Technische Universität Darmstadt

Telecooperation Lab
Prof. Dr. Max Mühlhäuser

TK3: Ubiquitous (& Mobile) Computing

Chapter 4: Human-Computer Interaction (HCI)

Lecturer: Dr. Mohammadreza Khalilbeigi

Who are we?

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- Dr. Mohammadreza Khalilbeigi
  - Area Head „Tangible Interaction“
  - PhD: TU Darmstadt
  - Master: RWTH Aachen
  - Research areas:
    - Physical computing
    - Interactive surfaces
    - Flexible displays

Tangible Interaction - Our Vision

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Make user interfaces and interaction techniques

- more usable
- more joyful
- "invisible": more seamlessly integrated into the everyday world

→Integrate user interfaces into objects of the everyday life

Our website: https://www.tk.informatik.tu-darmstadt.de/de/research/tangible-interaction/

Our Youtube Channel: https://www.youtube.com/user/TKLabs/videos

Agenda

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- **What is HCI?**
- Good and Poor Design
- Usabillity and User Experience
- Design Principles:
  - Conceptual Models
  - Affordances
  - Visibility and Feedback
  - Mapping
  - Constraints
  - Metaphors

Literature

- *Donald Norman:*
  The Design of Everyday Things (DOET)
- *Yvonne Rogers, Helen Sharp and Jenny Preece:*
  Interaction Design: Beyond Human-Computer Interaction
- *Alan Dix et al.:*
  Human-Computer Interaction

- You can find them at
  - Fachlesesaal MINT in der ULB Stadtmitte, 4. Obergeschoss
  - Lernzentrum Informatik

Human-Computer Interaction

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- Human-Computer interaction is

> "[...] 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 (1992)

Human-Computer Interaction (2)

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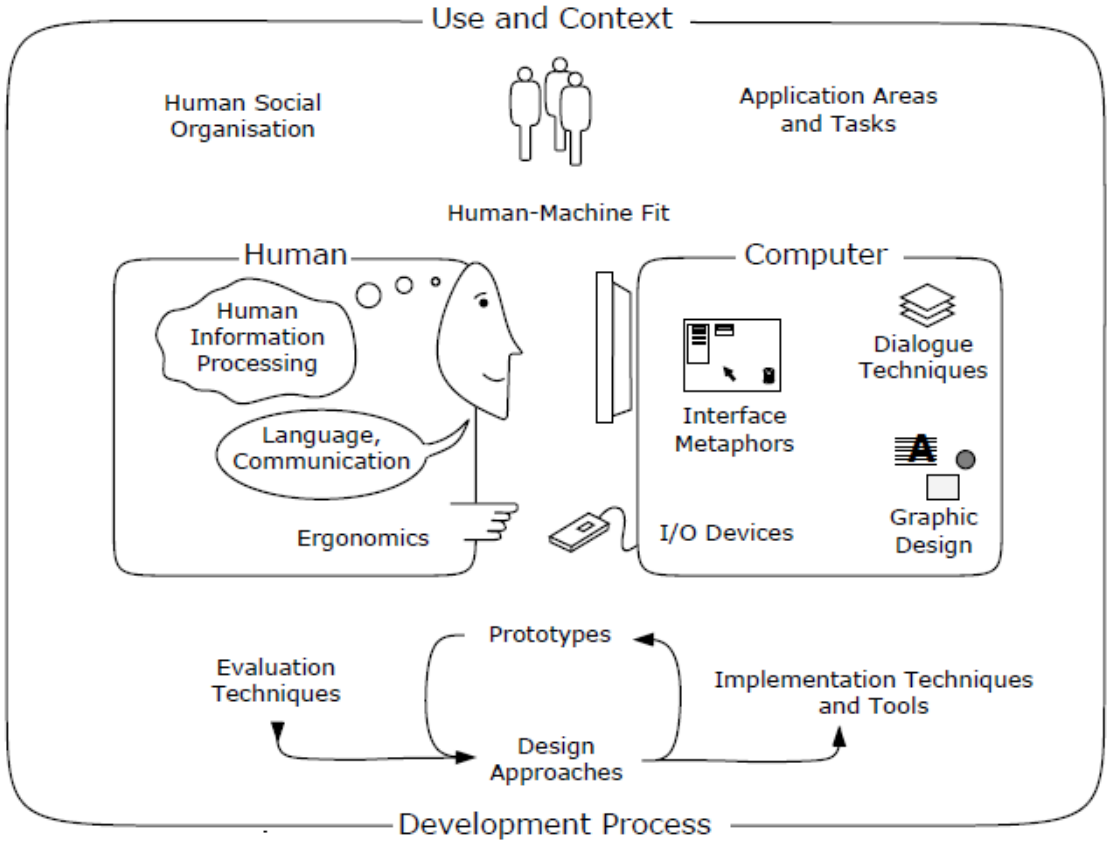
Adapted



Involved Disciplines

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Academic Disciplines	Design Practices
• Computer Science • Informatics • Psychology • Social Sciences • Engineering • Ergonomics	• Graphic design • Product design • Media design • Industrial design

Good and Poor Design (1)

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Good and Poor Design (2)

Good and Poor Design (4)

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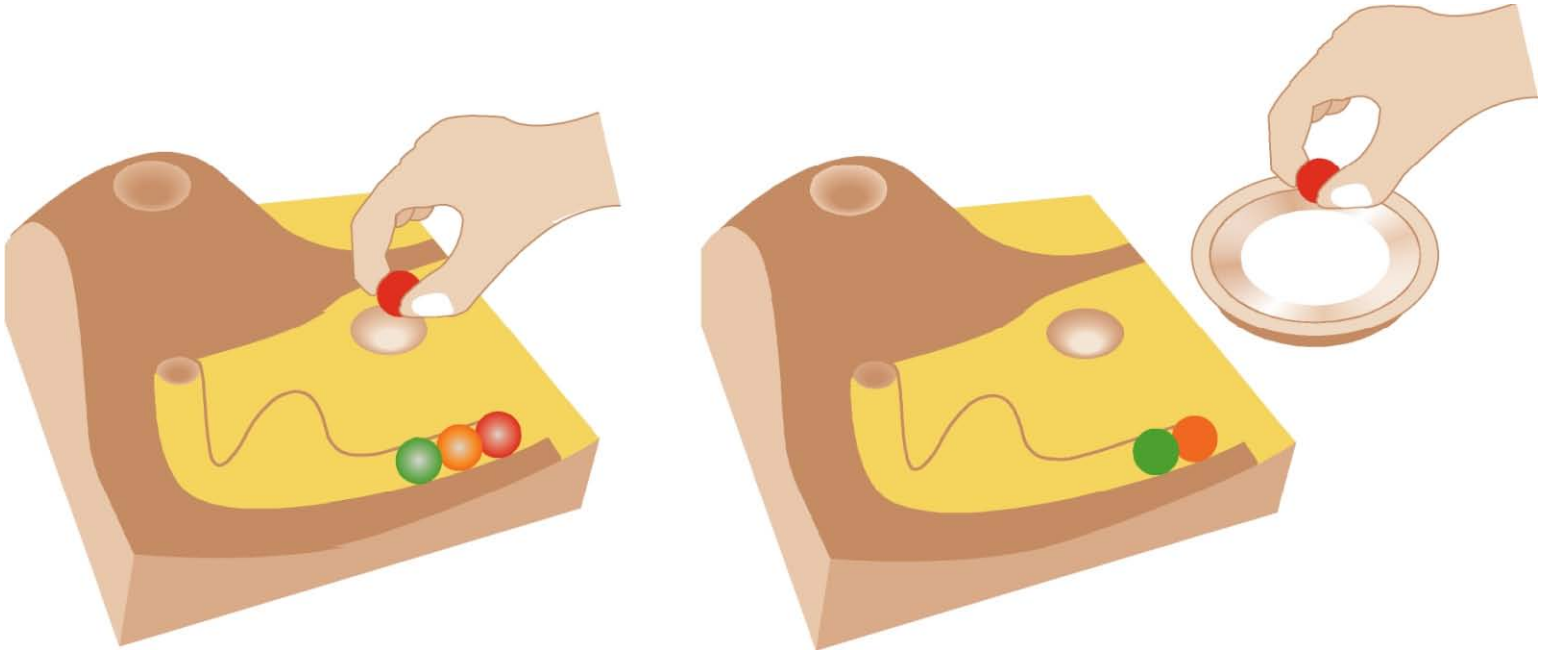
- The marble answering machine, Bishop 1995



Good and Poor Design (5)

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- Differences to traditional mailbox interfaces?
  - Haptic/tangible instead of audio
  - Familiar physical objects utilized to represent the messages
  - Amount of messages obvious
  - Requires only one-step actions
  - Simple but elegant design
- Drawbacks: robustness

→ *Where* will the product be deployed, *who* will be the users and *how* will it be used?

Good and Poor Design (6)

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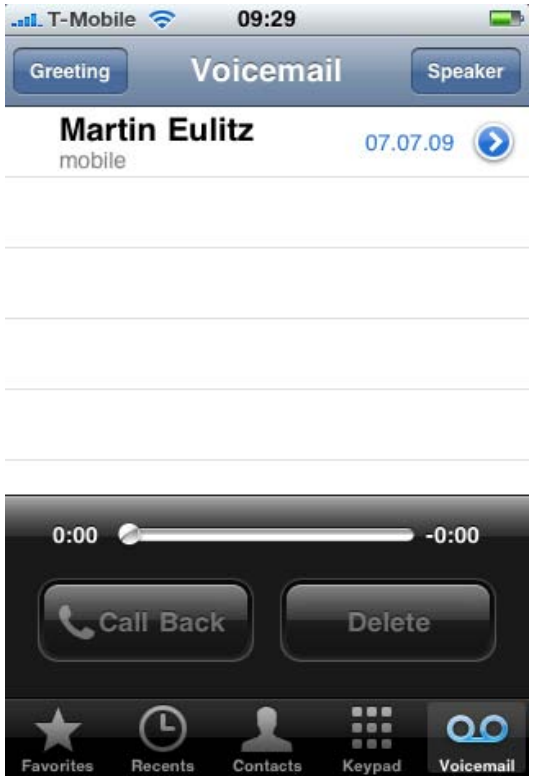
- Today ‘s more advanced “marble” answering machine? ☺



Usability Goals (1)

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- **Effectiveness**
  "Is the product capable of allowing users to perform tasks accurately and completely?"
  (doing "right" things, good quality results)
- **Efficiency**
  "Once users have learned how to use a product to carry out their tasks, can they sustain a high level of productivity?"
  (doing things in the most economical way)
- **Safety**
  "What is the range of errors that are possible using the product and what measures are there to permit users to recover easily?"

Usability Goals (2)

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- **Utility**
  "Does the product provide an appropriate set of functions that will enable users to carry out all their tasks in the way they want to do them?"
- **Learnability**
  "Is it possible for the user to work out how to use the product by exploring the interface and trying out certain actions?"
- **Memorability**
  "What kinds of interface support have been provided to help users remember how to carry out tasks?"

Usability and User Experience

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- Historically HCI focused on usability goals
- Currently a paradigm shift is going on:
  user experience is recognized as a key aspect in HCI

  (But of course: Usability remains highly important)

User Experience (UX)

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- Behaviour of product, how it is being used
- How people feel about a product
- Design *for* a user experience, not the UX itself

> "[...] every product that is used by someone has a user experience: newspapers, ketchup bottles, reclining armchairs, cardigan sweaters."
>
> - Jesse Garrett (2003)

Activity

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- Apple ‘s iPods were a phenomenonal success.
- Why?

User Experience Goals

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- satisfying
- enjoyable
- engaging
- exciting
- aesthetically pleasing
- supportive of creativity
- fun
- …

- boring
- frustrating
- annoying
- …

→ Subjective *qualities*

Agenda

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  - Affordances
  - Visibility and Feedback
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  - Constraints
  - Metaphors

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Conceptual Model (1)

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- You know the former products cannot “work” – why?
  - You form a conceptual model of how the product work and
  - Simulate its behavior.
- What about this car stereo?

Alpine.com


iXA-W404R
TUNE / • A.ME
SETUP
iPod
13:45
Five Winds
Dreams
Lucas Corbin
LUCAS CORBIN
ALPINE
ENTER
BAND
TA
AF TA
USB R·D·S EON
MultEQ
AUDYSSEY MULTEQ XT
SOURCE

Alpine.com

Conceptual Models (2)

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> „A conceptual model is a high-level description of how a system is organized and operates.“
>
> - Johnson and Henderson (2002)

- Allows to predict effects of our actions
- Allows to cope with problems
- Formed through experience, practice, instruction

Conceptual Models (3)

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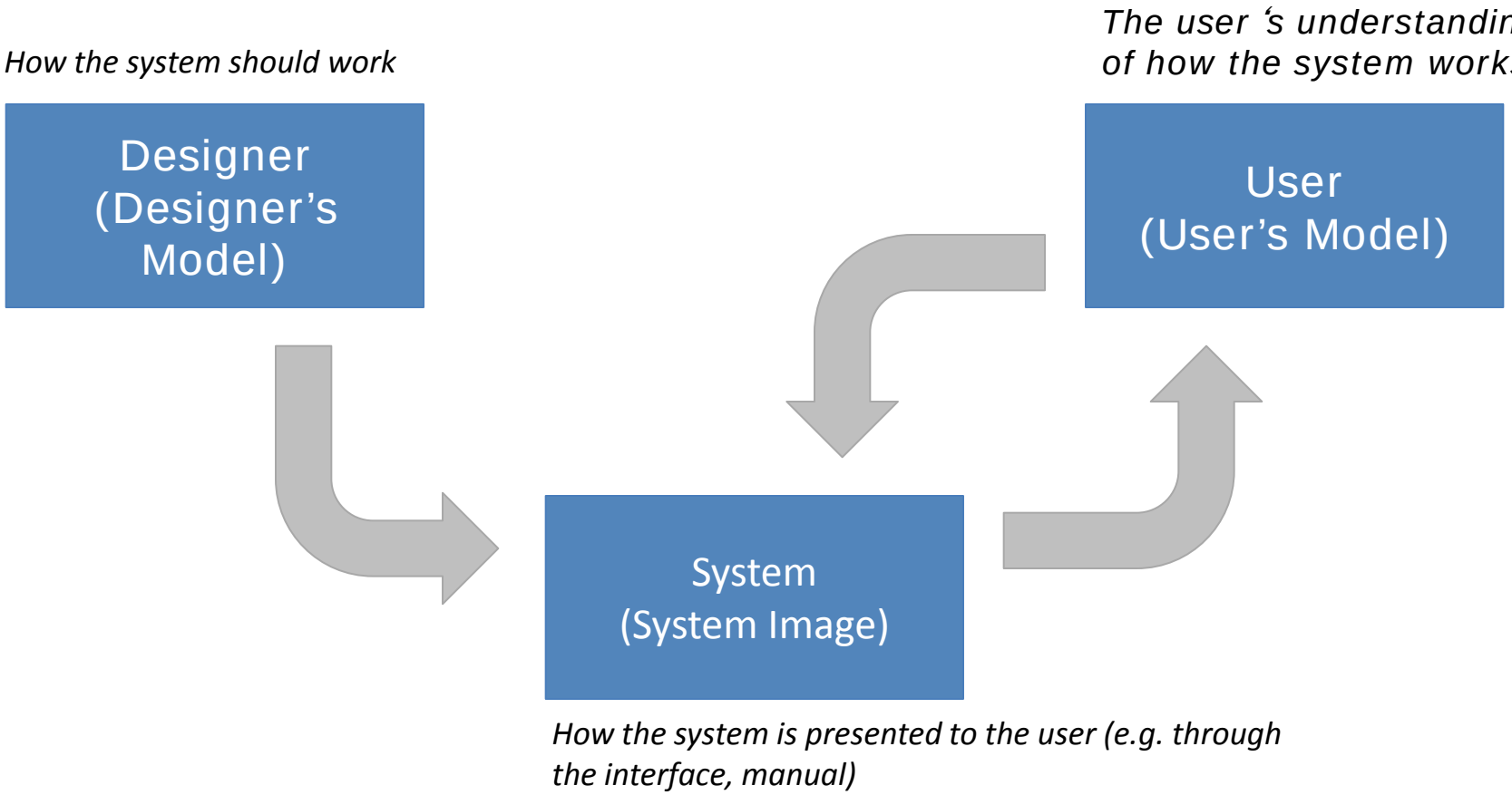
- Principle of good design: **Provide a good conceptual model**
  - Note: this is *not* a description of the user interface!

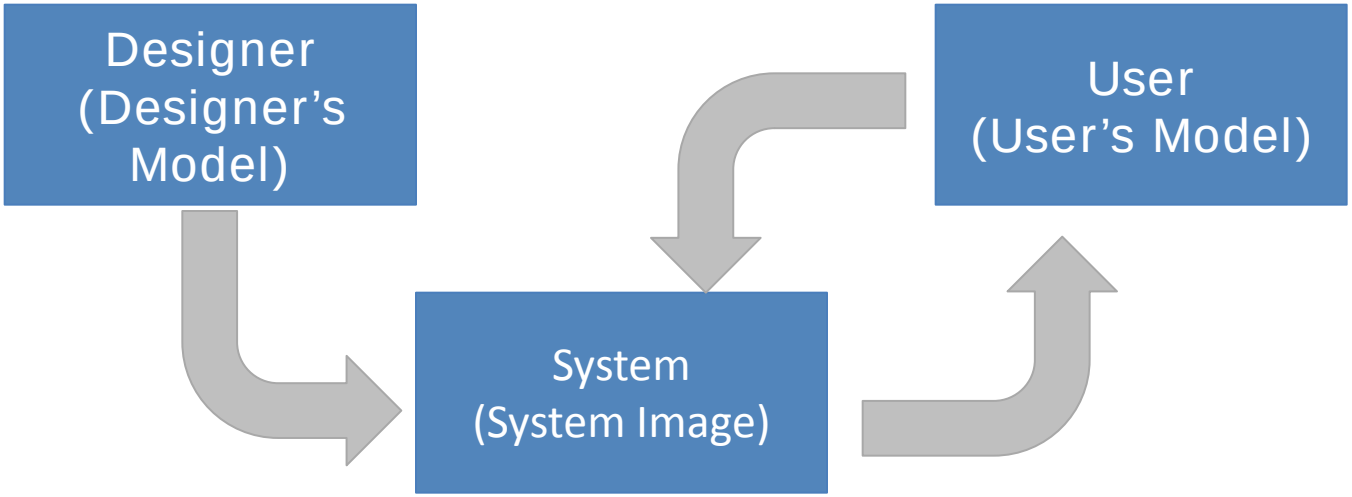
- Otherwise: blind operation, users will
  - not appreciate your interface
  - require clear instructions
  - not know what to do when things go wrong

Conceptual Models (4)



Conceptual Models (5)

- Design the interactive system such that the system image makes the designer ‘s model clear to the user
- Problems arise when the designer ‘s model is different from what emerges as the user ‘s mental model
- Human error is often really *design error*



Errors

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- People tend to make errors, blaming themselves
- Taught helplessness: mathematics curriculum
  - “I‘ve failed twice, I‘ll never learn that. ☹”
- Learned helplessness: conspiracy of silence

→ Avoid errors already by the design, wherever possible

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Teapot for Masochists

Jacques Carelman

Affordances (1)

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> "[...] the term affordance refers to the perceived and actual properties of the thing, primarily those fundamental properties that determine just **how** the thing could **possibly** be **used**."
>
> - Norman (DoET p. 9 – 2002)

- Affordances are the actions that the design of an object suggests to the user
- Affordance can be substituted with "is for"
- Examples: knobs are for ("afford") turning, slots are for inserting, chairs are for sitting

Affordances (2)

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- The term “affordances” has been popularized
- Norman refined the term to
  - *real* and
  - *perceived* affordances
- Real affordances
  - Physical objects, affording e.g. grasping
  - Perceptually obvious
- Perceived affordances
  - Screen-based interfaces, “learned conventions”

Affordances (3)

Act

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- What is the affordance of the door locks in this building?
- Design a better knob for locking/unlocking the door

A “Norman Door”

The label „PUSH“ is a one-word manual – is it really necessary to study a manual, just to open a door?

Source: http://www.flickr.com/photos/authentic/175678013/

Utility of Affordances

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- Affordances provide strong clues
  - No instructions/labels needed
  - A design with labels is often a bad design!
- Exceptions: complex, abstract functions that do not support simple “physical” affordances

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Visibility (1)

- Elevator control panel for a parking deck
- Labels identify the floor
- Problems
  - Which buttons can be pushed?
  - What are their functions?
  - Below or above ground?

→ **Lack of visibility**

Source: http://bit.ly/TbIYT

Visibility (2)

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- Visibility is one of the most important aspects in design!

- The mind is excellent at noticing and interpreting clues in the world, rationalizing, explaining cause and effect
  - Much everyday knowledge is in the world, not in the head
  - Ideally natural clues are made visible, requiring no conscious thought

Visibility (3)

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- Visibility is of major concern, especially when
  - Number of possible actions exceeds number of controls
  - There are invisible functions
  - There is a need for a reminder of what can be done
- But beware...
  - Think twice about invisible functions and whether they can be ommited (e.g. doors with labels, push/pull) → affordances!
  - A good relationship between the placement of a control and what it does decreases memory effort

→ Mapping problem

Visibility (4)

- How do you switch on the answering machine?

- No! Call 1999

Feedback

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> "Sending back to the user information about what action has actually been done, what result has been accomplished."
>
> - Norman (DoET p. 27 – 2002)

- Modern systems
  - Many functions
  - Little feedback

Activity

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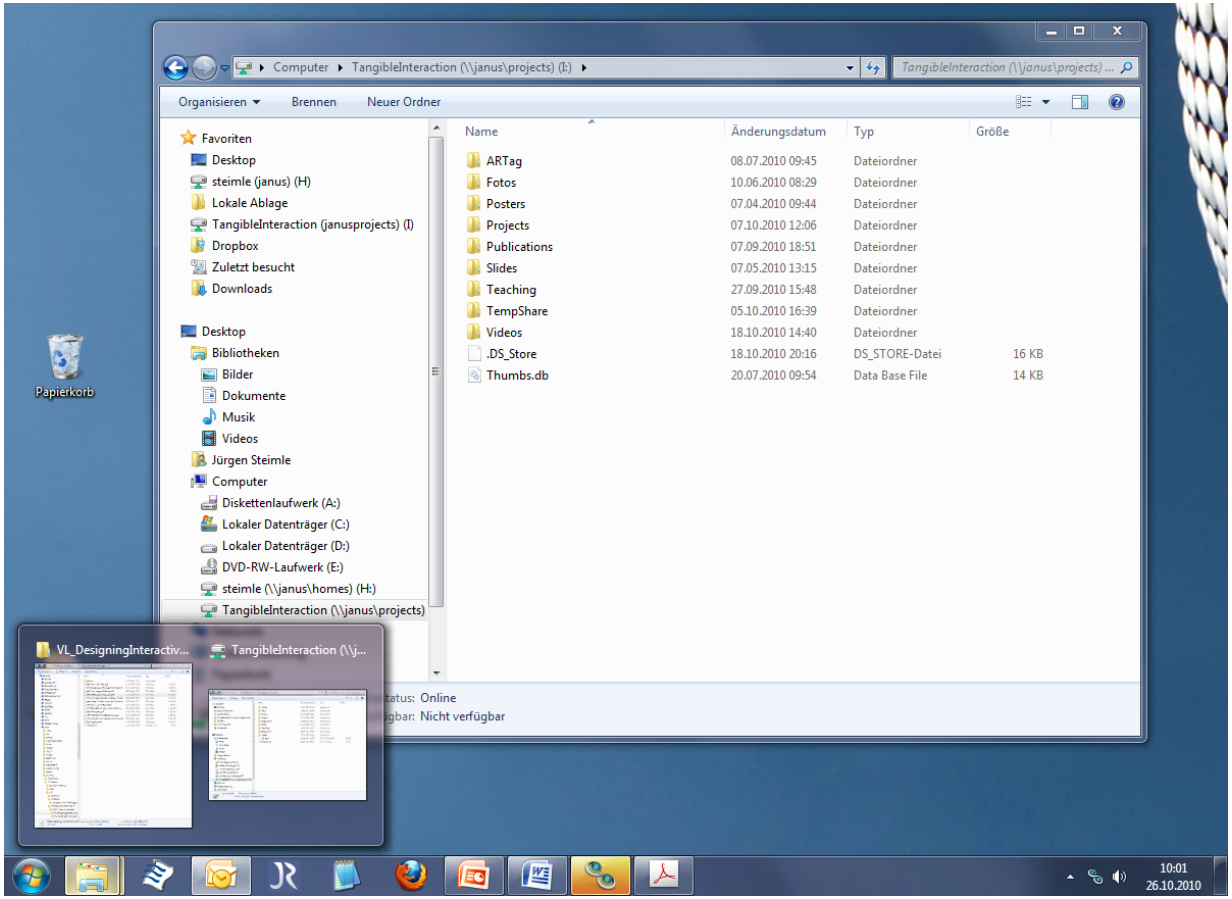
- What kinds of feedback is used by the Windows 7 desktop?



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Mapping

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- Connect functionality to UI elements/to the real world
  - E.g. element for adjusting volume
  - Map volume level to input control
  - Map volume level to output

- Which control for input?

  E.g.:
  - On/off switch?
  - Press button(s)?
  - Joystick?
  - Mouse?
  - Slider?

- Which output for state monitoring?

  E.g.:
  - Numerical output?
  - Color?
  - Size?
  - Sound?
  - Adjust slider position?

Natural Mappings

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- **Provide natural mappings**
  - Use spatial and physical analogies
  - Use cultural standards
  - Use perception

  → Supports understanding and remembering

- **Spatial analogies**

  Arrange controls in the same way that their real-world counterparts are arranged
  - Room lamps
  - Driving wheel
  - Car stereo audio fader

Natural Mapping?

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- How are the controls mapped?

Source: http://bit.ly/16e0m0

More Natural Mapping

Source: http://bit.ly/yC85z

Natural Mapping?

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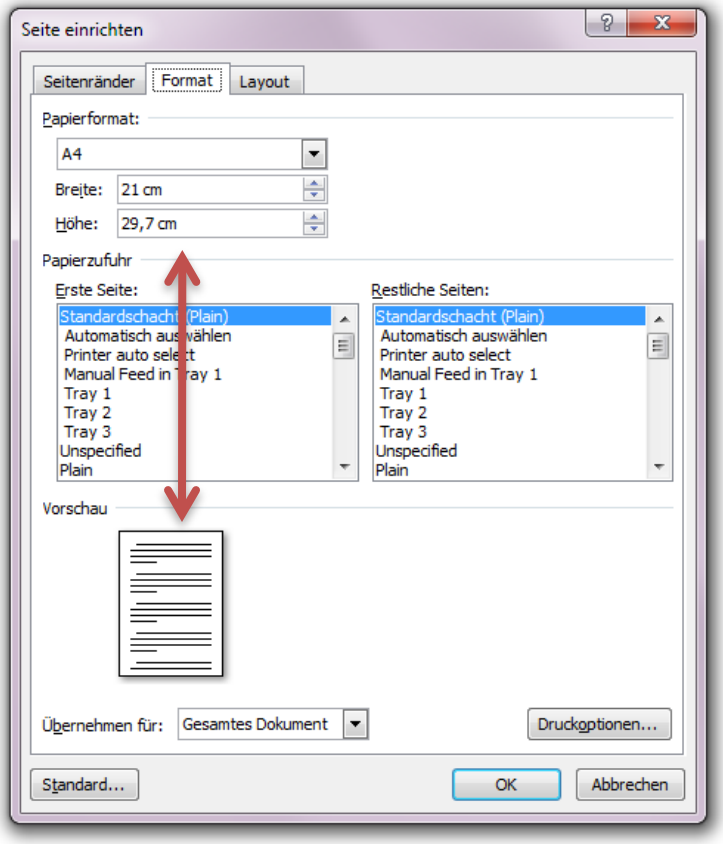
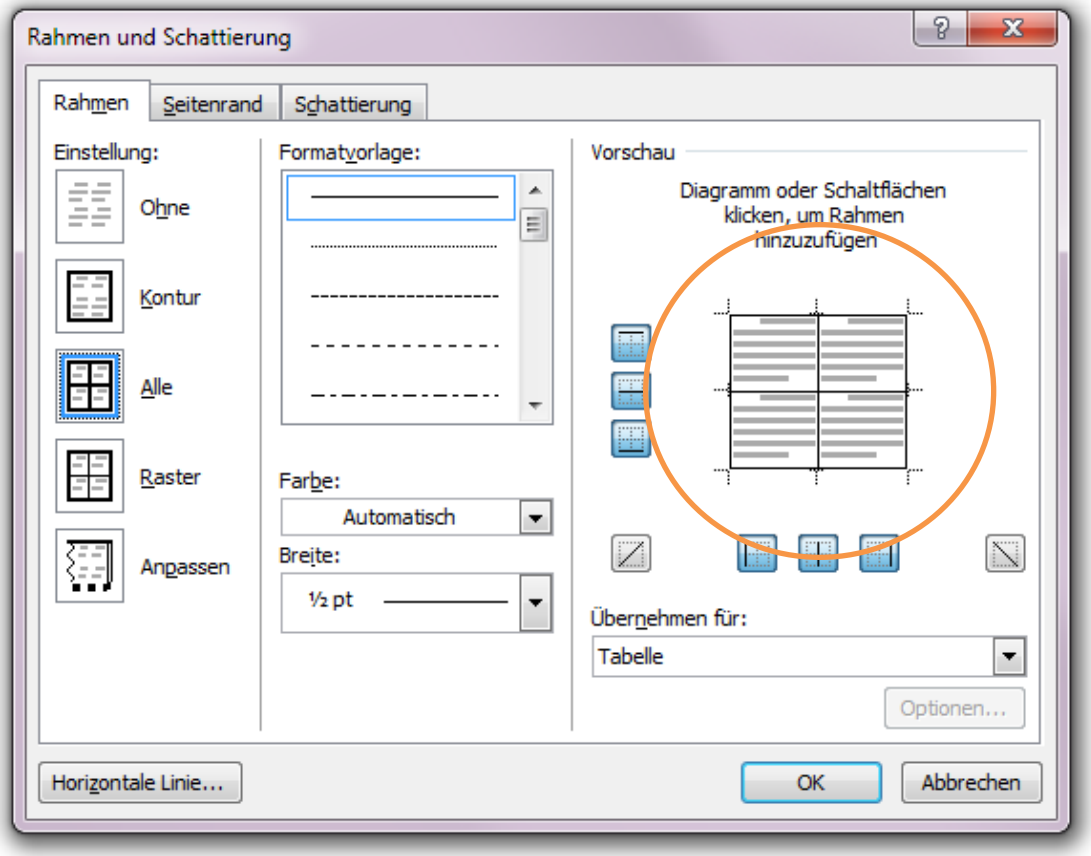
No spatial analogy



Spatial analogy



Natural Mappings

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- **Physical analogies**
  Mapping follows physical real-world behavior

- Example:
  Rising level = more
  Falling level = less
  - Natural for all additive dimensions
    e.g. amount (water level), heat (thermometer), volume, line thickness, brightness, weight, …
  - But not for substitutive dimensions
    e.g. color, taste, …

Natural Mappings

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- **Cultural analogies**
  Mapping follows cultural conventions

- Example:
  - Western cultures write from left to right, so an arrangement from left to right can be used to convey a linear ordering
  - But this might be not natural in other cultures!

- Note: An order from top to bottom is less culture-dependent

The Quick Brown
Fox Jumps Over
The Lazy Dog.

א היא האות הראשונה
באלף-בית העברי. אחת
מאותיות אהו״י אשר
מציינות תנועה. אות זו
מצוייה כאם-קריאה
אחרי כל התנועות.

Natural Mappings

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- **Perceptual analogies**
  The input device for controlling something (or output device for monitoring its state) looks like the actual thing itself

- Example: Mercedes car seat controls [Norman, DOET]

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Constraints

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- **Restricting the possible actions** that can be performed
- "Inverse" of affordances, possibly augmenting them

- Goals
  - Avoid usage errors
  - Minimize the information to be remembered

- Types of constraints
  - Physical, semantic, logical, cultural

Physical Constraints (1)

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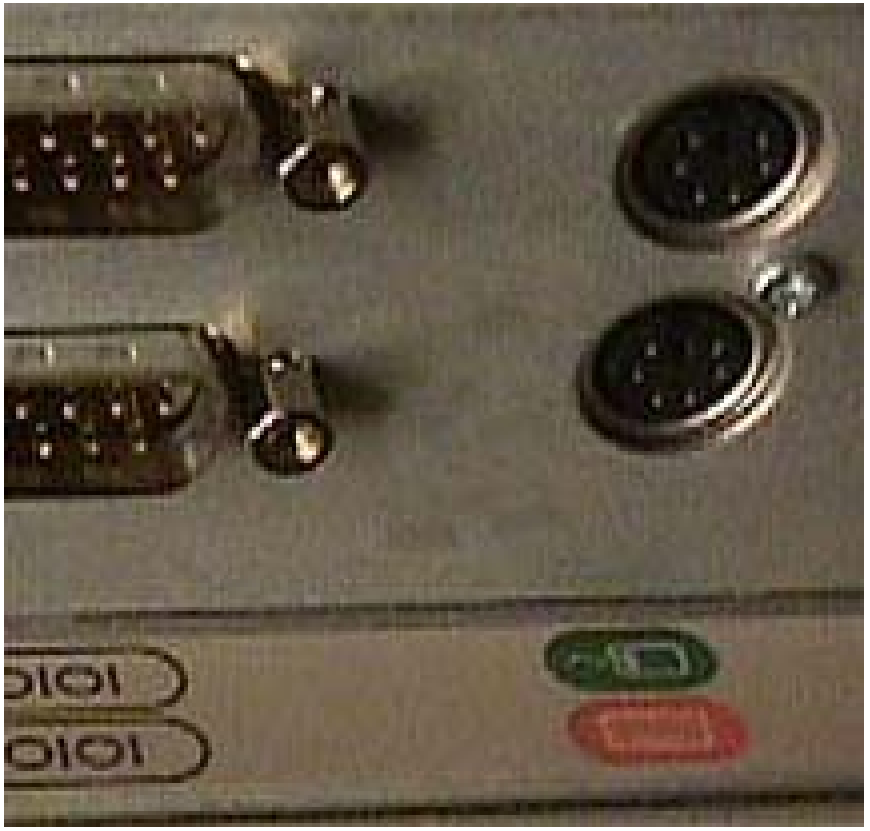
- Limit number of possible operations
- Limit through
  - E.g. Physical shape
    → Keys
  - E.g. Placement
    → Controls not reachable by children
- Useful if constraint is visible ahead of time

Physical Constraints (2)

- Where do you plug in the mouse and the keyboard?
- Does the coloring help?
- How can this be improved?



Source: baddesigns.com

Logical Constraints

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- Use logical conclusions to exclude certain solutions
  - Example: all parts of jigsaw puzzle are to be used
- Natural mappings often use logical constraints

Semantic Constraints

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- Use our common knowledge about the world and particularly the meaning of the current situation
- Example: Driver ‘s figurine in a model plane construction kit has to sit facing forward to make sense
- Powerful means to improve intuitiveness

- But: Only rules that are valid throughout your user population!

Cultural Constraints

- Rely on generally accepted cultural conventions
- Example: red = stop/attention
- This applies only to a specific cultural group!
  - Hand gestures are not interpreted equally
  - Writing direction differs
  - ...

Source: http://commons.wikimedia.org/wiki/File:Ampel_3931.jpg

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Interface Metaphors

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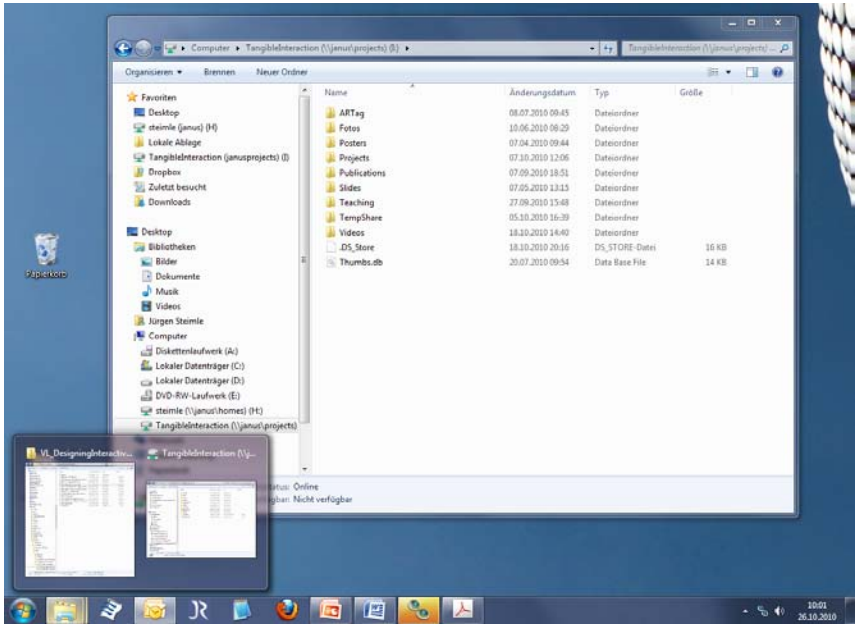
- Designed to be similar to a physical entity

- Example: Desktop metaphor
  - Monitor is treated as if it is the user's desktop
  - Objects (documents, folder, ...) can be placed and moved on this desktop
  - Objects can be opened into a window (represents a paper copy)
  - Objects can be moved to the recycle bin, the printer, ...



Benefits of Metaphors

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- Exploit user's familiar knowledge, helping them to understand "the unfamiliar"
- Helps users understand the underlying conceptual model
- Makes learning new systems easier
- Can be innovative and enable the product's access to a greater diversity of users

Problems with Metaphors

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- Breaks conventional and cultural rules, conflicts with design principles
  - e.g. recycle bin placed on desktop
  - e.g. move document to trashpaper bin for *deleting*; move CD/DVD to trashpaper bin for ejecting
- Too constraining: Can constrain designers in the way they conceptualize a problem space
  - e.g. text search is helpful for opening documents, but not provided by original desks
- Forces users to only understand the system in terms of the metaphor
- Designers can inadvertently use bad existing designs and transfer the bad parts over
- Limits designers' imagination in coming up with new paradigms and models

What to Take Home

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- Human Computer Interaction focuses on the human use of interactive computer system
- Usability and user experience goals are key factors for the design of good interactive products
- Remember interdependent factors like cultural differences, user groups, or context of use
- Our world is full of poor design. Many errors made by users are due to **design errors**
- Good design takes care, planning thought. It requires conscious **attention to the needs of the user**
- Provide a good **conceptual model**. This is a high-level description of a product. The goal is to design the product such that the user can form a correct conceptual model
- Make the relevant parts **visible** (knowledge in the world, not only in the head)
  - Take advantage of **affordances** and **constraints**
  - The correct things must be visible and they must convey the correct message
  - The user knows what to do just by looking. No label is required. Simple things should not require explanations
- Use **natural mappings**
  - Operating parts should be visible and implications should be clear
  - Good example: scissors. // Bad example: digital wrist watch with 4 buttons
- **Feedback**: Give each action an immediate and obvious effect
- Interface **metaphors** are commonly used as part of a conceptual model, but must be used with care