Design of Everyday Things

Design of everyday things

- Summary so far:
  - many so-called human errors are actually errors in design
  - human factors became important as human performance limitations reached when handling complex machinery
- You will soon know these important concepts for designing everyday things
  - Affordances
  - Conceptual models
  - Mapping
  - Constraints
  - To Err is Human
  - Causality
  - why design is hard

Affordances

- 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.
  - A chair affords ("is for") support and, therefore, affords sitting.
  - Glass is for seeing through, and for breaking.
  - Wood is used for solidity, opacity, support, or carving.
  - Flat, porous smooth surfaces are for writing on. So wood is also for writing on.

Affordances

- Affordances provide strong clues to the operations of things.
  - Plates are for pushing.
  - Knobs are for turning.
  - Slots are for inserting things into.
  - Balls are for throwing or bouncing.
- The user knows what to do just by looking: no picture, label, or instruction is required.
- Complex things may require explanation, but simple things should not.
- When the simple things need pictures labels, or instructions, the design has failed.

Perceived Affordance

- The perceived properties of the object that suggest how one could use it

chairs are for sitting
table for placing things on

knobs are for turning

slots are for inserting
handles are for turning

buttons are
for pressing

switch for toggling

computer for…

Many concepts in this section are adapted from Don Norman's book: The Design of Everyday Things

Perceived Affordances

- Product design
  - perceived affordances:
    - design invites people to take possible actions
  - actual affordances:
    - the actual actionable properties of the product
- Problems occur when
  - these are not the same,
  - people's perceptions are not what the designer expects

In-depth discussion available at www.jnd.org/dn.mss/affordances-and-design.html

Perceived Affordances

Perceived Affordance Problems

Perceived Affordances

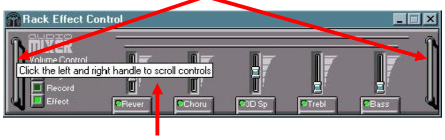
- GUI design
  - perception only through visuals
  - designer creates appropriate visual affordances via
    - familiar idioms
    - metaphors

Perceived Affordances

Perceived Affordance Problems

Perceived Affordance Problems

- Handles are for lifting,
  but these are for scrolling!



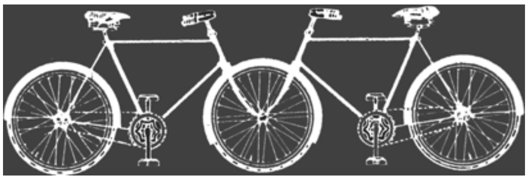
- Complex things may need explaining but simple things should not
  - when simple things need labels & instructions, then design has failed

AudioRack 32, a multimedia applicaiton

Conceptual model

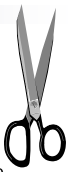
- People have “mental models” of how things work, built from
  - affordances
  - causality
  - constraints
  - mapping
  - positive transfer
  - population stereotypes/cultural standards
  - instructions
  - interactions
- models allow people to mentally simulate operation of device
- models may be wrong
  - particularly if above attributes are misleading

Conceptual model



- Consider the Carelman’s Tandem “Convergent Bicycle” in the above figure.
- You know it won’t work because you form a conceptual model of the device and mentally simulate its operation.
- Other clues to how things work come from their visible structure in particular from *affordance*, *constraints*, and *mappings*.

Good example: Scissors



- affordances:
  - holes for something to be inserted
- constraints:
  - the sizes of the holes provide constraints to limit the possible fingers
- mapping:
  - between holes and fingers suggested and constrained by appearance
- conceptual model:
  - implications clear of how the operating parts work

Bad example: Digital watch

- affordances:
  - four push buttons to push, but not clear what they will do
- constraints and mapping unknown
  - no visible relation between buttons, possible actions and end result
- transfer of training
  - little relation to analog watches
- cultural idiom
  - somewhat standardized core controls and functions
  - but still highly variable
- conceptual model:
  - must be learnt

Fundamental principles of designing for people

- Provide a good conceptual model
- Make things visible.
- A good mapping
- Feedback

- Provide a good conceptual model
  - A good conceptual model allows us to predict the effects of our actions.
  - Some products are made difficult because the manufacturer provides a false conceptual model.

Fundamental principles of designing for people

- Make things visible
  - Whenever the number of possible actions exceeds the number of controls, there is about to be difficulty.
  - The telephone system has twenty four functions, yet only fifteen controls – none of them are labeled for specific action.

  - Functions are invisible, hidden from sight.
  - Controls of the car are visible and, through their location and mode of operation.
  - Visibility acts as a good reminder of what can be done and allows the control to specify how the action is to be performed.

Fundamental principles of designing for people

- Good mapping
  - It is possible to determine the relationships between actions and result, between the controls and their effects, and between the system state and what is visible.
- Feedback
  - The user receives full and continuous feedback about the results of actions.

The principle of Mapping

- The relationship between two things, in this case between the controls and their movements and the results in the world.
- Natural mapping, physical analogies and cultural standards, leads to immediate understanding.
- Spatial analogy:
  - to move an object up, move the control up.
  - To control an array of lights, arrange the controls in the same pattern as the lights.
- Some natural mappings are cultural or biological, as in the universal standard that a rising level represents more, a diminishing level, less. Similarly, a louder sound can mean a greater amount.

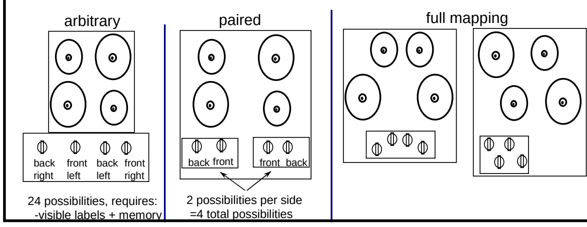
The principle of Mapping

- A device is easy to use when there is visibility to the set of possible actions, where the controls and displays exploit natural mappings.
  - BAD Example: Front/Rear speaker selector of an automobile radio. Rotating the knob left right makes the sound come entirely out of the front or rear.
  - GOOD Example: Seat Adjustment control from a MercedesBenz. The control is the shape of the seat itself.

http://www.roadfly.com/2007-car-review-mercedes-benz-cl-550.html

Mapping

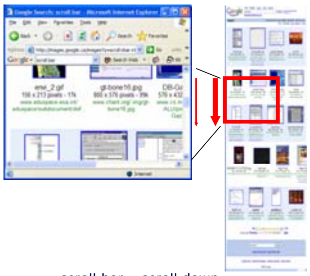
- The set of possible relations between objects
- Control-display compatibility
  - the natural relationship between controls and displays
  - e.g., visual mapping of stove controls to elements



Mapping

- Control-display compatibility
  - cause and effect

steering wheel- turn left, car turns left



scroll bar – scroll down viewport goes down

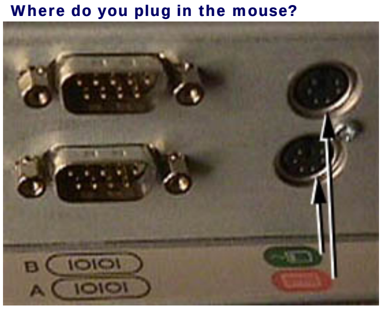
Mapping Problems

Quick, open the top drawer

- Photograph courtesy of www.baddesigns.com

Mapping Problems

Where do you plug in the mouse?



Mapping ambiguous

- Photograph courtesy of www.baddesigns.com

The principle of Feedback

- Feedback- "Sending back to the user information about what action has actually been done, what result has been accomplished" – is a well know concept in the science of control and information theory.
- Imagine trying to talk to someone when you can not hear your own voice, or trying to draw a picture with a pencil that leaves no mark.
- Why are the modern telephone systems so difficult to learn and to use? Basically, the problem is that the systems have more features and less feedback.

Knowledge in the Head and in the World

- Why the apparent discrepancy between the precision of behavior and the imprecision of knowledge?
  - Not all the knowledge required for precise behavior has to be in the head.
  - It can be distributed partly in the head, partly in the constraints of the world

Information is in the world

- There is a tradeoff between speed and quality of performance and mental effort.
- Typing
  - Without looking at a keyboard: you remember a keyboard layout by using information in the head
  - Looking at labels on the keyboard: you are taking information from the world
- Learning is to get information from the world to the head
  - Increase speed and accuracy
  - Decrease mental effort

Information is in the world

- People function through their use of two kinds of knowledge:
  - Knowledge of (Declarative Knowledge) includes the knowledge of facts and rules
    - Stop at the red lights
    - Huahin is located to the south of Bangkok
  - Knowledge how (Procedural Knowledge) is the knowledge that enables a person to
    - Perform music
    - Stop a car smoothly with a flat tire on an icy road.

Great Precision is not Required

- People can remember enough to distinguish one familiar coin from another although they may be unable to remember the faces, pictures, and words on the coins.

www.about.com

Great Precision is not Required

- What's in the bottle?
  - A lot of manufacturers package both shampoo and conditioner in nearly identical bottles.
  - You ought to be able to easily distinguish between them in the shower without your glasses on.

http://www.baddesigns.com/

Memory is Knowledge in the Head

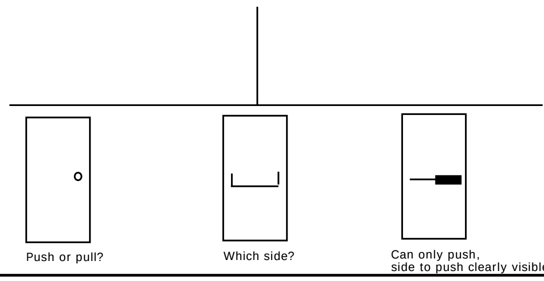
- A combination, or a password, or the secret to opening the door.
- When the number of secret codes gets too large, memory fails.
- Most of us can't, even with the use of mnemonics to make some sense of nonsensical material.
- Therefore, we put the memory in the world, writing things down in books, on paper or even back of our hands.

Knowledge in the World and in the Head

- If a design depends upon labels, it may be faulty.
- Labels are important and often necessary for them.
- Whenever labels seem necessary, consider another design
- Knowledge in the world acts as its own reminder
- Knowledge in the head is efficient: no search and interpretation of the environment is required
- However, it might require considerable amounts of learning.

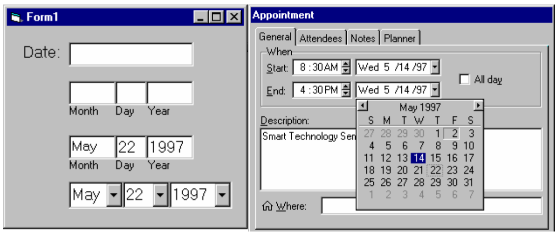
Constraints

- Limitations of the actions possible perceived from object's appearance
  - provides people with a range of usage possibilities



Constraints: Entering a Date

- The more constraints, the less opportunity for error
  - particularly important for managing user input



Controls constructed in Visual Basic

A Classification of Everyday Constraints

- Physical Constraints
- Semantic Constraints
- Cultural Constraints
- Logical Constraints

http://www.lego.com

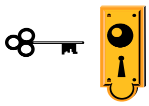
Physical Constraints

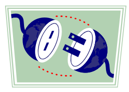
- Physical constraints limited what part would fit together
  - Large peg cannot fit into a small hole
  - Windshield would fit in only one place, with only one orientation
- With the proper use of physical constraints there should be only a limited number of possible action

http://www.lego.com

Physical Constraints

- The everyday door key can be inserted into a vertical slot only if the key is held vertically.
- However, this still leave two possible orientations.
- A well design key will either work in both orientations or provide a clear physical signal for the correct one. (Automobile key)





Semantic Constraints

- Semantic constraints rely upon the meaning of the situation to control the set of possible actions.
- There is only meaningful location for the rider, who must sit facing forward.
- Semantic constraints rely upon our knowledge of the situation and of the world.

http://www.lego.com

Cultural Constraints

- Red is the culturally defined standard for a stop light, which place in the rear.
- White or yellow (in Europe) is the standard color for headlights which go in the front.
- Each culture has a set of allowable actions for social situations

http://www.lego.com

Logical Constraints

- Logic dictated that all the pieces should be used, with no gaps in final product
- Consider lights in motorcycle, many people had no cultural or semantic information that would help them place the blue light.
- For them, logic provides answer: only one piece left, only one possible place to go

http://www.lego.com

Logical Constraints

- Natural mapping work by providing logical constraints, no physical or cultural principles here
- There is a logical relationship between the spatial or functional layout of components and the things that they affect or are affected by.
- If two switches control two lights, the left switch should work the left light, the right switch the right light
- If the lights are mounted one way and the switches another, the natural mapping is destroy

Apply Affordances and Constraints to Everyday Objects

- The problem with doors
- The problem with switches

The problem with doors

- Suppose the door opens by being pushed
- The easiest way is to put a plate at the spot where the pushing should be done.
- A plate, If large enough for the hand, clearly and unambiguously marks the proper action
- However,
  - Doors that should be pulled or slid sometimes has plates.
  - Doors that should be pushed sometimes have both plates and knobs or handle and no plate
- The proper designed will use cultural constraints so that the signal to pull will dominate

The problem with switches

- The switches problems in a auditorium are annoying, but similar problems in airplane and nuclear power plants are dangerous
- There are two difficulties.
  - Grouping problem: how to determine which switch goes with which function
  - Mapping problem: how to determine which light switch control which light

The problem with switches

- Grouping problem solution
  - Set the switches for one set of functions apart from the switches that control other functions
  - Or, use different types of switches (solution can be combined)
- Room lights are arranged in two dimensional structure but switches are arrange in one dimensional row, how can we map?

Visibility and Feedback

- When we use a novel objects, a number of question guide our actions
  - Which parts move; which part fixed?
  - Where should the objected be grasped? Which part is to be manipulated? Where is the had to be inserted?
  - What kind of movement is possible: pushing, pulling, ...etc
  - Etc.
- The important things to watch should be visible and clearly marked the results of any action should be immediately apparent.

Making Visible the Invisible

- No sign of doors or drawers, let alone of how those doors and drawers might be operated.
- Electric switches are often hiding: On Off switch is hidden in the rear.
- Many systems are vastly improved by the act of making visible what was invisible before (VCR)
- Visibility makes all the difference

Making Visible the Invisible

- Examples of adding visibility to everyday devices
  - Display the song titles for compact Discs
  - Display the name of television programs
  - Print the cooking information for foods on the food package in computer-readable form

Using Sound for Visibility

- Sound should be generated so as to give information about the source.
- They should convey something about the actions that are taking place.
- The buzzes, clicks, and hums that you hear while a telephone call is being completed are one good example
- Take out those noises and you are less certain that the connection is being made.

Using Sound for Visibility

- Natural sound is as essential as visual information because sound tells us about things we can't see
- Sound could play an important role in computer-based applications
  - Naturalistic sounds could serve as auditory icons, caricatures of naturally occurring
- The absence of sound can mean an absence of information, and if feedback an action is expected to come from sound, silence can lead to problems

To Err is Human: Slips and Mistakes

- Slip: Form an appropriate goal but mess up in the performance
  - Misplaced action
  - The wrong thing moved (Desired action undone)
- Mistake: Form a wrong goal
  - Difficult to detection since the action performed is appropriate for the goal

Mode Errors

- Occur when devices have different modes of operation and the action appropriate for one mode has different meanings in other modes
- Are likely where the equipment does not make the mode visible
- User is expected to remember what mode has been established
- Example: Digital Watches

Detecting slips

- Easy to detect because there is a clear discrepancy between goal and result
- Detection can only take place if there is feedback
- If the result of the action is not visible, how can a misaction be detected!?

Design Lesson from the Study of Slips

- Preventing slips before they occur
  - Automobile manufacturers try to minimize these errors (a combination of description and mode errors) by making the different compartments look different
    - Size
    - Shape
    - Color
    - Etc

Design Lesson from the Study of Slips

- Detecting and correcting them when they do occur
  - Requiring confirmation before a command will be executed is common for preventing errors
  - When user has requested deletion of the wrong file but the confirmation is unlikely to catch the error
  - User is confirming the action, not the file name
  - Thus asking for confirmation can not catch all slips
- The request to remove a file would be handled by the computer's moving the file to some temporary holding place. Then the user would have time for reconsideration and recovery

Forcing Functions

- Forcing function are a form of physical constraint:
  - The actions are constrained so that failure at one stage prevents the next step from happening
- Forcing function are the extreme case of strong constraints that make it easy to discover erroneous behavior
- There are 3 specialized methods for prevention of accidents interlocks, lockins, and lockouts

Forcing Functions

- Interlock: forces operations to take place in proper sequences
  - The interlock disconnects the power the instant the door of microwave is opened
- Lockin: keeps an operation active, preventing someone from prematurely stopping it
  - Turn off Microsoft office word without first saving their work could be avoided with the use of a locking
- Lockout: prevent someone from entering a place, or preventing an event from occurring
  - Stairways of public building is not to allow simple passage from the ground floor to the basement

The Structure of Tasks

- Wide and Deep structures
  - Good example is a decision trees of tic-tac-toe
  - Wide in sense that at each point in the tree there are many alternatives
  - Deep in the sense that most branches of the tree go on for a considerable distance
- Everyday activities don't require the kind of complex analyses required like tic-tac-toe or chess
- Everyday structures are either shallow or narrow

http://en.wikipedia.org/wiki/Game_tree

The Structure of Tasks

- Shallow structures
  - Ice cream store provides a good example of a shallow structure
  - There are many alternative actions, but each is simple
  - The major problem is to decide which action to do

http://www.arkivatropika.com/cgi-bin/tags.cgi?tags="hawaii"

The Structure of Tasks

- Narrow Structures
  - A cookbook recipe is a good example of a narrow structure
  - A narrow structure arise when there are only a small number of alternatives, perhaps one or two.

http://en.wikipedia.org/wiki/Game_tree

The Nature of Everyday Tasks

- Everyday activities must usually be done relatively quickly, often simultaneously with other activities
- Neither time nor mental resources may be available
- As a result, everyday activities structure themselves so as to minimize conscious mental activity, which means they must minimize planning and mental computation.
- If the structure is narrow, depth is not important
- If the structure Is shallow, width is not important

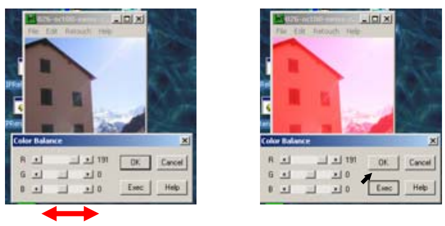
http://en.wikipedia.org/wiki/Game_tree

Causality

- the thing that happens right after an action is assumed by people to be caused by that action
  - interpretation of "feedback"
  - false causality
    - incorrect effect
      - invoking unfamiliar function just as computer hangs
      - causes "superstitious" behaviors
    - invisible effect
      - command with no apparent result often re-entered repeatedly
      - e.g., mouse click to raise menu on unresponsive system

Causality Problems

- Effects visible only after Exec button is pressed
  - Ok does nothing!
  - awkward to find appropriate color level



LViewPro

Proverbs on individual differences

- You do **not** necessarily represent a good average user of equipment or systems you design
- Do not expect others to think and behave as you do, or as you might like them to.
- People vary in thought and behaviour just as they do physically

Why design is hard

- Over the last century
  - the number of things to control has increased dramatically
    - car radio: AM, FM1, FM2, 5 pre-sets, station selection, balance, fader, bass, treble, distance, mono/stereo, dolby, tape eject, fast forward and reverse, etc (while driving at night!)
  - display is increasingly artificial
    - red lights in car indicate problems vs flames for fire
  - feedback more complex, subtle, and less natural
    - is your digital watch alarm on and set correctly?
  - errors increasing serious and/or costly
    - airplane crashes, losing days of work...

Why design is hard

- Marketplace pressures
  - adding functionality (complexity) now easy and cheap
    - computers
  - adding controls/feedback expensive
    - physical buttons on calculator, microwave oven
    - widgets consume screen real estate
  - design usually requires several iterations before success
    - product pulled if not immediately successful

Why design is hard

- People consider cost and appearance over design
  - bad design not always visible
  - people tend to blame themselves when errors occur
    - "I was never very good with machines"
    - "I knew I should have read the manual!"
    - "Look at what I did! Do I feel stupid!"
  - eg the new wave of cheap telephones:
    - accidentally hangs up when button hit with chin
    - bad audio feedback
    - cheap pushbuttons—mis-dials common
    - trendy designs that are uncomfortable to hold
    - hangs up when dropped
    - functionality that can't be accessed (redial, mute, hold)

What you now know

- Many human errors are actually errors in design
  - don't blame the user!
- Designers help by providing a good conceptual model
  - affordances
  - causality
  - constraints
  - mapping
  - positive transfer
  - population stereotypes and idioms
- Design to accommodate individual differences
  - decide on the range of users
- Design is difficult for reasons that go beyond design

User-Centered Design

- Design should
  - Make it easy to determine what actions are possible at any moment (Make use of constraints)
  - Make things visible, including the conceptual model of the system, the alternative actions, and the results of actions
  - Make it easy to evaluate the current state of the system
  - Follow natural mapping between intentions and the required action
- Make sure that
  - The user can figure out what to do
  - The user can tell what is going on

Seven Principles Transforming Difficult Tasks into Simple One

- Use both knowledge in the world and knowledge in the head
- Simplify the structure of tasks
- Make things visible
- Get the mapping right
- Exploit the power of constraints
- Design for error
- When all else fails, standardize

References

- http://pages.cpsc.ucalgary.ca/~saul/wiki/pmwiki.php
- Donald Norman "Design of Everyday Things"