Human Factor Theories – Part I

Part of the Human Computer Interaction course Notes

2008-2009

Human Cognitive Systems

- Source: course of Dr. Pearl PU, Human Computer Interaction Group, Institute for Core Computing Science, Faculty of Communication and Information Sciences, EPFL

- How the mind works
- Why study cognitive science
- Why humans behave in certain ways

Outline

- Model of how our mind works
- Cognition
  - Mental models
  - Problem solving
  - Learning
- Attention and memory
- Perception (visual and auditory)
- Motor skills
- Social science, dialog with computer
- Design guidelines

Where we are

- **Model of how our mind works**
- Cognition
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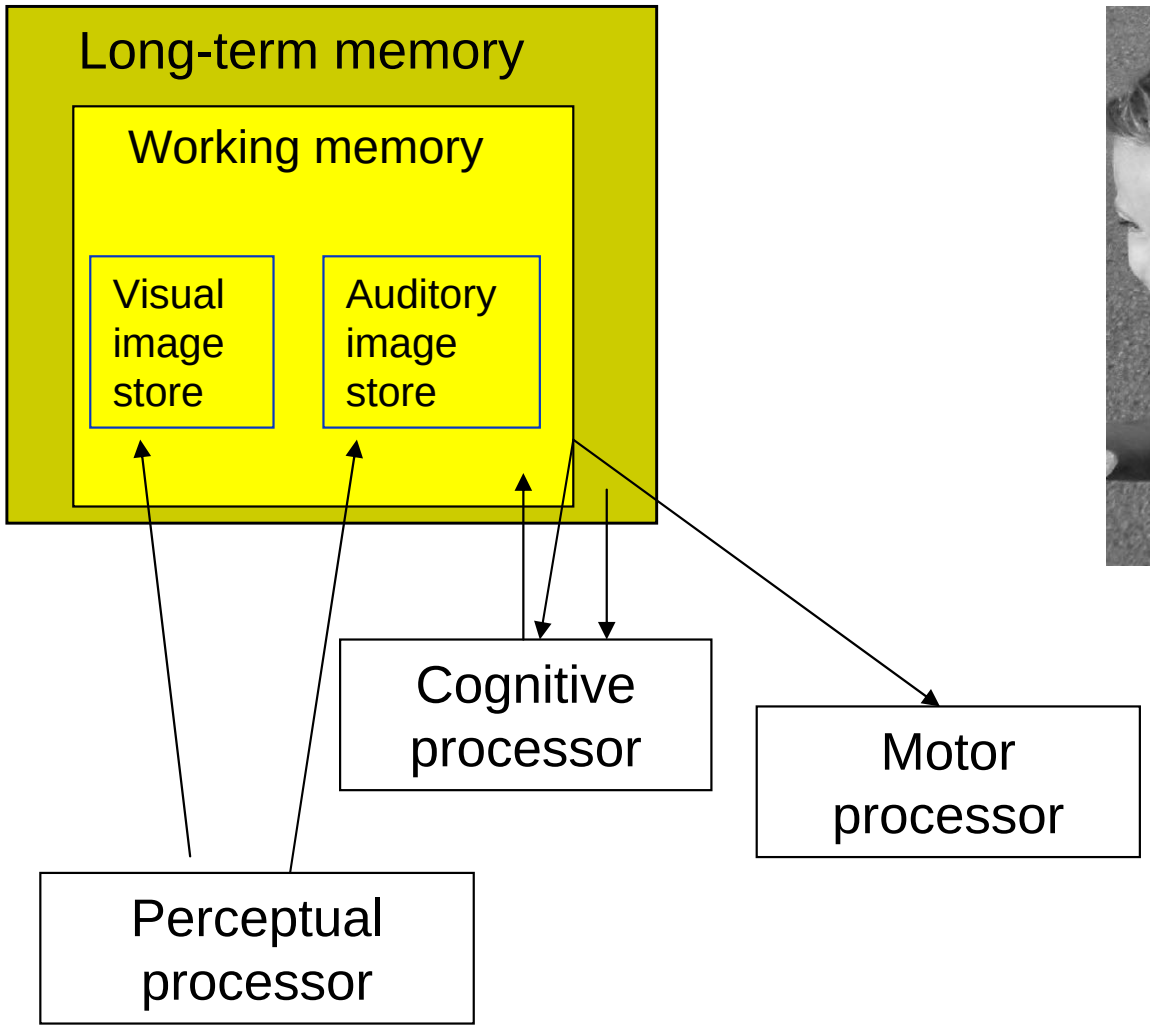
Model of how our mind works



What is fun and yummy?
How can I get it?

Architectural components

- Each has its own memory and processor.
- The brain works in a series of processing stages, whereby the different processors and memories are organized in the way depicted by the figure
- The functionality of each box is explained in following text, but the communication is reflected in the figure.

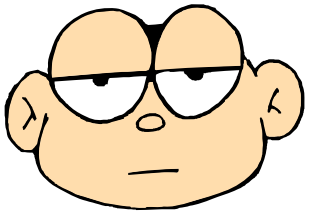
The computer metaphor

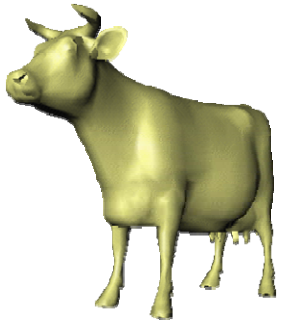
- Activity of the brain is analogical to the programming steps of a computer.
- *Perceptual* processor is for seeing, touching, and hearing.
- *Information* is stored in the *working memory*.
- The storage for visual and auditory information is separate.
- *Motor process* controls the movement of fingers, eyes, hands, and other limbs.
- The *cognitive* processor performs the main reasoning relying on facts and knowledge stored in working and long-term memory.

Mental models

- Definition: *mental models* are *representations* in the mind of real or imaginary situations
- The mind constructs "small-scale models" of reality that it uses to anticipate events
- Mental models can be either constructed from the way a system looks, how it behaves, or from a metaphor of a situation already know to us
- Once constructed, mental models allow people tomake predictions about how things work
  - how does your car start?
  - how does an ATM machine work?
  - how does your computer boot?
- We use mental models to deal with new and unfamiliar environments based on our existingxknowledge

Cognitive models





back

Awkward mental model: the bath faucets example

- A bathtub with two faucets and two spouts (rubinetti e valvole)
- One spout for hot water and one for cold water (easy to construct)

- After water has been running, you realize that the temperature is too cold, but the flow is okay. How do you change it?
- Solution: turn down the cold water, increase the hot water. But can you get it right in one try?

Psychological variables diff. from physical ones!

What is wrong here?

Psychological and Physical variable

- Psychological variables are *task oriented* parameters with which users manipulate to control the achievement of their tasks
  - flow, temperature
- Physical variables are device related parameters with which devices function
  - left faucet for cold water, right faucet for hot water

Psychological and Physical variable

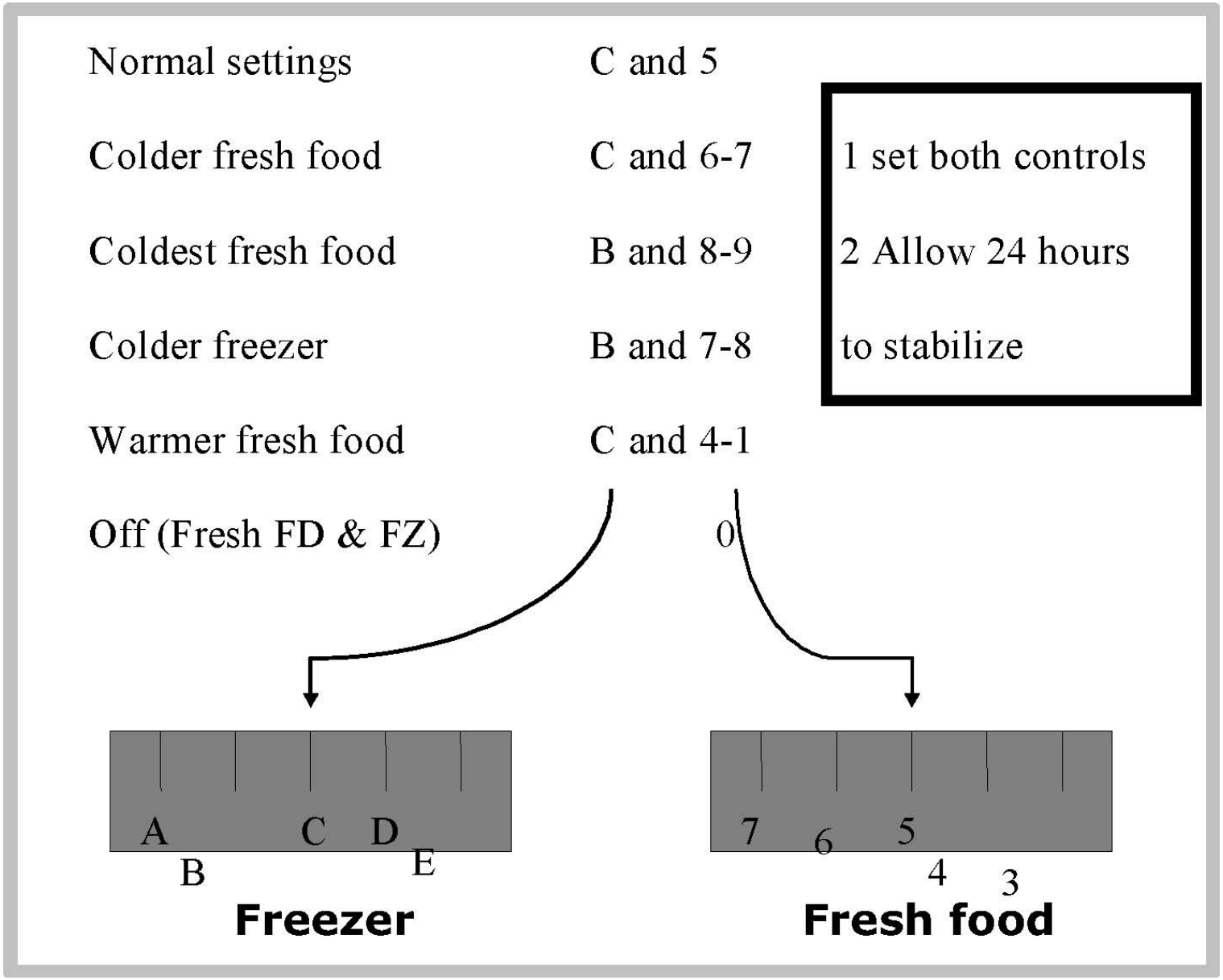
- Users care about rate of total flow and the temperature of water in the tub
- total flow = sum of two
- temperature= difference or ratio
- difficult to evaluate if water temp. is desirable

Mental model: Principle 1

- Know your users and their needs by performing user analysis (see *user-centered* design for performing user analysis)
- Make *psychological variables* coincide with *physical variables*

Incorrectly derived mental model

Example: a refrigerator w/freezer



What is the system image

- Appears that the higher the number, the colder it is for the fresh food unit. The other control unit, A-E is for the freezer, where A is the warmest and E the coldest.

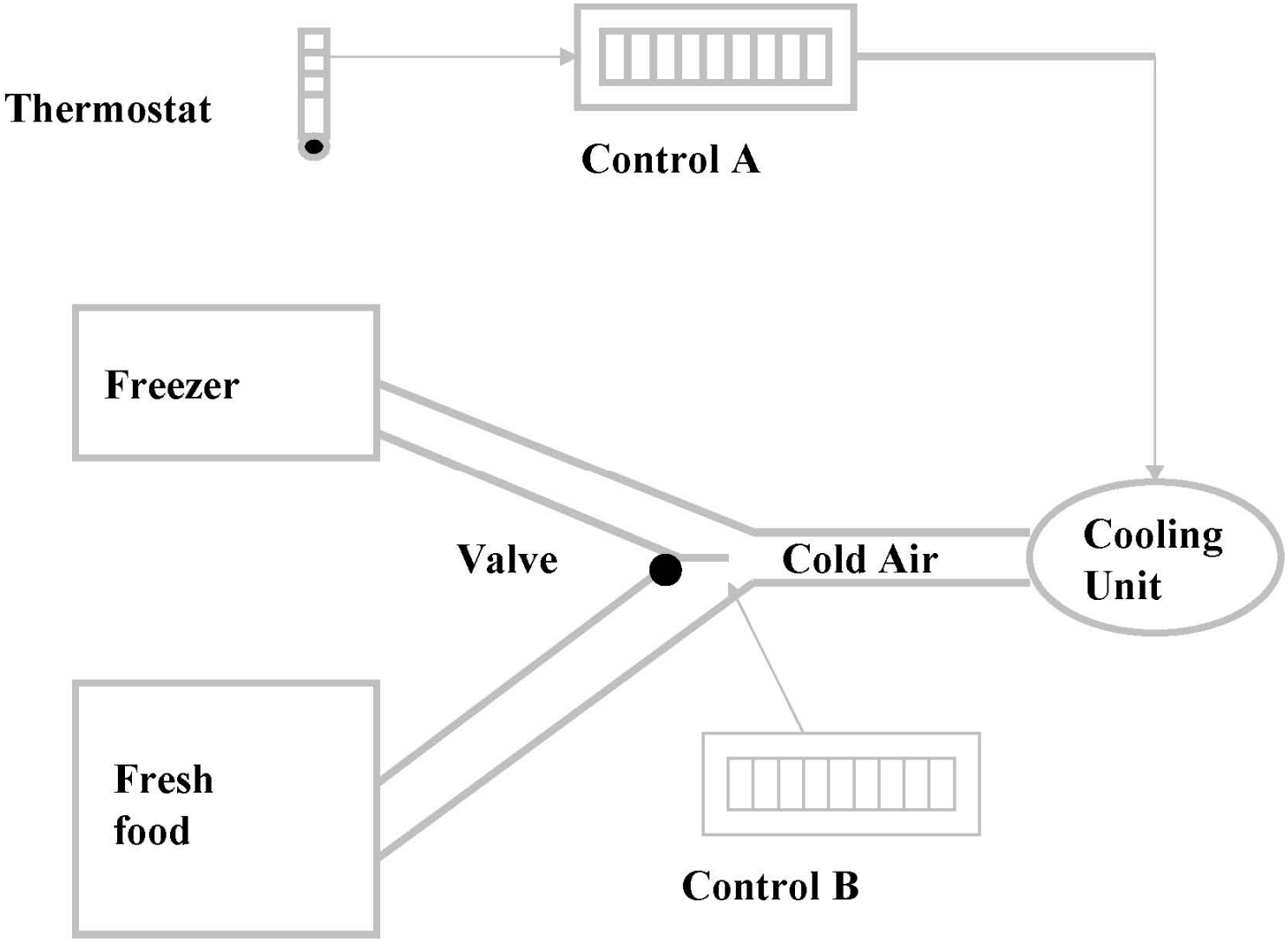
Suppose the freezer is too cold, the fresh food section just right. How do you adjust the controls?

- Answer: keep the numerical setting unchanged. Change the alphabetic setting, C -> B

The physical model

- There is only one thermostat and only one cooling mechanism.
- One control adjusts the thermostat setting, the other the relative proportion of cold air sent to each of the two compartments of the refrigerator.

The model in reality



Freezer is too cold, fresh food section ok

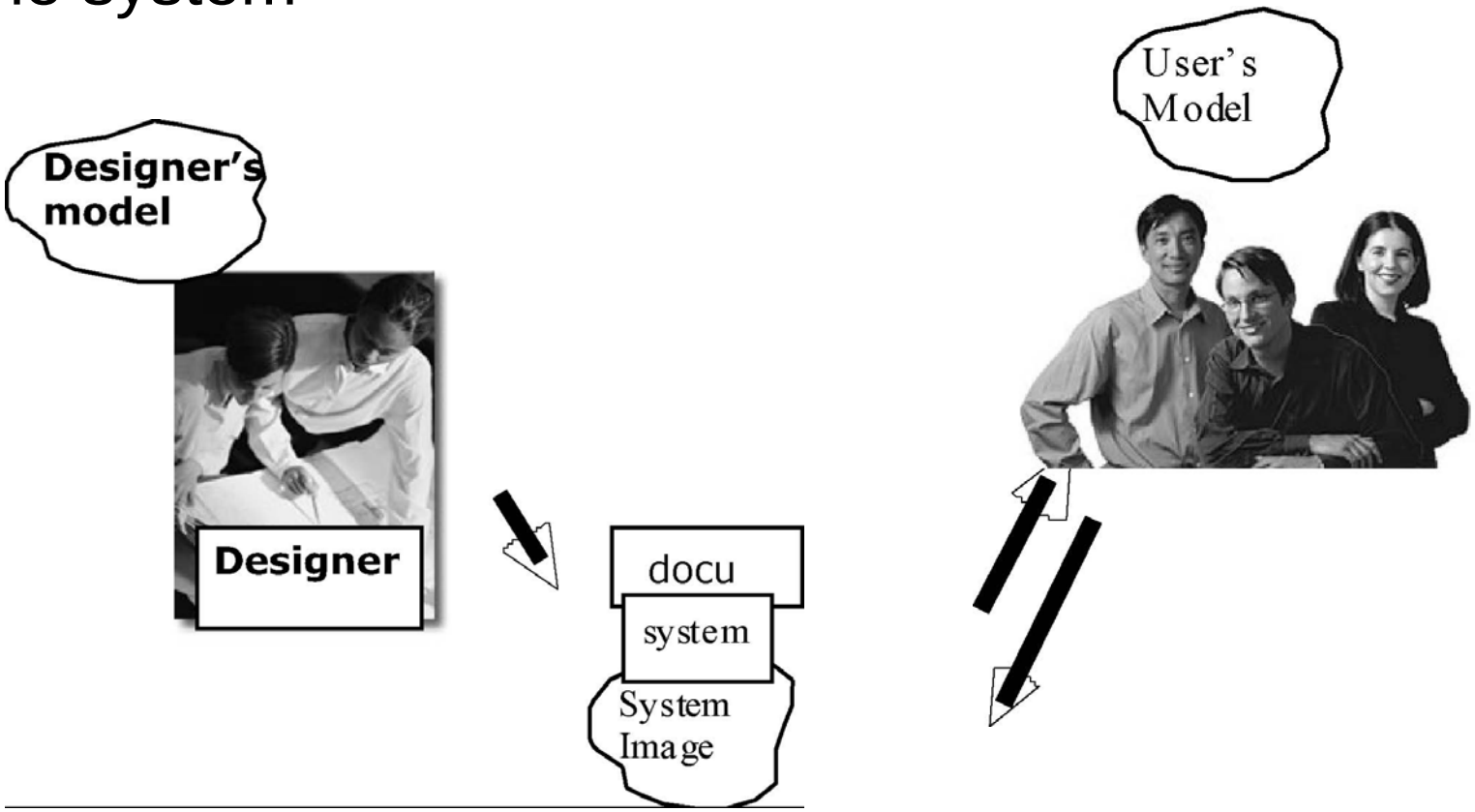
- How to adjust the controls?
- The previous answer (keep the numerical setting unchanged. Change the alphabetic setting, C -> B) will not be exactly correct anymore.
- Correct answer: lower control A (C-> B), and lower control B (5->4) to reduce the air going to freezer.
- Exactly how much, you'd have to find out in 24 hours

User’s and designer’s mental models

- *Designers* of (physical) systems construct their mental models of how the system should function. This is called the *designmodel.*
- *The user’s model:* Users develop their own mental models of how their tasks should be accomplished, and through interacting with the system.
- *System image*: this is the mental model that users derive from interacting with the (physical) structure. This image is the onlyway designers communicate to users.

Gulf of execution

- *Gulf of execution* is the distance between user's goals and the methods disposable to achieve them through the system



Mental model: Principle 2

- Close the gap between designer's and user's models
  - user analysis helps minimizing this gap (see user-centered design for more detail on user analysis)
- Correctly *convey* the designer's model via the system image – more on this topic later

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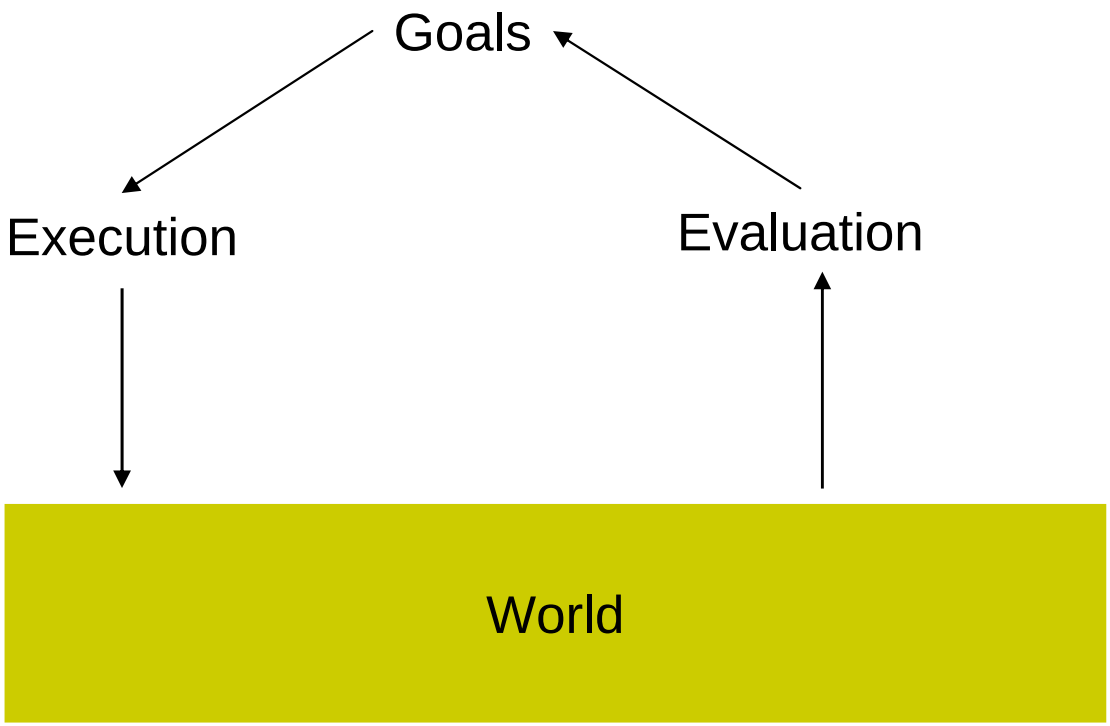
Problem solving

According to American heritage dictionary: “problem solving is the process of devising and implementing a strategy for finding a solution or for transforming a less desirable condition into a more desirable one”.

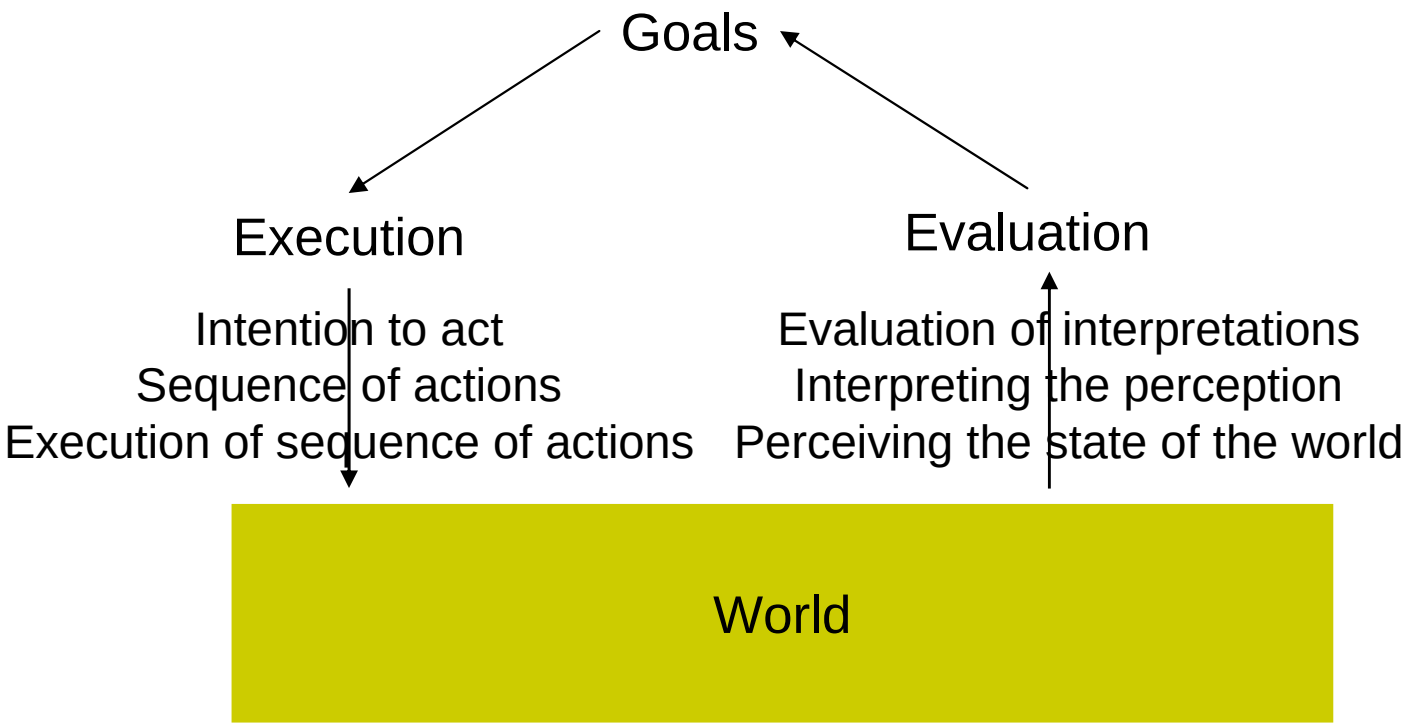
When solving problems, we

1. Set up goals
2. Plan our actions
3. Execute actions
4. Evaluate if actions help us achieve goals
5. Change strategies if necessary

Problem solving cycle



Problem solving cycle in more details



Norman’s action cycle

- Execution has three stages:
  1. Start with a goal
  2. Translate into an intention
  3. Translate into a sequence of actions
- Now execute the actions
- Evaluation has three stages:
  1. Perceive world
  2. Interpret what was perceived
  3. Compare with respect to original intentions

Gulf of evaluation

- The gulf of evaluation is the *amount of effort* a person must exert to interpret
  - the physical state of the system
  - how well the *expectations and intentions* have been met
  - how a user's model matches with the designers' model
- We want a small gulf!

Correct MM but problem solving fails

- Heating control device
- Mental model was correctly derived, but problem solving failed.

Mental model and website navigation

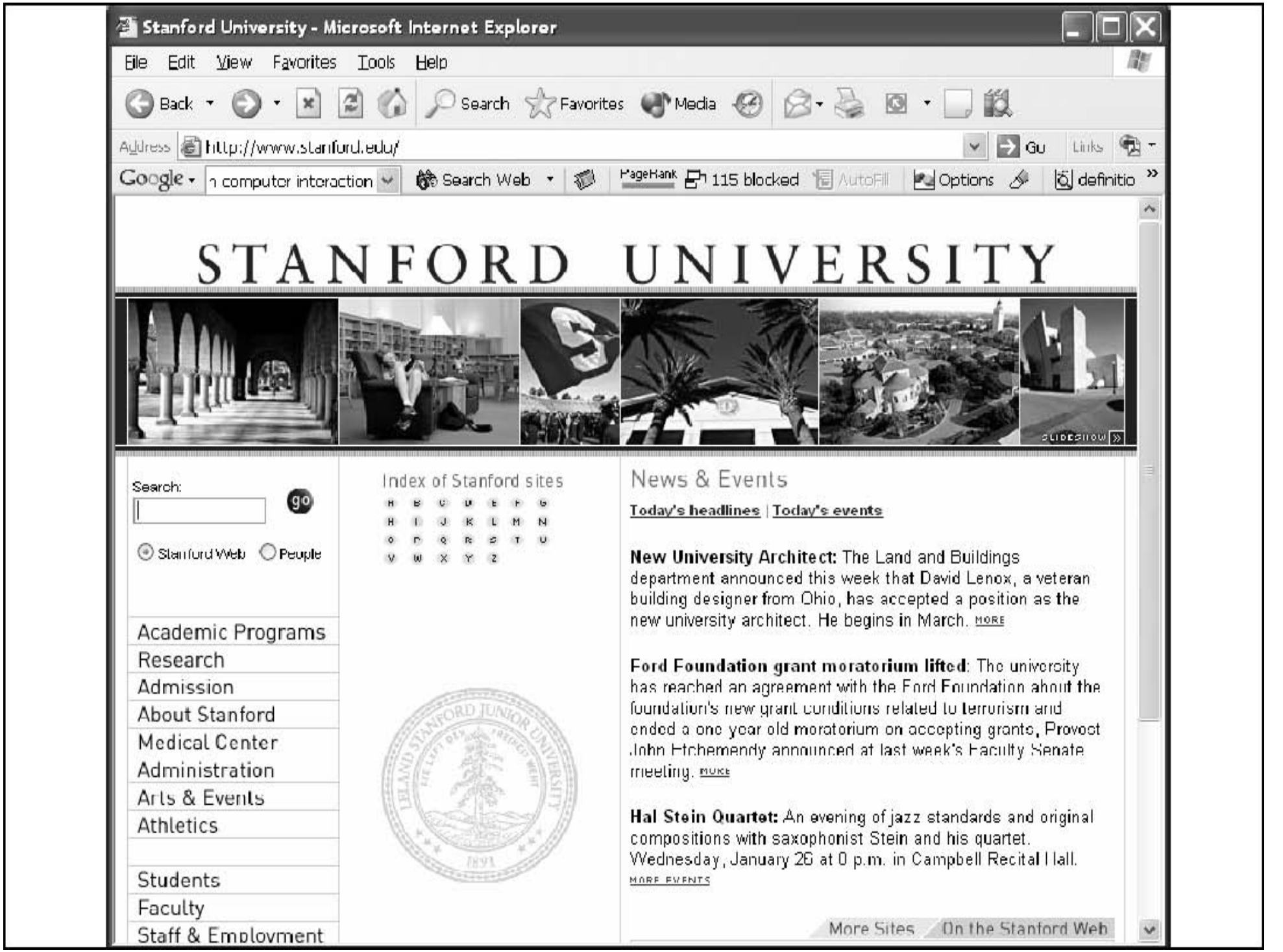
- The design of a good website establishes a correct mental model for its users
- The mental model then helps users navigate through its website
- Examples: university websites
  - The goals of a university website
  - Provide information to outsiders about the organizational structure of a university
  - Provide information to university users
  - Etc.

Two users

- Let us imagine a student who is interested in obtaining a master degree in computer science
- She comes up with a list of universities where she wants to get some information on the master degree program and downloads an application form
- Before she goes to a particular site, what kind of mental model she anticipates?

Mental model

- University is an organization
- Organization has structures (departments)
- Each unit has substructures
- When I get to the target subunit, I hope to find detailed information
  - What will I study if I choose computer science?
  - If I decide to study computer science, how do I apply ?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New University Architect: The Land and Buildings department announced this week that David Lenox, a veteran building designer from Ohio, has accepted a position as the new university architect. He begins in March. MORE
Ford Foundation grant moratorium lifted: The university has reached an agreement with the Ford Foundation about the foundation's new grant conditions related to terrorism and ended a one year old moratorium on accepting grants, Provost John Etchemendy announced at last week's Faculty Senate meeting. MORE
Hal Stein Quartet: An evening of jazz standards and original compositions with saxophonist Stein and his quartet. Wednesday, January 26 at 0 p.m. in Campbell Recital Hall.
MORE EVENTS
More Sites On the Stanford Web

Stanford University

In 4 clicks, I get a page called “Consider CS?”

-> departments

-> computer science

-> master degrees

-> official program description

1 more clicks, . -> admissions

Computer science graduate admissions

A small exercise

- Compare these four university websites (you may add your favourite ones) and make some comments about whether the site designer has succeeded in conveying a correct mental model
- Compare the navigation paths the user has to take in order to find the information and download the applications. Then comment on the site design.

How to critique a website design?

- Describe the situation or context
- Describe the problem
- Show evidence with screen shots or photographs
- Rate the severity of problem
- Propose solutions

Informative feedback: help user eval.

- *Informative feedback*: the return of information about the result of a process
- Via feedback, users can gauge the effects of their actions.
- Two types of feedbacks can be identified : *articulatory* and *semantic*.
  - Articulatory feedback confirms users' haptic skills r.s.p. to the choices as users go through them;
  - Semantic feedback confirms users' cognitive skills r.s.p the choices as users go through them.

Examples

- Objects that give articulatory feedback
  - surgery simulation tools which provide force feedback;
  - isomorphic joysticks and trackpoints (provides force feedback)
  - Keyboards
- Objects that give semantic feedback
  - Progress bar
  - Confirmation messages of user actions
  - ….

Give users appropriate status indicators

- Don’t forget the time device when an operator requires waiting.
- A continuously moving (or animated) device is known to help users relax, like having an aquarium in one’s office.

How quickly a feedback should be given?

- How users perceive delays
  - 0.1 second max: perceived as “instantaneous” 1 seconds max: user’s flow of thought stays uninterrupted, but delay noticed 10 seconds: limit for keeping user’s attention focused on the dialog
  - > 10 seconds: user will want to perform other tasks while waiting

Task closure

- *Task closure* – the end of all steps involved in accomplishing a task
- Designers should allow users to reach the task closure without having to distract their attention by forcing them to work in different windows, traversing a long list of choice items.
- Designers should focus users by providing clear cues for context switching if side paths are necessary

How do people accomplish complex tasks?

- When a problem chunk is too big, there are two commonly known ways to divide a task: top-down or bottom up
- In the *top-down* approach, a user divides a task into subtasks, then divides subtasks into sub-subtasks. Then he solves a small unit of the problem, and backtracks to upper levels in order to proceed

How do people accomplish complex tasks?

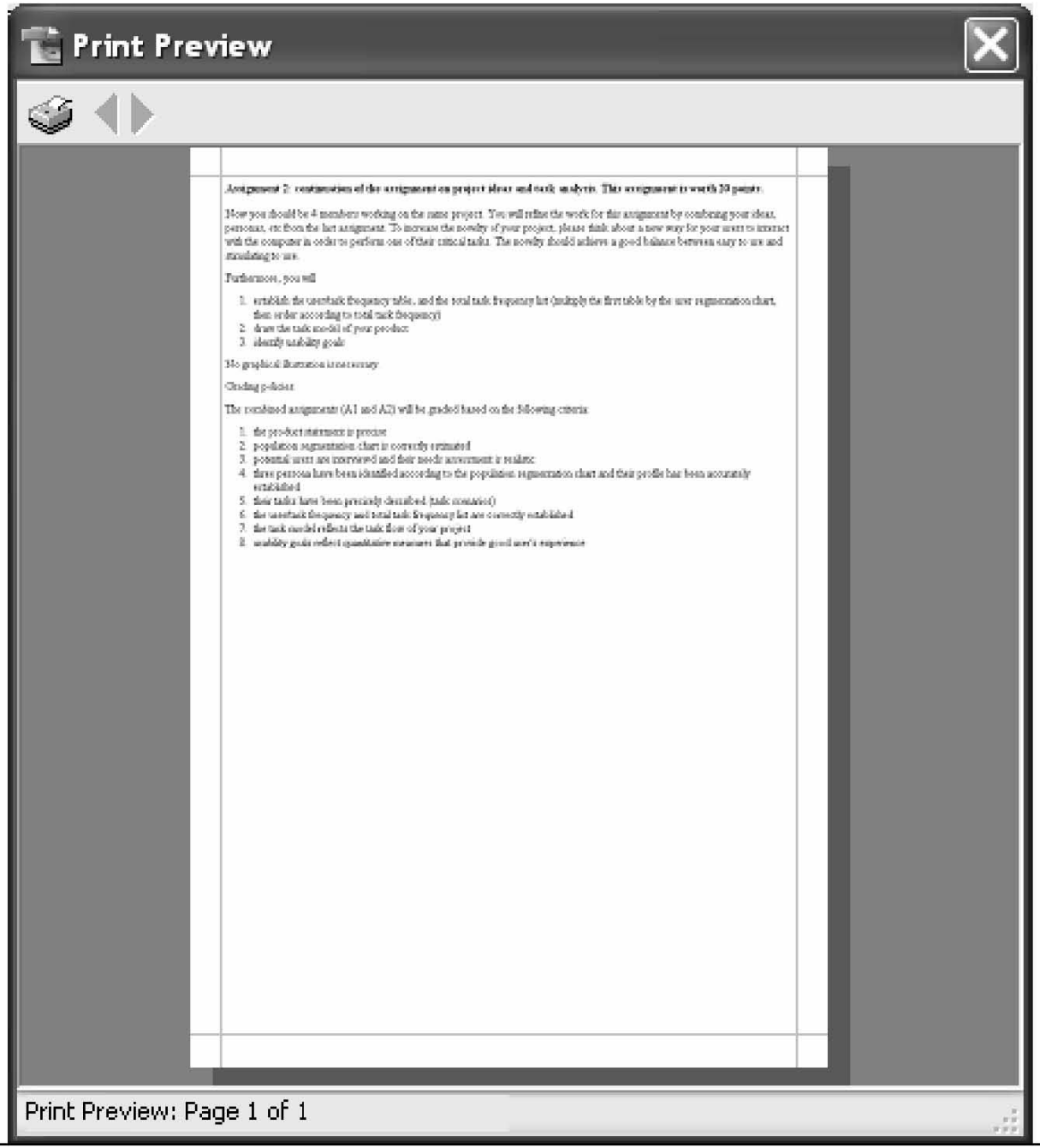
- In the *bottom up* approach: a user constructs solutions to small chunks of problems. Then he constructs a bigger solution by combining small solutions.
- In reality, people employ a hybrid approach.
- Example: writing a scientific article

Stacking of sub-problems

- When solving problems in the top-down approach, intermediate solutions need to be memorized (stacking of solutions).
- This way, the user can concentrate on solving small tasks at the bottom level.
- In the bottom-up approach, sufficient methods should be provided to combine small solutions.

Do not assume the normal task closure

- What is wrong with the following graphical user interface (GUI)?


Print Preview
Assignment 2: continuation of the assignment on project ideas and task analysis. This assignment is worth 10 points.
Now you should be 4 members working on the same project. You will refine the work for the assignment by combining your ideas, personas, etc from the last assignment. To increase the novelty of your project, please think about a new way for your users to interact with the computer in order to perform one of their crucial tasks. The novelty should achieve a good balance between easy to use and stimulating to use.
Furthermore, you will
1. establish the user/task frequency table, and the total task frequency list (multiply the first table by the user representation chart, then order according to total task frequency)
2. draw the task model of your product
3. identify usability goals
No graphical illustration is necessary
Grading policy
The combined assignment (A1 and A2) will be graded based on the following criteria
1. the product statement is precise
2. population representation chart is correctly estimated
3. potential users are interviewed and their needs assessment is realistic
4. three personas have been identified according to the population representation chart and their profile has been accurately established
5. their tasks have been precisely described (task scenarios)
6. the user/task frequency and total task frequency list are correctly established
7. the task model reflects the task flow of your project
8. usability goals reflect quantitative measures that provide good user's experience
Print Preview: Page 1 of 1

Answer

- You have to print. If you are not satisfied with the way it looks, you cannot cancel the printing job.

Multitasking (when attention can be divided)

- People are accustomed to carry out numerous tasks at the same time.
- But in a demanding environment like the cockpit, when multitasking is performed, humans need cognitive aids to get reminded of certain crucial moments.

Routinized tasks

- A *routine* task: a prescribed, detailed course of action to be followed regularly; a standard procedure.
  - reading, writing, speaking in a native language, riding a bike, typing, putting your foot on the gas pedal, and even skiing.
- The execution of these tasks eventually becomes automatic.

Difficult tasks

- Certain tasks, however, remain difficult, such as spelling your name backward, programming a piece of code, or drawing something meaningful.
- That’s called problem-solving which requires full attention.
- Humans can do one problem-solving task at any given time, while they may be able to perform several routine tasks simultaneously, or one problem-solving and one routine task simultaneously.

What can be routinized?

- The so-called sensory-motor tasks can often be made automatic
- Cognitive tasks are more difficult to be made automatic.
- However, it is easier to change a controlled process than a routine process.
- Try to drive your friend’s car (in england), or type the text on an american keyboard.

Consequence to interface design?

- Make most interaction activities as routine as possible
- Users can concentrate on problem solving
- Try to be as consistent as possible with assignment of key strokes.
  - Ctrl-P for printing
  - Later Ctrl-P for page layout or next page
  - Once learned, it’s difficult to unlearn the routine tasks.