FRANKFURT UNIVERSITY OF APPLIED SCIENCES

Usability

Human-Computer Interaction Lecture

Slides adapted from hci-lecture.org (A. Schmidt, N. Henze, K. Wolf, V. Schwind), Image from: https://pxhere.com/de/photo/956874

Learning Goals

- Understand …
  - Principles to Support Usability
  - Eight Golden Rules
  - Usability Heuristics
  - Errors
  - Basic Usability Guidelines and Universal Design
- Be able to explain …
  - these principles and give examples
  - user interface designs with regard to these principles

Revelant Work on Usability

- **“Principles to Support Usability”**
  - According to Alan Dix
- **“Eight Golden Rules”**
  - According to Ben Shneiderman
- **“Usability Heuristics”**
  - According to Lauesen and Nielson
- **General Usability Design Guidelines**
- **Universal Design**

Principles to Support Usability

According to Alan Dix

Principles to Support Usability by Dix et al.

- Principle 1: **Learnability**
- Principle 2: **Flexibility**
- Principle 3: **Robustness**

Dix, A. J., Finlay, J., Abowd, G. D., & Beale, R. (2003). Human-computer interaction. Pearson Education https://hcibook.com/.

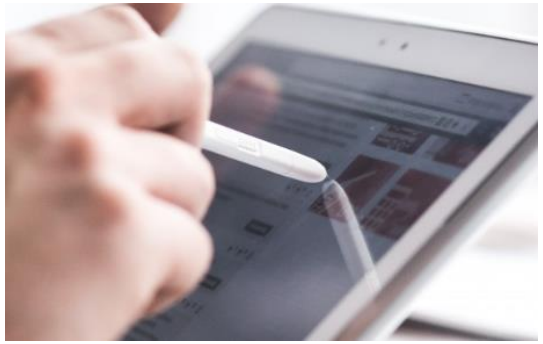
Principle 1: Learnability

- The ease with which new users can begin effective interaction and achieve maximal performance.
  - **Predictability**
    - Determining effect of future actions based on past interaction history
    - Visibility of operations and effects
  - **Familiarity**
  - **Generalizability**
  - **Consistency**
  - **Synthesizability**

Dix, A. J., Finlay, J., Abowd, G. D., & Beale, R. (2003). Human-computer interaction. Pearson Education https://hcibook.com/.

Principle 1: Learnability

- The ease with which new users can begin effective interaction and achieve maximal performance.
  - **Predictability**
  - **Familiarity**
    - how prior knowledge applies to a new system
    - affordance (‘guessability’)
  - **Generalizability**
  - **Consistency**
  - **Synthesizability**



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Principle 1: Learnability

- The ease with which new users can begin effective interaction and achieve maximal performance.
  - **Predictability**
  - **Familiarity**
  - **Generalizability**
    - extending specific interaction knowledge to new situations
  - **Consistency**
  - **Synthesizability**

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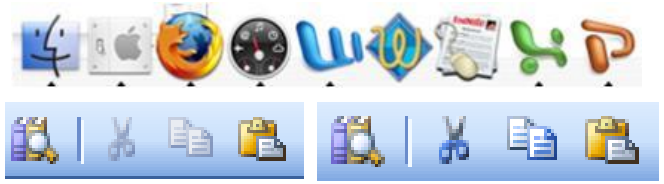
Principle 1: Learnability

- The ease with which new users can begin effective interaction and achieve maximal performance.
  - **Predictability**
  - **Familiarity**
  - **Generalizability**
  - **Consistency**
    - likeness in input/output behavior arising from similar situations or task objectives
  - **Synthesizability**



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Principle 1: Learnability

- The ease with which new users can begin effective interaction and achieve maximal performance.
  - **Predictability**
  - **Familiarity**
  - **Generalizability**
  - **Consistency**
  - **Synthesizability**
    - ability of the user to assess the effect of operations
    - the user should see the changes of an operation

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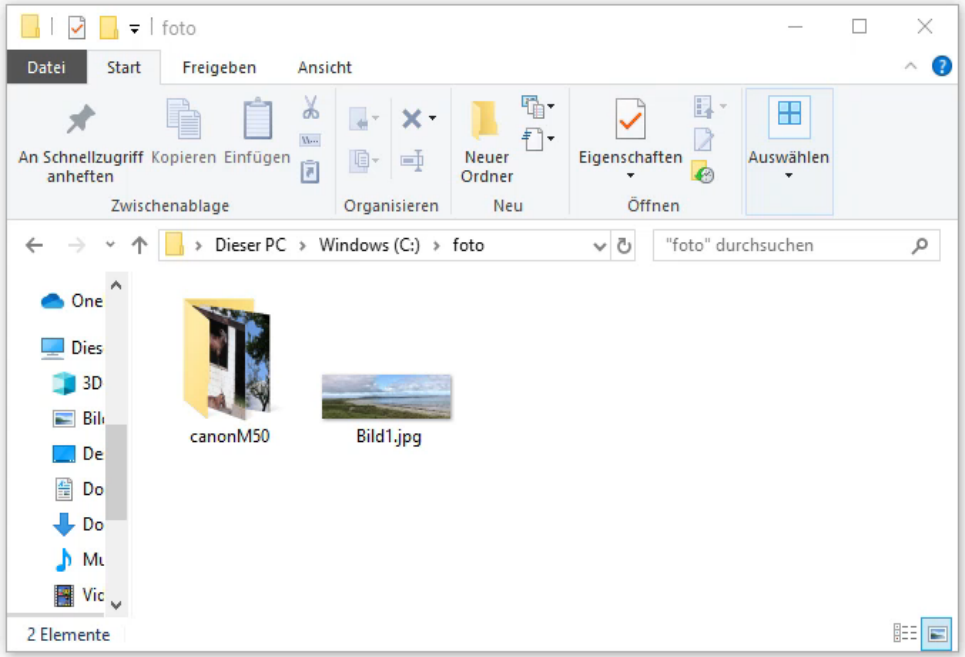
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Ansicht
An Schnellzugriff anheften
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Zwischenablage
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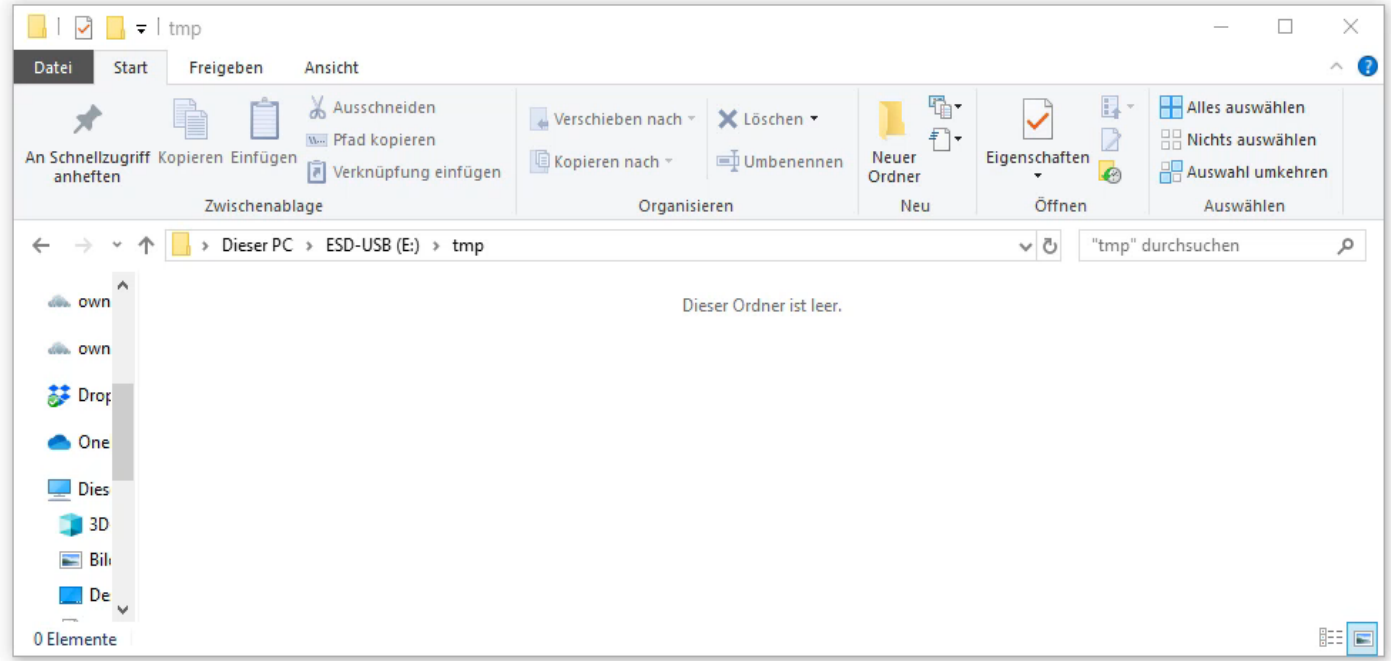
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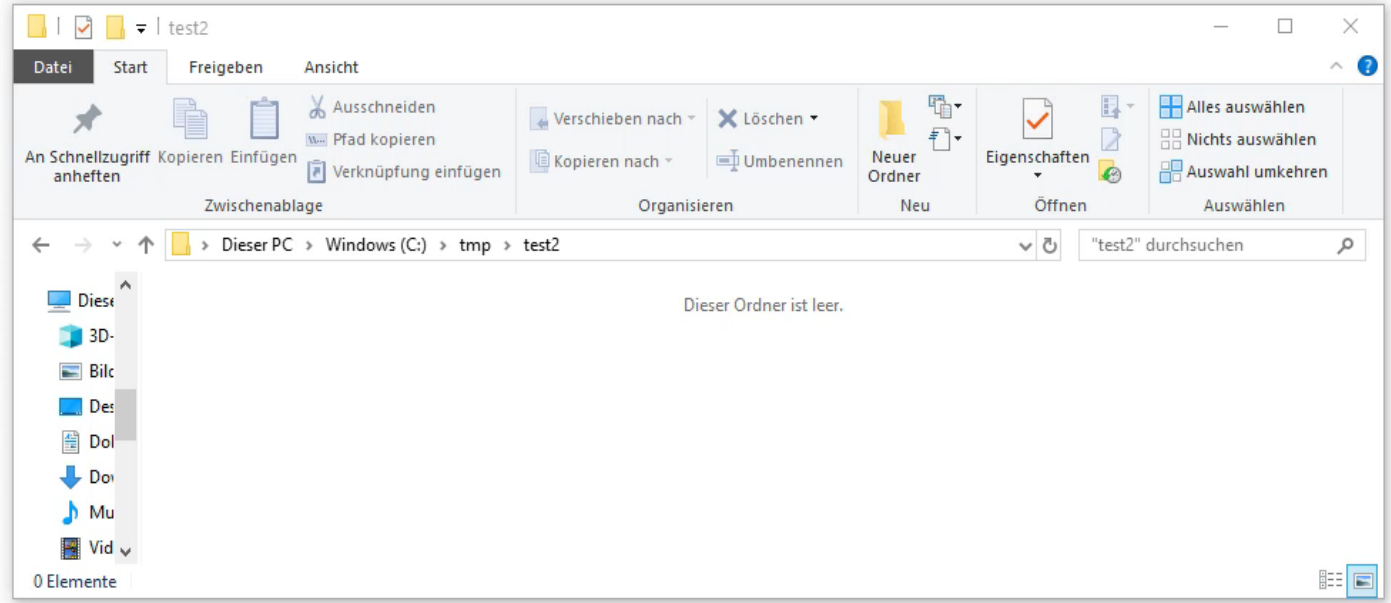
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Alles auswählen
Nichts auswählen
Auswahl umkehren
Auswählen
Dieser PC › Windows (C:) › tmp › test2
"test2" durchsuchen
Dieser Ordner ist leer.
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Principle 2: Flexibility

- The multiplicity of ways the user and system exchange information.
  - **Dialogue initiative**
  - **Multithreading**
  - **Task migratability**
  - **Substitutivity**
  - **Customizability**

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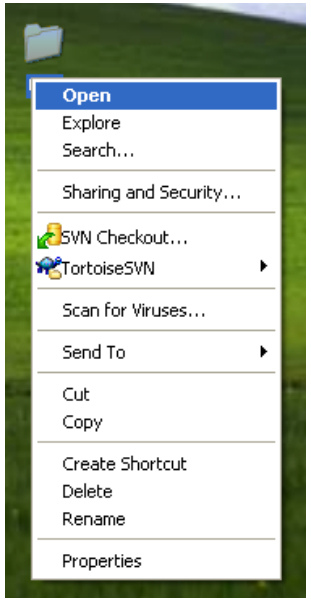
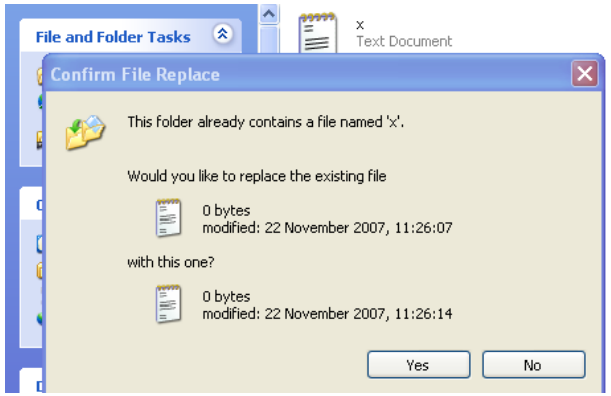
Principle 2: Flexibility

- The multiplicity of ways the user and system exchange information.
  - **Dialogue initiative**
    - freedom from system-imposed constraints on input dialogue
    - user preemptiveness: user initiates dialog
    - system preemptiveness: system initiates dialog
  - **Multithreading**
  - **Task migratability**
  - **Substitutivity**
  - **Customizability**

user preemptiveness



system preemptiveness



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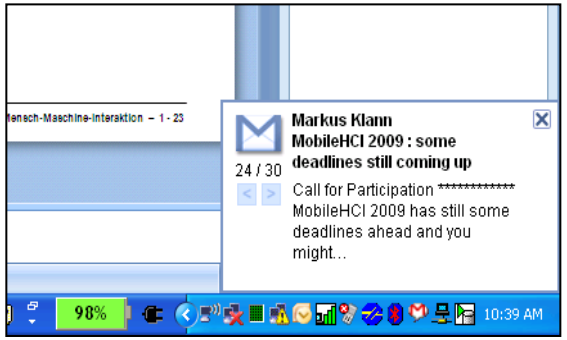
Principle 2: Flexibility

- The multiplicity of ways the user and system exchange information.
  - **Dialogue initiative**
  - **Multithreading**
    - System supports user interaction for several tasks at a time
      - concurrent multimodality: simultaneous communication of information pertaining to separate tasks
      - interleaving multimodality: permits temporal overlap between separate tasks, dialog is restricted to a single task
  - **Task migratability**
  - **Substitutivity**
  - **Customizability**



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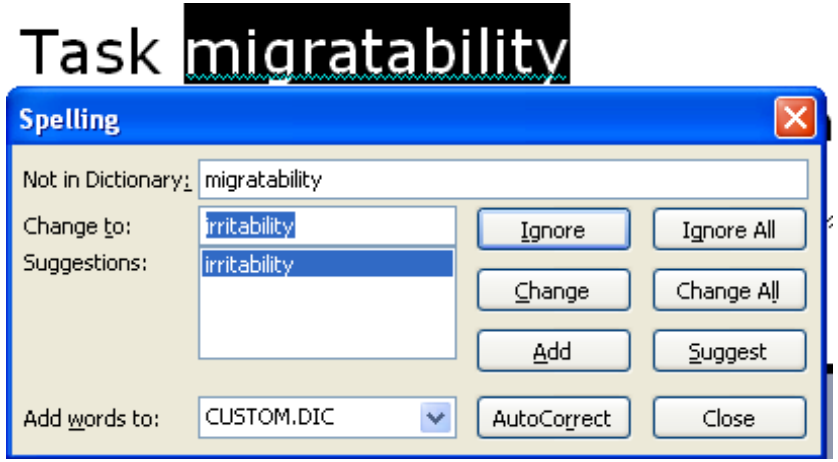
Principle 2: Flexibility

- The multiplicity of ways the user and system exchange information.
  - **Dialogue initiative**
  - **Multithreading**
  - **Task migratability**
    - passing responsibility for task execution between user and system, e.g., spell checking
  - **Substitutivity**
  - **Customizability**



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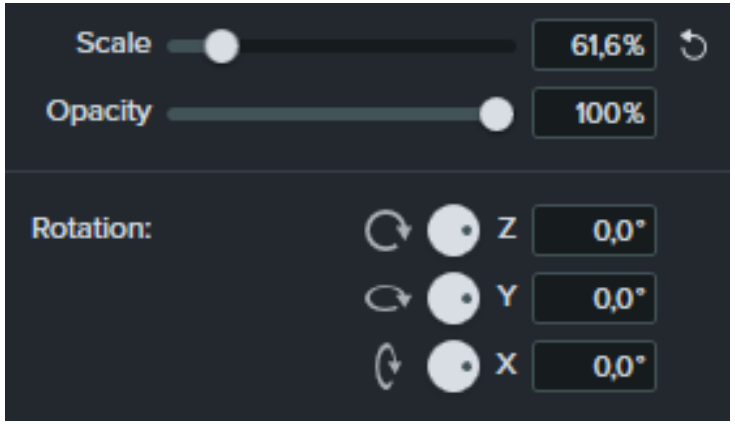
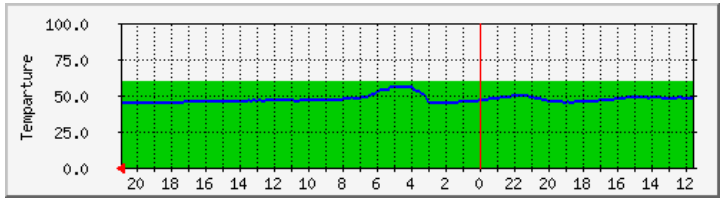
Principle 2: Flexibility

- The multiplicity of ways the user and system exchange information.
  - **Dialogue initiative**
  - **Multithreading**
  - **Task migratability**
  - **Substitutivity**
    - allowing equivalent values of input and output to besubstituted for each other
    - representation multiplicity
    - equal opportunity: blurs the distinction between input and output
  - **Customizability**



	A	B	C	D
1				
2	Summand 1	1	2	1
3	Summand 2	2	2	2
4	Summand 3	3	3	3
5	Total sum	6	7	6



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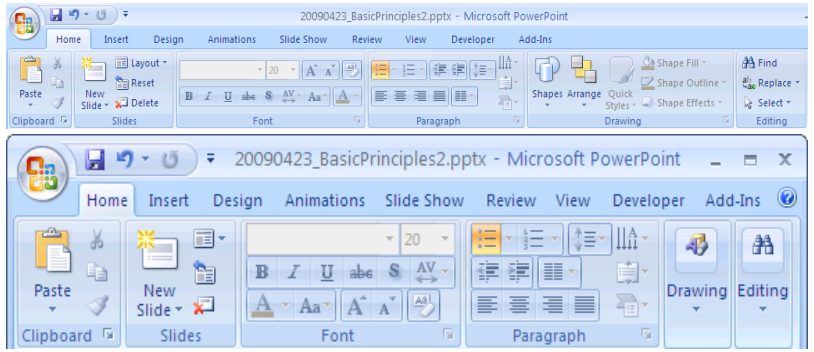
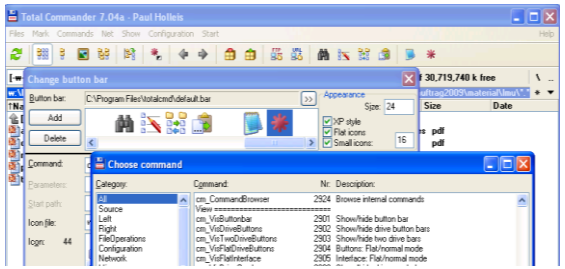
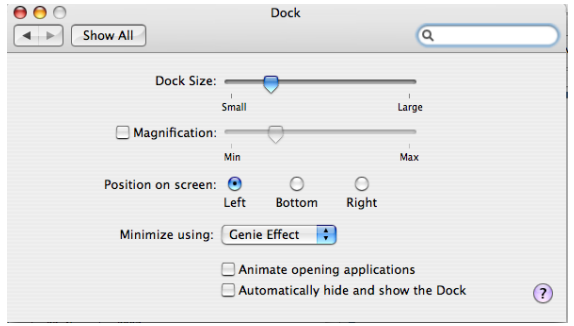
Principle 2: Flexibility



- The multiplicity of ways the user and system exchange information.
  - **Dialogue initiative**
  - **Multithreading**
  - **Task migratability**
  - **Substitutivity**
  - **Customizability**
    - modifiability of the UI by the user (adaptability) or system (adaptivity)
    - adaptability (*anpassbar*): users' ability to adjust input and output
    - adaptivity (*adaptive*): automatic customization of the user interface by the system





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Principle 3: Robustness

- The level of support provided to the user in determining successful achievement and assessment of goal-directed behaviour.
  - **Observability**
  - **Recoverability**
  - **Task conformance**
  - **Responsiveness**

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Principle 3: Robustness

- The level of support provided to the user in determining successful achievement and assessment of goal-directed behaviour.
  - **Observability**
    - ability of the user to evaluate the internal state of the system from its perceivable representation
  - **Recoverability**
  - **Task conformance**
  - **Responsiveness**

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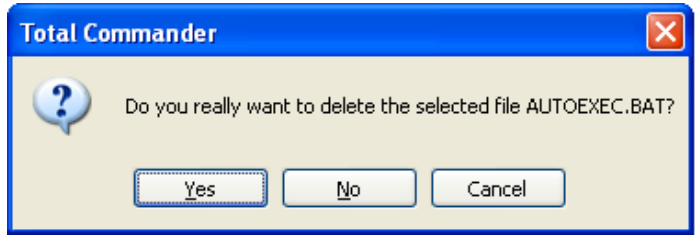
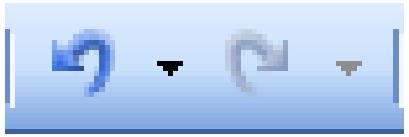
Principle 3: Robustness

- The level of support provided to the user in determining successful achievement and assessment of goal-directed behaviour.
  - **Observability**
  - **Recoverability**
    - ability of the user to correct a recognized error
    - reachability (states): forward (redo) / backward (undo) recovery
    - commensurate effort (more effort / steps for deleting a file than for moving it)
  - **Task conformance**
  - **Responsiveness**





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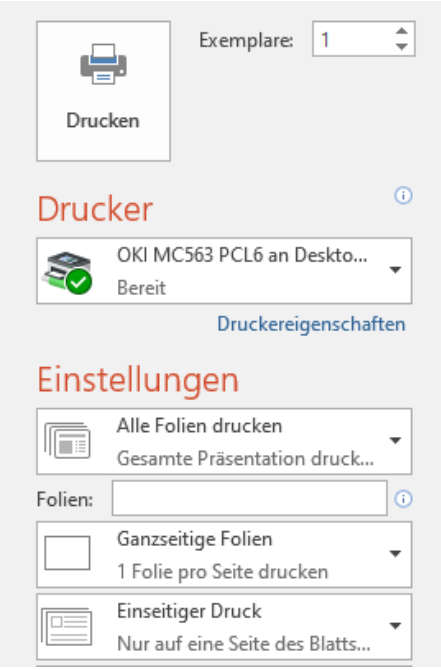
Principle 3: Robustness

- The level of support provided to the user in determining successful achievement and assessment of goal-directed behaviour.
  - **Observability**
  - **Recoverability**
  - **Task conformance**
    - degree to which system services support all of the user's tasks
    - task completeness
    - task adequacy
  - **Responsiveness**



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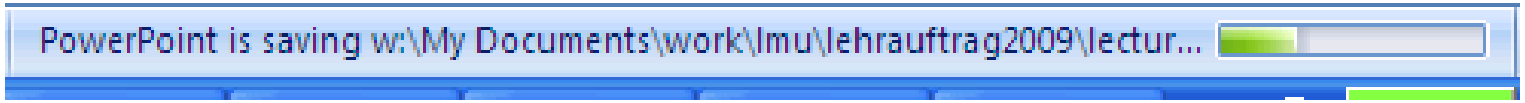
Principle 3: Robustness

- The level of support provided to the user in determining successful achievement and assessment of goal-directed behaviour.
  - **Observability**
  - **Recoverability**
  - **Task conformance**
  - **Responsiveness**
    - how the user perceives the rate of communication with the system
    - preferred: short durations and instantaneous responses
    - stability and indication of response time



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Eight Golden Rules

According to Ben Shneiderman

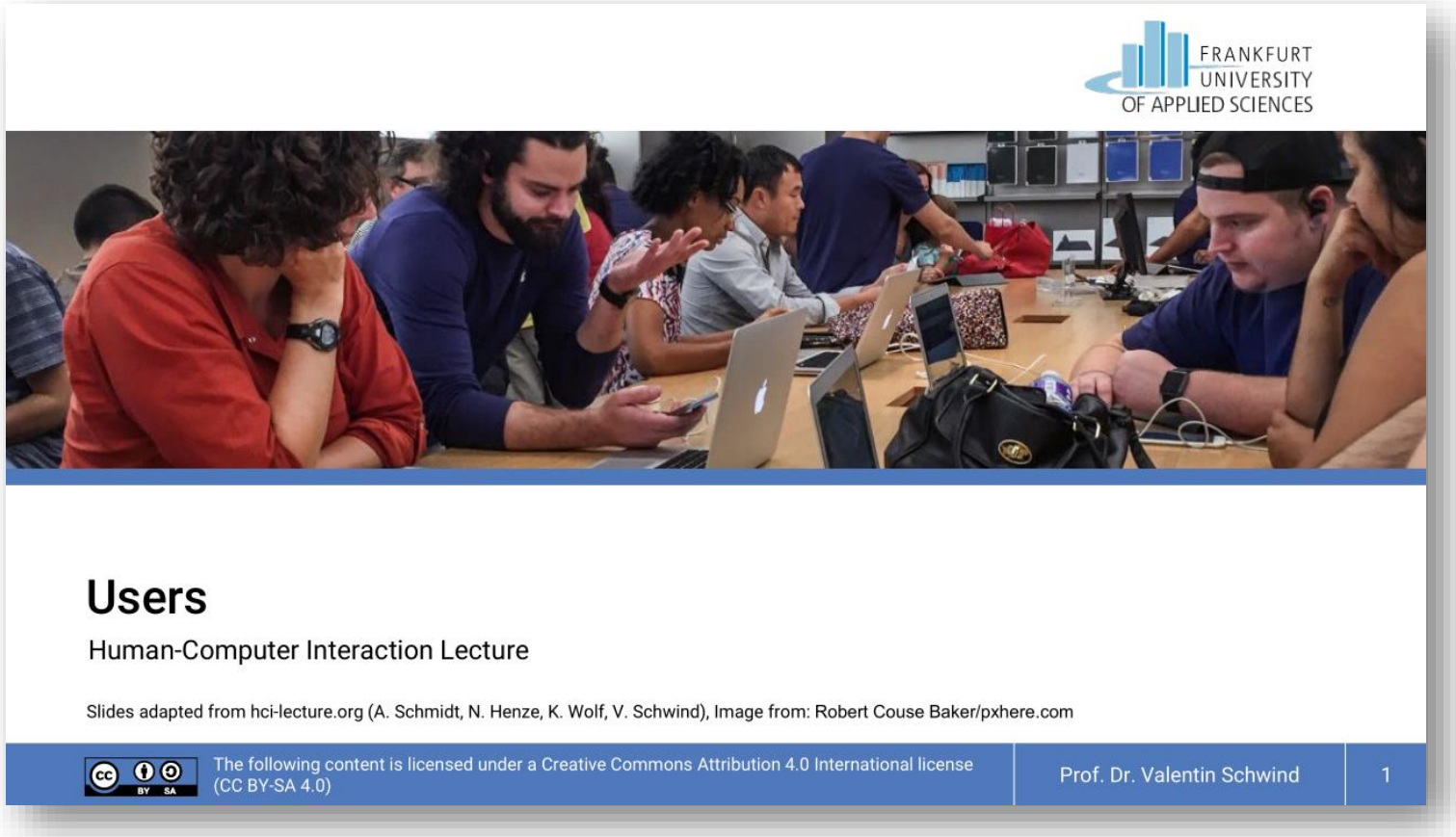
Principles for UI-Design

- Principle 1: **Recognize User Diversity**
- Principle 2: **Follow the Eight Golden Rules**
- Principle 3: **Prevent Errors**

Image from:
https://www.designprinciplesftw.com/authors/ben-shneiderman

Shneiderman, B., Plaisant, C., Cohen, M., Jacobs, S., Elmqvist, N., & Diakopoulos, N. (2016). Designing the user interface: strategies for effective human-computer interaction. Pearson. http://www.cs.umd.edu/hcil/DTUI6/

Principle 1: Recognize User Diversity



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Principle 2: Follow the 8 Golden Rules*

1. **Strive for consistency**
2. **Seek universal usability**
3. **Offer informative feedback**
4. **Design dialogues to yield closure**
5. **Prevent errors**
6. **Permit easy reversal of actions**
7. **Keep users in control**
8. **Reduce short-term memory load**

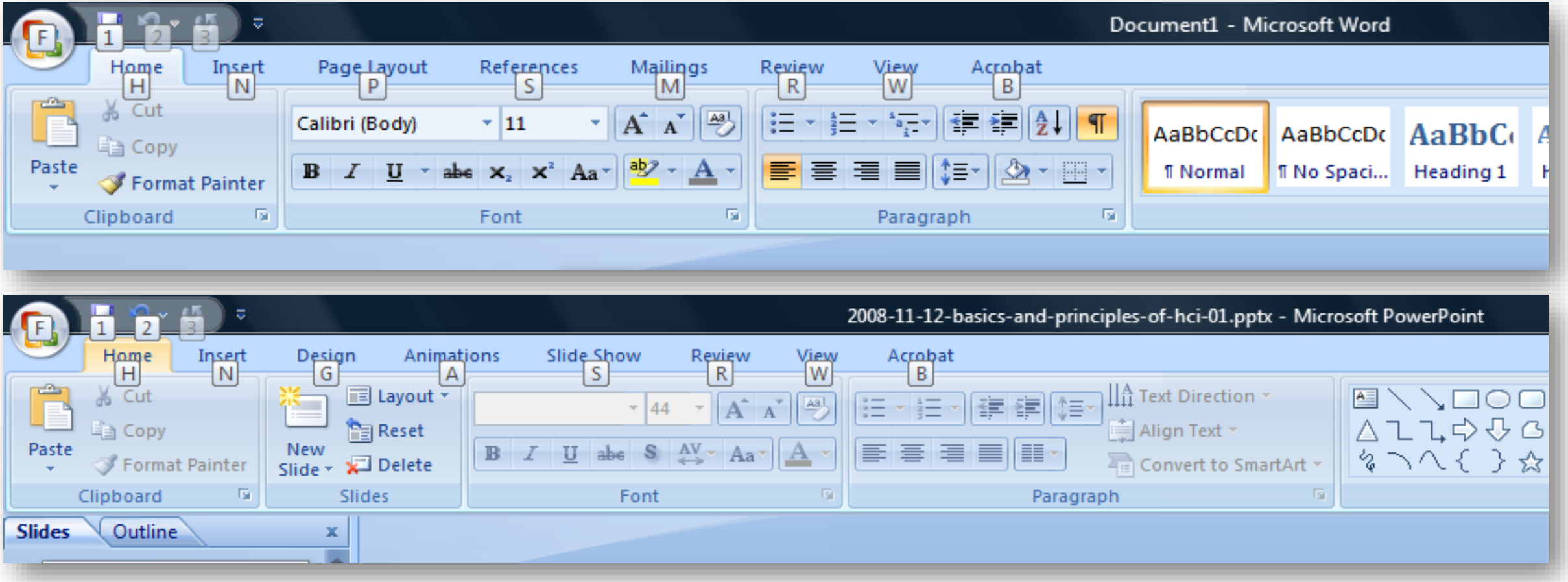
* Sometimes you will find a 9th: **Enable frequent users to use shortcuts**

Shneiderman, B., Plaisant, C., Cohen, M., Jacobs, S., Elmqvist, N., & Diakopoulos, N. (2016). Designing the user interface: strategies for effective human-computer interaction. Pearson. http://www.cs.umd.edu/hcil/DTUI6/

Strive for consistency

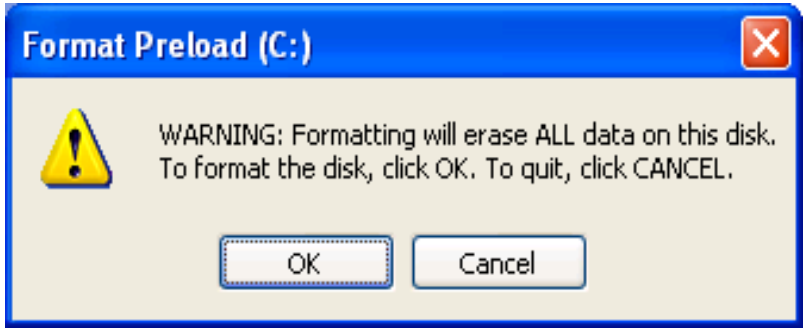
- “Consistent **sequences of actions** should be required in similar situations;
- identical **terminology** should be used in prompts, menus, and help screens;
- and consistent **color, layout, capitalization**, fonts, and so on, should be employed throughout.
- **Exceptions**, such as required confirmation of the delete command or no echoing of passwords, should be comprehensible and limited in number”

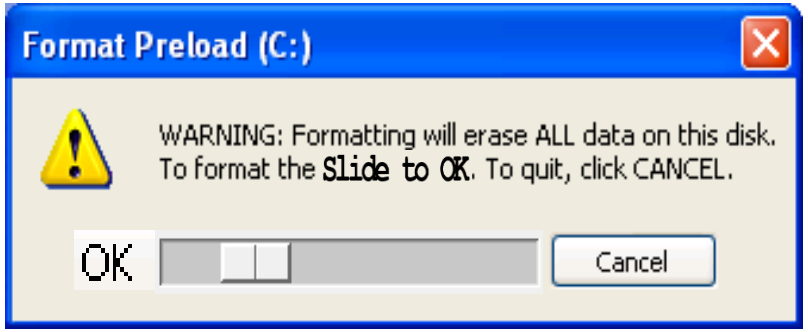
Strive for consistency



Inconsistencies

- Dragging file operations?
  - folder on same disk vs. folder on different disk
  - file to trash can vs. disk to trash can
- Bigger buttons for more often used operations?
- Inconsistency across platforms, e.g.
  - MacOS vs. Windows
  - Websites on different platforms
  - Mobile device vs. TV vs. PC
- Inconsistency can be used for attracting attention





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Seek universal usability

- “Recognize the needs of **diverse users** and design for plasticity, facilitating **transformation of content.**
  - **Novice to expert** differences,
  - **age** ranges, **disabilities**, **international** variations,
  - **technological** diversity
- **[…] spectrum of requirements** that guides design.”

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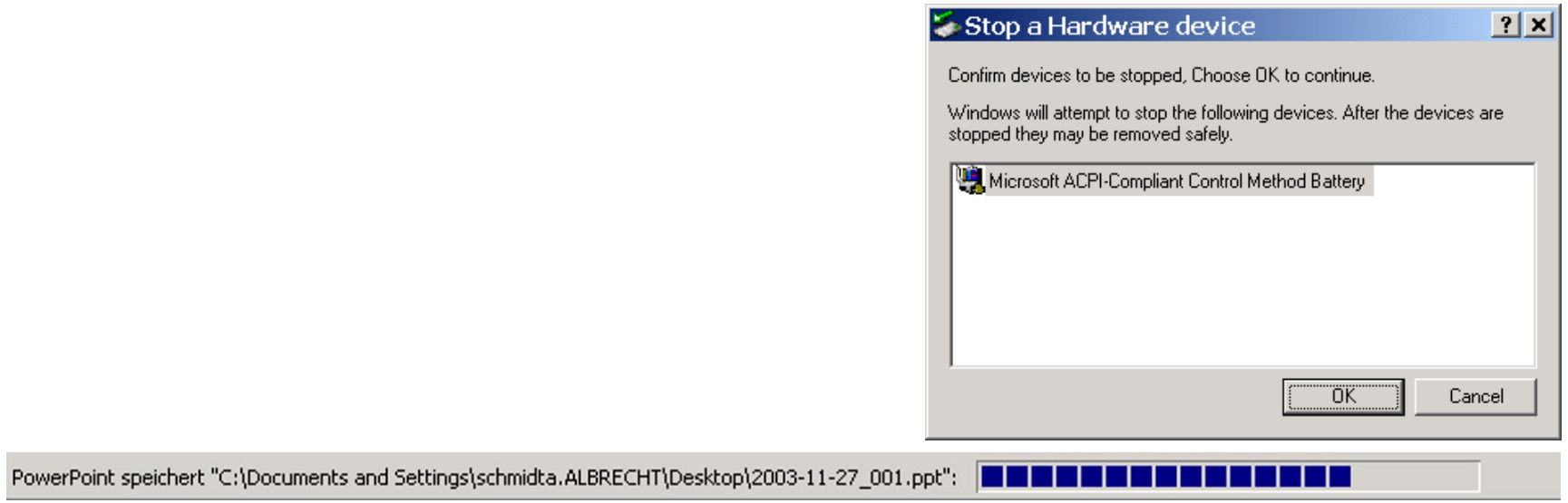
Offer informative feedback

- “For **every user action**, there should be an **interface feedback**.
- For **frequent** and **minor** actions, the response can be **modest**, whereas
- for **infrequent** and **major** actions, the response should be more **substantial**.”



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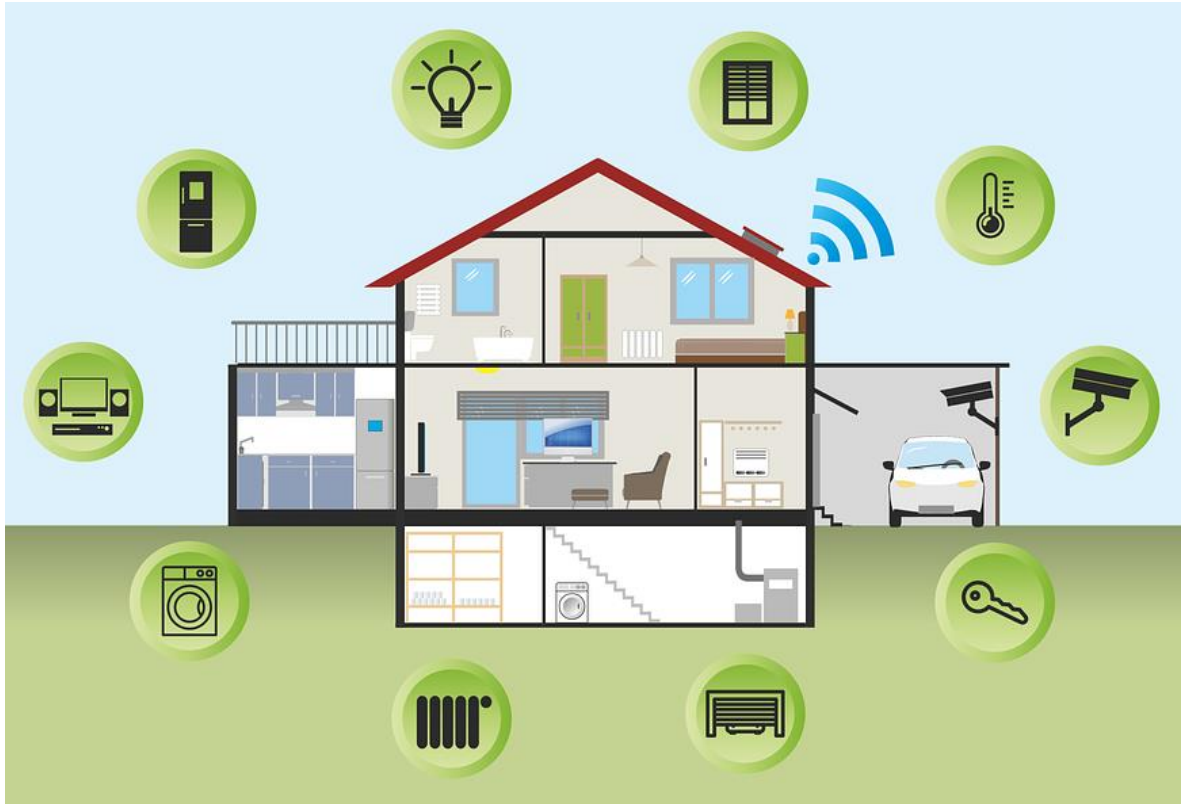
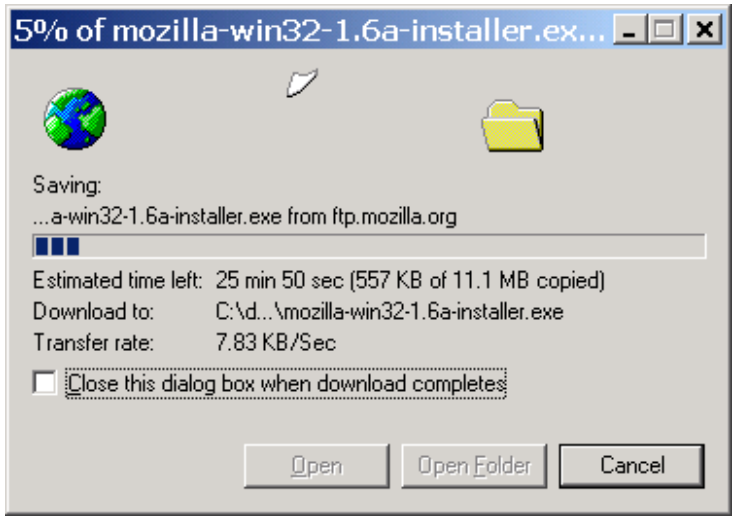
Offer informative feedback

- Question: Will ubiquitous computing change this?



Design dialogues to yield closure

- “**Sequences of actions** should be organized into groups with a **beginning, middle**, and **end**.
- Informative **feedback at the completion** of a group of actions gives users the satisfaction of accomplishment, a sense of relief […]
- For example, e-commerce websites move users from selecting products to the checkout, ending with a clear confirmation page that completes the transaction.”
- Important for actions that are **not immediate** and span over a longer time or multiple steps



Prevent errors

- As much as possible, **design** the interface so that **users cannot make serious errors** […]
- If users make an error, the interface should offer simple, constructive, and specific instructions for **recovery**“
- Detecting errors
- Different options how to handle it:
  - Involve the user with dialogs (current practice)
  - Prevent the error **or its consequences on system level** (e.g. create backups/versions when a file is overwritten, keep all files that have been created by the user)

Permit easy reversal of actions

- As much as possible, **actions should be reversible**.
- This feature **relieves anxiety**, since users know that errors can be undone, and **encourages exploration** […]
- The units of reversibility may be a single action, a data-entry task, or a complete group of actions”
- Providing **UNDO functions**
  - Possibly with infinite depth
  - Over sessions
- Not trivial (conceptually as well as technically)
  - *write a text, copy it into the clipboard, undo the writing, the text is still in the clipboard…*

Permit easy reversal of actions

- As a basic rule – all actions should be reversible
- When is this not possible?
  - Communication applications (e.g. email)
  - Smart environments
  - Machines
  - Cars
- In certain settings processes and basic **physical laws prevent reversal of actions.** Here an interaction layer (buffering user interaction) may be possible – but not always (e.g. breaks, emergency stop)
- What is the cost?
  - Memory?
  - Complexity?

Keep users in control

- “Experienced users strongly desire the sense that they are **in charge of the interface** and that the interface responds to their actions.
- They **don’t want surprises** or changes in familiar behavior”
- Avoid non-causality
- The system should be predictable
- Current developments (AI, Ubicomp) are in contrast:
  - Intelligent agents
  - Smart environments
- …or just feeling in control

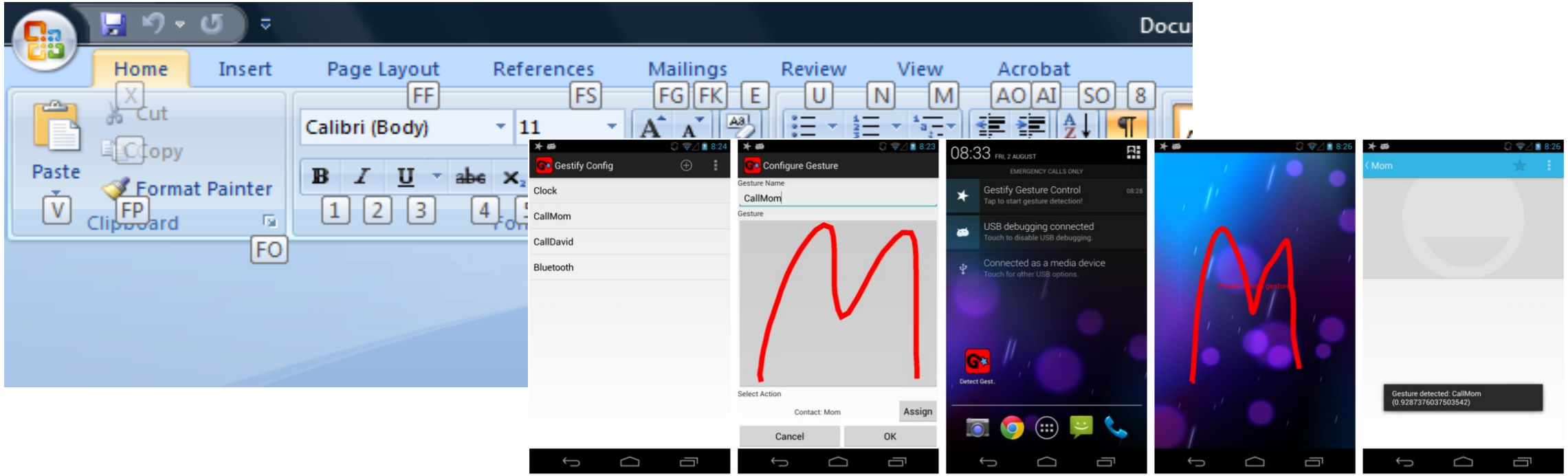
Reduce short-term memory load

- “Humans’ **limited capacity for information processing** in short-term memory requires that designers avoid interfaces
  in which users must remember information from one display and then use that information on another display.”
- “rule of thumb is that people can remember ‘**seven plus or minus two chunks**’ of information”
- The system should remember, not the user
  - Make information that is required visible
  - Recognition is easier than recall, use memory aids (visual or audio)

Enable frequent users to use shortcuts

- Improves **speed** for **experienced users**
- Shortcuts on different levels
  - Access to **single commands**, e.g. CTRL+S or toolbar
  - **Customizing** of commands and environments, e.g. printer pre-set (duplex, A4, …)
  - **Reusing actions** performed, e.g. history in command lines, macro functionality
- Shortcuts to single commands are related to consistency
  - CTRL+X, CTRL+C, CTRL+V in Microsoft applications for cut, copy, and paste
  - However CTRL+S (saving a document) is only implemented in some applications…

Shortcuts



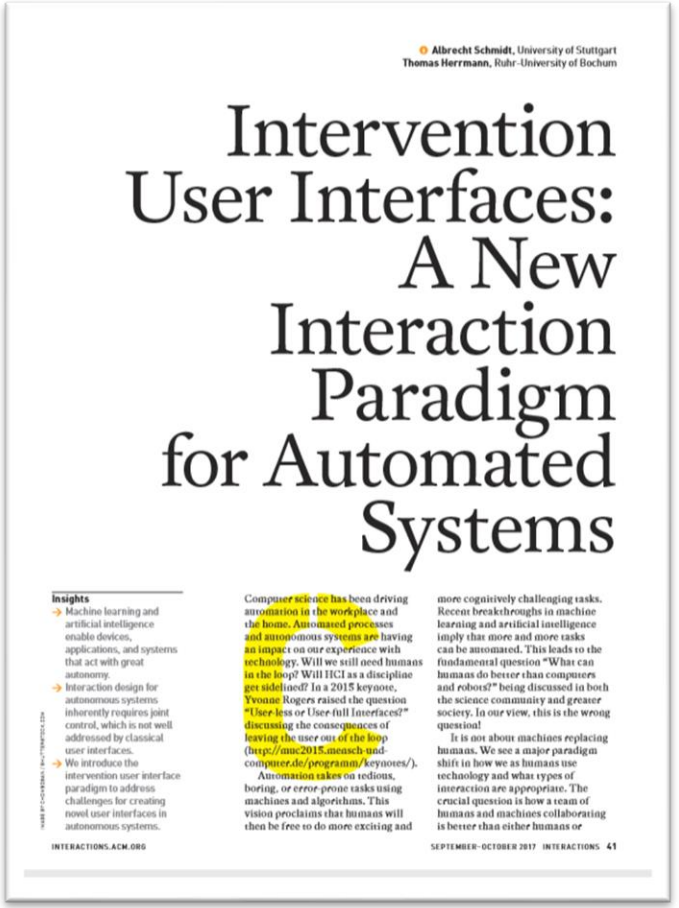
(a) List of existing gestures. (b) Add a new gesture. (c) Trigger detection through one of the provided activators, e.g., notification bar. (d) Draw gesture in recognition activity. (e) A pop-up indicates that the gesture is detected.

Figure 1. Gestify is an Android application that allows users to define and execute their own shortcut gestures. If gestures were trained to the system they can be recognized via different activators, i.e., through the lock screen, the notification bar, the wallpaper, and through a separate activity. If a gesture is detected, a toast is shown and the linked action is executed.

Poppinga, B., Sahami Shirazi, A., Henze, N., Heuten, W., & Boll, S. (2014, September). Understanding shortcut gestures on mobile touch devices. In Proc. of the 16th int. conf. on Human-computer interaction with mobile devices & services (pp. 173-182). ACM.

How can humans stay in control?

- “In the future, we believe that a large class of **automated and autonomous systems** allow for **joint control**, where the majority of decisions are automated but **where users can intervene.**
  - Ensure expectability and predictability.
  - Communicate options for interventions.
  - Allow easy exploration of interventions.
  - Easy reversal of automated and intervention actions.
  - Minimize required attention.
  - Communicate how control is shared.



Albrecht Schmidt, University of Stuttgart
Thomas Herrmann, Ruhr-University of Bochum

Intervention User Interfaces: A New Interaction Paradigm for Automated Systems

Insights

- Machine learning and artificial intelligence enable devices, applications, and systems that act with great autonomy.
- Interaction design for autonomous systems inherently requires joint control, which is not well addressed by classical user interfaces.
- We introduce the intervention user interface paradigm to address challenges for creating novel user interfaces in autonomous systems.

Computer science has been driving automation in the workplace and the home. Automated processes and autonomous systems are having an impact on our experience with technology. Will we still need humans in the loop? Will HCI as a discipline get sidelined? In a 2015 keynote, Yvonne Rogers raised the question "User-less or User-full Interfaces?" discussing the consequences of leaving the user out of the loop (http://muc2015.mensch-und-computer.de/programm/keynotes/).

Automation takes on tedious, boring, or error-prone tasks using machines and algorithms. This vision proclaims that humans will then be free to do more exciting and more cognitively challenging tasks. Recent breakthroughs in machine learning and artificial intelligence imply that more and more tasks can be automated. This leads to the fundamental question "What can humans do better than computers and robots?" being discussed in both the science community and greater society. In our view, this is the wrong question!

It is not about machines replacing humans. We see a major paradigm shift in how we as humans use technology and what types of interaction are appropriate. The crucial question is how a team of humans and machines collaborating is better than either humans or

INTERACTIONS.ACM.ORG

SEPTEMBER–OCTOBER 2017 INTERACTIONS 41

Schmidt, A., & Herrmann, T. (2017). Intervention user interfaces: a new interaction paradigm for automated systems. interactions, 24(5), 40-45.

Principle 3: Prevent Errors

- Question: What is an error?

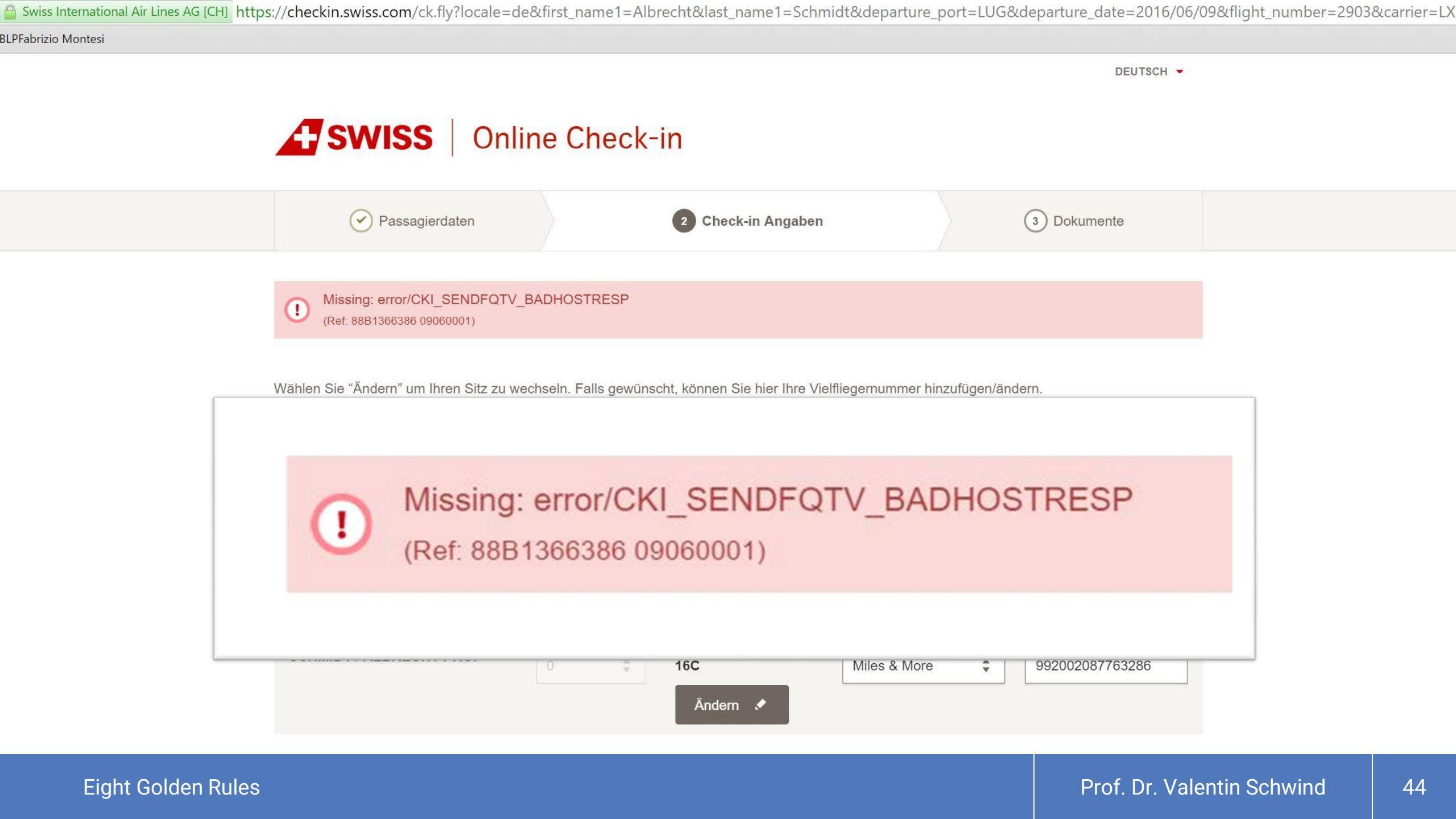
Bob Ross Happy Little Accidents Mega Funky Chunky Magnet
BY AQUARIUS ENTERTAINMENT - BRAND THE JOY OF PAINTING, Image from: https://www.bigbadtoystore.com/Product/VariationDetails/138279

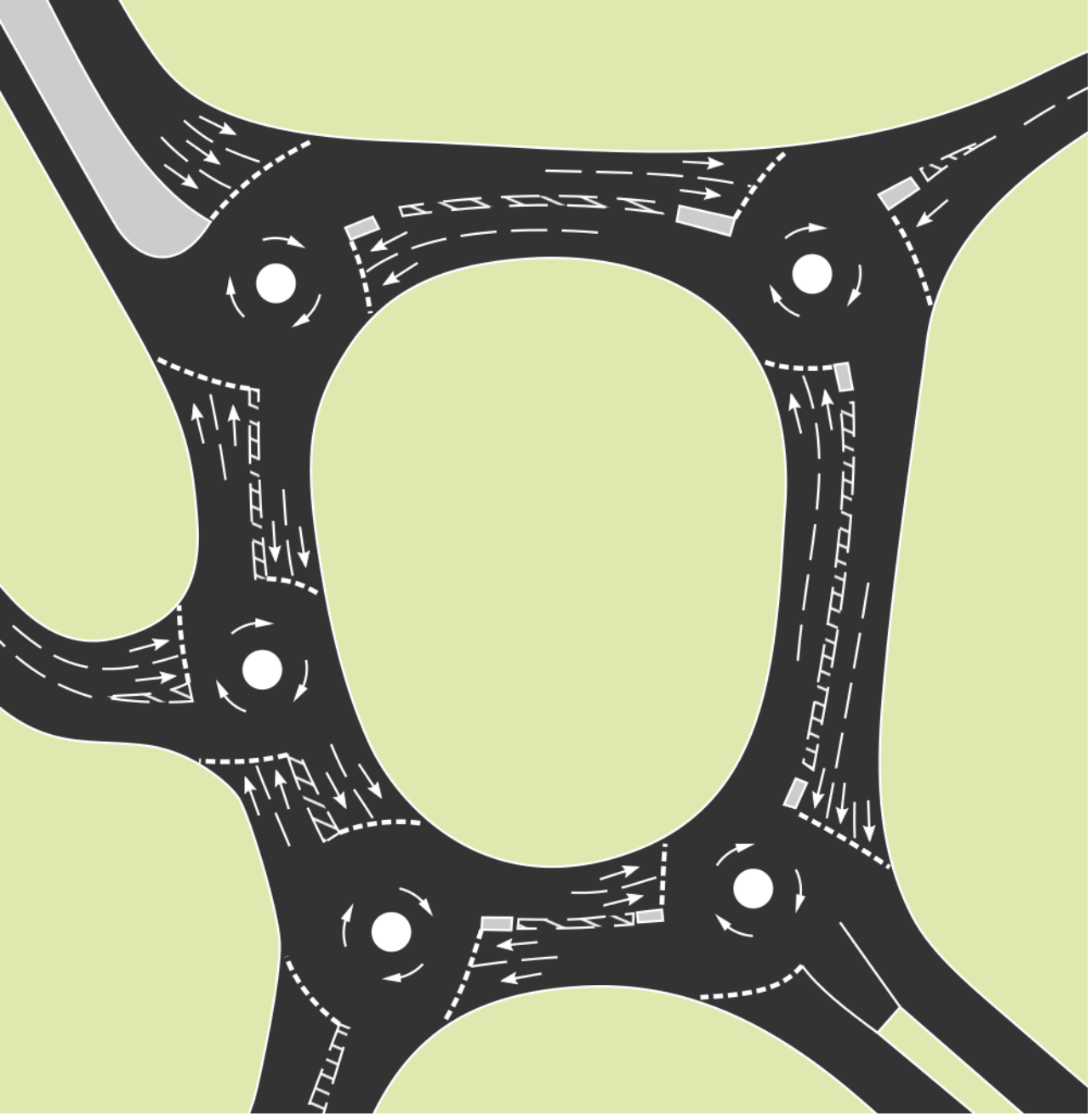
Communicating Systems Errors

- What to do, if an error in the system occurs?
- Will the user benefit from knowing about the error?
- Can the user do something about the error?
- What other solutions are available?
- If the error is provided to the user it must be
  - Understandable (the user gets what the problem is)
  - Actionable (the user gets options to do things)


```
public final int STARTSTOP = 05;
public final int BACK = 05;
public final int FORWARD = 06;
public final int
public final int DECREASE = 08;
```

integer number too large: 08


Swiss International Air Lines AG [CH] https://checkin.swiss.com/ck.fly?locale=de&first_name1=Albrecht&last_name1=Schmidt&departure_port=LUG&departure_date=2016/06/09&flight_number=2903&carrier=LX
BLPFabrizio Montesi
DEUTSCH
SWISS | Online Check-in
Passagierdaten
2 Check-in Angaben
3 Dokumente
Missing: error/CKI_SENDFQTV_BADHOSTRESP
(Ref: 88B1366386 09060001)
Wählen Sie “Ändern” um Ihren Sitz zu wechseln. Falls gewünscht, können Sie hier Ihre Vielfliegernummer hinzufügen/ändern.
Missing: error/CKI_SENDFQTV_BADHOSTRESP
(Ref: 88B1366386 09060001)
16C
Miles & More
992002087763286
Ändern



When do errors happen?

- Who is responsible if an accident happens?
- The program?
- The user?
- Another user?
- The developer?
- The product management?

The “Human Error” as the Ultimate Explanation?

Deadly crash on German monorail

Twenty-three people died and 10 were injured when an elevated magnetic train ploughed into a maintenance vehicle in north-western Germany.

Rescuers had to use ladders and cranes to reach the train

The train, which floats on a monorail via a magnetic levitation system called maglev, was going at nearly 200km/h (120 mph) when it crashed near Lathen.

[...]

'Human error'

The maintenance vehicle hit by the train had two crew members.

A spokesman for IABG, the company which operates the train, said the accident had been caused by human error, rather than a technical fault.

http://news.bbc.co.uk/1/hi/world/europe/5370564.stm

Bei der Analyse der Unfallursachen stützt sich der Bericht laut «Nordwest-Zeitung» auf zwei Gutachten zu dem Unglück:

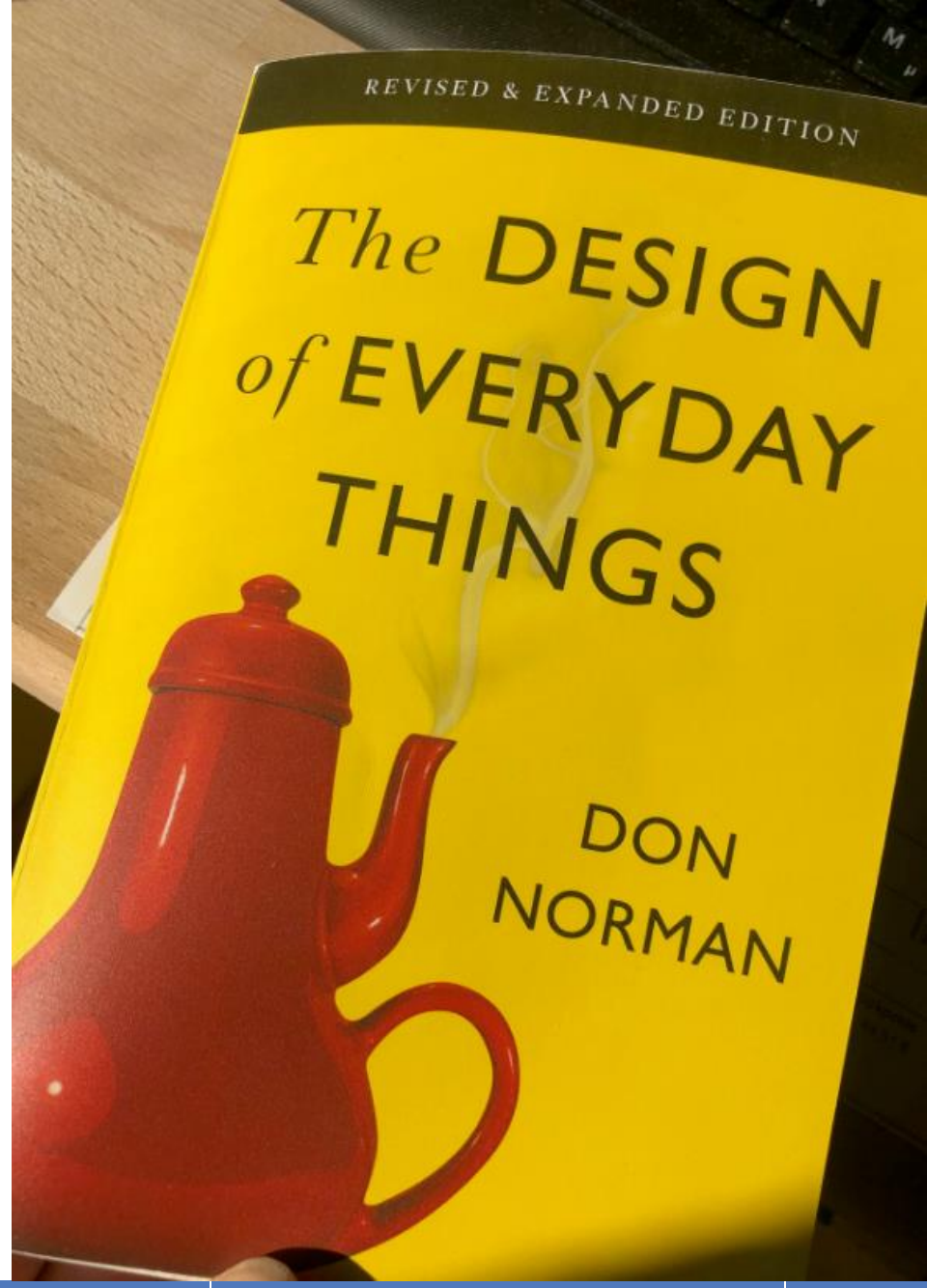
Nach Ansicht der Gutachter verstieß der Fahrdienstleiter gegen die Betriebsvorschriften, weil er die elektronische Streckensperre nicht setzte.

Als weitere Ursache wird die Missachtung des Vier-Augen-Prinzips im Leitstand der Teststrecke genannt.

http://www.netzeitung.de/politik/deutschland/720674.html

About (Human) Errors…

- “**If an error is possible, someone will make it**”
  - Dan Norman
- “Human Error” are a starting point to look for design problems.



Norman, D. A. (2013). The design of everyday things: Revised and expanded edition. New York: Doubleday.

About (Human) Errors…

- Design implications
  - Assume **all possible errors will be made**
  - **Minimize the chance** to make errors (constraints)
  - **Minimize the effect** that errors have (is difficult!)
  - Include mechanism to **detect errors**
  - Attempt to make actions **reversible**
- Prevent that users make errors in the first place
  - Make it **impossible to enter wrong commands**
  - Ensure that users **can always recover**

Understanding Errors

- **Errors are routinely made**
  - Communication and language is used between people to clarify – more often than one imagines
  - Common understanding of goals and intentions between people helps to overcome errors
- **Two fundamental categories**
  - Mistakes = wrong goal
    - overgeneralization
    - wrong conclusions
  - Slips = right goal but wrong action
    - Result of “automatic” behaviour
    - Appropriate goal but performance/action is wrong

Types of Slips

- **Capture errors**: Two actions with common start point, the more familiar one captures the unusual (driving to work on Saturday instead of the supermarket)
- **Description errors**: Performing an action that is close to the action that one wanted to perform (putting the cutlery in the bin instead of the sink)
- **Data driven errors**: Using data that is visible in a particular moment instead of the data that is well-known (calling the room number you see instead of the phone number you know by heart)
- **Associate action errors**: You think of something and that influences your action. (e.g., saying come in after picking up the phone)
- **Loss-of-Activation error ~ forgetting**: In a given environment you decided to do something but when leaving then you forgot what you wanted to do. You go back to the start/last place you remember.
- **Mode error**: You forget that you are in a mode that does not allow a certain action or where an action has a different effect (e.g., trying to set your alarm clock instead of winter time)

Correcting Errors

- If something goes wrong, we **attempt corrections on the lowest level**
- A task includes action on different levels
  - Drive to University
  - Get into the car
  - Open the car door
  - Insert car key and turn
  - Apply pressure to the key
  - …

Preventing Errors

- Example
  - User: “remove the file ‘most-important-work.txt’”
  - computer: “`are you sure that you want to remove the file ‘most-important-work.txt’`?”
  - User: “yes”
  - Computer: “`are you certain`?”
  - User: “yes of course”
  - Computer: “`the file ‘most-important-work.txt’ has been removed`”
  - User: Oops, damm
- The user is **not reconsidering the overall action** – the users **only prompts to think about the immediate action** (clicking)
- A solution is to **make the action reversible**

Detecting and Handling Errors

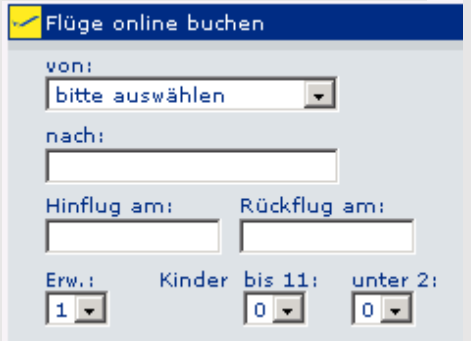
- When “human” errors are detected
  - get into an understandable dialog with the user (check your internet connection)
  - automatically correct the error (spell checker)
- Force a function
  - **Interlock** (e.g., functions can only be done in a certain order)
  - **Lock-Ins** (e.g., you can not leave, before you have not done something)
  - **Lock-Outs** (e.g., you can get in, before you have not done something)
- Put the user into contraint

Constraints to prevent errors

- Physical constraints
  - Basic physical limitations
- Semantic constraints
  - Assumption to create something meaningful
- Cultural constraints
  - Borders and context provided by cultural conventions
- Logical constraints
  - Restrictions due to reasoning
- Applying constraints is a design decision!
  - Practical way to realize the principle “prevent errors”

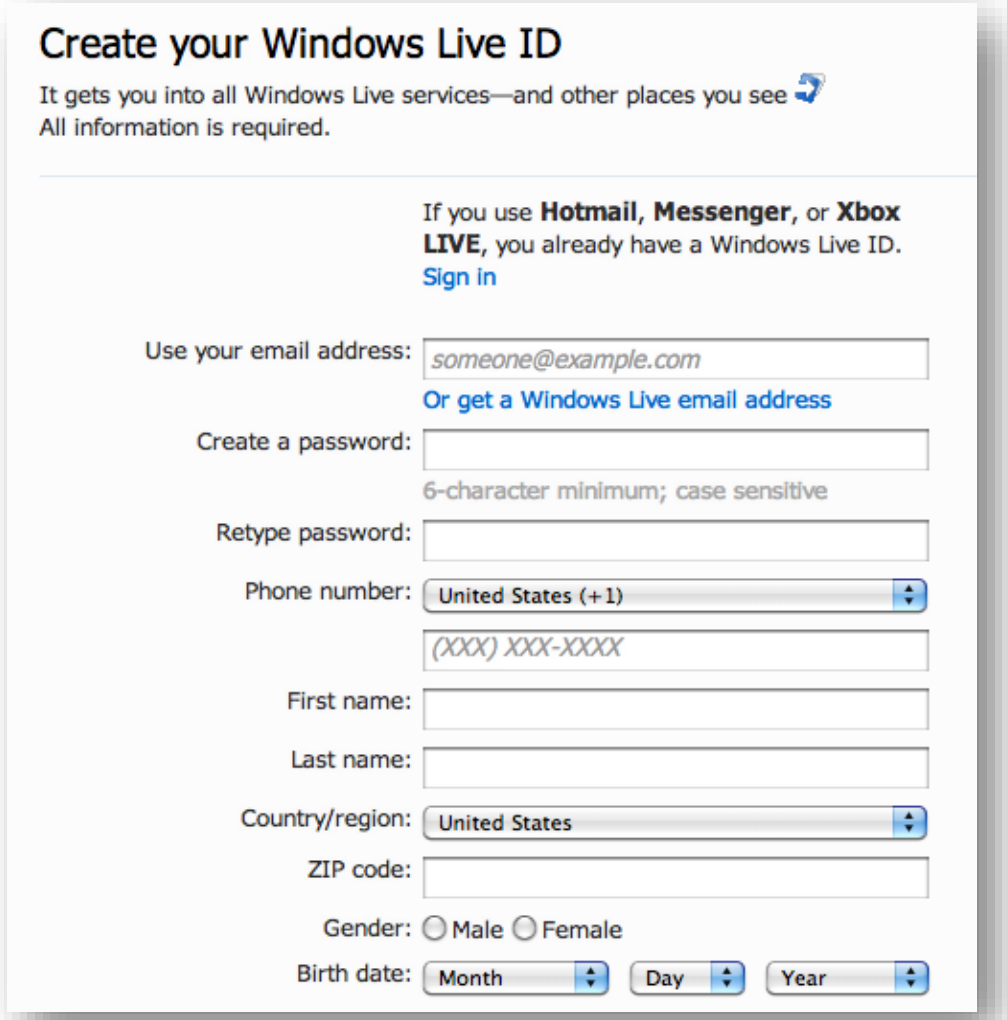
GUI Example

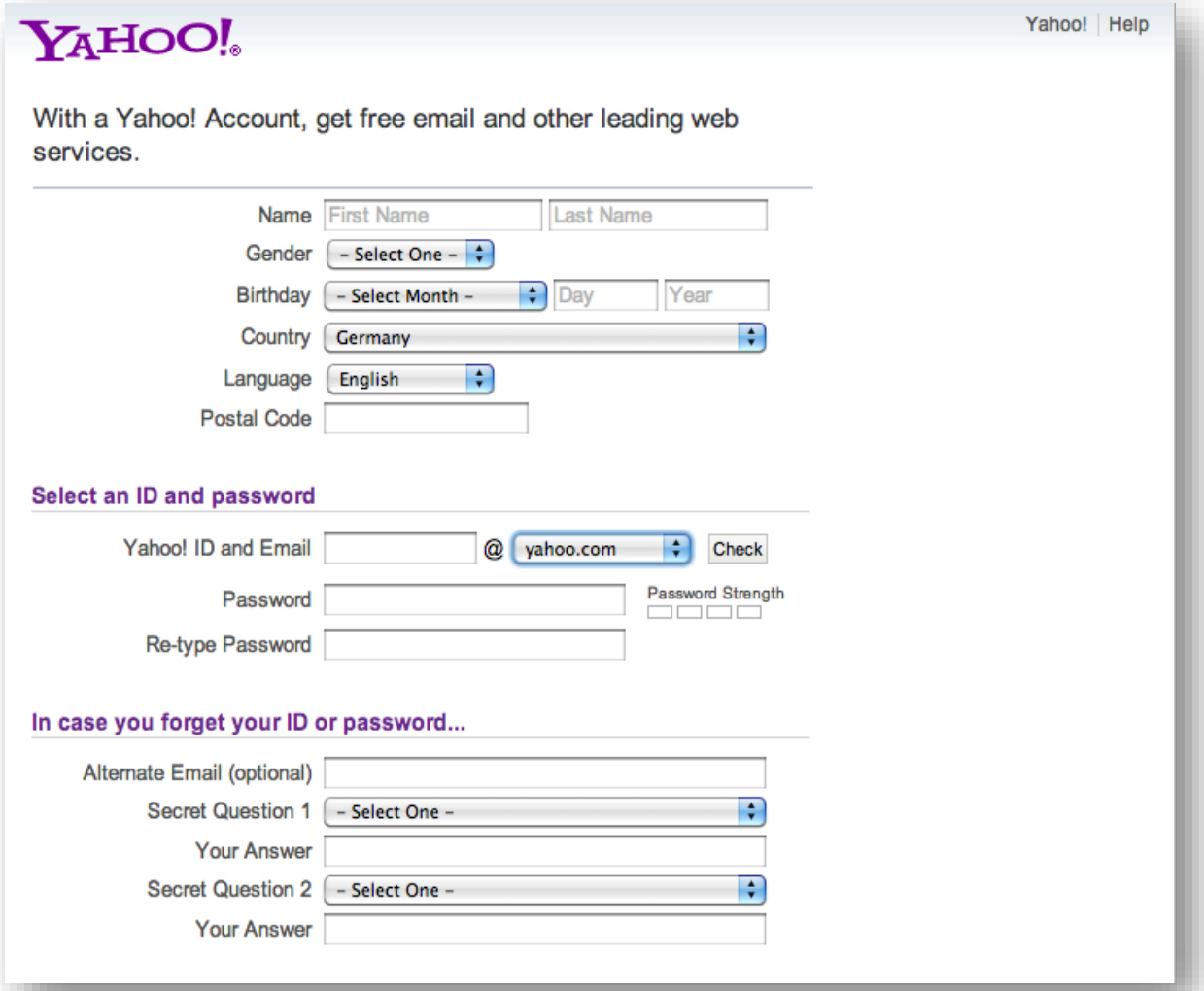
Date unconstrained



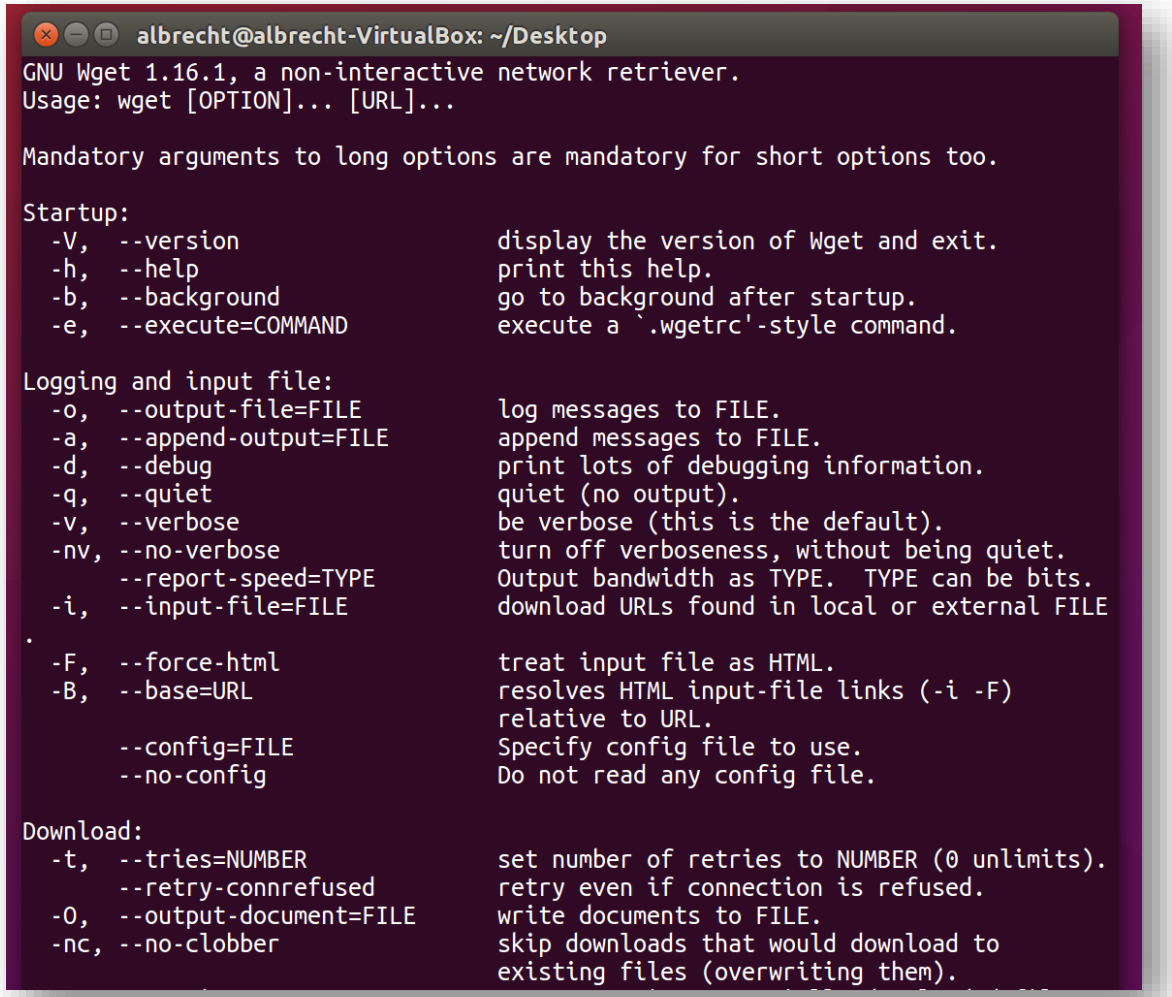
Date constrained

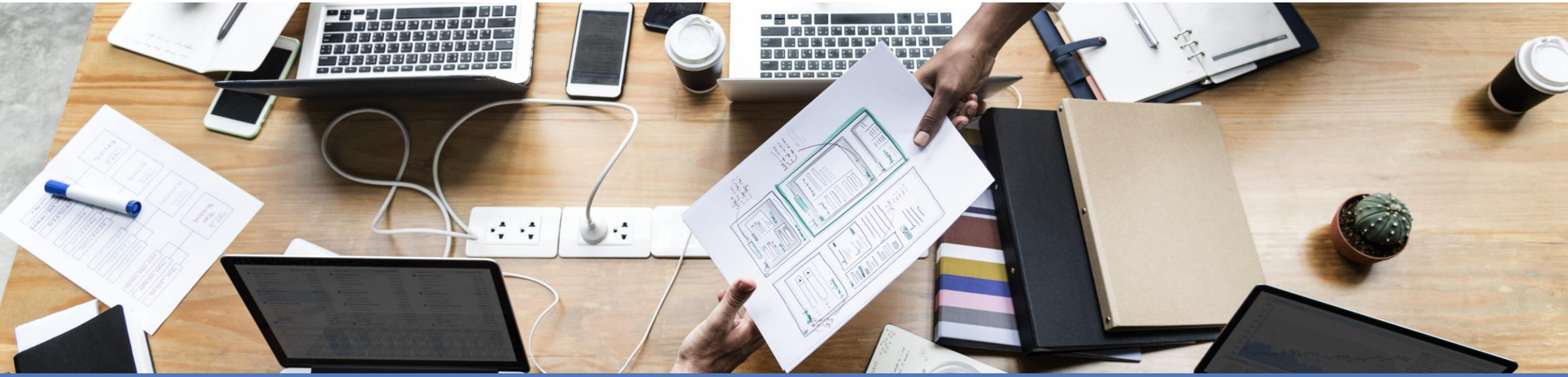
What errors do you expect?





What errors do you expect?





Usability Heuristics

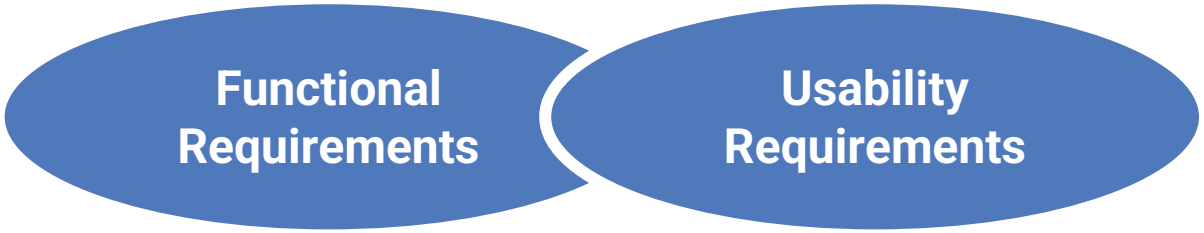
According to Lauesen and Nielson

Slides adapted from C. Thomas, Image from: https://pxhere.com/de/photo/1434201

Usability by Lauesen and Nielson

- 6 Dimensions of Usability

Usability =



(1) **fit for use**

(2) **ease of learning**
(3) **task efficiency**
(4) **ease of remembering**
(5) **subjective satisfaction**
(6) **ease of understanding**

The 7 Usability Heuristics

1. Suitability for the Task
2. Self-descriptiveness
3. Controllability
4. Conformity with User Expectations
5. Error Tolerance
6. Suitability for Individualization
7. Suitability for Learning

1. Suitability for the Task

- **The dialogue should be suitable for the user's task and skill level**
- Examples:
  - On a website contact information can be found, so that a user / customer can directly contact that person via e-mail.
  - In a form no information is asked for that is not needed for the process.
  - In a form that must be corrected, the cursor is directly positioned to the correcting field.
  - Interim results of a longer online transaction can be stored.
  - For visitors that visit a website more often, short-cuts to the main pages are provided.

2. Self-Descriptiveness

- **The dialogue should make it clear what the user should do next**
- Examples:
  - Links are named in a way that one directly can predict where they lead.
  - A Web application has an online help that are context-specific operating instructions.
  - Once a request has been sent to a database, a message "request is being processed, “please wait” should appear.

3. Controllability

- **The user should be able to control the pace and sequence of the interaction**
- Examples:
  - A table has buttons with which the information can be sorted by column
  - A search engine offers the possibility to adjust the number of displayed hits
  - A tool that allows users to interrupt a file download and resume it later
  - Extensive graphics are first shown as "thumbnails", which may be extended by the user if required

4. Conformity with Users Expectations

- **A user interface should be consistent**
- Examples:
  - The link to the home page is placed under the logo top left.
  - The "basket" in an online store is always and in all contexts named "basket".
  - Underlined words are always hyperlinks.
  - Pressing the tab key moves the cursor to the next input field

5. Error Tolerance

- **The dialogue should be forgiving**
- Examples:
  - When going back in a web application with the Back button, the information is always updated to not falsely gives the impression processing steps have been reversed
  - About a script, the data of a form for plausibility, missing or incomplete entries are checked before they are sent
  - Error messages do not use technical terms user does not understand

6. Suitability for Individualization

- **The dialogue should be able to be customized to suit the user needs**
- Example:
  - Customized keyboard short cut for often used commands
  - Customized menu for quick access
  - Custom gestures for mobile device usage

7. Suitability for Learning

- **The dialogue should support learning**
- In a "guided tour", users are familiar with specific “tricks” to use an application.
- In a booking system of a travel agent, it is possible to make a test reservation.
- A Sitemap visualizes the logical structure of a site.

5 Es by Nielson

- **Effective**: How completely and accurately the work or experience is completed or goals reached
- **Efficient**: How quickly this work can be completed
- **Engaging**: How well the interface draws the user into the interaction and how pleasant and satisfying it is to use
- **Error Tolerant**: How well the product prevents errors and can help the user recover from mistakes that do occur
- **Easy to Learn**: How well the product supports both the initial orientation and continued learning throughout the complete lifetime of use

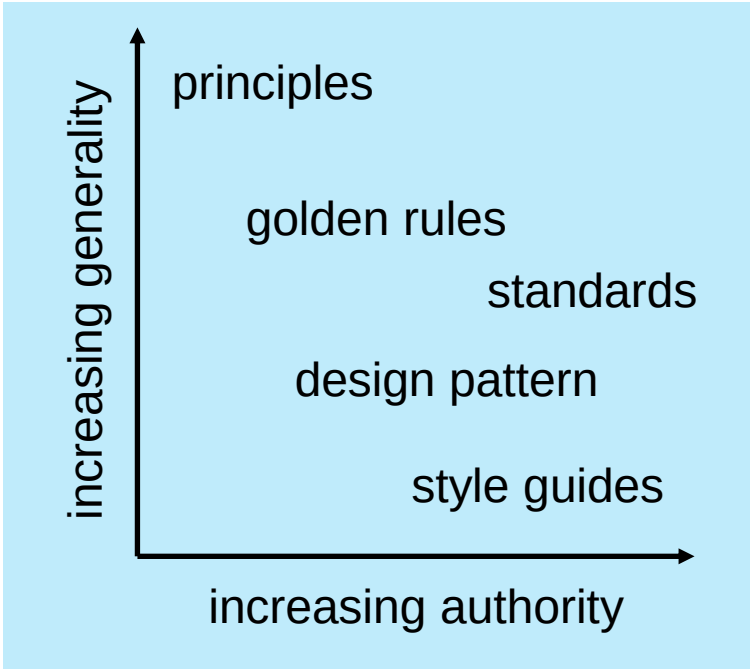
General Usability Design Guidelines

Constraints, Mappings and Aesthetics

Slides adapted from hci-lecture.org (A. Schmidt, N. Henze, K. Wolf, V. Schwind), Image from: https://pxhere.com/de/photo/956874

Types of Design Principles

- **Principles**
  - abstract design rules
- **Golden rules and heuristics**
  - more concrete than principles
- **Standards**
  - (very) detailed design rules
- **Design patterns**
  - generic solution for a specific problem
- **Style guides**
  - provided for devices, operating systems, widget libraries



- **Authority**: whether or not a rule must be followed or whether it is just suggested
- **Generality**: applied to many design situations or focused on specific application situation.

Physical Constraints

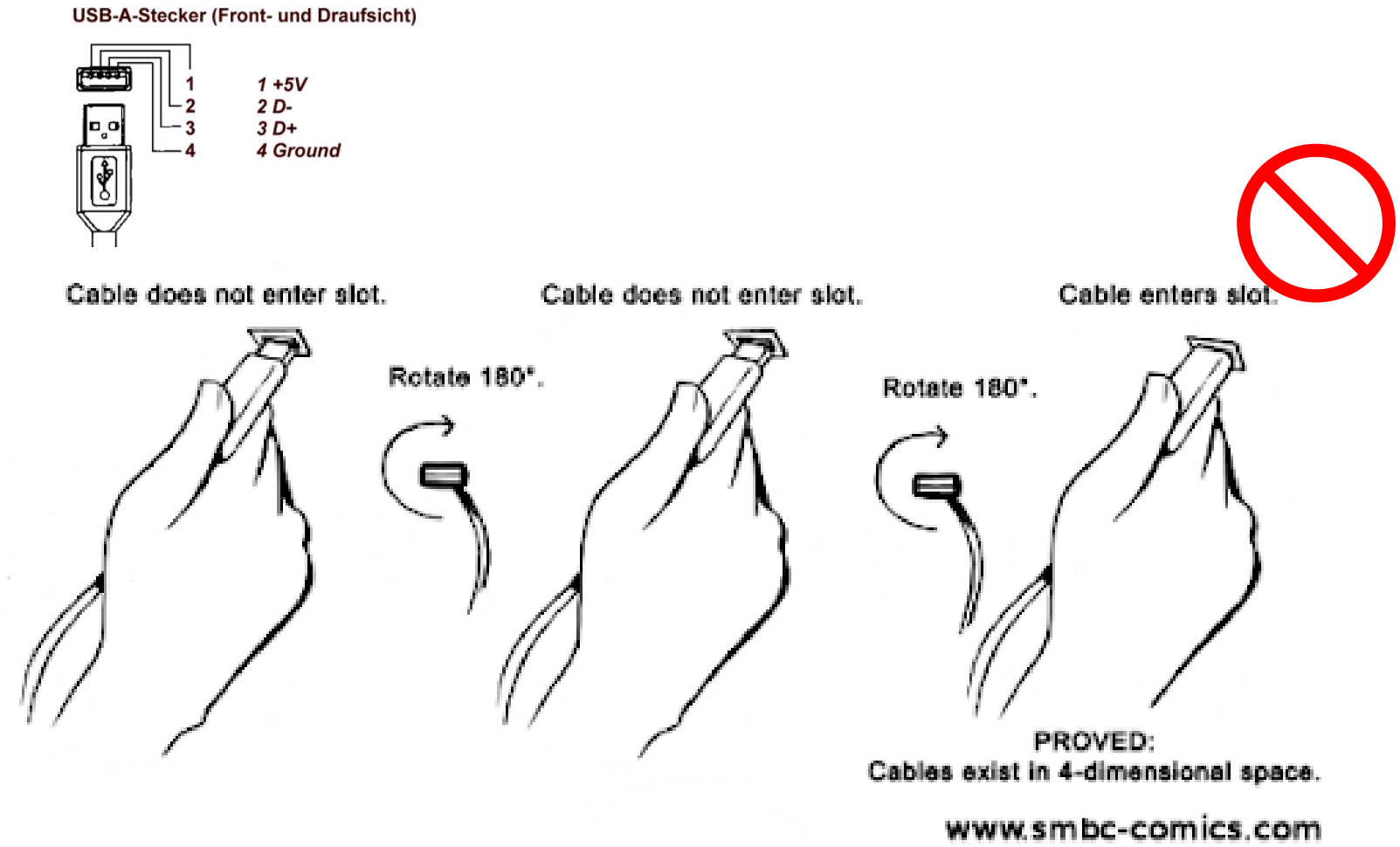
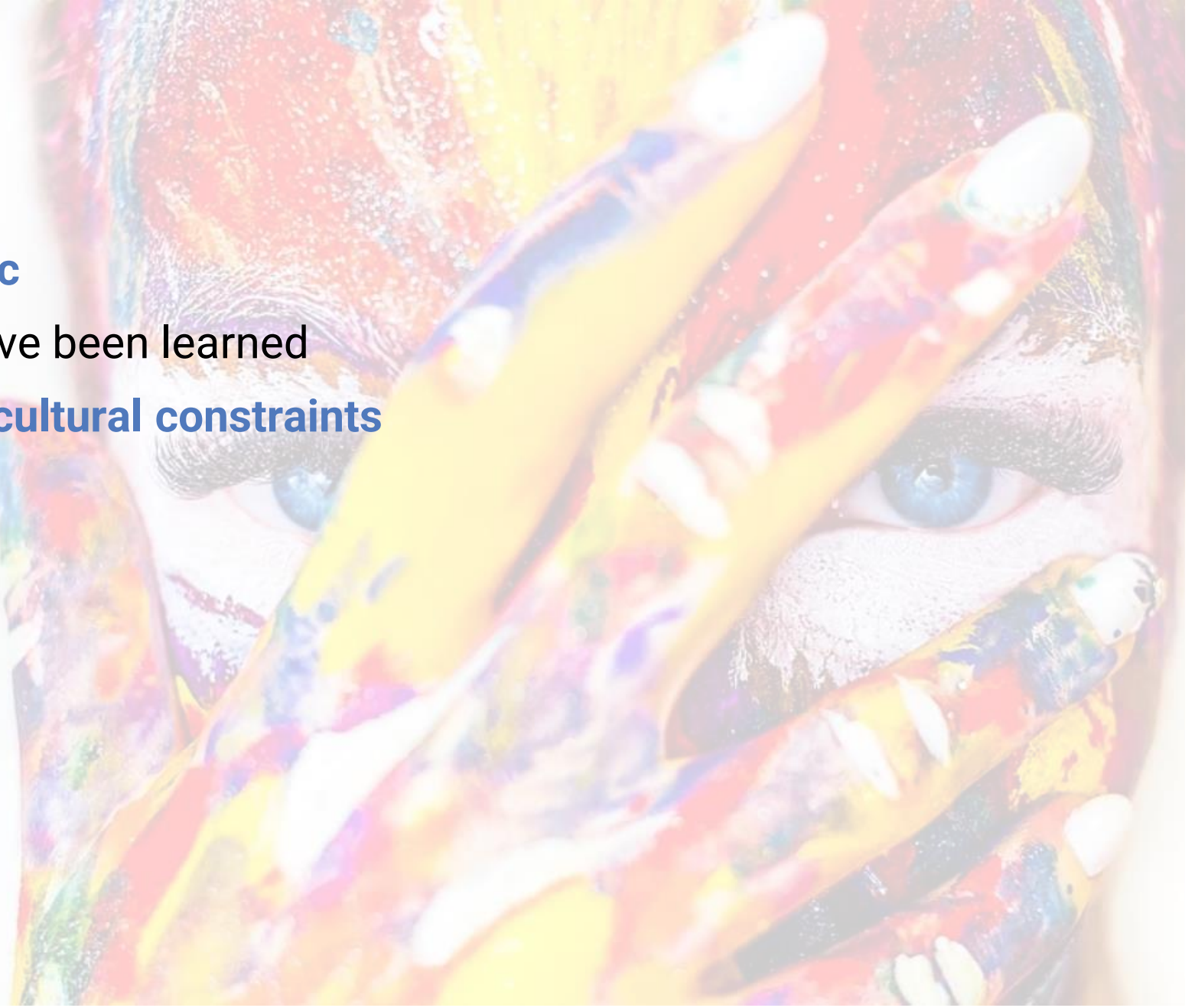


Image: Thomas Braun

Constraints

- **Physical** constraints
  - Basic physical limitations
- **Semantic** constraints
  - Assumption to create something meaningful
- **Cultural** constraints
  - Borders and context provided by cultural conventions
- **Logical** constraints
  - Restrictions due to reasoning
- Applying constraints is **a design decision**!
- A **Practical way to realise the principle “prevent errors”**

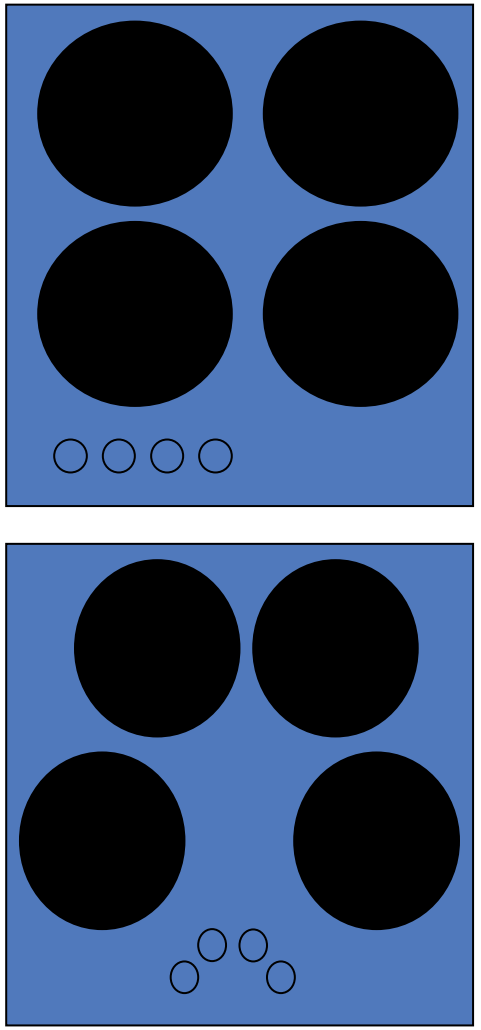
Cultural Constraints



- **Universal or culturally specific**
- **Arbitrary conventions** that have been learned
- **Users' expectations build on cultural constraints**
- Example Colors
  - Red
  - Green
  - Blue

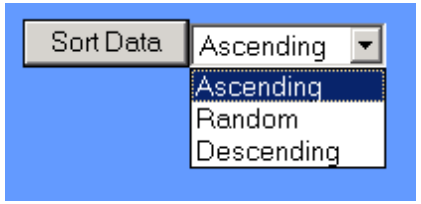
Mapping

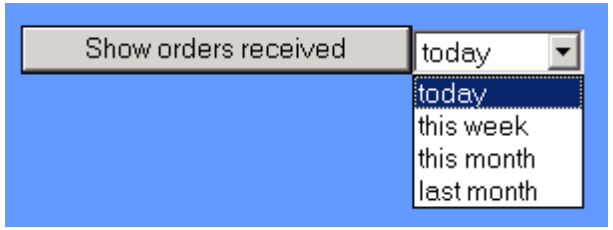
- **Relationship between controls and action**
- Mappings should be
  - Understandable
    (e.g. moving the mouse up move the slider up)
  - Consistent
  - Recognizable or at least quickly
    learnable and easy to recall
  - Natural, meaning to be consistent
    with knowledge the user already has
- Example: cooker
- For these issues see also: Gestalt theory!

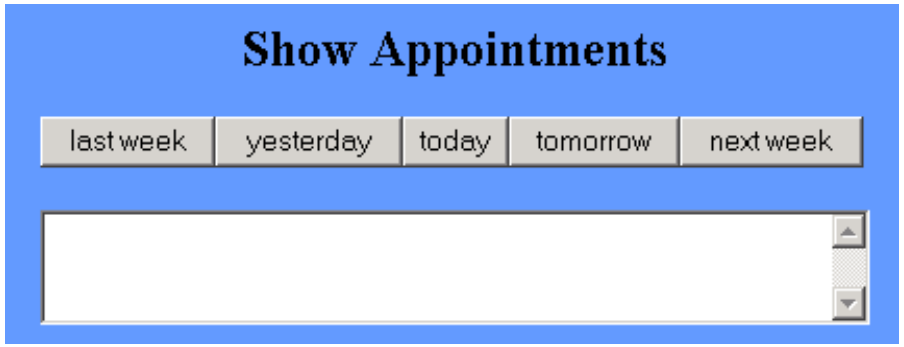


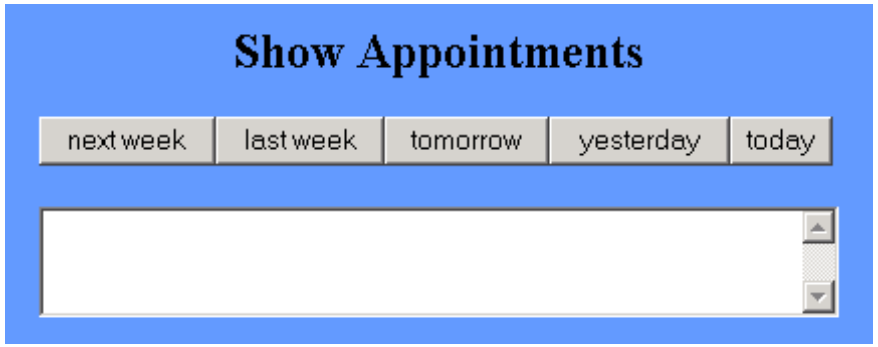
Mapping

- “Natural” mappings can be found in many areas
- It is not always obvious what the “natural” mapping is
- Correlation with cultural constraints





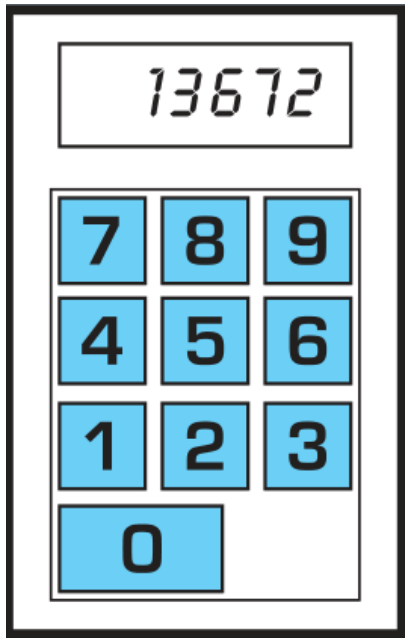




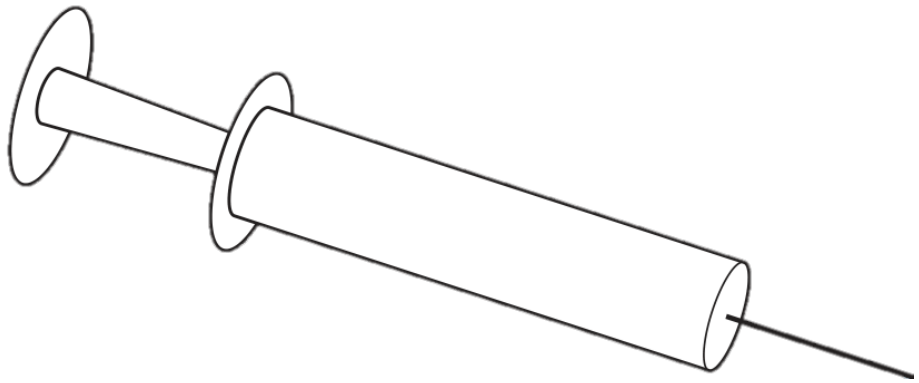
Guidelines? Guidelines!

- User centered design
- Know the user
- **Involve the user**
- Prevent user errors
- Optimize user operation
- Keep control with the user
- Help the user to get started
- Give a task-based mental model
- Be consistent
- Keep it simple
- Design for memory limitations
- Use recognition rather recall
- Use cognitive directness
- Draw on real world analogies
- Use informative feedback
- Give status indicators
- Use user-centred wording
- Use non-threatening wording
- Use specific constructive advice
- Make the system take the blame
- Do not anthropomorphise
- Use modes cautiously
- Make user action reversible
- Get attention judiciously
- Maintain display inertia
- Organize screen to manage complexity
- Accommodate individual difference

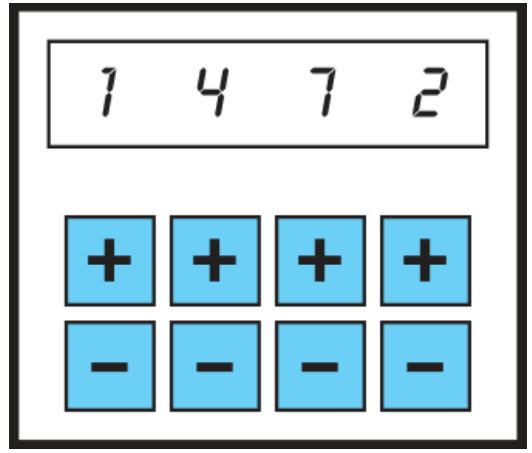
Involve the User



What the programmers suggested



Mechanical syringe



What the nurses suggested

Dix, A., Finlay, J., Abowd, G. D., & Beale, R. (2003). Human-computer interaction. Pearson Education.

ISO 9241 – Ergonomics of Human–system Interaction

- Part
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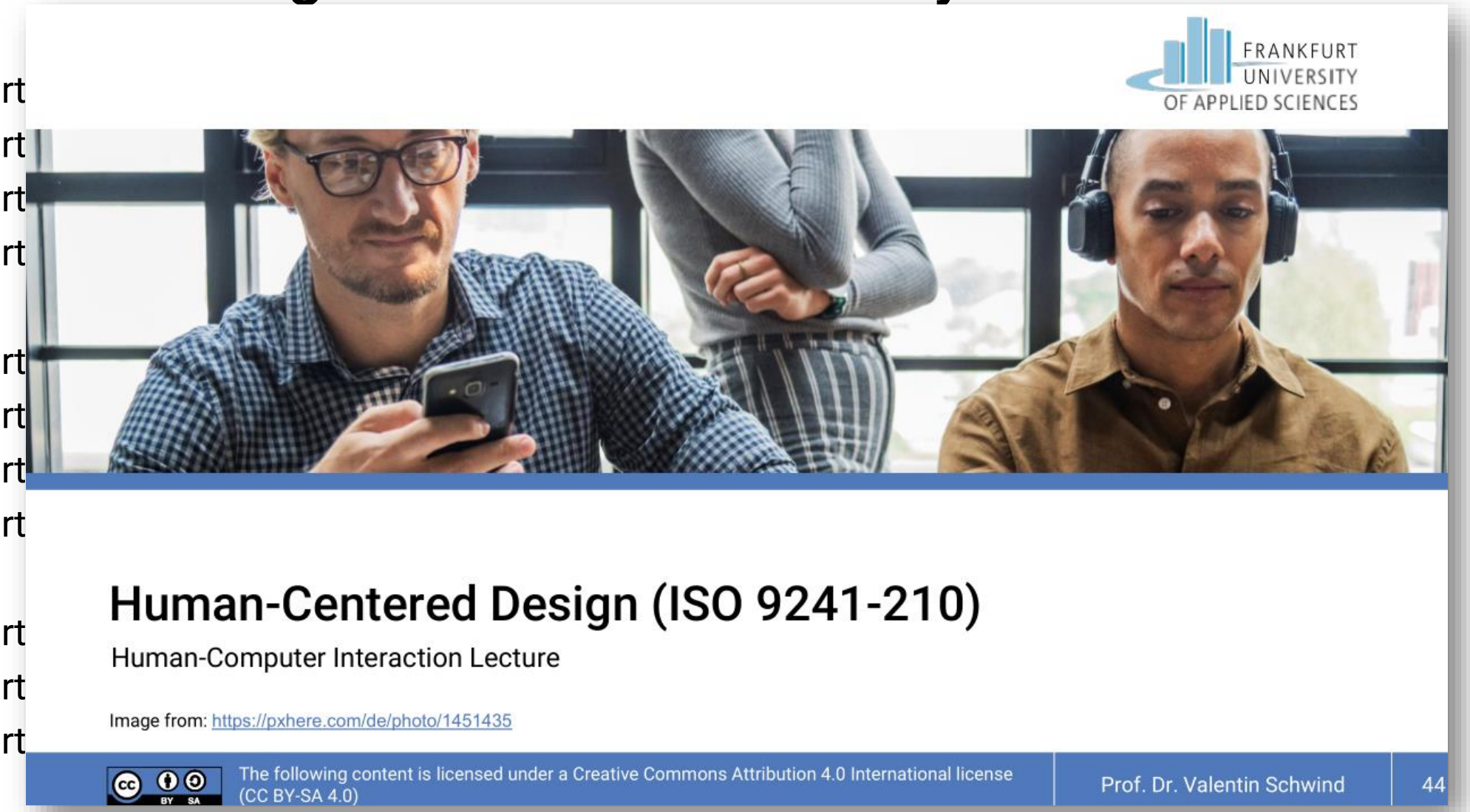


Recommendations, Regulations & Laws

- Verordnung über Arbeitsstätten (Arbeitsstättenverordnung - ArbStättV)
  1. Allgemeine Anforderungen
  2. Maßnahmen zum Schutz vor besonderen Gefahren
  3. Arbeitsbedingungen
  4. Sanitär-, Pausen- und Bereitschaftsräume, Kantinen, Erste-Hilfe-Räume und Unterkünfte
  5. Ergänzende Anforderungen und Maßnahmen für besondere Arbeitsstätten und Arbeitsplätze
  6. **Maßnahmen zur Gestaltung von Bildschirmarbeitsplätzen**
     1. Allgemeine Anforderungen an Bildschirmarbeitsplätze
     2. Allgemeine Anforderungen an Bildschirme und Bildschirmgeräte
     3. Anforderungen an Bildschirmgeräte und Arbeitsmittel für die ortsgebundene Verwendung an Arbeitsplätzen
     4. Anforderungen an tragbare Bildschirmgeräte für die ortsveränderliche Verwendung an Arbeitsplätzen
     5. Anforderungen an die Benutzerfreundlichkeit von Bildschirmarbeitsplätzen

Arbeitsstättenverordnung – ArbStättV

6.5 Anforderungen an die **Benutzerfreundlichkeit** von Bildschirmarbeitsplätzen

(1) Beim Betreiben der Bildschirmarbeitsplätze hat der Arbeitgeber dafür zu sorgen, dass der Arbeitsplatz den Arbeitsaufgaben **angemessen** gestaltet ist. Er hat insbesondere **geeignete Softwaresysteme** bereitzustellen.

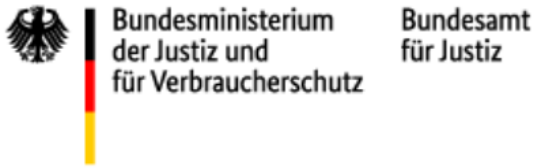
(2) Die Bildschirmgeräte und die Software müssen **entsprechend den Kenntnissen und Erfahrungen der Beschäftigten** im Hinblick auf die jeweilige **Arbeitsaufgabe angepasst** werden können.

(3) Das Softwaresystem muss den Beschäftigten **Angaben über die jeweiligen Dialogabläufe** machen.

(4) Die Bildschirmgeräte und die Software müssen es den Beschäftigten ermöglichen, die **Dialogabläufe zu beeinflussen**. Sie müssen eventuelle Fehler bei der Handhabung beschreiben und eine **Fehlerbeseitigung** mit begrenztem Arbeitsaufwand erlauben.

(5) Eine Kontrolle der Arbeit hinsichtlich der qualitativen oder quantitativen Ergebnisse darf ohne Wissen der Beschäftigten nicht durchgeführt werden.

Recommendations, Regulations & Laws



Startseite

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Aktualitätendienst

Titelsuche

Volltextsuche

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Hinweise

Impressum

Tastenkombinationen

Verordnung zur Schaffung barrierefreier Informationstechnik nach dem Behindertengleichstellungsgesetz

zur Gesamtausgabe der Norm im Format: HTML PDF XML EPUB

- Eingangsformel
- § 1 Ziele
- § 2 Anwendungsbereich
- § 2a Begriffsdefinitionen
- § 3 Anzuwendende Standards
- § 4 Erläuterungen in Deutscher Gebärdensprache und Leichter Sprache
- § 5 Ausschuss für barrierefreie Informationstechnik
- § 6 Beratung und Unterstützung durch die Bundesfachstelle für Barrierefreiheit und die Informationstechnik-Dienstleister des Bundes
- § 7 Erklärung zur Barrierefreiheit
- § 8 Überwachungsverfahren
- § 9 Berichterstattung
- § 10 Folgenabschätzung
- Anlage 1 (weggefallen)
- Anlage 2 (zu § 3 Absatz 2)

Recommendations, Regulations & Laws

§ 1 Ziele

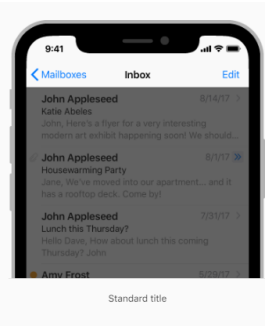
- (1) Die Barrierefreie-Informationstechnik-Verordnung dient dem Ziel, eine umfassend und grundsätzlich uneingeschränkt **barrierefreie Gestaltung moderner Informations- und Kommunikationstechnik** zu ermöglichen und zu gewährleisten.
- (2) Informationen und Dienstleistungen öffentlicher Stellen, die elektronisch zur Verfügung gestellt werden, sowie elektronisch unterstützte Verwaltungsabläufe mit und innerhalb der Verwaltung, einschließlich der Verfahren zur elektronischen Aktenführung und zur elektronischen Vorgangsbearbeitung, sind **für Menschen mit Behinderungen zugänglich und nutzbar zu gestalten**

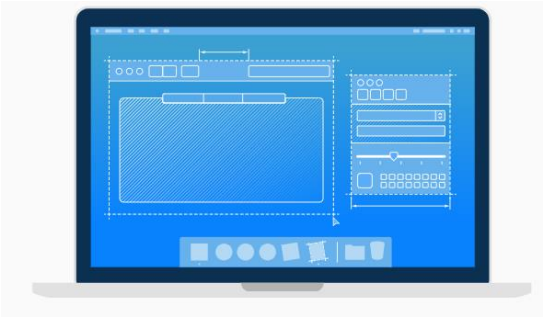
Web Content Accessibility Guidelines (WCAG) 2.1

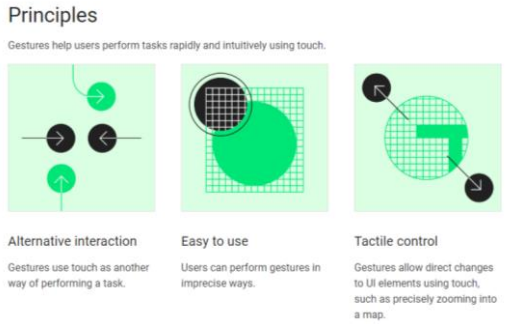
- Perceivable
  - Provide **text alternatives** for non-text content,
  - Provide captions and other **alternatives for multimedia**.
  - Create content that can be **presented in different ways**, including by assistive technologies, without losing meaning.
  - Make it easier for users to **see and hear** content.
- Operable
  - Make all functionality available from a **keyboard**.
  - Give users **enough time** to read and use content.
  - **Do not use content that causes seizures or physical reactions**.
  - Help users **navigate** and find content.
  - Make it easier to use **inputs other** than keyboard.
- Understandable
  - Make text **readable and understandable**.
  - Make content appear and operate in **predictable ways**.
  - Help users **avoid and correct mistakes**.
- Robust
  - Maximize **compatibility** with current and future user tools.”

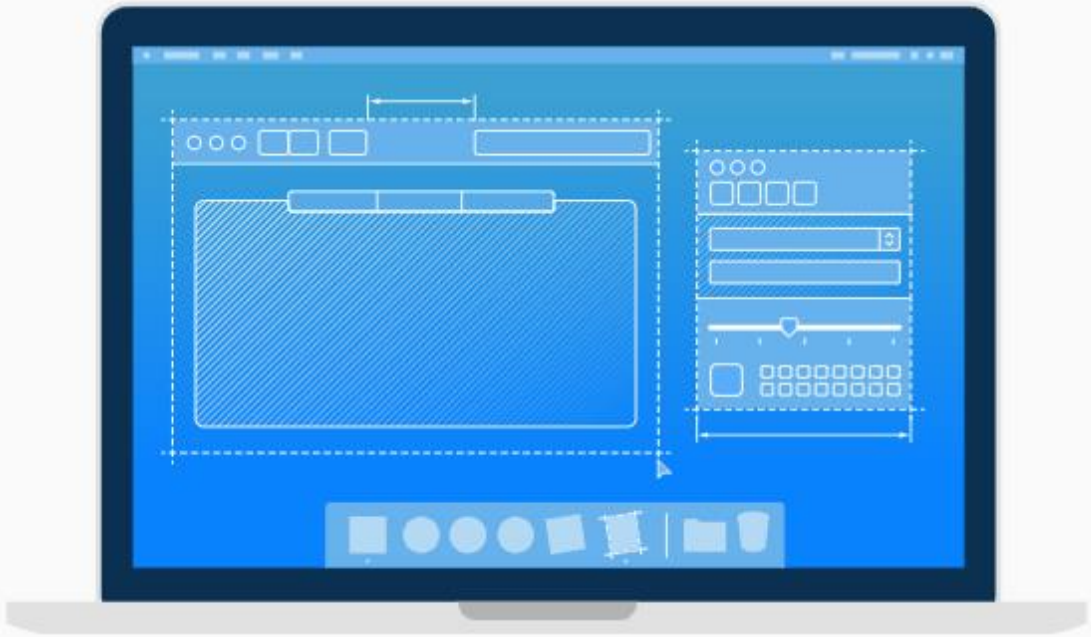
User Interface Guidelines

- Define how the user interface
  - looks
  - is being operated
  - reacts
  - feels
- Usually most is “encoded” in the libraries, frameworks and corresponding UI builder
- **Need to learn, how to find it and how to read it**









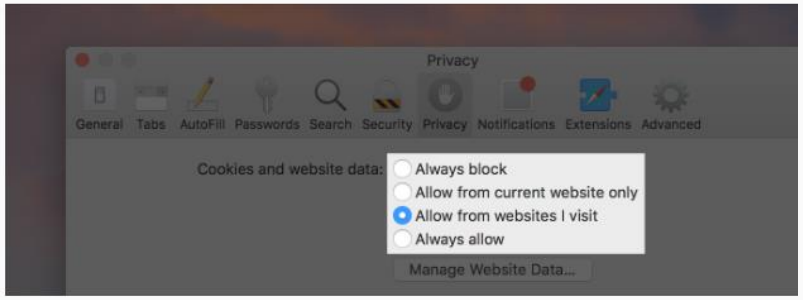
macOS Design Themes

Four primary themes differentiate macOS apps from iOS, tvOS, and watchOS apps. Keep these themes in mind as you imagine your app's identity.

Radio Buttons

A radio button is a small, circular button followed by a title. Typically presented in g two to five, radio buttons provide the user a set of related but mutually exclusive cl radio button's state is either on (a filled circle) or off (an empty circle).

A radio button can also permit a mixed state (a circle containing a dash) that's part and partially off. However, it's better to use checkboxes when your app requires a state.



Give radio buttons meaningful titles. Each radio button's title should clearly des effect of choosing it. Generally, use sentence style capitalization without ending punctuation.

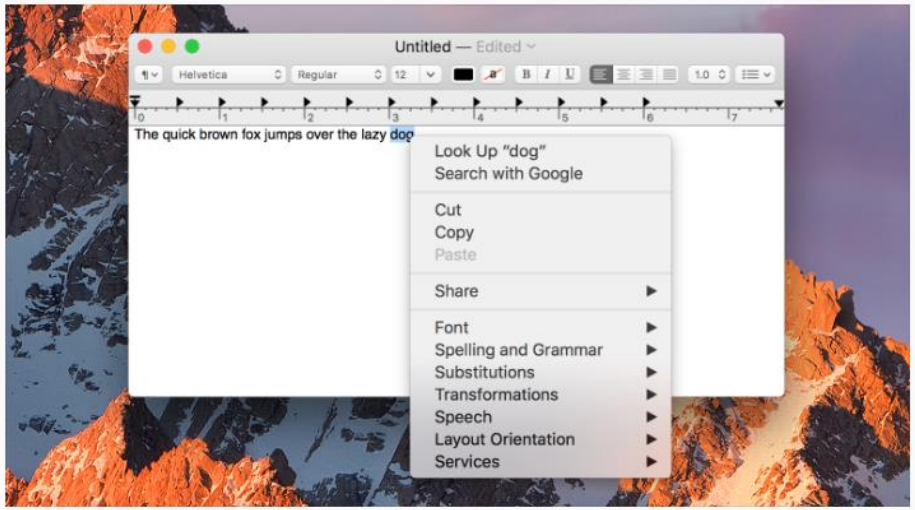
Prefer a standard button instead of a radio button to initiate an action. Radic present options to the user. A radio button that initiates an action is confusing and nonintuitive.

Use radio buttons in a view, not a window frame. Radio buttons aren't intende within portions of window frames, such as in toolbars and status bars.

Consider using a label to introduce a group of radio buttons. Describe the se options and align the label's baseline with the baseline of the first radio button's tit

Contextual Menus

A contextual menu, or *shortcut menu*, gives people access to frequently used commands related to the current context. A contextual menu is revealed by Control-clicking a view or selected element in an app. For example, Control-clicking selected text in TextEdit displays a contextual menu containing text-specific menu items for initiating actions like changing the font and checking spelling.



Always follow menu design best practices. In general, all menus and menu items should be consistently arranged and titled. See Menu Anatomy.

Include only the most commonly used commands that are appropriate in the current context. For example, in the contextual menu for selected text, it makes sense to include editing commands but it doesn't make sense to include a Save or Print command.

Limit the hierarchical depth of contextual menus to one or two levels. Submenus in contextual menus can be difficult to navigate without accidentally dismissing the contextual

Developer Discover Design Develop Distribute Support Account

Human Interface Guidelines

Overview Resources Videos What's New

watchOS
- Themes
- Apps
- Interface Essentials
- App Architecture
- User Interaction
- System Capabilities
- Visual Design
- Icons and Images
- Interface Elements

iOS
macOS
tvOS
Technologies

watchOS Design Themes

As you design your watchOS app, understand the foundations on which Apple Watch itself was designed:

- **Lightweight interactions.** Apple Watch was designed for quick interactions that make the most of the display and its position on the user's wrist. Information is quick and easy to access and dismiss. The best apps support fast interactions and focus on the content that users care about the most.
- **Holistic design.** Apple Watch was designed to blur the boundaries between device and software. For example, Force Touch and the Digital Crown let users interact seamlessly

Guidelines

Overview Resources Videos What's New

Pickers

Pickers display lists of items that are navigable using the Digital Crown. They are meant to be a precise and engaging way to manage selections. Pickers present their items in one of three styles.

Play

List. Displays text and images in a scrolling list. This style displays the selected item and the previous and next items if those items are available.

Play

Stack. Displays images in a card stack style interface. As the user scrolls, images are animated into position with the selected image on top. This style is best for photo browser interfaces.

Play

Sequence. Displays one image from a sequence of images. As the user turns the Digital Crown, the picker displays the previous or next image in the sequence without

material.io/design

MATERIAL DESIGN

Material System

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Material studies

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Foundation overview

Environment

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Learn how to design a dark theme version of your Material UI

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Material guidelines

Use sound to communicate information in ways that augment the user experience

material.io/design/interaction/gestures.html#principles

MATERIAL DESIGN

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Selection

States

Communication

Gestures

Gestures let users interact with screen elements using touch.

CONTENTS

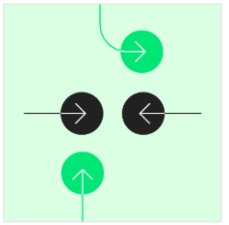
Principles

Properties

Types of gestures

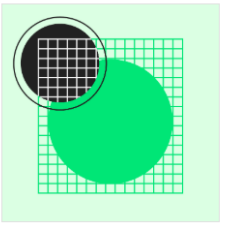
Principles

Gestures help users perform tasks rapidly and intuitively using touch.



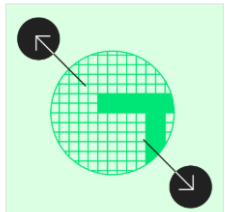
Alternative interaction

Gestures use touch as another way of performing a task.



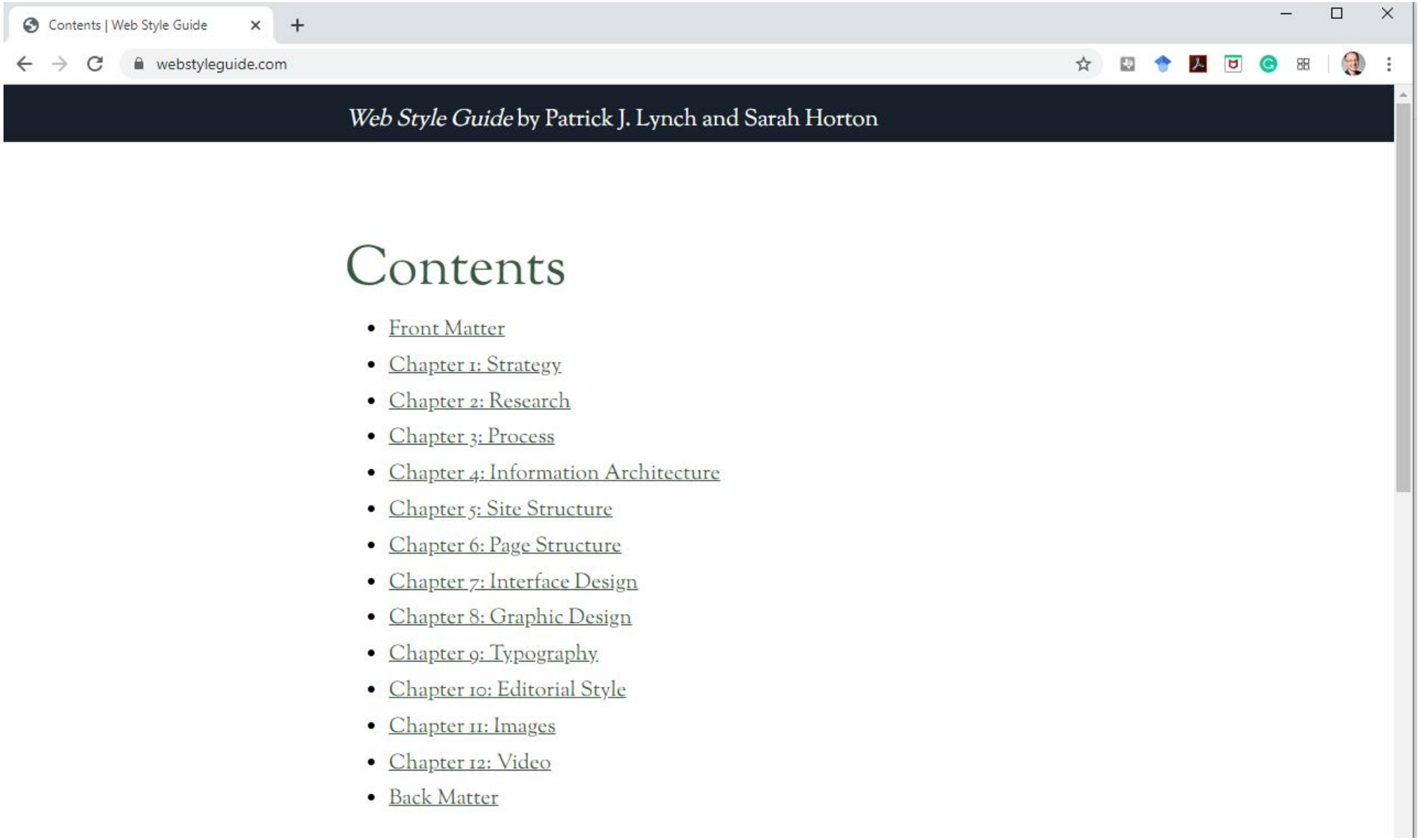
Easy to use

Users can perform gestures in imprecise ways.



Tactile control

Gestures allow direct changes to UI elements using touch, such as precisely zooming into a map.



https://webstyleguide.com/

Apple Human Interface Guidelines (2005)

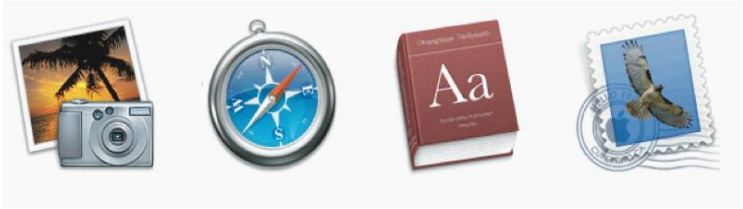
Icon Genres and Families

Icon genres help communicate what you can do with an application before you open it. Applications are classified by role—user applications, software utilities, and so on—and each category, or genre, has its own icon style. This differentiation is very important for helping users easily distinguish between types of icons in the Dock.

Figure 10-1 Application icons of different genres—user applications and utilities—shown as they might appear in the Dock

For example, the icons for user applications are colorful and inviting, while utilities have a more serious appearance. Figure 10-2 shows user application icons in the top row and utility icons in the bottom row. These genres are further described in "User Application Icons" (page 125) and "Utility Icons" (page 126).

User application icons in top row



utility icons in bottom row

Apple Human Interface Guidelines (2005), Apple Computer, Inc., p55

Figure 13-29 A standard alert

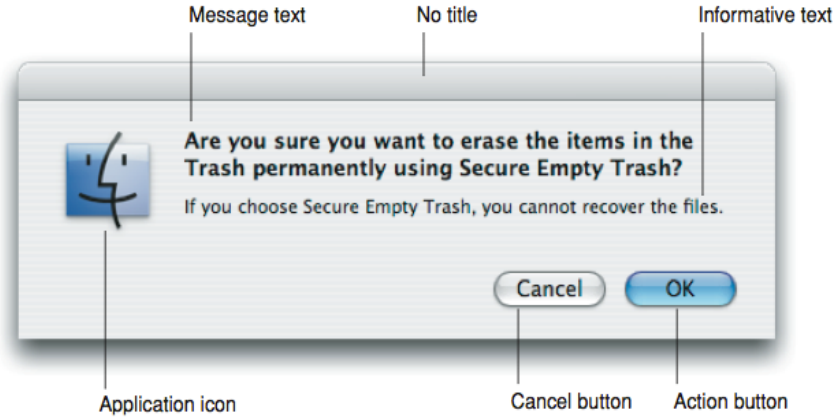
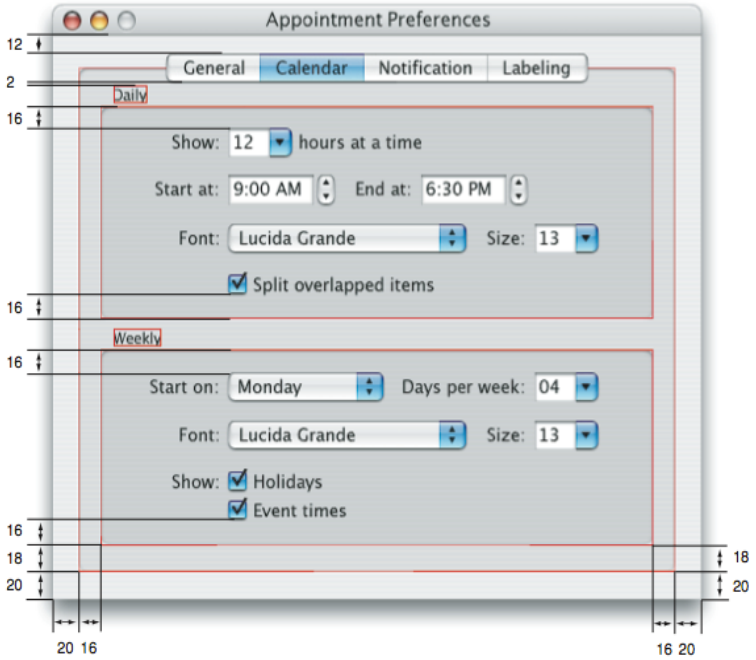


Figure 15-8 Layout dimensions for a changeable pane dialog



Scrolling List Specifications

Figure 14-51 Scrolling list dimensions

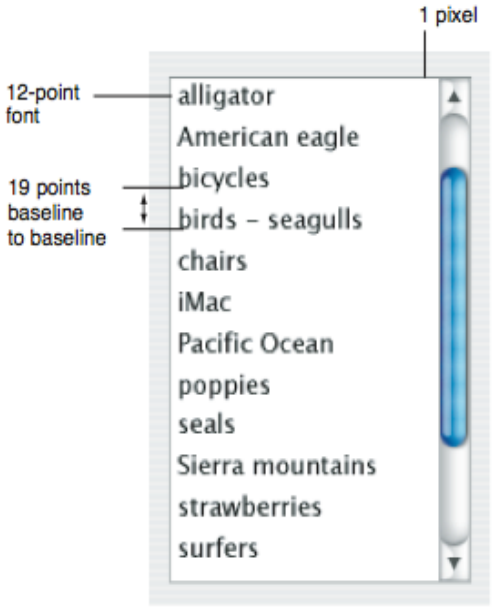
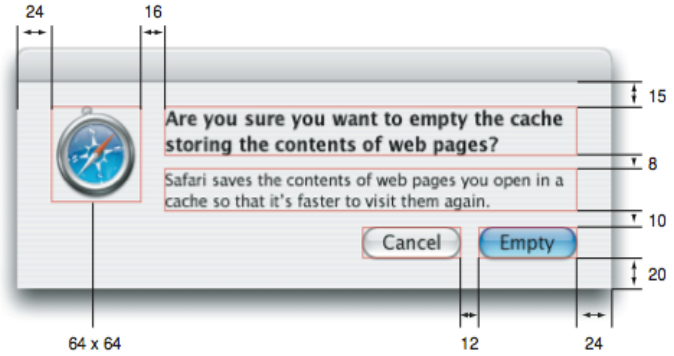


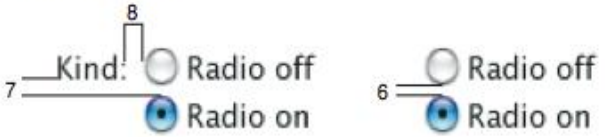
Figure 15-10 Layout dimensions for a standard alert



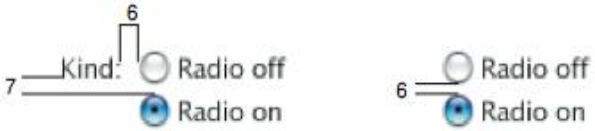
Radio Button Specifications

Figure 14-14 Radio button spacing

Full-size radio button



Small radio button



Mini radio button

Align the baselines of the label and the first button's text.

4.25 Standard shortcut keys

If your application uses any of the standard functions listed in the following tables, use the recommended standard keyboard shortcut for that function.

4.25.1 Standard application shortcuts

Function	Shortcut	Description
Help	F1	Show the help content pages for the current application
Quit	Ctrl+Q	Quit the application

4.25.2 Standard content shortcuts

Function	Shortcut	Description
New	Ctrl+N	Create a new document
Open	Ctrl+O	Open a document
Save	Ctrl+S	Save the current document
Print	Ctrl+P	Print the current document
Close	Ctrl+W	Close the current document

4.25.3 Standard edit shorcuts

Function	Shortcut	Description
Undo	Ctrl+Z	Undo the last operation
Redo	Shift+Ctrl+Z	Redo the last operation

If your application requires both Edit > Find and Edit > Search menu items, use Shift+Ctrl+F as the shortcut for Search.

Gnome User Interface Checklist

Table 2-7 **Magnification checklist**

MG	Magnification	Pass/Fail/NA
MG.1	The application provides the ability to magnify the work area.	
MG.2	The application provides the option to scale the work area.	
MG.3	The application's functionality is not affected by changing the magnification or scale settings.	

Table 2-8 **Audio checklist**

AU	Audio	Pass/Fail/NA
AU.1	Sound is not used as the only means of conveying any items of information.	
AU.2	The user can configure the frequency and volume of all sounds and warning beeps.	

Table 2-9 **Animation checklist**

AN	Animation	Pass/Fail/NA
AN.1	There are no flashing or blinking elements with a frequency greater than 2Hz or lower than 55Hz.	
AN.2	Any flashing or blinking is confined to small areas of the screen.	
AN.3	If animation is used, an option is available to turn it off before it is first shown.	

References

- Shneiderman, B. The Eight Golden Rules of Interface Design. https://www.cs.umd.edu/~ben/goldenrules.html
- Shneiderman, B., Plaisant, C., Cohen, M., Jacobs, S., Elmqvist, N., & Diakopoulos, N. (2016). Designing the user interface: strategies for effective human-computer interaction. Pearson. http://www.cs.umd.edu/hcil/DTUI6/
- Urban Stress: Experiments on Noise and Social Stressors. DC Glass, JE Singer - 1972 - Academic Press
- Euphemia Wong. Shneiderman's Eight Golden Rules Will Help You Design Better Interfaces. https://www.interaction-design.org/literature/article/shneiderman-s-eight-golden-rules-will-help-you-design-better-interfaces
- Poppinga, B., Sahami Shirazi, A., Henze, N., Heuten, W., & Boll, S. (2014, September). Understanding shortcut gestures on mobile touch devices. In Proc. of the 16th int. conf. on Human-computer interaction with mobile devices & services (pp. 173-182). ACM.
- Schmidt, A., & Herrmann, T. (2017). Intervention user interfaces: a new interaction paradigm for automated systems. *interactions*, *24*(5), 40-45.
- Norman, D. A. (2013). The design of everyday things: Revised and expanded edition. New York: Doubleday.
- Shneiderman, B., Plaisant, C., Cohen, M., Jacobs, S., Elmqvist, N., & Diakopoulos, N. (2016). Designing the user interface: strategies for effective human-computer interaction. Pearson. http://www.cs.umd.edu/hcil/DTUI6/

References

- Hix and Hartson, Developing User Interfaces, Wiley, 1993
- ISO 9241 Ergonomics of human–system interaction
- Verordnung über Arbeitsstätten (Arbeitsstättenverordnung - ArbStättV) https://www.gesetze-im-internet.de/arbst_ttv_2004/anhang.html
- Verordnung zur Schaffung barrierefreier Informationstechnik nach dem Behindertengleichstellungsgesetz https://www.gesetze-im-internet.de/bitv_2_0/index.html
- Web Content Accessibility Guidelines (WCAG) 2.1 www.w3.org/TR/WCAG21
- https://developer.apple.com/design/human-interface-guidelines/macos/
- https://developer.apple.com/design/human-interface-guidelines/ios/views/
- https://developer.apple.com/design/human-interface-guidelines/watchos/overview/themes/
- https://material.io/design
- https://docs.microsoft.com/en-us/windows/uwp/design/
- https://webstyleguide.com/
- Apple Human Interface Guidelines (2005), Apple Computer, Inc
- https://people.gnome.org/~fpeters/hig3.pdf
- https://developer.gnome.org/hig/stable/pointer-and-touch-input.html.en
- https://developer.gnome.org/accessibility-devel-guide/stable/gad-checklist.html.en