/articles/moderated-remote-usability-test-why/`

+ Kate Moran and Kara Pernice; *Remote Moderated Usability Tests: How to Do Them*; NNGroup, 26 Apr 2020 `https://nngroup.com/articles/moderated-remote-usability-test/`

+ Amy Schade; *Remote Usability Tests: Moderated and Unmoderated*; NNGroup, 12 Oct 2013 `https://nngroup.com/articles/remote-usability-tests/`

+ Rebecca Costa; *Remote User Testing: Your Guide*; Justinmind blog, 28 Nov 2019 `https://justinmind.com/blog/remote-user-testing/`

+ Salma Patel; *Remote User Research Tips*; 22 Mar 2020 `https://salmapatel.co.uk/user-research/remote-user-research-tips/`

+ Behzod Sirjani; *Conducting Remote Research*; 47-min video talk/interview, 02 Apr 2020 `https://userinterviews.com/blog/remote-user-research-tips-from-slacks-head-of-research-and-analytics-ops`


### Specialist Remote Testing Tools and Services

- UserZoom; `userzoom.com`.
- Lookback LiveShare; `lookback.io`.
- Userbrain; `userbrain.net`.
- UserTesting; `usertesting.com`.
- TryMyUI; `trymyui.com`.

- Userlytics; `userlytics.com`.
- UX Testing; `uxtesting.io`.
- Playbook; `playbookux.com`.

Some tools support only moderated remote testing, some only unmoderated, others both.

Some services will organise remote test users for you (at extra cost).

#### Generic Videoconferencing Tools

- Cisco Webex; `webex.com`.
- Zoom; `zoom.us`.
- Skype; `skype.com`.
- GoToMeeting; `gotomeeting.com`.
- Google Meet; `meet.google.com`.
- jitsi; `jitsi.org`.

#### Example Moderated Remote Thinking Aloud Test with Webex

- Figure 9.26 shows a checklist for a moderated, remote thinking aloud test.
- Figure 9.27 shows a remote thinking aloud test of the Austrian Railways web site `oebb.at` underway with Cisco Webex.
- Figure 9.28 shows the user filling out the post-test background questionnaire with Acrobat Reader.

#### Pros and Cons of Remote User Testing

\+ can reach global user base

\+ no travel involved

\+ user's natural device and environment

\- often technical hurdles and difficulties

-- not the same as being in the room

## Remote Test Checklist

1. Preparatory Online Meeting:
   - ☐ Explain test procedure and recording.
   - ☐ Install any local software (Acrobat Reader, Webex native client, ...).
   - ☐ Practice filling and signing with Acrobat Reader.
   - ☐ Check test user's environment: internet connection (upload!), browser installed, screen sharing, usercam, audio/mic, recording, etc.
   - ☐ Ask user to read, sign, and return consent form (sign using Acrobat and return by file share).
   - ☐ Schedule online test session with user.
2. Opening:
   - ☐ Start online session. Facilitator shares their screen.
   - ☐ Start recording.
   - ☐ Greet the participant.
   - ☐ Go through orientation script and set the stage.
   - ☐ Fill out background questionnaire (facilitator asks questions and fills out PDF form live in Acrobat).
3. Test Session:
   - ☐ Provide any prior training.
   - ☐ Provide training of thinking aloud.
   - ☐ Pass screensharing to test user.
   - ☐ Document test user environment (OS version, browser version).
   - ☐ User begins with tasks.
   - ☐ Provide tasks one by one (as individual PDFs by file sharing).
   - ☐ User begins with first task.
   - ☐ Encourage user to think out loud.
   - ☐ User finishes last task.
4. Closing:
   - ☐ Screensharing stays with test user.
   - ☐ Interview: how was it?
   - ☐ Structured interview questions.
   - ☐ Individual interview questions arising from test.
   - ☐ Feedback questionnaire (user fills out form live in Acrobat and returns by file sharing).
   - ☐ Thank participant, close online session.
5. Wrap-Up:
   - ☐ Summarise thoughts about this test.
   - ☐ Save and check session recordings.
   - ☐ Organise data sheets and notes.

**Figure 9.26:** A example checklist for a remote thinking aloud test.

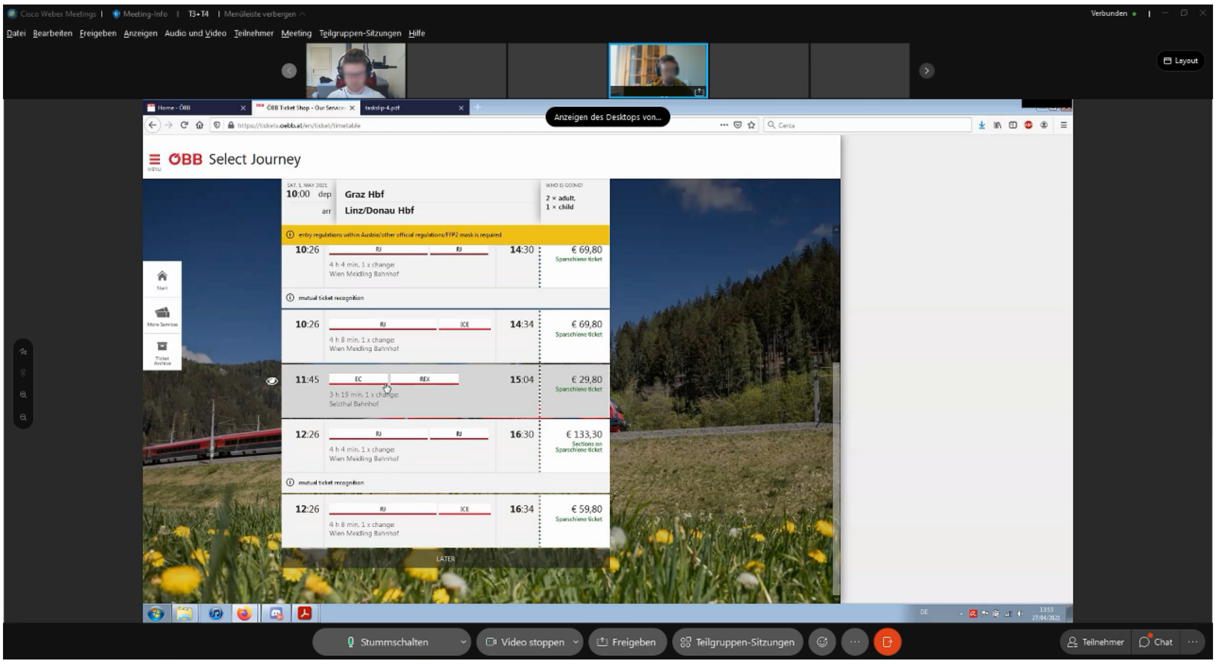


**Figure 9.27:** A remote thinking aloud test of the Austrian Railways web site `oebb.at` underway with Cisco Webex. [Used with kind permission of Sebastian Überreiter and Mattia Zoggia.]

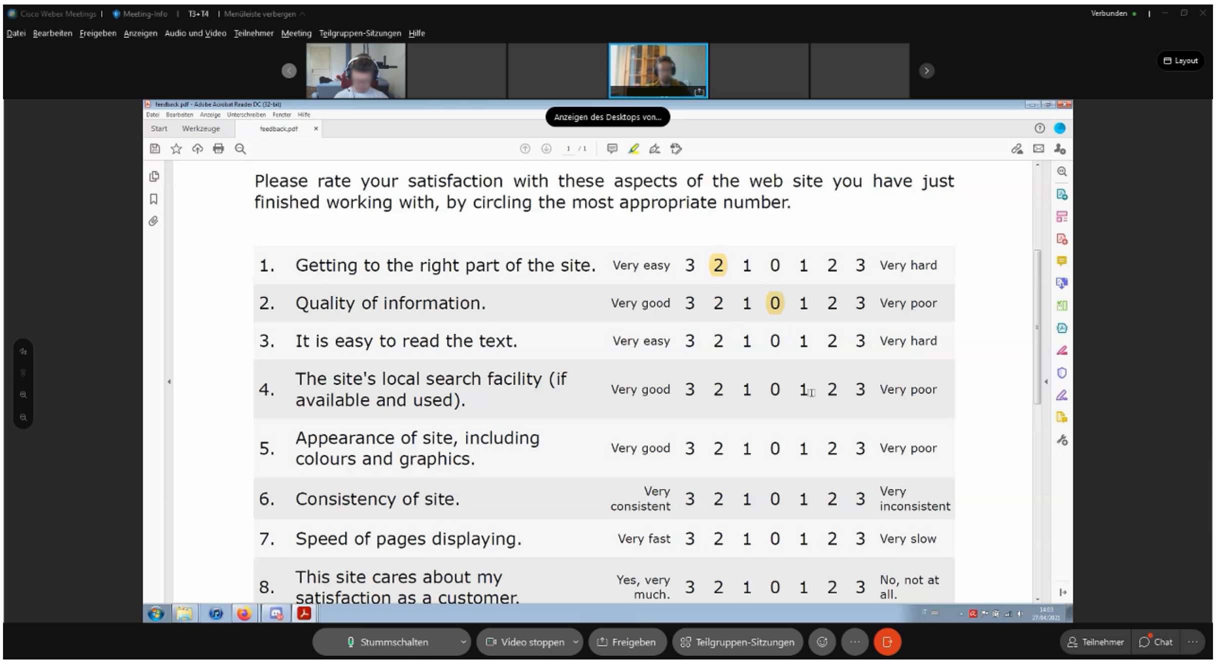


**Figure 9.28:** At the end of the test, the participant fills out the post-test background questionnaire with Acrobat Reader. [Used with kind permission of Sebastian Überreiter and Mattia Zoggia.]

# Chapter 10

# Usability in Practice

### Resources

++ Rolf Molich; *Comparative Usability Evaluation - CUE*; `https://dialogdesign.dk/cue-studies/`

+ Rolf Molich; *Sample Usability Test Report*; `https://dialogdesign.dk/sample-usability-test-report/`

+ Nigel Bevan et al; *New ISO Standards for Usability, Usability Reports and Usability Measures*; HCI International 2016. [Bevan et al. 2016]

◦ NIST; *Industry Usability Reporting*; `https://nist.gov/itl/iad/industry-usability-reporting`

◦ Jakob Nielsen; *Guerrilla HCI: Using Discount Usability Engineering to Penetrate the Intimidation Barrier* `https://nngroup.com/articles/guerrilla-hci/`

◦ Michael Wiklund (Ed.); *Usability in Practice*; Academic Press, 1994. ISBN 0127512500 (com, uk) [Wiklund 1994] [Out of print]

## 10.1 Comparison of Evaluation Techniques

Table 10.1 gives an overview of the various usability evaluation methods.

| | *Obj./ Subj./ Obs.* | *Qual./ Quant.* | *Data Collec-ted* | *Time Required* | *Equipment Required* | *Expertise Required* | *Insp./ Test* | *# Usability Experts* | *# Test Users* |
|---|---|---|---|---|---|---|---|---|---|
| **Exploratory Methods** | | | | | | | | | |
| *Diary Study* | subj. | both | usage | medium | low | low | test | 1–2 | 3–5 |
| *Software Logging* | obj. | quant. | usage | medium | medium | medium | test | 1–2 | 20+ |
| *Observational Study* | observ. | both | usage | high | medium | medium | test | 1–2 (+ 4–8 video analysts) | 3–5 |
| **Predictive Methods** | | | | | | | | | |
| *Action Analysis* | subj. | quant. | bottom-line | med./high | low | med./high | insp | 1–2 | 0 |
| **Formative Methods** | | | | | | | | | |
| *Heuristic Evaluation* | subj. | qual. | process | low | low | medium | insp | 3–5 | 0 |
| *Guideline Checking* | subj. | qual. | process | medium | low | low | insp | 1–2 | 0 |
| *Cognitive Walkthrough* | subj. | qual. | process | medium | low | high | insp | 3–5 | 0 |
| *Thinking Aloud Test* | observ. | qual. | process | medium | low/med. | low/med. | test | 2–4 | 3–5 |
| *Post-Test Interview* | observ. | qual. | process | medium | low | medium | test | 1–2 | >3 |
| **Summative Methods** | | | | | | | | | |
| *Guideline Scoring* | subj. | quant. | bottom-line | medium | low | low | insp | 1–2 | 0 |
| *Formal Experiment* | obj. | quant. | bottom-line | high | medium | med./high | test | 2–3 | 20–50+ |
| *A/B Test* | obj. | quant. | bottom-line | medium | medium | med./high | test | 2–3 | 1000s |
| *Post-Test Questionnaire* | subj. | both | bottom-line + process | medium | low | medium | test | 1–2 | 20+ |

**Table 10.1:** Comparison of usability evaluation techniques.

## 10.2 Methods and Tools Used in Practice

### Activities Perfomed by UX Professionals

Nielsen-Norman Group did a survey of 693 UX practitioners in 2019 [Rosala and Krause 2019]:

- Activities Perfomed by All UX Professionals;
  `https://nngroup.com/reports/user-experience-careers/`
  `https://media.nngroup.com/media/reports/free/UserExperienceCareers_2nd_Edition.pdf#page=24`

### Tools Used by UX Professionals

UXtools run a Design Tools Survey:

- The 2023 survey had 3,281 respondents:
  `https://uxtools.co/survey/2023/`

## 10.3 Discount Usability Engineering

“*Some* usability evaluation is always better than none” [Jakob Nielsen]

| *Study* | *Date* | *#Teams* | *Interface* |
|---|---|---|---|
| CUE-1 | Mar 1998 | 4 | Task Timer for Windows |
| CUE-2 | Dec 1998 | 9 | hotmail.com |
| CUE-3 | Sep 2001 | 11 | avis.com |
| CUE-4 | Mar 2003 | 17 | hotelpenn.com |
| CUE-5 | Aug 2005 | 13 | IKEA wardrobe planner |
| CUE-6 | Oct 2006 | 13 | enterprise.com |
| CUE-7 | Mar 2007 | 8 | ikea.com |
| CUE-8 | Jun 2009 | 15 | enterprise.com |
| CUE-9a | Jun 2011 | 17 | uhaul.com in Atlanta |
| CUE-9b | Aug 2011 | 18 | uhaul.com in Chemnitz |
| CUE-10 | May 2018 | 16 | ryanair.com |

**Table 10.2:** An overview of the ten CUE studies.

- *User and Task Analysis*: observe users on location, keep quiet, don't interfere.
- *Scenarios*: paper mock-ups, simple prototyping tools.
- *Heuristic Evaluation*: 3 evaluators.
- *Thinking Aloud*: pencil and paper notes, 2–3 users.

## 10.4 Differences in Evaluation Practices

"A recent survey shows that 80% of all Danish drivers think that their driving skills are above average." [Rolf Molich]

How about usability testers?

- Take a web site.
- Take N professional usability teams.
- Let each team evaluate the web site.
- Are the results similar?

### Comparative Usability Evaluation (CUE)

- Rolf Molich, DialogDesign, Denmark.
- There have now been a total of 10 CUE studies since 1998, as can be seen in Table 10.2.
- Retrospective overview of all 10 CUE studies in Interactions [Molich 2018a].
- Original materials, team reports, papers, etc. are available [Molich 2018b].
- All results point in the same direction: teams produce widely differing reports and results!

[Thanks to Rolf Molich for permission to use his materials in this section.]

### CUE-2

Nine teams evaluated Hotmail [Molich 1998]:

- Seven professional labs and two student teams.
- Four from Europe, five from the USA.

The purpose of study was:

- a) to investigate the reproducibility of usability test results, and
- b) to survey the state-of-the art within professional usability testing.

not to pick a winner or make a profit.

### CUE-2 Procedure

- Web site address (`hotmail.com`) disclosed at start of three week evaluation period.
- Client scenario provided to teams.
- Email access to client through intermediary.
- Three weeks to evaluate using each team's standard approach.
- Deliver anonymised usability report.

### CUE-2 Results

- The vast majority of problems found were only reported by one team, as shown in Table 10.3.
- Teams put in considerable time and effort into the CUE-2 evaluations, as can be seen in Table 10.4. Team J spent 218 person-hours, with 6 usability pros taking part in the exercise, Team D was a professor with 50 students.
- The longest reports were 36 pages. Five of the reports contained an executive summary, four did not. Only two reports contained more than 2 screenshots. See Table 10.5.
- Eight of the nine teams reported positive findings as well as negative findings (problems). The number of problems reported varied from 10 to 150. A large proportion of the problems were only reported by one team. See Table 10.6.

### Problem Reported by Seven Teams

- During registration process, users asked to enter a "password hint question" (see Figure 10.1).
- Most users did not understand the concept of a password hint.
- Some users entered their Hotmail password in the hint question box.
- Redesigned as "secret question" with careful explanation (see Figure 10.2).

| *Number of Problems Found* | *CUE-1* | *CUE-2* |
|---|---|---|
| Total | 141 | 300 |
| by seven teams | - | 1 |
| by six teams | - | 1 |
| by five teams | - | 4 |
| by four teams | 1 | 4 |
| by three teams | 1 | 15 |
| by two teams | 11 | 49 |
| by only one team | (91%) 128 | (75%) 226 |

**Table 10.3:** The number of problems reported in the CUE-1 and CUE-2 studies. In both cases, the vast majority of problems found were only reported by one team.

| | *A* | *B* | *C* | *D* | *E* | *F* | *G* | *H* | *J* |
|---|---|---|---|---|---|---|---|---|---|
| *Person-Hours* | 136 | 123 | 84 | (16) | 130 | 50 | 107 | 45 | 218 |
| *# Usability Pros* | 2 | 1 | 1 | 1 | 3 | 1 | 1 | 3 | 6 |
| *# Tests* | 7 | 6 | 6 | 50 | 9 | 5 | 11 | 4 | 6 |

**Table 10.4:** The resources used by the nine teams who participated in CUE-2.

| | *A* | *B* | *C* | *D* | *E* | *F* | *G* | *H* | *J* |
|---|---|---|---|---|---|---|---|---|---|
| *# Pages* | 16 | 36 | 10 | 5 | 36 | 19 | 18 | 11 | 22 |
| *Exec. Summary* | y | y | n | n | n | y | n | y | y |
| *# Screen Shots* | 10 | 0 | 8 | 0 | 1 | 2 | 1 | 2 | 0 |
| *Severity Scale* | 2 | 3 | 2 | 1 | 2 | 1 | 1 | 3 | 4 |

**Table 10.5:** Overview of the usability evaluation reports produced by the nine teams who participated in CUE-2.

| | *A* | *B* | *C* | *D* | *E* | *F* | *G* | *H* | *J* |
|---|---|---|---|---|---|---|---|---|---|
| *# Positive Findings* | 0 | 8 | 4 | 7 | 24 | 25 | 14 | 4 | 6 |
| *# Problems Reported* | 26 | 150 | 17 | 10 | 58 | 75 | 30 | 18 | 20 |
| *% Exclusive* | 42 | 71 | 24 | 10 | 57 | 51 | 33 | 56 | 60 |
| *% Core (100%=26)* | 38 | 73 | 35 | 8 | 58 | 54 | 50 | 27 | 31 |
| *Person Hours* | 136 | 123 | 84 | (16) | 130 | 50 | 107 | 45 | 218 |

**Table 10.6:** Overview of the usability findings reported by the nine teams who participated in CUE-2.

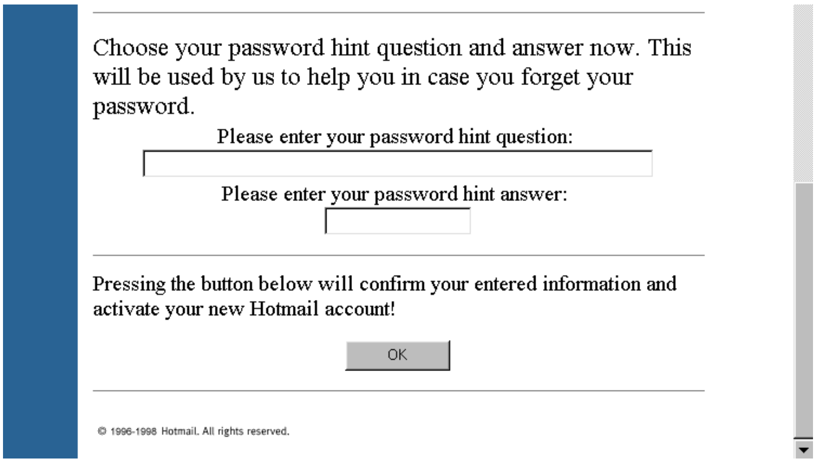


**Figure 10.1:** Part of the Hotmail resgistration process involved asking for a "password hint question".

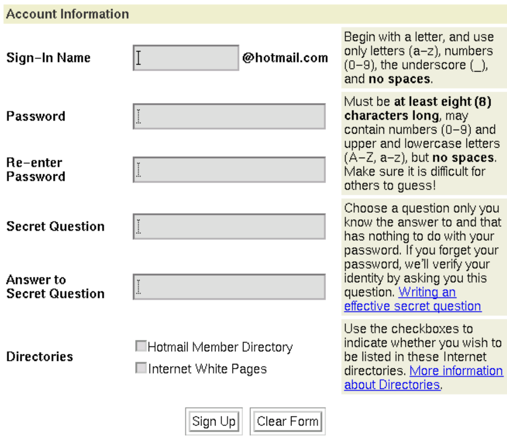


**Figure 10.2:** After testing, the dialogue was redesigned as a "secret question".

### Language-Related Problem Reported by all European Teams

- To send a new message, users must select the "Compose" button in the left-hand panel (see Figure 10.3).
- European users did not understand the term "Compose".
- "Create New Message" or "Write Mail" would be better.

### Hotmail Summary of Findings

From the client's (Hotmail) point of view, of the 300 findings reported:

- New findings (4%).
- Validation of known issues (67%).
- Problems beyond Hotmail usability (29%):
  - business reasons for not changing.
  - beyond Hotmail control (partner sites).

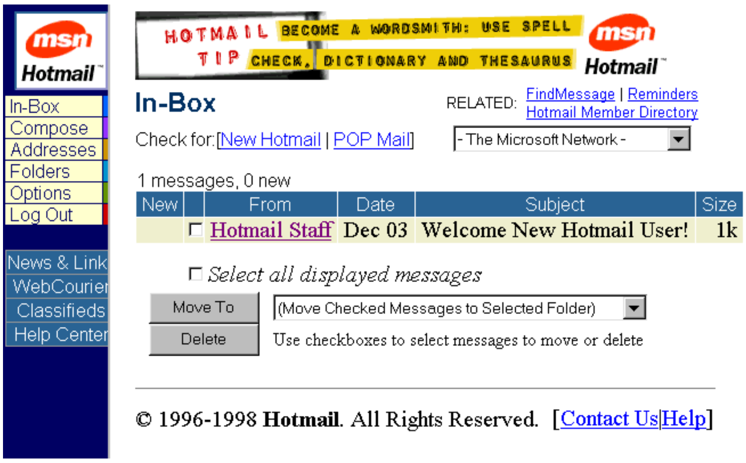


**Figure 10.3:** The term “Compose” for writing a new message was not understood by European users.

  – problems generic to the web.

### Current Boundaries to State-of-the-Art

- No specific expert user test, although four teams also recruited expert users.
- Few tests which required complicated setup, such as sending attachments.
- Little testing of boundary conditions, such as a large number of emails in the in-box.

### Advice for a Usable Usability Report

- List problems with a severity rating.
- State the number of users experiencing the problem.
- Include positive findings.
- Provide short executive summary.
- Keep it short (less than 25 pages).
- Distinguish clearly between:
  - personal opinions,
  - expert opinions,
  - user opinions, and
  - user findings.

### Video: Rolf Molich

- Rolf Molich’s talk at UX Sheffield on 28 Sep 2016 about his insights from the CUE studies [Molich 2016, 12:36-33:42]. [Video: `https://youtu.be/u__leVMmKb8?t=12m36s`]

#### Conclusions from All Ten CUE Studies

As reported by Molich [2018a] and in the individual CUE study reports:

- There are overwhelmingly many usability problems.
- Many of the problems found are serious.
- Limited overlap between team findings.
- Virtually no overlap between tasks used by different teams.
- Many of the teams found more problems than they actually reported. How do you select those to report?
- Almost all reported issues were valid (few false alarms).
- The quality of the test reports varied dramatically.
- Expert reviews (Heuristic Evaluations) done by experts produce results comparable in quality to usability tests (Thinking Aloud tests), and are usually less expensive to run.
- Five users are not enough to find 75% or even 25% of usability problems.
- Claims like "Method x finds at least 80% of all serious usability problems" are not in accordance with the results of the CUE studies.

## 10.5 Usability Reporting Formats

### 10.5.1 Report Formats for Formative Evaluations

#### References

+ Cooley and Barnum; *How Do Other People Do It? A Comparative Review of Usability Study Reports*; User Experience Magazine, Volume 1, Number 1, Mar 2019. [Cooley and C. Barnum 2019]

+ UXQB; *CPUX-UT Usability Test Report Example*; Version 1 EN, 12 Mar 2015 [Molich et al. 2015]. Annotated sample report for a thinking aloud test.

◦ Theofanos et al; *Reporting on Formative Testing*; UPA 2005 Workshop Report. [Theofanos et al. 2005]

◦ Theofanos and Quesenbery; *Towards the Design of Effective Formative Test Reports*; Journal of Usability Studies, Volume 1, Number 1, Nov 2005. [Theofanos and Quesenbery 2005]

#### CIF Formative

- Standard report format for thinking aloud tests.
- Project initiated by NIST: `https://web.archive.org/web/20160726201123/http://zing.ncsl.nist.gov/iusr/formative/`
- ISO 25066:2016; *Systems and software Quality Requirements and Evaluation (SQuaRE) – Common Industry Format (CIF) for Usability — Evaluation Report*. ISO, 13 Jun 2016. [ISO 2016]

### CUE-10 Reports Overview

CUE-10 focussed on facilitation (moderation) styles [Molich 2018c].

However, Cooley and C. Barnum [2019] analysed and compared the 16 thinking aloud test reports from CUE-10:

- 9 were slide-deck style, 7 were document style.
- 11 had an executive summary.
- 4 included the tasks given to test users.
- 9 included task completion data.
- 14 included screenshots.
- 8 included quotations from test users.
- 11 used severity ratings.
- 9 included recommendations.
- 2 included embedded video clips.

### UsabML

Usability Markup Language (UsabML):

- Standardised XML format for Heuristic Evaluation (HE) and Thinking Aloud test (TA) reports.
- XML elements such as `<finding>` and `<videoclip>`, as illustrated in Listing 10.1.
- HTML and PDF versions can be generated using XSL stylesheets.
- Findings can be imported into issue/bug tracking systems such as Redmine.
- Papers at HCSE 2012 [Feiner and Andrews 2012] and EICS 2010 [Feiner et al. 2010].

## 10.5.2 Report Formats for Summative Evaluations

Common Industry Format (CIF) for Usability Test Reports:

- Standardised report format for summative studies (formal experiments).
- Grew from the IUSR project at NIST [NIST 2019].
- CIF v1.0 [NIST 1999a] and an example report [NIST 1999b] are archived at the Internet Archive.
- Was standardised in 2006 as ISO 25062:2006; *Software engineering – Software product Quality Requirements and Evaluation (SQuaRE) – Common Industry Format (CIF) for Usability Test Reports*; ISO, 31 Mar 2006. [ISO 2006]
- Was updated in 2025 as ISO 25062:2025; *Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Common Industry Format (CIF) for reporting usability evaluations*; ISO, Jan 2025. [ISO 2025]

```
...
<finding findingtype="positive">
  <title>Interface</title>
  <description>
    The website's interface is well-structured and gives
    a good overview. The layout is based on the...
  </description>
  <videoclip personid="tp2">
    <description></description>
    <starttime>00:08:05</starttime>
    <endtime>00:08:15</endtime>
  </videoclip>
  <videoclip personid="tp3">
    <description></description>
    <starttime>00:06:50</starttime>
    <endtime>00:06:55</endtime>
  </videoclip>
  <document>
    <description>Interface</description>
    <filename>images/ui.png</filename>
  </document>
</finding>
...
```

**Listing 10.1:** UsabML defines XML elements to mark up Heuristic Evaluation (HE) and Thinking Aloud test (TA) reports.

## 10.6 Agile UX

### References


++ Rex Hartson and Pardha Pyla; *The UX Book: Agile UX Design for a Quality User Experience*; 2nd Edition, Morgan Kaufmann, 14 Dec 2018. ISBN 0128053429 (com, uk) [Hartson and Pyla 2018] [3rd Edition coming in Jun 2025.]

\+ Gothelf and Seiden; *Lean UX: Creating Great Products with Agile Teams*; O'Reilly, 3rd Edition, 22 Oct 2021 [Gothelf and Seiden 2021]

\+ Gilbert Cockton et al (Eds); *Integrating User-Centred Design in Agile Development*; Springer, 30 Sep 2016 [Cockton et al. 2016]

\+ Jeff Patton; *Twelve Emerging Best practices for Adding UX Work to Agile Development*; 27 Jun 2008 https://jpattonassociates.com/emerging_best_agile_ux_practice/

\+ Jeff Gothelf; *5 Rules for Integrating UX with Agile and Scrum*; 22 Mar 2019 https://medium.com/swlh/5-rules-for-integrating-ux-with-agile-scrum-b048babb9a89

∘ Nielsen Norman Group; *Effective Agile UX Product Development*; Nielsen Norman Group, 3rd Edition, 2017. $148. https://nngroup.com/reports/agile-development-user-experience/

### Video: Bridging the Gap Between Agile & UX

- Johanna Kollmann; *Collaboration. Customers. Conflict? Bridging the Gap Between Agile & UX* Talk at UX Day Graz 2013. 16 Nov 2013 [08:39-14:59] [Video: `https://cdn.isds.tugraz.at/uxdaygraz2013/videos/kollmann-uxdg2013-agile-ux.mp4`]

### Video: RITE Rapid Iterative Testing and Evaluation

- Miki Konno and Bethany Fong; *Agile UX Research Practice in Android* Talk at Google I/O 2013. [09:26-12:02] [Video: `https://youtu.be/6MOeVNbh9cY?t=09m26s`]
- Medlock et al; *The Rapid Iterative Test and Evaluation Method*; In Cost-Justifying Usability, 2nd Edition, Chapter 17, Morgan Kaufman, 2005 [Medlock et al. 2005].
- Medlock et al; *Using the RITE Method to Improve Products*; UPA Conference 2002 [Medlock et al. 2002].

### Video: Pulse Study

- Miki Konno and Bethany Fong; *Agile UX Research Practice in Android* Talk at Google I/O 2013. [19:25-20:48] [Video: `https://youtu.be/6MOeVNbh9cY?t=19m25s`]

### Video: Google Design Sprint

- Jake Knapp; Google Ventures (GV); *GV's Sprint Process in 90 Seconds*; 08 Dec 2016. [Video: `https://youtu.be/K2vSQPh6MCE`]
- Knapp et al; *Sprint: How to Solve Big Problems and Test New Ideas in Just Five Days*; Simon & Schuster, 2016 [Knapp et al. 2016].

## 10.7 Professional UX Services

### Professional Bodies for UX

- UXPA Austria `uxpa-austria.at`
- UX Pro Austria `uxpro.at`

### Professional Usability Certifications

- UXQB; *Certified Professional for Usability and User Experience (CPUX)*; `https://uxqb.org/en/certification/`

  The full curricula are available at `https://uxqb.org/en/documents/`.
- UXQCC; *Certified Professional for Usability Engineering and User Experience Design*; `https://uxqcc.com/personal-certifications/`
- NN/g; *UX Certification* `https://nngroup.com/ux-certification/`

### UX Consulting Companies

- youspi; `youspi.com` [Graz]
- Simplease; `simplease.at` [Graz]
- Interface Consult; `usability.at` [Vienna]
- intuio; `intu.io` [Vienna]
- USECON; `usecon.com` [Vienna]
- UXfocus; `uxfocus.at` [Linz]

### Pricing for External Heuristic Evaluation

- Nielsen Norman Group:
  Expert Design Review, from US$ 45,000.
  `https://nngroup.com/consulting/expert-review/`
- Interface Consult, Vienna (Martina Manhartsberger): Web Express Review (1 evaluator), for between € 396 and € 1,056. `https://usability.at/leistungen/web-express-review.html`
- Simplease, Graz: Usability Review, for between € 5,000 and € 8,000. `https://simplease.at/usability`

### Pricing for External Thinking Aloud Test

- Nielsen Norman Group:
  Starts at US$ 40,000.
  `https://nngroup.com/consulting/user-testing/`
- DialogDesign, Copenhagen (Rolf Molich):
  TA test with 6 users, no video taping, on customer premises [2020]: € 6,500 (48,000 DKK)
  `https://web.archive.org/web/20200512095930/https://dialogdesign.dk/Prices.htm`
- Simplease, Graz: Remote Usability Test, for between € 8,000 and € 15,000.
  `https://simplease.at/usability`
- Catalysts, Linz: (now part of cloudflight)
  TA test with 2 users [2020]: € 1,008
  `https://web.archive.org/web/20201001170451/https://catalysts.cc/loesungen/individual-software/`
- Interface Consult, Vienna (Martina Manhartsberger):
  Usability Quick Test [2017]: TA test, 5 users, 20 mins. each, test on Tue, results on Thu, report as Powerpoint slides, € 1,074.
  `https://web.archive.org/web/20171115214340/https://usability.at/leistungen/usability-schnell-test.html`

# Chapter 11

# Visual Design and Typography

## 11.1 Visual Design

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## 11.2 Typography

Typography . . . the style and appearance of text.

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◦ Viljami Salminen; *Typography for User Interfaces*; 21 Jun 2016 `https://viljamis.com/2016/typography-for-user-interfaces/`

\+ Fonts In Use; independent archive of typography; `fontsinuse.com`

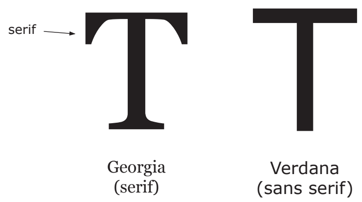


**Figure 11.1:** Georgia is a serif font, Verdana a sans serif font.

\+ Font Squirrel; free fonts; `fontsquirrel.com`

### Font Sizes

Font sizes are traditionally expressed in printers' points (pt):

$$
\begin{array}{lllllll}
1\text{ pt} & = & \frac{1}{72}\text{ inch} & = & \approx 0.35\text{ mm} & & \\
1\text{ pica} & = & \frac{1}{6}\text{ inch} & = & \approx 4.20\text{ mm} & = & 12\text{ pt}
\end{array}
$$

### Serif and Sans Serif Fonts

- A *serif* is a slight projection or embellishment at the end of a letter stroke, as shown in Figure 11.1.
- Examples of serif fonts include Times Roman and Georgia.
- A *sans serif* (French = without serif) font does not have such embellishments.
- Examples of sans serif fonts include Arial, Helvetica, and Verdana.
- When reading passages of text on paper (very high resolution), serif text may be easier to read than san serif, but the evidence is not conclusive [Schriver 1997, Chapter 5].

  See Figure 11.1.

## 11.3 Factors Influencing the Legibility of Text

### 11.3.1 Font Type

Proportional fonts consume less space and are more legible than fixed width fonts.

See Figure 11.2.

### 11.3.2 Font Size

- 10 pt is legible, 11 pt or 12 pt is better.
- The distinction between font sizes should be at least 2 pt. [Smaller changes cannot be discriminated by the eye.]
- For example, use:

Proportional fonts consume less space and are more legible than fixed width fonts. Proportional fonts consume less space and are more legible than fixed width fonts. Proportional fonts consume less space and are more legible than fixed width fonts.

Proportional fonts consume less space and are more legible than fixed width fonts. Proportional fonts consume less space and are more legible than fixed width fonts. Proportional fonts consume less space and are more legible than fixed width fonts.

**Figure 11.2:** Proportional versus fixed width fonts.

2 Sixteen Point Fonts Might Be Used for Titles

2.1 Fourteen Point Fonts for Section Headings

Twelve point is great for flowing text such as this[a]. Remember that font size changes should be differentiated by at least two points.

[a] 10 pt might be used for subscripts and footnotes.

**Figure 11.3:** Font size changes should be differentiated by at least two points.

- 12 pt for flowing text
- 10 pt for subscripts and footnotes
- 14 pt for section headings
- 16 pt or larger for titles

as shown in Figure 11.3.

### 11.3.3 Case

Prefer mixed case to all upper case:

- Mixed case is more compact and legible than all upper case, as illustrated in Figure 11.4.
- All upper case slows reading speed by about 12%.
- Word recognition is based partly on word shape. Lower and mixed case words have more irregular and thus more recognisable word shapes, as shown in Figure 11.5.

SETTING A LARGE AMOUNT OF TEXT IN CAPITAL LETTERS SERIOUSLY IMPAIRS LEGIBILITY. UPPER CASE SHOULD ONLY REALLY BE USED FOR EMPHASIS, BUT REMEMBER TO SET THE FONT SIZE A LITTLE SMALLER THAN THAT OF THE SURROUNDING TEXT.

Setting a large amount of text in capital letters seriously impairs legibility. Upper case should only really be used for EMPHASIS, but remember to set the font size a little SMALLER than that of the surrounding text.

**Figure 11.4:** Using all upper case slows reading speed.

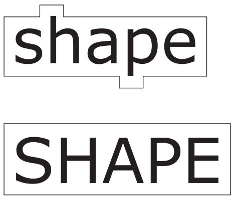


**Figure 11.5:** Lower and mixed case words have more recognisable word shapes.

### 11.3.4 Character, Word, and Line Spacing

- Character spacing depends largely on font.
- Word spacing ≈ width of an ‘n’. See Figure 11.6.
- Line spacing ≈ 2 pt. See Figure 11.7.

### 11.3.5 Line Length

- ≈ 10 words (60 chars.) per line for books.
- ≈ 5 words (30 chars.) per line for newspapers.

See Figure 11.8.

### 11.3.6 Justification

*Justification* is the insertion of extra space within a line to create flush left *and* right margins.

- Justification without hyphenation slows reading due to gaps between words.
- Use either flush left, or justified with hyphenation.

  See Figure 11.9.

### 11.3.7 Overall Text Environment

Maximum of:

| | |
|---|---|
| word spacing | thin space |
| word  spacing | en space |
| word   spacing | em space |

**Figure 11.6:** En and em word spacing.

The space between lines is important. Too much space and lines can float away. Too little space and lines become too densely packed to read comfortably. In the old days strips of lead "leading" were inserted between the lines of type. Nowadays, text processing systems make it easy to experiment with different values of leading.

The space between lines is important. Too much space and lines can float away. Too little space and lines become too densely packed to read comfortably. In the old days strips of lead "leading" were inserted between the lines of type. Nowadays, text processing systems make it easy to experiment with different values of leading.

**Figure 11.7:** Too much or too little space between lines makes reading difficult.

- two typefaces,
- two slants (normal, italic),
- two weights (medium, bold),
- and four sizes (title, subtitle, text, footnote).

### 11.3.8 Layout

Use an underlying spatial grid to ensure consistent location and extent of text, columns, titles, illustrations, etc., as shown in Figure 11.10.

### 11.3.9 Margins

Avoid "word processor syndrome" (text right up to edge of the window) → leave ample margins.

See Figure 11.11.

If a line is too long, readers have difficulty finding the beginning of the next line. The first example here has about 90 characters per line. For books, about 60 characters or ten words per line is about right. Newspaper columns typically have around 30 characters or five words per line.

If a line is too long, readers have difficulty finding the beginning of the next line. The first example here has about 90 characters per line. For books, about 60 characters or ten words per line is about right. Newspaper columns typically have around 30 characters or five words per line.

If a line is too long, readers have difficulty finding the beginning of the next line. The first example here has about 90 characters per line. For books, about 60 characters or ten words per line is about right. Newspaper columns typically have around 30 characters or five words per line.

**Figure 11.8:** For books, about 60 characters or ten words per line is about right. Newspaper columns typically have around 30 characters or five words per line.

### 11.3.10 Typographic Distinction

Information is “any difference that makes a difference” [Gregory Bateson]

distinction $\Leftrightarrow$ information

Use typographic distinction such as bold, italics, font change, etc. only if it conveys extra information.

#### Video: Fluid Typography

- Richard Rutter; *Fluid Typography*; State of the Browser 2024 talk, 30-minute video [Rutter 2024, 03:01-26:48, 27:41-29:51]. [Video: `https://youtu.be/X9uEszeeSOk?t=03m01s`]

**Flush Left (Ragged Right)**

Human-computer interaction is a discipline concerned
with the design, evaluation and implementation of
interactive computing systems for human use and with
the study of major phenomena surrounding them.

**Flush Right (Ragged Left)**

Human-computer interaction is a discipline concerned
with the design, evaluation and implementation of
interactive computing systems for human use and with
the study of major phenomena surrounding them.

**Centered**

Human-computer interaction is a discipline concerned
with the design, evaluation and implementation of
interactive computing systems for human use and with
the study of major phenomena surrounding them.

**Justified without Hyphenation**

Human-computer interaction is a discipline concerned
with the design, evaluation and implementation of
interactive computing systems for human use and with
the study of major phenomena surrounding them.

**Justified with Hyphenation**

Human-computer interaction is a discipline concerned
with the design, evaluation and implementation of inter-
active computing systems for human use and with the
study of major phenomena surrounding them.

**Figure 11.9:** Flush and justified text styles.

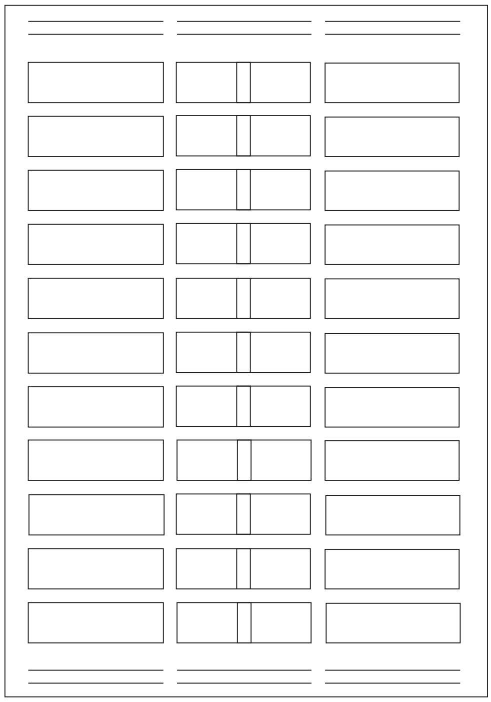

**Figure 11.10:** A layout grid ensures consistent location and extent of text, columns, titles, and illustrations.

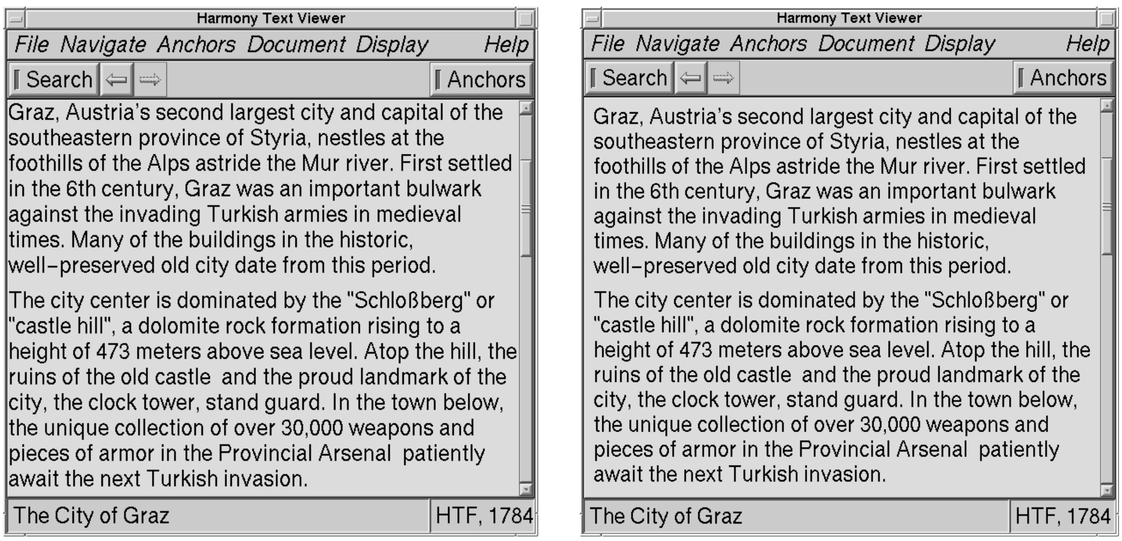


**Figure 11.11:** Text right up to edge of the window with no margins is difficult to read: "word processor syndrome". Small margins all around make the text much easier to read.

# Chapter 12

# Icon Design

Icon . . . small visual symbol (broad definition)

> "A picture is worth a thousand words."

*Well-designed* icons:

- save screen space
- are recognised quickly in a busy visual environment
- are easily remembered
- help interfaces become international.

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◦ The Icon Archive; `iconarchive.com`

◦ Icon Finder; `iconfinder.com`

◦ stockio; `stockio.com`

◦ Nicolas Mollet; *The Map Icons Collection*; `mapicons.mapsmarker.com`

## 12.1 Visual Association

Which companies do these logos represent?

- Visual symbols are easy to remember.
- Powerful association, even though all colours were removed.

## 12.2 Standard Parts of an Icon

- Border
- Background

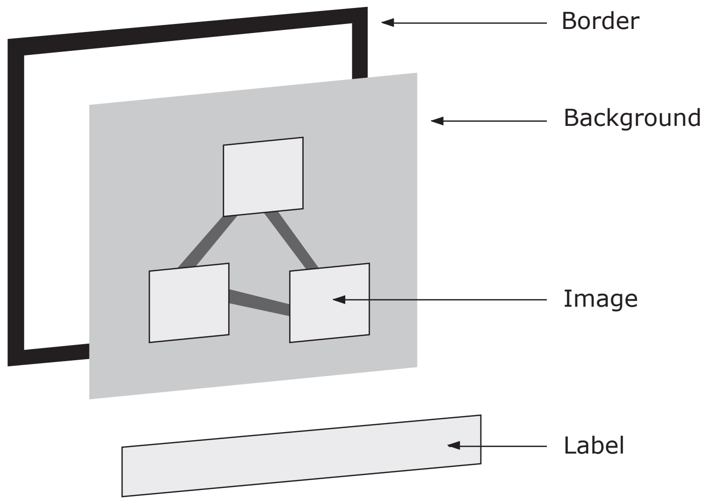



**Figure 12.1:** The standard parts of an icon.

- Image
- Label

See Figure 12.1.

## 12.3 Icon Design Principles

### 12.3.1 Coherency

- Design a set of icons *as a whole*.
- Icon set should be *consistent* in terms of size, colours, metaphor, level of realism (abstraction), etc.
- The icons in a set should be visually *balanced*.
- Visual distinctions should have significance – extraneous decorations distract.

#### Visually Imbalanced Icons

An early version of Paintbrush displayed visually incoherent icons, as can be seen on the left in Figure 12.2.

- The lower icons are simple and visually lightweight, the upper icons are very full (heavy).
- The redesigned icons in MS Paint (on the right) are more balanced and consistent.

#### Levels of Realism

From photorealistic to a simple silhouette:

- Photograph
- Drawing

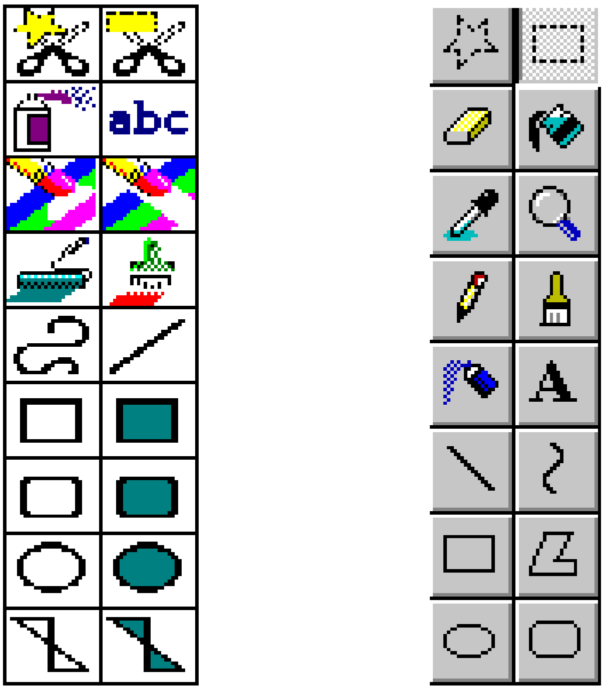



**Figure 12.2:** Visually imbalanced icons. On the left, the icon palette from an early version of Paintbrush for Windows. On the right, the redesigned icons from MS Paint.

- Caricature
- Outline
- Silhouette

However, stick to just *one* level of realism, unlike the mixture of levels of realism illustrated in Figure 12.3.

Symbols can also be drawn at different levels of abstraction, as shown in Figure 12.4.

### 12.3.2 Legibility

- As far as the pixel real estate allows, use large objects, bold lines, and simple areas.
- Take into account screen resolution and viewing distance.
- Good foreground/background contrast.
- Avoid arcs and oblique lines (“jaggies”).
- External shape (silhouette) conveys most info.

#### Typical Viewing Distances

- A desktop monitor: 60cm.
- A paper document: 45cm.

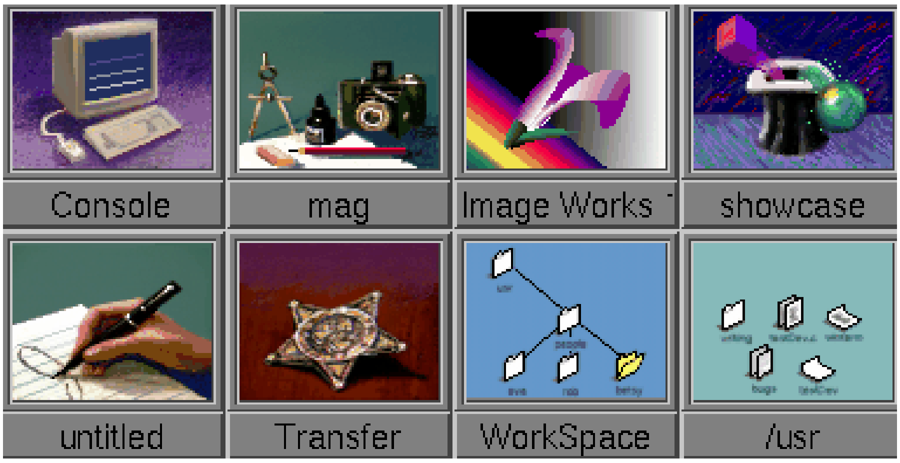



**Figure 12.3:** Mixed levels of realism in icons. Many of the icons from SGI's IRIX systems are photorealistic. However, some icons break the mould, like the abstract icons in the bottom right.

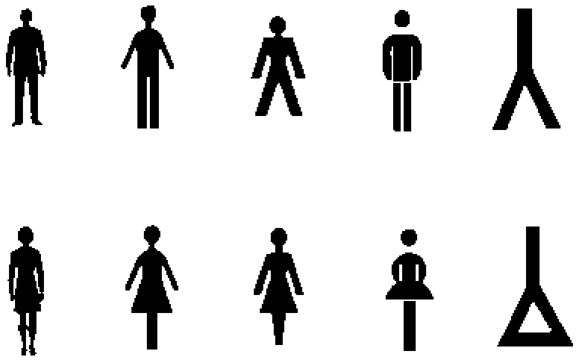


**Figure 12.4:** Symbols for men and women at different levels of abstraction.

- A laptop screen: 30cm.

A 30 × 30 pixel icon will appear *much* larger at 30cm on an 11" 640 × 480 laptop screen, than at 60cm on a 17" 1280 × 1024 workstation monitor.

See Figure 12.5.

#### Silhouette Conveys Most Information

The external shape (silhouette) of a symbol conveys the most information.

See Figure 12.6.

### 12.3.3 Recognition and Recall

- Where possible, choose a metaphor familiar to the viewer.
- Use concrete objects wherever possible, abstract concepts and actions are difficult to visualise.
- Do you know of a good icon for "Shortcut"?

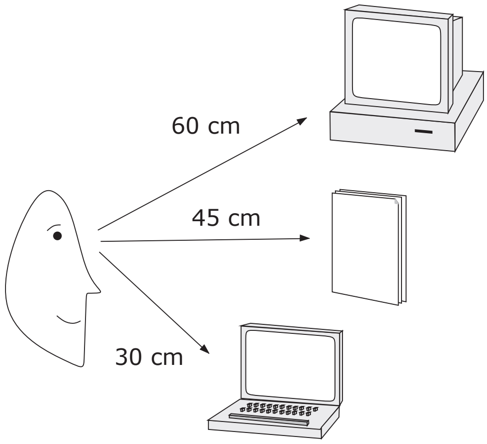



**Figure 12.5:** Typical viewing distances to icons.

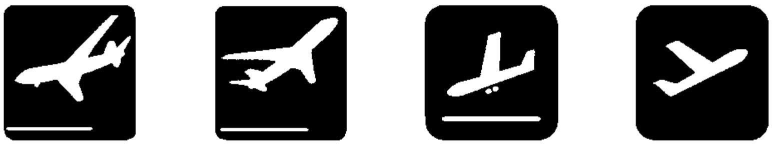


**Figure 12.6:** Simple aircraft outlines to denote arrivals and departures areas in an airport. Note how the silhouette conveys all of the information.

- For years there was no good icon for the concept of "Undo", but in the meantime there is a convention of a backwards curving arrow.
- Provide textual labels (at least by default).

### 12.3.4 Use Colour Sparingly

- Design first for black and white, add any colour later.
- Gratuitous use of colour overloads the viewer, use grey tones and one or two colours.


**Figure 12.7:** Garish multicolour icons competing for the user's visual attention in a Windows 3.1 desktop.

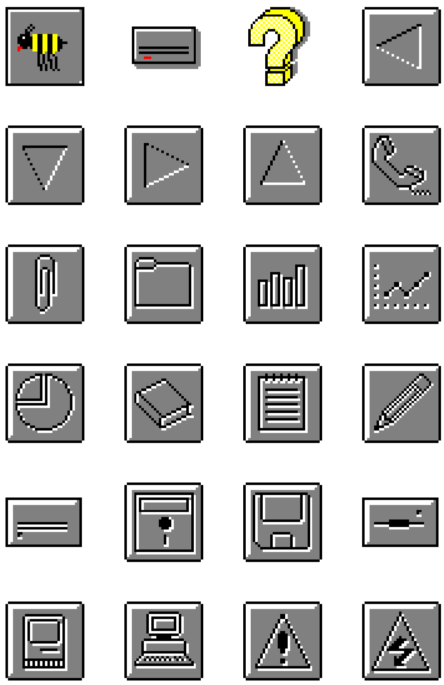


**Figure 12.8:** A well-balanced, consistent set of icons with restrained use of colour.

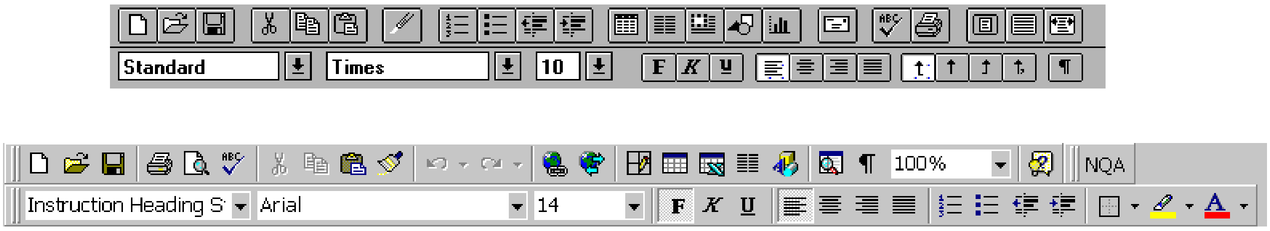



**Figure 12.9:** The evolution of the Microsoft Word icon bar from simple greyscale in Word 3.0 to limited use of colour in Word 95.


**Figure 12.10:** Icons from the English and German versions of Word97. Text or alphabetic characters within an icon are language-dependent and will often have to be translated.

## 12.4 Cultural and International Issues

- Beware of using text or alphabetic characters inside an icon (as opposed to the label). Otherwise, different language versions of the icon will probably be needed. See Figure 12.10.
- Hand symbols, facial appearances, etc. vary immensely from culture to culture → don't use them in icons.
- Beware also of metaphors dependent on a particular culture, e.g. the US mailbox for incoming mail. See Figure 12.11.

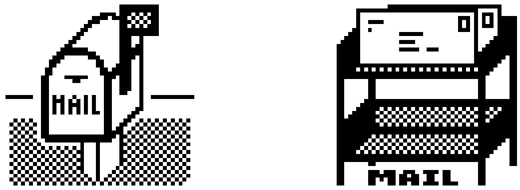



**Figure 12.11:** Two icons for incoming mail from different versions of Unix. The US mail box is unrecognisable for many Europeans; the letter tray is more universal. Note that these icons also use text within the icons proper which may need to be translated.

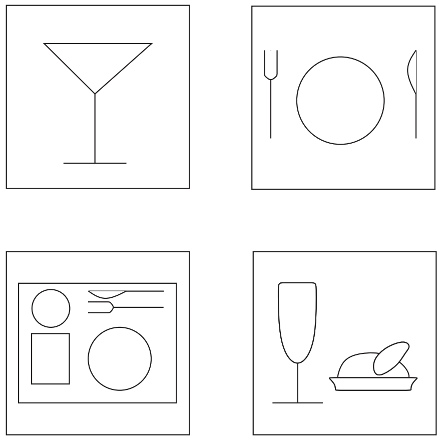


**Figure 12.12:** Icons for various types of food and drink area. What do the icons mean?

## 12.5 Do Not Always Use Icons

For more abstract concepts and subtle distinctions, verbal representations can sometimes work better than iconic representations.

See Figures 12.12 and 12.13.

Bar

Snacks

Selfservice

Restaurant

**Figure 12.13:** Compared to the iconic representations in the previous figure, here words convey the subtle distinction better.

## 12.6 Iconic Language

For larger sets of icons, it is often useful to develop an *iconic language*.

An iconic language is a systematic way of combining elementary symbols into more complex icons:

- *Vocabulary*: set of primitive symbols.
- *Grammar*: rules for combining them.

#### Example Iconic Language – Harmony

Primitive symbols for document, link, and visited are combined for various types of document in the Harmony authoring tool for Hyperwave web servers [Andrews 1996].

Document = [Link to] + DocType [+ Visited]

See Table 12.1.

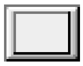
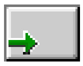
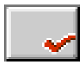
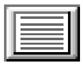
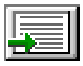
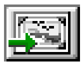
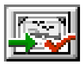
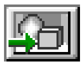
| | |
|---|---|
| **Elementary Symbols** | |
| Document |  |
| Link |  |
| Visited |  |
| **Generated Icons** | |
| Text document |  |
| Visited text document |  |
| Link to text document |  |
| Visited link to text document |  |
| Image document |  |
| Visited image document |  |
| Link to image document |  |
| Visited link to image document |  |
| 3D model |  |
| Visited 3D model |  |
| Link to 3D model |  |
| Visited link to 3D model |  |

**Table 12.1:** Iconic language for document and link icons in Harmony.

## 12.7 The Icon Design Lifecycle

Usability engineering lifecycle for icons:

> Design, test, redesign.

See Figure 12.14.

### Icon Design Iterations

- Start with simple black and white, hand-drawn sketches on paper (silhouette conveys the most information).

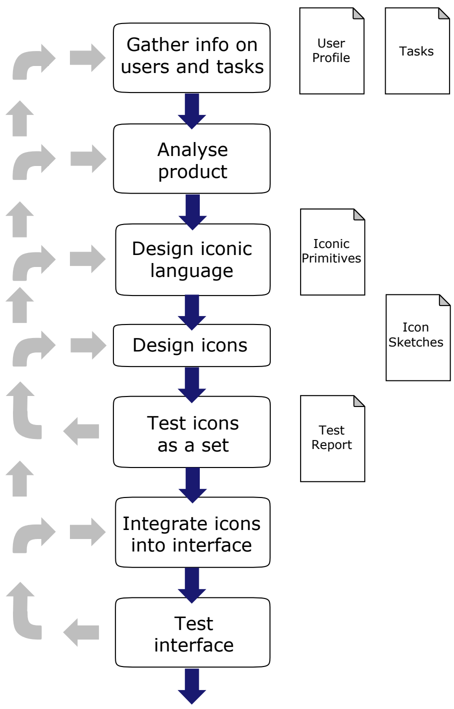



**Figure 12.14:** The icon design lifecycle. Based on the figure on page 270 of [Horton 1994].

- Test and redesign until the basic symbols work.
- Add greys and perhaps colour. Design on computer. Print out colour versions of the designs, at the approximate real size.
- Test and redesign until the icons work.

### Icon Intuitiveness Testing

Test the intuitiveness of (a set of) icons by running a simple thinking aloud usability test:

- Mount each icon design on a piece of card.
- Tape up an area of the table with masking tape, into which the icons are placed, as shown in Figures 12.15 and 12.16, so the video camera remains focussed and test users are less tempted to pick up the icon cards.
- Better still, use a book stand to present icon designs at approximately the correct viewing angle and distance.
- The test facilitator places the icons one after the other, in a random sequence, into the taped up area or onto the book stand.
- Use *thinking aloud* to capture:
  - the user's initial reaction
  - what they think the symbol *is*,
  - and what they think it might be intended to *represent*.

  See Figure 12.16.

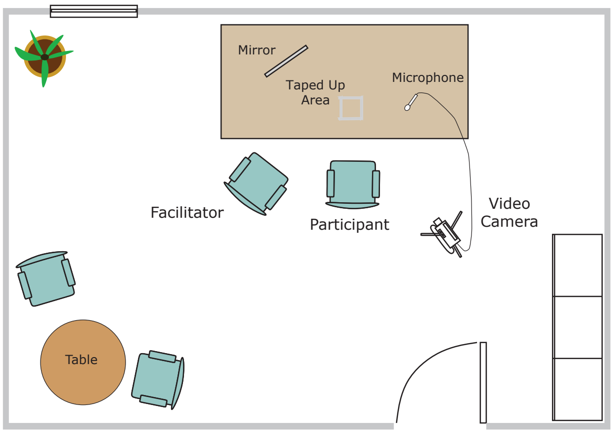



**Figure 12.15:** Test setup for an icon intuitiveness test.

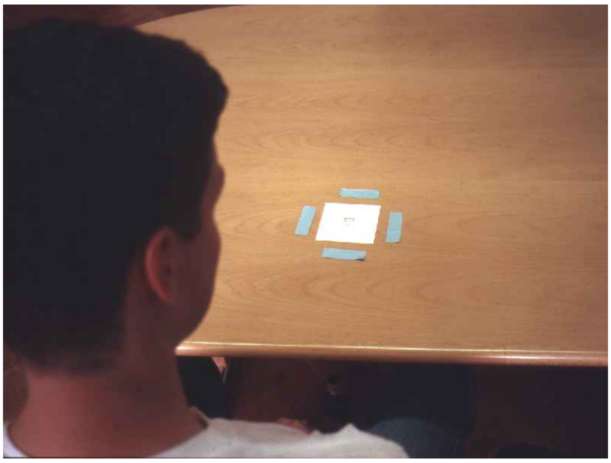


**Figure 12.16:** An icon intuitiveness test in progress. Each icon is printed out in colour and mounted on card. The taped up area of the desk keeps the icon in camera view.

- At the end of the test, interview the test user in more detail. Provide an overview sheet/printout of all the icons to aid discussion.

**Figure 12.17:** Room setup for an icon test. Note the video camera and clip-on microphone.

## 12.8 Designing Icons for Sun's Public Web Site

- In the spring of 1995, Sun Microsystems' public web site was redesigned.
- Icons were used to represent parts of the web site, such as "Technology and Developers", "Products and Solutions", and "Sun on the Net".
- Thanks to Jakob Nielsen for permission to use the material in this section.

### Icon Designs for Concept of "Technology and Developers"

Three rounds of icons were designed and tested to represent the concept of "Technology and Developers", as can be seen in Tables 12.2, 12.3, and 12.4.

### Icon Designs for Concept of "Products and Solutions"

Figure 12.18 shows the iterations of icon designs for the concept of "Products and Solutions".

### Icon Designs for Concept of "Sun on the Net"

Figure 12.19 shows the iterations of icon designs for the concept of "Sun on the Net".

### Video: Jon Hicks

- Jon Hicks' talk at Beyond Tellerrand Berlin 2014 [Hicks 2014, 00:32-32:46]. [Video: `https://youtu.be/DGtAgmXx-1Q?t=00m32s`]

| *Icon* | *Intended Meaning* | *User Interpretation* |
|---|---|---|
|  | Chip, CD-ROM. | Too hard, finished product. |
|  | Computer, chip. | Too hard, finished product. |
|  | Construction worker. | Negative connotation of "under construction". |

**Table 12.2:** Initial set of black and white designs for an icon to represent the concept of "Technology and Developers" and their interpretation after user testing. [Thanks to Jakob Nielsen for permission to use these images.]

| *Icon* | *Intended Meaning* | *User Interpretation* |
|---|---|---|
|  | Developer, construction. | Liked most, but too much emphasis on hardware. |
|  | Developer, power. | Liked idea of "harnessing the power". |
|  | Developer, computer. | |

**Table 12.3:** Second round of icon sketches for "Technology and Developers". [Thanks to Jakob Nielsen for permission to use these images.]

| *Icon* | *Intended Meaning* | *User Interpretation* |
|---|---|---|
|  | Developer, power, construction. | "thunder and lightning",<br>"electric – looks painful",<br>"person being killed by technology",<br>"dance machine",<br>"why do Sun developers look bug-eyed?". |
|  | Power and cog wheels. | Lightning striking machinery. |
|  | CD-ROM and cog-wheels. | Development and engineering. |

**Table 12.4:** Third round of icons for "Technology and Developers". The most promising of the black and white designs have been drawn on computer and colour has been added. [Thanks to Jakob Nielsen for permission to use these images.]

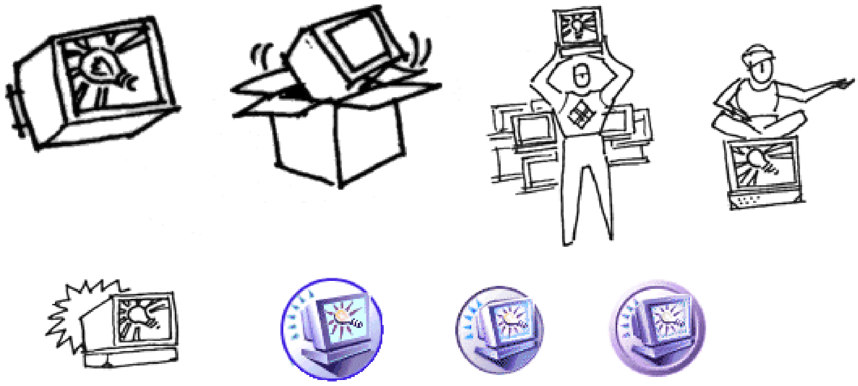


**Figure 12.18:** Eight iterations of the icon design for "Products and Solutions". Between each iteration, icon testing was carried out. [Thanks to Jakob Nielsen for permission to use these images.]

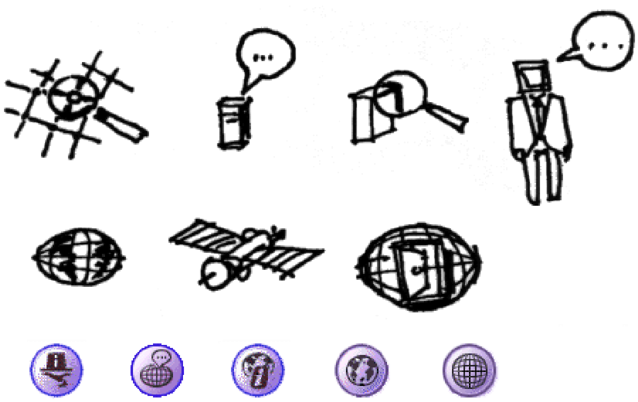


**Figure 12.19:** Twelve iterations of the icon design for "Sun on the Net". Between each iteration, icon testing was carried out. [Thanks to Jakob Nielsen for permission to use these images.]

# Chapter 13

# Early History of HCI

### References

++ Jonathan Grudin; *From Tool to Partner: The Evolution of Human-Computer Interaction*; Morgan Claypool, 2017. ISBN 1627059636 (com, uk) [Grudin 2017]

+ Ben Shneiderman; *Encounters with HCI Pioneers: A Personal History and Photo Journal*; Morgan Claypool, 2019. ISBN 1681734788 (com, uk) [Shneiderman 2019]

+ Adele Goldberg; *A History of Personal Workstations*; Addison-Wesley, 1988. ISBN 0201112590 (com, uk) [Goldberg 1988]

+ Brad Myers; *A Brief History of Human-Computer Interaction Technology*; ACM interactions, 1998. [Myers 1998]

### Online Resources

+ The Interface Experience: 40 Years of Personal Computing; `interface-experience.org`

◦ DigiBarn Computer Museum; `digibarn.com`

◦ Wikipedia; *History of the Graphical User Interface*; `https://wikipedia.org/wiki/History_of_the_graphical_user_interface`

◦ Wikipedia; *WIMP (computing)*; `https://wikipedia.org/wiki/WIMP_(computing)`

◦ Computer History Museum; `computerhistory.org`

◦ Matthias Rauterberg ; *History of HCI*; `https://rauterberg.employee.id.tue.nl/presentations/HCI-history/`

◦ Howard Rheingold; *Tools For Thought*; `https://rheingold.com/texts/tft/`

### Other Resources

++ Bob Cringely (real name Mark Stephens); *Triumph of the Nerds*; [PBS 1996] `https://youtu.be/c1yzXkH5Pfo`

[Three-part TV series made for PBS in USA in 1996. Includes interviews with Steve Jobs, Bill Gates, and many others. The VHS version is 200 minutes, the DVD version is cut down to 150 minutes.]

## 13.1 Early Interfaces

### Memex (1945)

- Vannevar Bush, 1945 [Bush 1945b].
- Memex = “memory extender”.
- Hypothetical design (never built) based on microfilm technology and mechanical levers integrated into a large desk.
- Vision of document repository with links between documents.
- “Trails” = chained sequence of links.
- Personal annotations.

#### Memex Chronology

- Bush started to formulate Memex ideas in 1932 [Nyce and Kahn 1991, page 42].
- Draft sent to FORTUNE magazine on 07 Dec 1939 [Nyce and Kahn 1991, page 52], but publication delayed by USA entering World War 2.
- Bush was presidential science advisor during World War 2.
- Memex article finally published in July 1945 in the Atlantic Monthly [Bush 1945b].
- A condensed version, with new illustrations by Alfred D. Crimi, was printed on 10 Sep 1945 in LIFE Magazine [Bush 1945a].
- Later also reprinted in Nyce and Kahn [1991] and Bush [1996].
- Second, revised article published in 1967 [Bush 1967], also reprinted in Nyce and Kahn [1991].

### Video: Mainframes and Machine Language

- Clip from PBS’ Triumph of the Nerds [PBS 1996], Part 1 [09:59-11:05] [Video: `https://youtu.be/rrC722gKCIc?t=09m59s`]

### SketchPad (1963)

- Ivan Sutherland, PhD Thesis, MIT, 1963.
- Drawing editor with built-in constraint solver.
- First graphical user interface: using a CRT and a lightpen (and various switches and knobs).
- First use of “windows” (virtual sheets of paper).
- First object-oriented program.
- Original PhD thesis (scanned by MIT) [Sutherland 1963a], reconstructed electronic edition produced by University of Cambridge [Sutherland 1963b].

**Figure 13.1:** The memex device. [Screenshot from the Memex animation [Adelman and Kahn 1995], used with kind permission of Paul Kahn.]


**Figure 13.2:** Part of a trail (A5) about the English long bow. Here a link between pages 3GK27 and 5AKD78R. [Screenshot from the Memex animation [Adelman and Kahn 1995], used with kind permission of Paul Kahn.]


**Figure 13.3:** Ivan Sutherland's SketchPad system. [Image taken from the sun.com web site (it is no longer there) and used under the terms of the Sun Microsystems Copyright Notice (see page xiii). ]

- Video of SketchPad in Alan Kay's video talk [Kay 1987, 04:06]. [Video: https://youtu.be/p2LZLYcu_JY?t=04m34s]
- Video in 1964 Science Reporter episode [Fitch 1964].

### NLS/Augment (1968)

NLS (for oNLine System) [Engelbart and English 1968a]:

- Doug Engelbart, Augmentation Research Center (ARC) of Stanford Research Institute (SRI), 1968.
- Later renamed Augment in 1978.
- Upto 12 remote workstations.
- First use of the mouse.
- Mouse and five-chord keyset for most interaction, keyboard only for entering longer pieces of text.
- Output was first displayed on a 5-inch high-res CRT. A high-res (875-line) CCTV camera transmitted the display to the 17-inch TV monitor of the remote workstation.
- First practical implementation of hypertext links.
- Drawing editor and image links.
- Interactive collaboration: multiple people could point and edit and see each other's pointers.

**Figure 13.4:** An NLS workstation with a CRT display, keyboard, push buttons, and mouse. [ Image used with kind permission of Stanford University, Special Collections. ]

### NLS Input Devices

Experimented with many different pointer devices [English et al. 1967]:

- Light Pen
- Grafacon
- Joystick
- Mouse (see Figure 13.5)
- Knee Control (see Figure 13.6)

and different text input devices:

- Keyboard (see Figure 13.7)
- Five-Chord Keyset (see Figure 13.7)
- Push Buttons

### Video: Doug Engelbart "Mother of All Demos" (1968)

- Famous live demo [DEI 2020b; Wikipedia 2020b] at AFIPS Fall Joint Computer Conference (FJCC), San Francisco, 08 Dec 1968.
- An excerpt from the demo is included on Alan Kay's video [Kay 1987, 10:55]. [Video: `https://youtu.be/p2LZLYcu_JY?t=10m55s`]

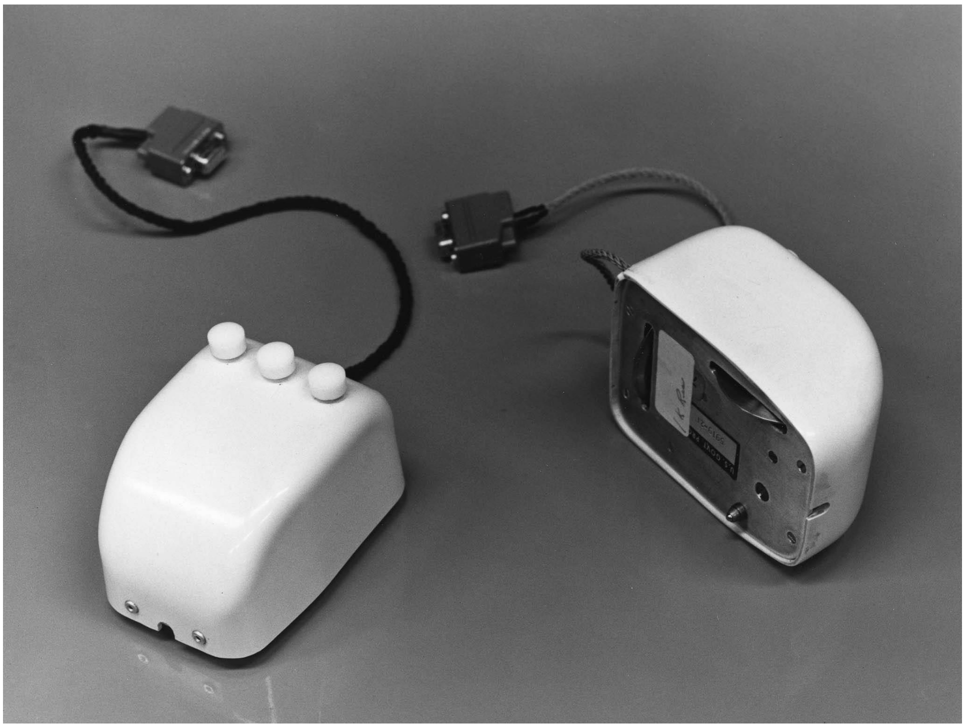


**Figure 13.5:** The NLS three-button mouse. Note the two potentiometer wheels mounted at right-angles to one another on the underside of the mouse. [ Image used courtesy of SRI International, Menlo Park, California. ]

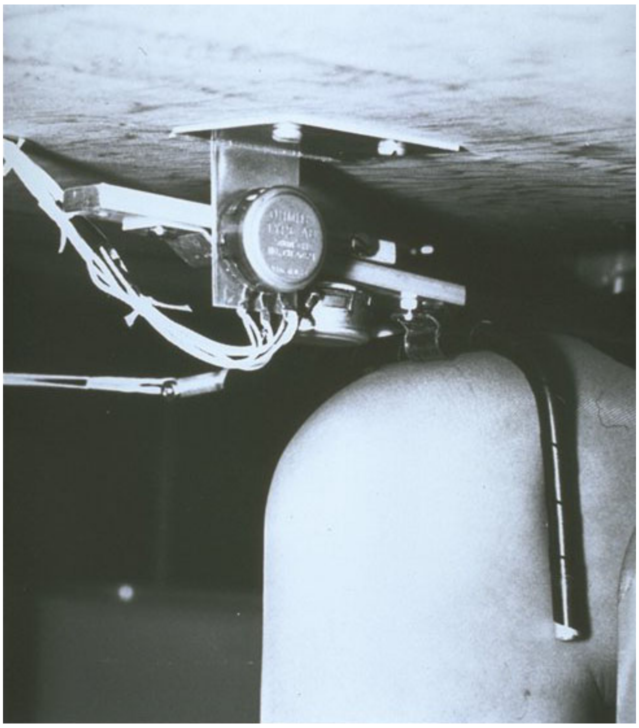


**Figure 13.6:** The experimental NLS knee control. [ Image used with kind permission of Stanford University, Special Collections. ]

**Figure 13.7:** The NLS Mobile Keyboard used by Doug Engelbart in the famous 1968 live demo. Mounted across a office chair on wheels. Five-chord keyset on the right, keyboard in the middle, and mouse to the right. [ Image used courtesy of SRI International, Menlo Park, California. ]

- The full “Mother of All Demos” video is on Vimeo [Engelbart and English 1968b].

#### Other Engelbart and NLS Resources

- NLS concept paper [Engelbart 1962].
- Comparative study of different pointer devices [English et al. 1967].
- The mouse patent [Engelbart 1970], filed in 1967, expired in 1987.
- The Doug Engelbart Institute (formerly The Bootstrap Institute) [DEI 2020a].
- Video interviews and background material at Invisible Revolution [Hegland and Klijnsma 2008].

## 13.2 WIMP Interfaces

WIMP stands for “Window, Icon, Menu, Pointing device”.

#### Xerox PARC

- Xerox Palo Alto Research Center (PARC) opened 01 Jul 1970.
- PARC’s Computer Science Lab had 50 or so of the best computer science researchers in the world (almost all with PhDs).

- “Bean-bag” culture.
- Clip from PBS’ Triumph of the Nerds [PBS 1996], Part 3 [05:17-07:09] [Video: https://youtu.be/WpdhFAKPsT4?t=05m17s]

### Xerox Alto (1973)

- Xerox licensed the mouse from SRI in 1971.
- Xerox Alto was first built in 1973.
- The first “personal computer”, designed to be used by only one person (a very radical idea at the time).
- For images, see http://righto.com/2017/10/the-xerox-alto-smalltalk-and-rewriting.html and https://interface-experience.org/objects/xerox-alto/.
- Several thousand Altos were built, but it was never released for sale commercially.
- The components alone cost over $10,000 per machine.

#### Alto GUI

- Raster graphics display with pixels: black and white 808 × 606 pixels resolution.
- windows
- a mouse and a cursor
- pop-up menus
- Word processor (Bravo)

#### Bravo and BravoX

Bravo (and later BravoX) was a word processor developed for the Alto by Charles Simonyi and Butler Lampson:

- WYSIWYG (what you see is what you get)
- split screen
- bold and italic
- font families
- variable-width characters (proportional fonts)

Simonyi later joined Microsoft and led development of Microsoft Word.

#### Networked Desktop Environment

Also at PARC at the same time:

- laser printer

- ethernet

In other words, PARC had developed the first networked desktop office environment.

#### Video: Xerox Alto

- Clip from PBS' Triumph of the Nerds [PBS 1996], Part 3 [07:32-08:33] [Video: `https://youtu.be/WpdhFAKPsT4?t=07m32s`]

#### Video: Apple I (1976)

- Two clip from PBS' Triumph of the Nerds [PBS 1996], Part 1 [31:48-32:38] and [33:18-50:37] [Video: `https://youtu.be/rrC722gKCIc?t=31m48s`] [Video: `https://youtu.be/rrC722gKCIc?t=33m18s`]

#### Video: Steve Jobs at PARC (Dec 1979)

- Clip from PBS' Triumph of the Nerds [PBS 1996], Part 3 [11:29-14:03] [Video: `https://youtu.be/WpdhFAKPsT4?t=11m29s`]

#### Xerox Star (1981)

- Designed as an office automation system.
- Computer as desktop of professionals in business organisations.
- Goal: computer invisible to the user.
- Easy-to-learn GUI.

#### Video: Xerox Star

- Video made by Xerox Star designers in 1982 [D. Smith and Irby 1982]. [Video: `https://youtu.be/Cn4vC80Pv6Q`]

#### Apple Lisa (1983)

#### Apple Macintosh (1984)

#### Microsoft Windows (1987)

#### Video: The Front Desk

- Bruce Tognazzini; *The Front Desk*; BBC and Open University, 1996, 30-minute video [BBC 1996]

#### Palm Pilot (1996)

#### Apple iPhone (2007)

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