Telecooperation Lab
Prof. Dr. Max Mühlhäuser

TK3: Ubiquitous (& Mobile) Computing

Chapter 4: Human-Computer Interaction (HCI)

Lecturer: Dr. Mohammadreza Khalilbeigi

Who are we?

- 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

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

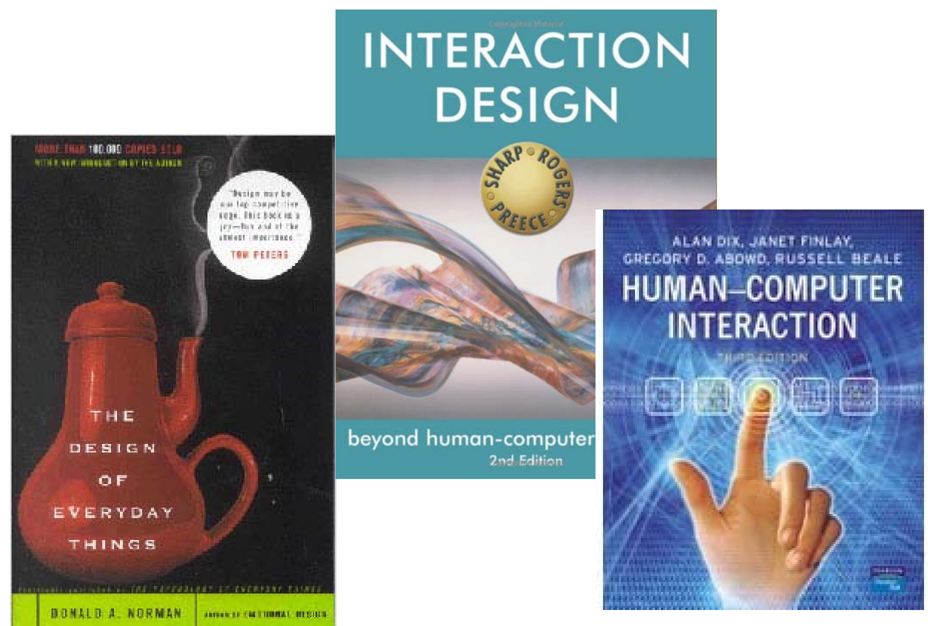
Agenda

- **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

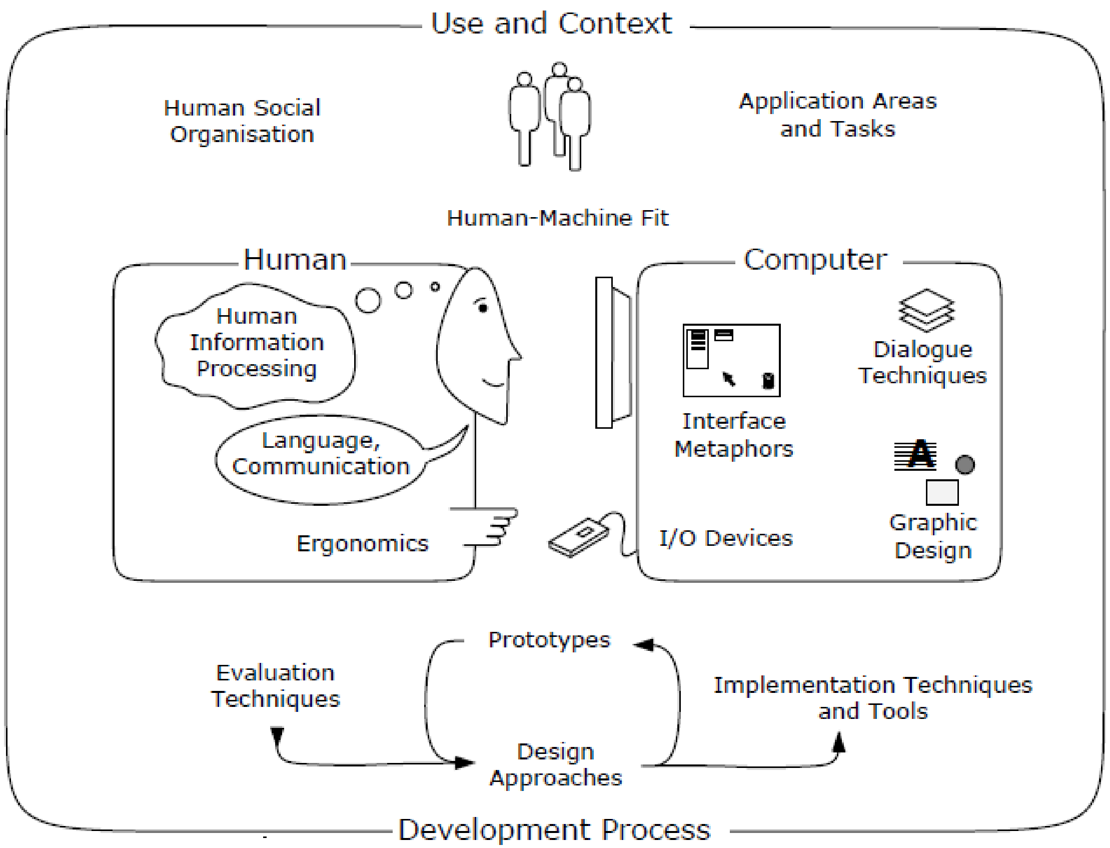
- You can find them at
  - Fachlesesaal MINT in der ULB Stadtmitte, 4. Obergeschoss
  - Lernzentrum Informatik



- Human-Computer interaction 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)



Adapted

Involved Disciplines

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

Good and Poor Design (1)

Good and Poor Design (2)

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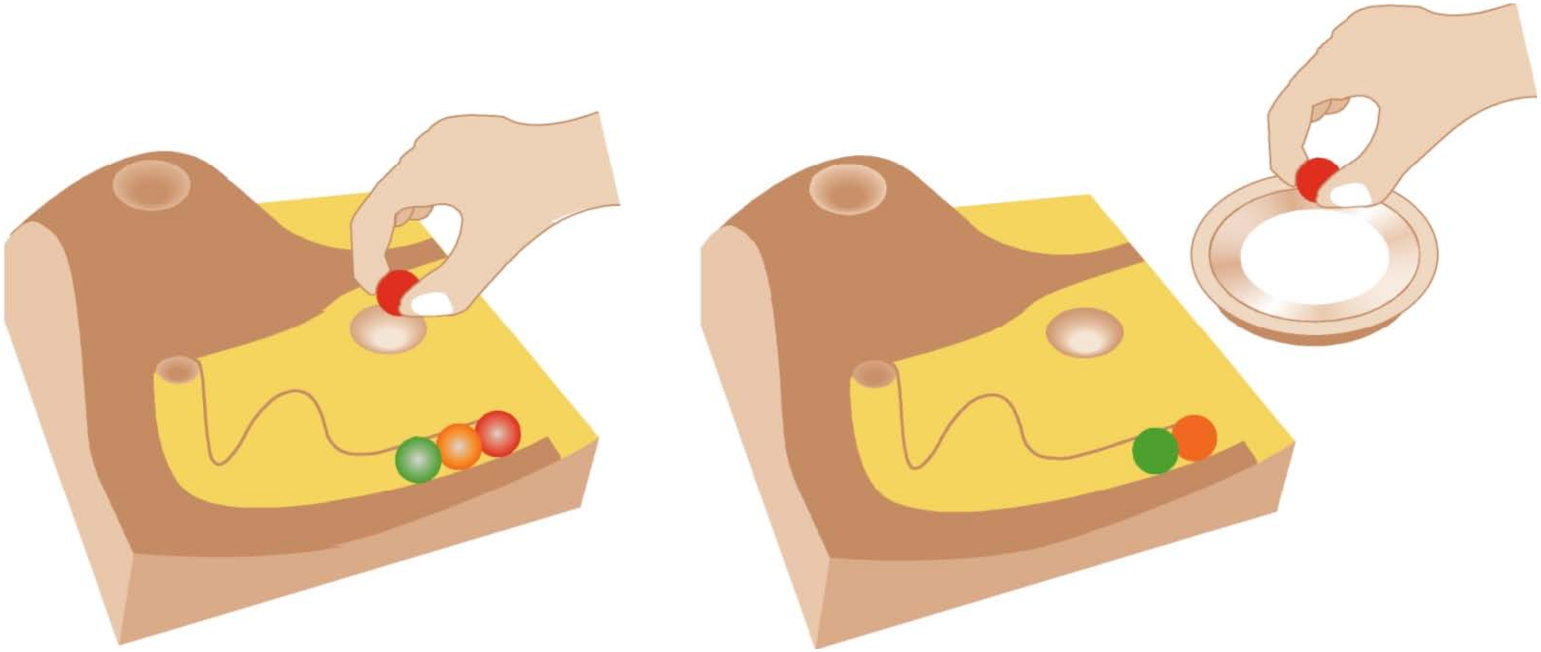
Good and Poor Design (4)

- The marble answering machine, Bishop 1995



Good and Poor Design (5)

- 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)

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

Usability Goals (1)

- **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)

- **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

- 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)

- 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

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

User Experience Goals

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

- boring
- frustrating
- annoying
- …

→ Subjective *qualities*

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  - Mapping
  - Constraints
  - Metaphors

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Conceptual Model (1)

- 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
SETUP
iPod
13:45
Five Winds
Dreams
Lucas Corbin
LUCAS CORBIN
ALPINE
ENTER
AF
TA
USB
R·D·S EON
BAND
•TA
MultEQ
AUDYSSEY
SOURCE

Alpine.com

Conceptual Models (2)

„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

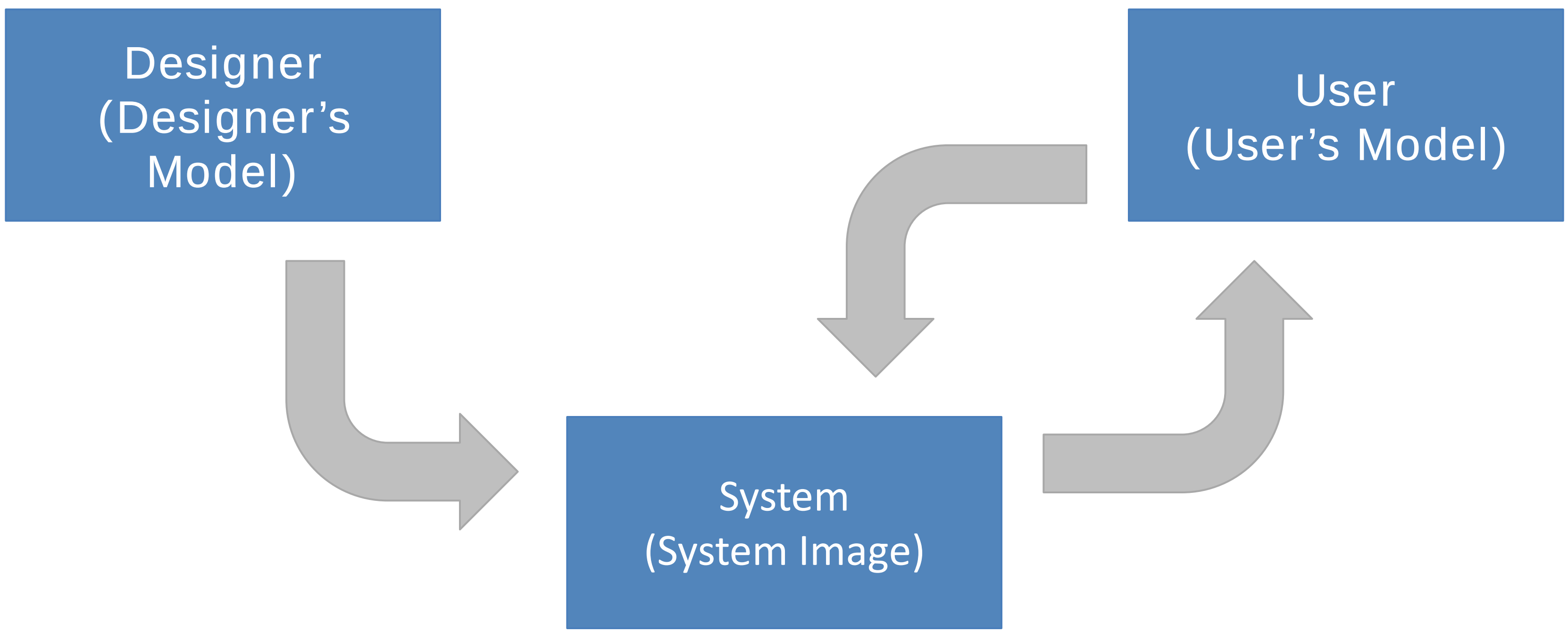
Conceptual Models (3)

- 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)

How the system should work

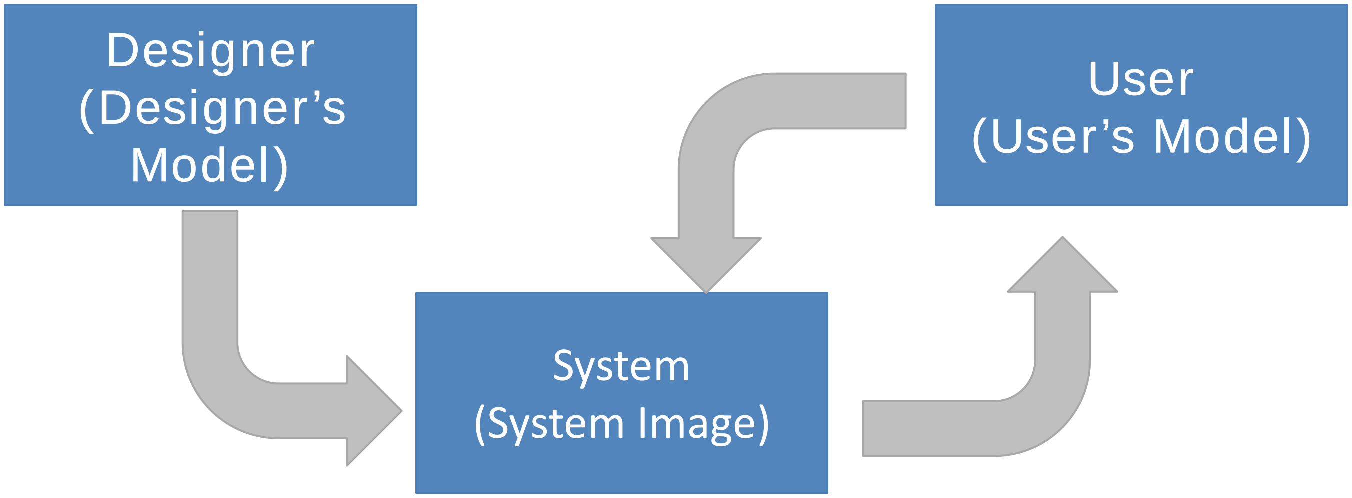
The user 's understanding of how the system works



How the system is presented to the user (e.g. through the interface, manual)

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

- 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)

"[…] 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)

- 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

- 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

- 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)

- 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)

- 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

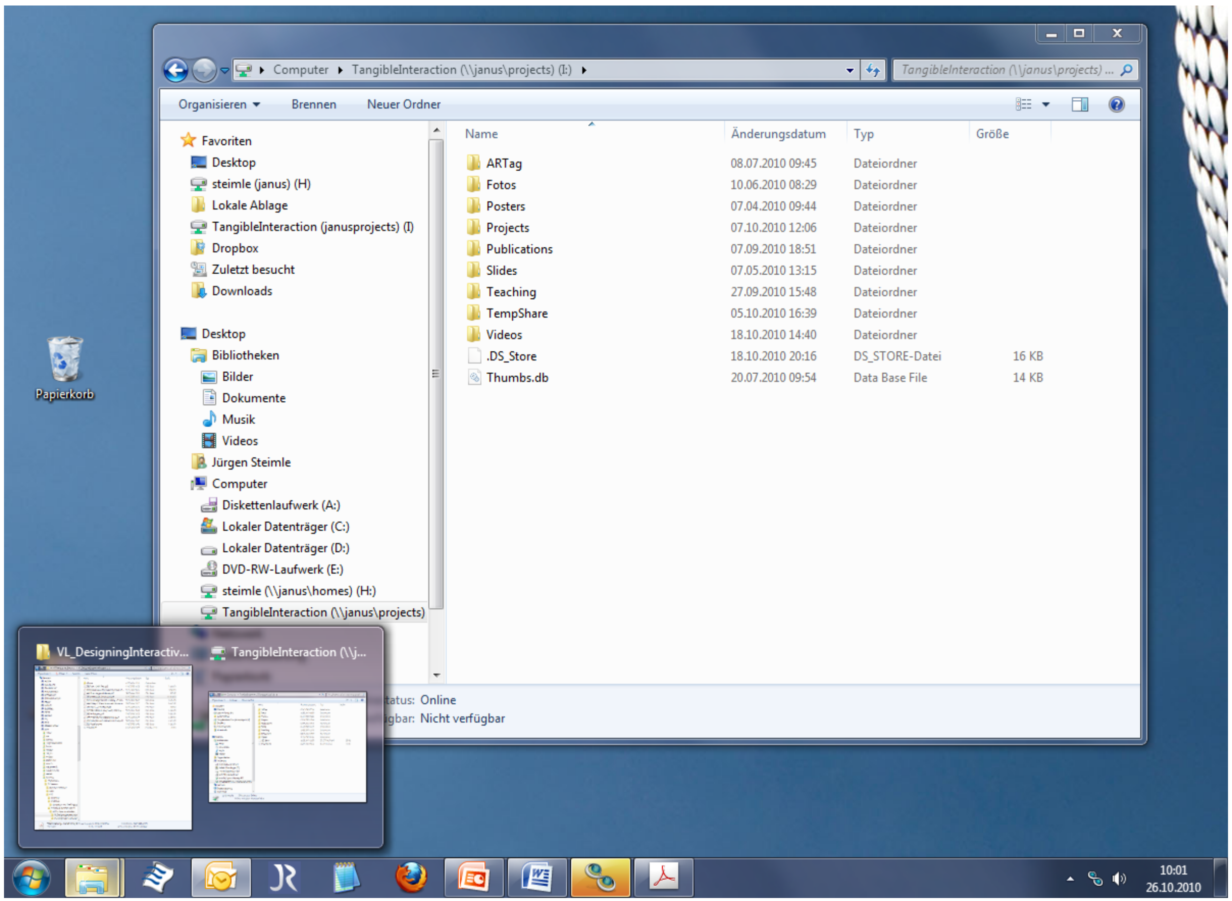
Feedback

> "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

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



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Mapping

- 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?

- How are the controls mapped?

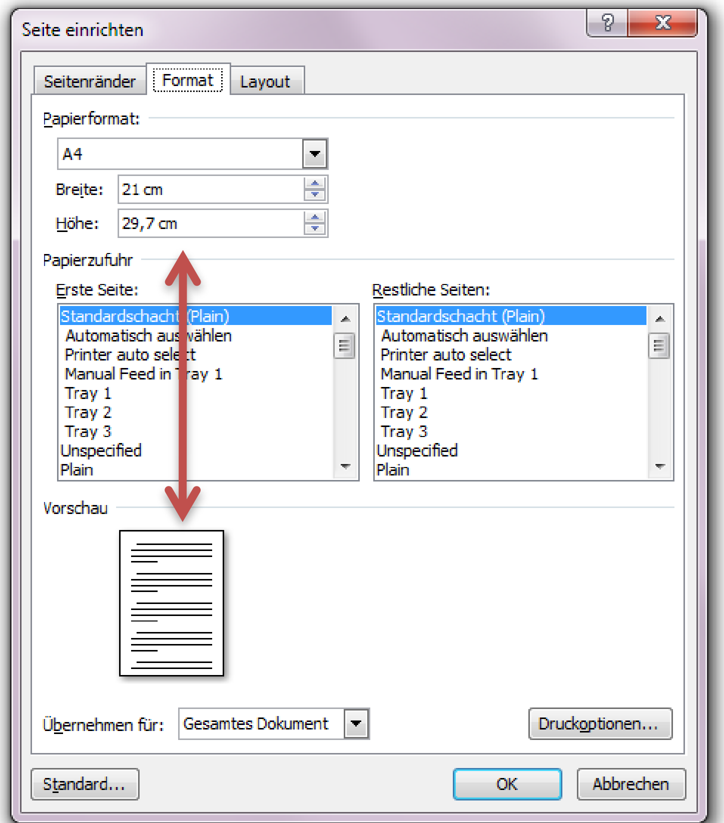
Source: http://bit.ly/16e0m0

More Natural Mapping

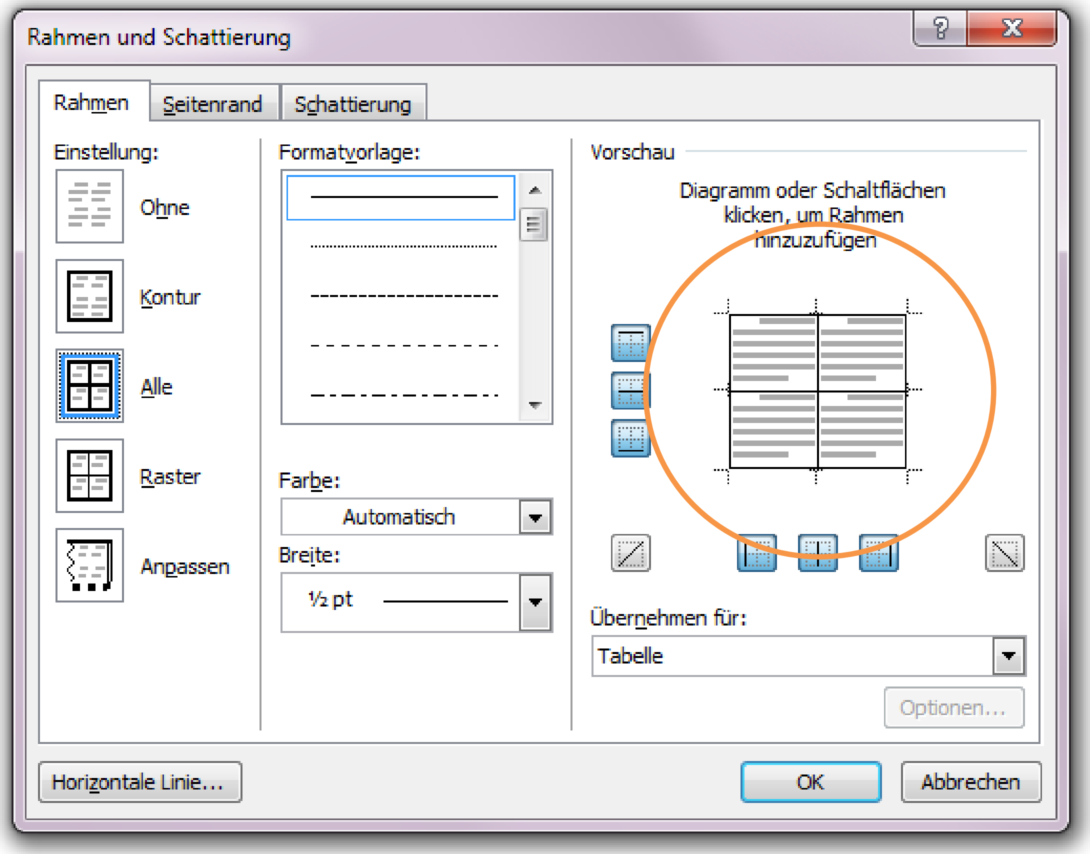
Source: http://bit.ly/yC85z

Natural Mapping?

No spatial analogy



Spatial analogy



Natural Mappings

- **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

- **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
מצויה כאם-קריאה
אחרי כל התנועות.

Natural Mappings

- **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

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

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

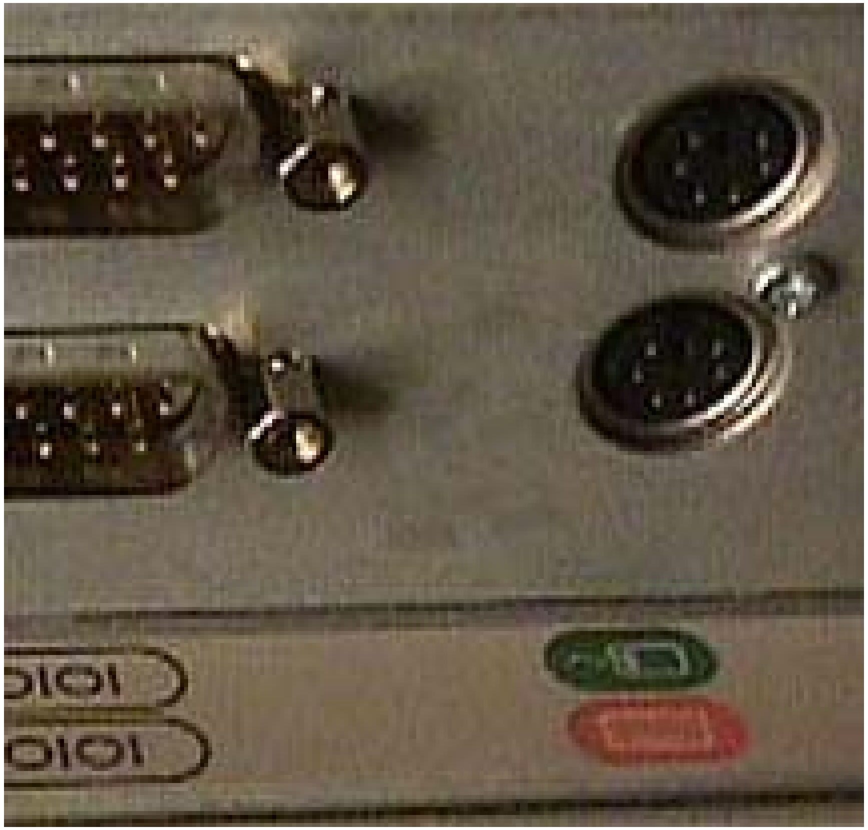
- Types of constraints
  - Physical, semantic, logical, cultural

Physical Constraints (1)

- 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

- 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

- 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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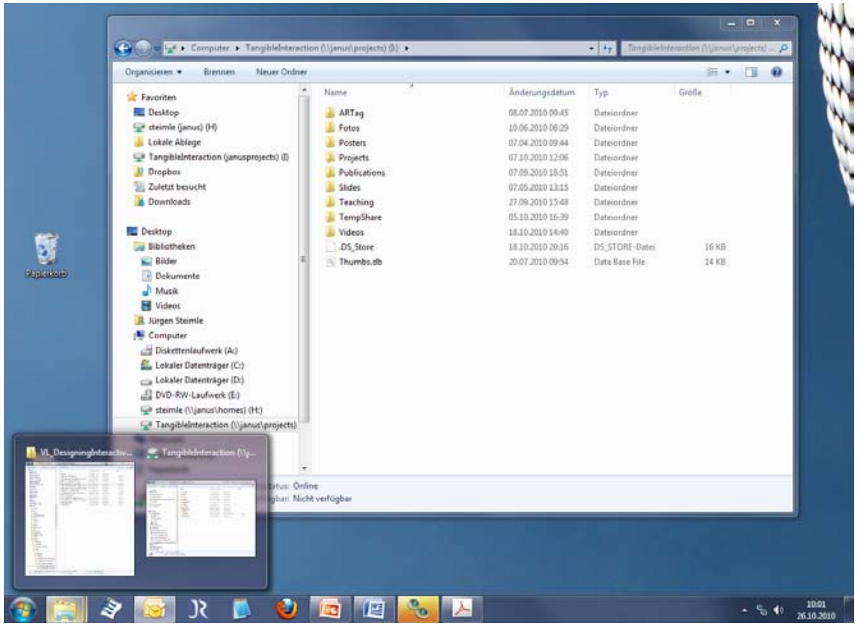
Interface Metaphors

- 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

- 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

- 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