CPEN441: user interface design

mental models

mental models

"In interacting with the environment, with others, and with the artifacts of technology, people form internal, mental models of themselves and of the things with which they are interacting.

These models provide predictive and explanatory power for understanding the interaction."

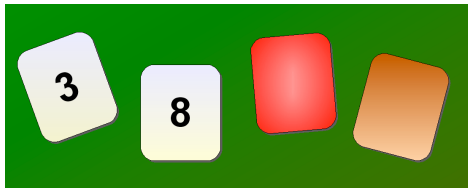
-Norman (in Gentner & Stevens, 1983) some ch

Topic covered in this set…

- mental models:
  - how users "**see**" the system through mental models
  - how users **rely** on mental models during usage
  - various **forms** of mental models
  - how mental models can **support** users' interaction
- conceptual design:
  - **defining** the intended mental model
    - hiding the technology of the system
  - **designing** a suitable system image
    - applying appropriate design guidelines
  - **analysis** using Cognitive Walkthrough: **examples**

A Classic example

Wason's selection task:

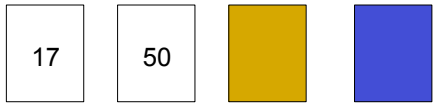


Which card(s) must be turned over to show that if a card shows an even number on one face, then its opposite face will be red?

A Classic example

You are the owner of a pub that follows the BC liquor laws about the drinking age of 19. Which person(s) do you check to confirm this.

"if you are underage, you have to drink non-alcoholic beverages?"



= lemonade = whiskey

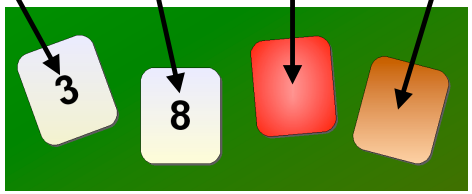
A Classic example

odd = legal age

even = under age

Red = lemonade

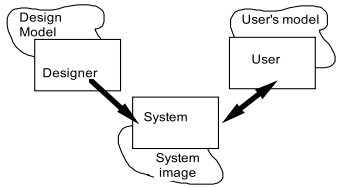
Brown = whiskey



Which card(s) must be turned over to show that if a card shows an even number on one face, then its opposite face will be red?

conceptual design:

- designing systems so users can understand them
- assisting the user to build useful mental models



various models

- **design model** is the designer's conceptual model
  - referred to as "conceptual model" in text
- **system model** is a model of the way the system works
- **system image** results from the physical structure of what has been built (including documentation, instructions, labels) – it is what the user "sees"
- **user's model** is the "**mental model"** developed by the user through interaction with the system
  - user tries to match the mental model to the system model
  - conceptual model can help with this
- **"user model"** - different:
  - this is the model the **system has of the user**

conceptual mismatch

misconceptions happen when mental model differs from the system model

- sizes of documents measured in bytes, not pages or words
  - Sun and SGI Unix use different measures for files
- dates may be in non-standard formats
  - whose birthday is 09-06-46 (what country are we in)?
- userids (and files) may be constrained by system design
  - userid hmitchel@cs.ubc.ca
- error message may use system-specific codes
  - Error 404 in HTTP

some characteristics of mental models

- incomplete
- constantly evolving
- not accurate representation
  (contain errors and uncertainty measures)
- provide a simple representation of a complex phenomena
- often represented by a set of if-then-else rules

acquiring mental models

during system usage:
- the user's own activity leads to a mental model
- explanatory theory, developed by the user
- often used to predict future behaviour of the system

observing others using the system:
- casual observation of others working
- asking someone else to "do this for me"
- formal training sessions

reading about a system
- documentation, help screens, "for Dummies" books

this is done **by the user** (not the designer)

runnable models:
'perturb' system to figure out how it works

these are **dynamic models**
- includes a notion of **causality**
- "doing this will result in this"

used for **explanation**
- to understand why the system responded as it did
- part of Norman's model of behaviour (interpretation)

used for **prediction**
- to select an appropriate action
- also part of Norman's model (intention)

runnable models: **'doing *x* will result in *y*'**

1. **Establishing the goal** to be achieved
2. **Forming the intention** for action
   to achieve goal
3. **Specifying the action** sequence
   corresponding to the intention
4. **Executing** the action sequence

what would be a good *x*?

5. **Perceiving** the system state
   resulting from the action sequence
6. **Interpreting** the perceived system state
7. **Evaluating** the system state
   with respect to the goal and the intentions

did *y* happen? what does it mean?

common forms of mental models

state transition model
- changes in state need to be "visible"
- telephone example

object-action models
- users think in terms of concrete or abstract objects
- the system supports action on the objects
- Unix `mv` example

mapping models
- users learn a sequence of actions to accomplish tasks
- hand-held calculator maps "math" to key presses

analogies/metaphors
- a new system (closely) resembles an old system
- desktop metaphor

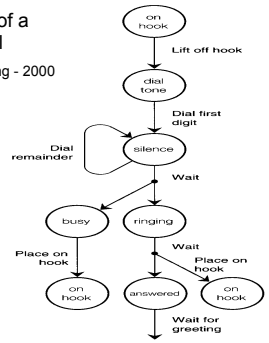
using a landline telephone example

typical mental model forms as a state transition diagram
- see *telephone state transition diagram*

MM predicts how long we wait at various points
- unexpected delays or unfamiliar responses not understood
- we try to map what we hear onto our model:
  - international calls may encounter different delays
  - international calls may have extra steps
  - international calls may result in different signals

Mental Model of a Telephone Call

Newman & Lamming - 2000
Fig 13.5



What is your mental model of calling with a mobile phone?

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MM's of complex systems: **lattices** of causal relationships

hierarchical object-action model:

- levels of understanding
  - simple: just actions operating on objects
  - more sophisticated: causal relations between elements
- beginner starts with a crude version (perhaps inadequate to solve some problems → possibly bad conceptual design!)
- expert fills in more elements → can address more complex situations

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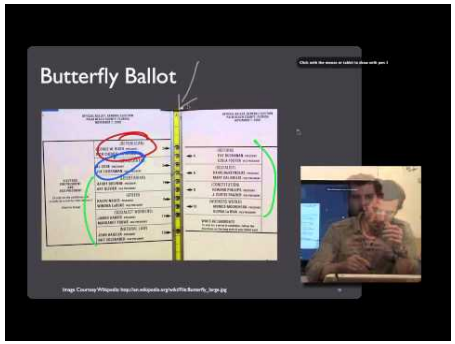
A refrigerator example

S. Klemmer: https://www.youtube.com/watch?v=swMZpv_BfgY

1:25



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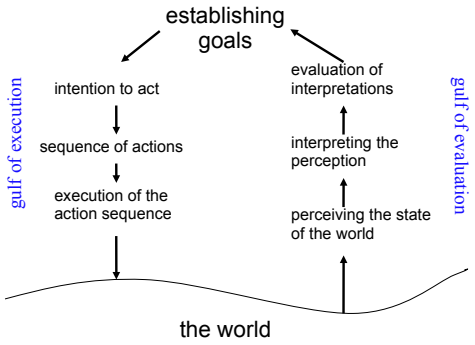
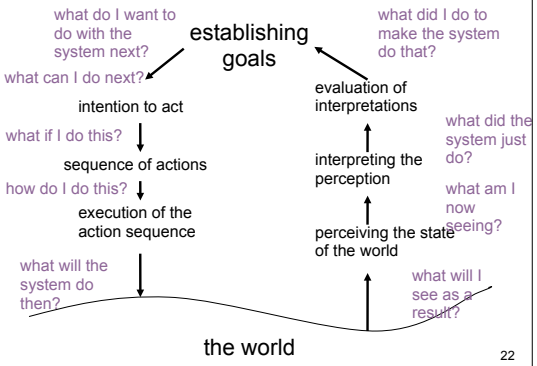
Let's look at your mental model of changing and saving files…

how can mental models support (or impede) users' interaction?

What Mental Models Tell the User



What Mental Models Tell the User



the system image/conceptual model

we have control over what users see

- responsible for turning the system model into the system image
- choose a system image to foster a good mental model

some interfaces **literally display the system model**

- all objects and actions may be visible at all times
- automobile dashboard provides a system image of the car
  … sensor displays, physical controls

currency (up-to-date-ness) is important

- the system image has to reflect the actual current state

consistency is important

- adaptive Microsoft drop-down menus violate consistency

presenting the system image

explicit representation

- provide a current and consistent map of everything

implicit representation

- provide cues about the system model
- progressively expose/reinforce the system model
- telephone voice mail example:
  - Good: *You have three new messages. Press 2 to hear your first new message.*
  - Bad: *Press 2 to hear new message.*

hiding system complexity

many systems have messy low-level details

- these may not be relevant to the user's activity
- the full functionality of the system may not be required

example: MS Word has hundreds of commands

- many users need only a small subset of these commands
- users themselves can hide complexity by customization
- IT administrators may provide macro capabilities
  - macros bundle low-level commands into a single concept
- wizards allow a user to "do what's right", skipping details
- Carroll and Mack (1984) advocated "training wheels"

examples
of where it helps to hide system complexity

water faucet

- the [real] **system model** has independent hot & cold
- the **system image** provides variable temperature
- some taps allow temperature control & volume control
- both "hot & cold" and "temperature & volume" are 2 DOF

audio-video conferencing link

- the real system model has four independent channels
- users might want to combine these in **standard** ways:
  - **"Glance"** has two-way video only
  - **"Office Share"** has two-way audio and video
  - **"Vphone"** has two-way audio only

conceptual design heuristics

- choose your conceptual model based on an intended mental model early in design
- link choice of conceptual model to style of interaction
- hide system features that conflict with user's activity
- exploit system image to foster intended mental model
- ensure that system image is current and consistent
- take into account users' existing mental models
- allow for both novice and expert mental models
- use simple, concrete, familiar metaphors
- obey "Law of Least Astonishment" (Occam's Razor)

Summary

- Models
  - people form mental models of the world
    - will make a mental model of your system
  - take many forms
  - useful for understanding how people (and designers) understand system
  - useful for starting evaluation of design
    - cognitive walkthrough of design to see what a user's mental model will be