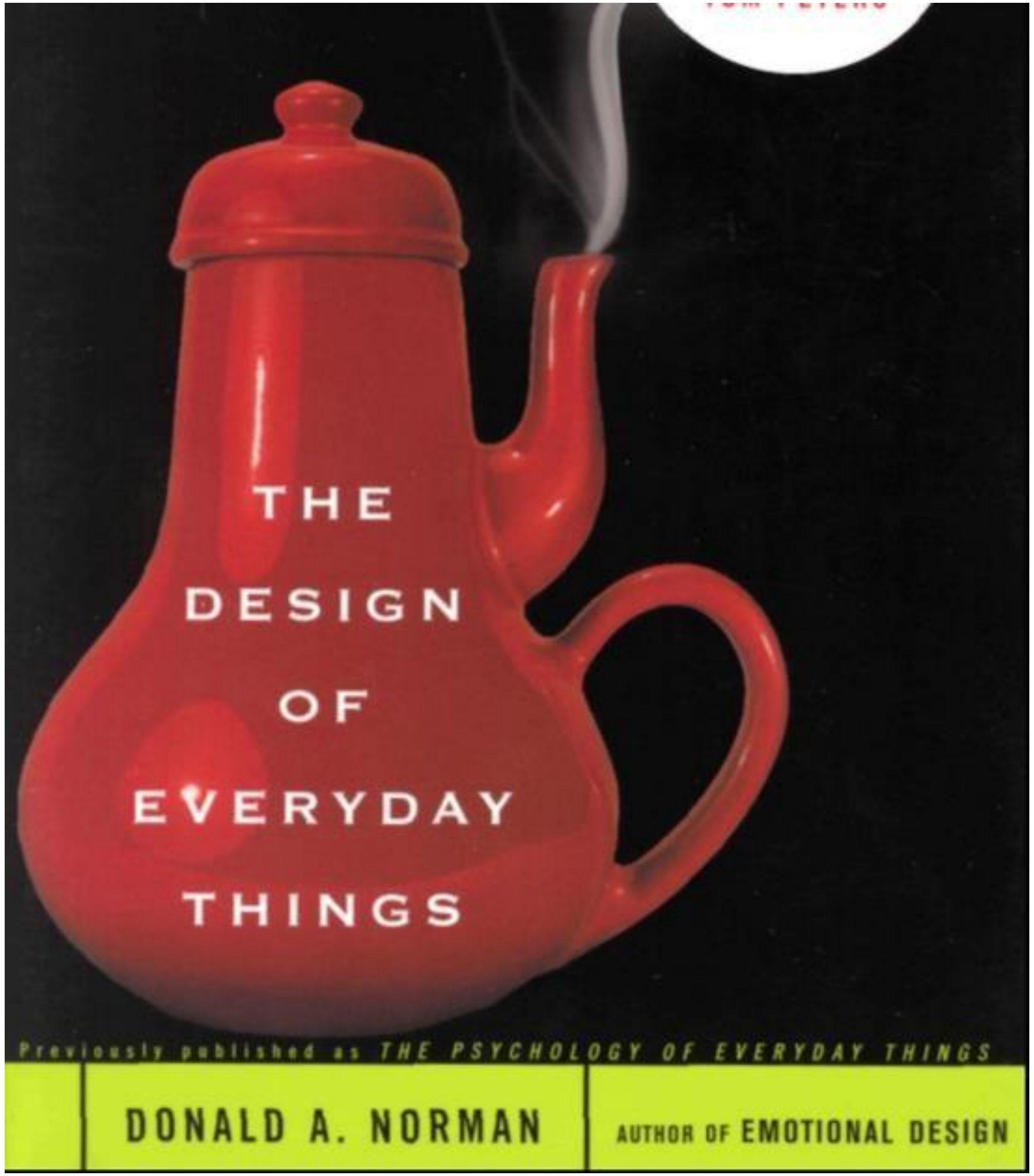
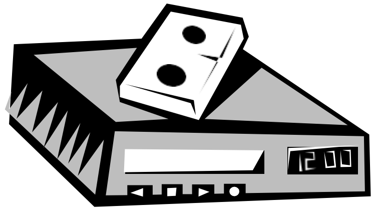
Fundamentals of Design


THE
DESIGN
OF
EVERYDAY
THINGS
Previously published as THE PSYCHOLOGY OF EVERYDAY THINGS
DONALD A. NORMAN
AUTHOR OF EMOTIONAL DESIGN

Daily Challenges

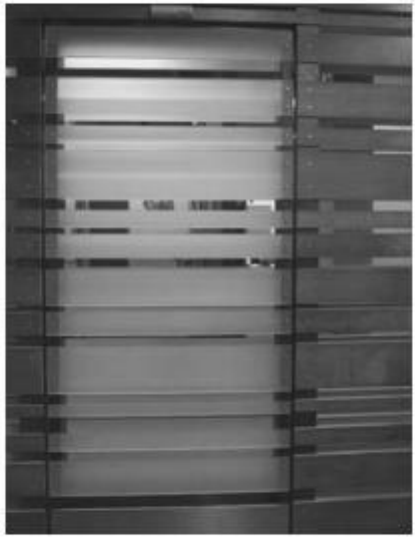


- How many of you can use all the functionality in your
  - Digital watch
  - Copy machine
  - Stereo system
  - Washing machine
  - Plumbing fixtures

  - Many of these things can be difficult to interpret and frustrating to use if they provide no clues or false clues as to how they operate

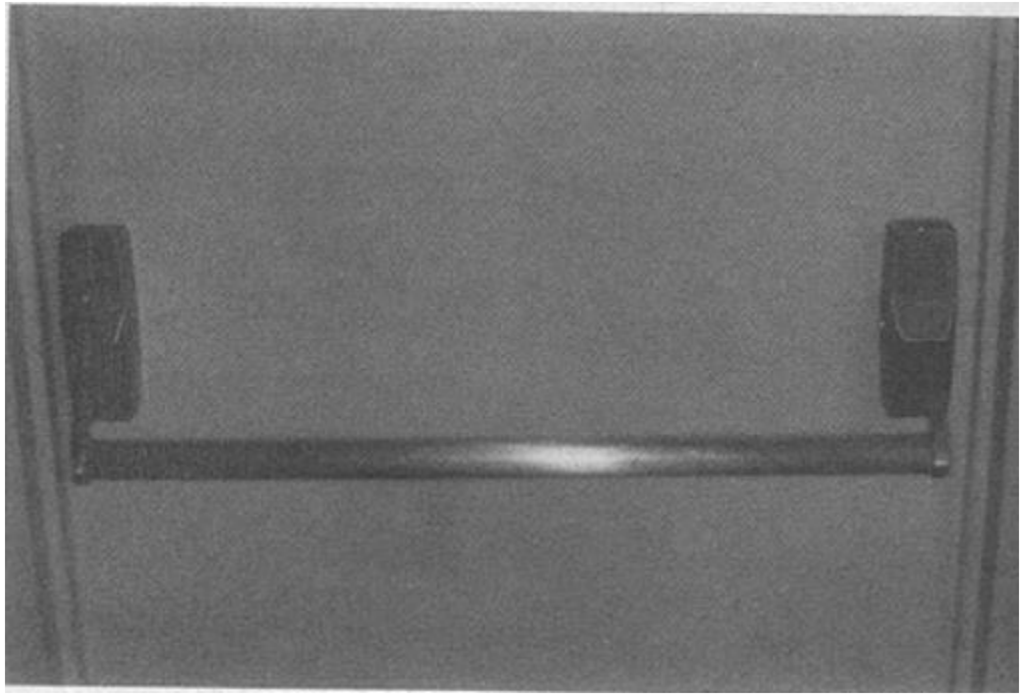
- Some doors slide to open, some need to be pushed, some pulled;
- some faucets need to be pushed, some pulled, and some operate by running one’s hand under them

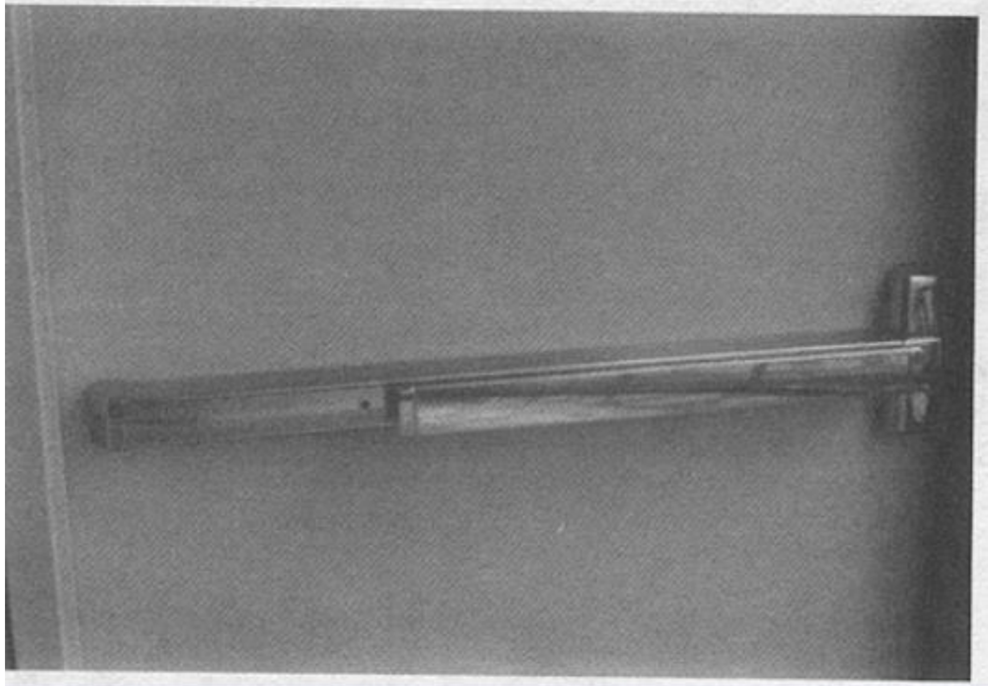
- Which side to push?



c.

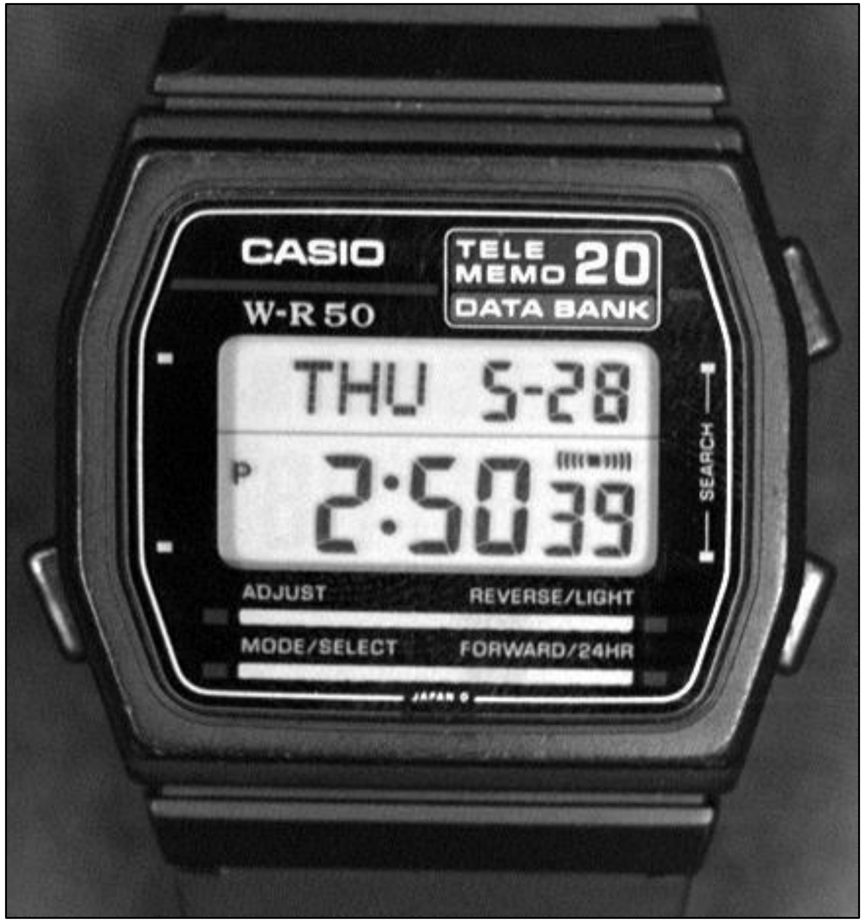
- With doors that push, the designer must provide signals that naturally indicate where to push.
- Put a vertical plate on the side to be pushed. Or make the supporting pillars visible.
- The vertical plate and supporting pillars are natural signals, naturally interpreted, making it easy to know just what to do: no labels needed.

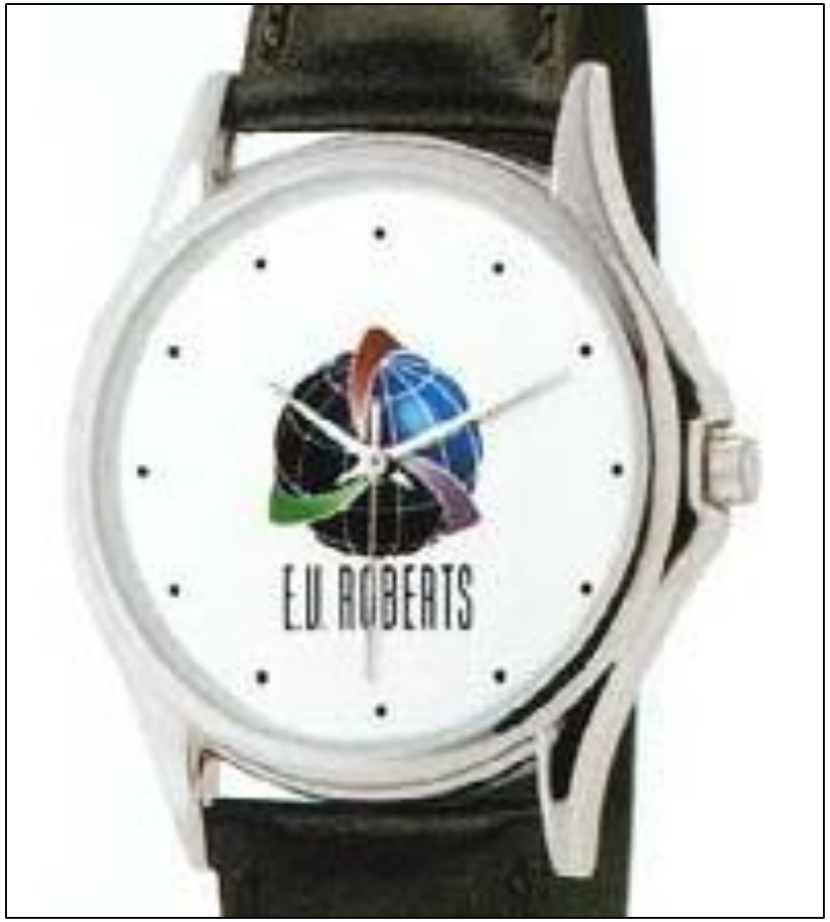




4.3 **Doors in Two Commercial Buildings.** Pushing the bar opens the door, but on which side do you push? Bar *A* (above) hides the signal, making it impossible to know on which side to push. A frustrating door. Bar *B* (below) has a flat plate mounted on the side that is to be pushed; this is a naturally interpreted signal. A nice design, no frustration for the user.

Which is Faster for Setting Time?





- Well designed objects are easy to interpret and understand
- They contain visible clues to their operation.
- Poorly designed objects can be difficult and frustrating to use. They provide no clues— or sometimes false clues.
- They trap the user and thwart the normal process of interpretation and understanding.
- The result is a world filled with frustration, with objects that cannot be understood, with devices that lead to error.

What is usability?

Usability is a measure of the **effectiveness**, **efficiency** and **satisfaction** with which specified users can achieve specified goals in a particular environment.

- ISO 9241

Why is usability important?

- poor usability results in
  - anger and frustration
  - decreased productivity in the workplace
  - higher error rates
  - physical and emotional injury
  - equipment damage
  - loss of customer loyalty
  - lost money

Usability is defined by Five quality components:

Learnability: How easy is it for users to accomplish basic tasks the first time they encounter the design?

Efficiency: Once users have learned the design, how quickly can they perform tasks?

Memorability: When users return to the design after a period of not using it, how easily can they re-establish proficiency?

Errors: How many errors do users make, how severe are these errors, and how easily can they recover from the errors?

Satisfaction: How pleasant is it to use the design?

- Two of the most important characteristics of good design are discoverability and understanding.

1. Discoverability: Is it possible to even figure out what actions are possible and where and how to perform them?

If the functions of a design are not discoverable, they may be used incorrectly and it may lead to frustration. Visibility, affordances, signifiers, constraints, mappings, and feedback. can be used to increase discoverability and reduce possible errors in use.

For example, look at the design of the roundabout in this picture:

If you are just seeing this for the first time , you might be confused as what the purpose of this roundabout is, or what actions you should take to use it properly. You may decide that you should move to the left of the roundabout to turn left. Signifiers are one thing that can be added to a design to increase discoverability. In this case, signs have been added to indicate that you should move counter clockwise around this structure when moving through the intersection.

2. **Understanding:**

What does it all mean? How is the product supposed to be used? What do all the different controls and settings mean?

- With complex devices, discoverability and understanding require the aid of manuals or personal instruction.
- We accept this if the device is indeed complex, but it should be unnecessary for simple things.
- Many products defy understanding simply because they have too many functions and controls.
- simple home appliances—stoves, washing machines, audio and television sets—we simply memorize one or two fixed settings to approximate what is desired.

Norman’s Principles of Design

- When we interact with a product, we need to figure out how to work it. This means discovering what it does, how it works, and what operations are possible: discoverability.
- Discoverability results from appropriate application of following fundamental psychological concepts – visibility, affordances, signifiers, constraints, mappings, and feedback.
- Another principle, perhaps most important of all: the conceptual model of the system. It is the conceptual model that provides true understanding

Visibility

- The correct parts must be visible and they must convey the correct message
- Natural signals are naturally interpreted
- Visibility problems occur when clues are lacking or exist in excess
- Just by looking the user should know
  - State of the system
  - Possible actions
- Don’t violate these principles to make something “look good”!

Visibility

- When functionality is hidden, problems in use occur
  - Occurs when number of functions is greater than number of controls
- When capabilities are visible, it does not require memory of how to use
- Visibility is the basic principle that the more visible an element is, the more likely users will know about them and how to use them.

- Car controls are positioned in a way that they can be easily found and used.
-

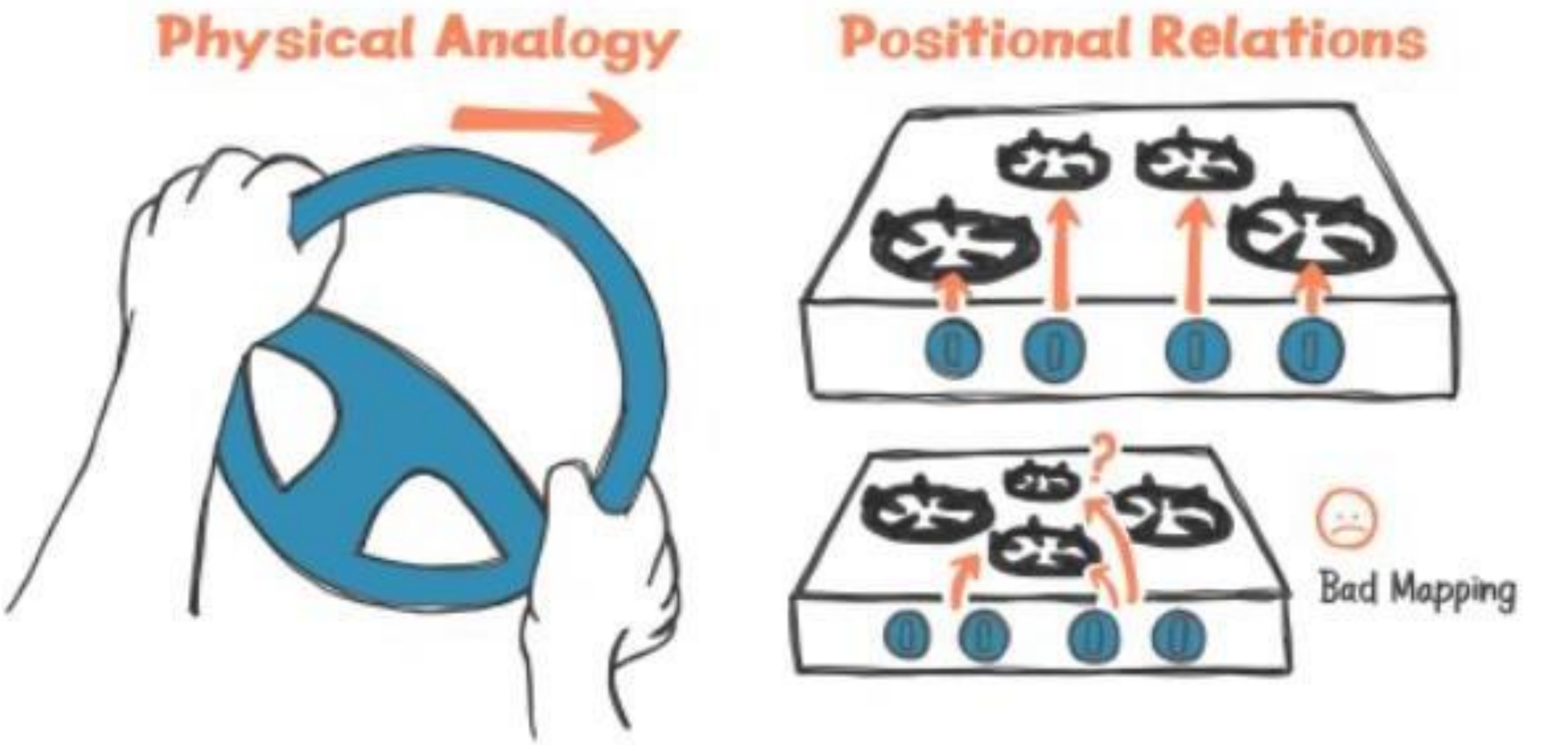
Sensor tap

- auto faucets with sensor technology. How many times have you been not sure how to use it and I to guess where to place your hands? Visible knobs, dials and buttons have been replaced by invisible and ambiguous “active zones”.

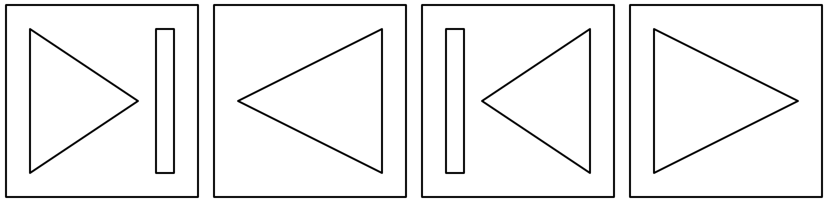
Mapping

- Relationship between control and action/result in the world
- Controls and displays should exploit natural mapping
- Natural mapping takes advantage of physical analogies and cultural standards
  - Physical: Steering wheel
  - Cultural: red means stop, green means go

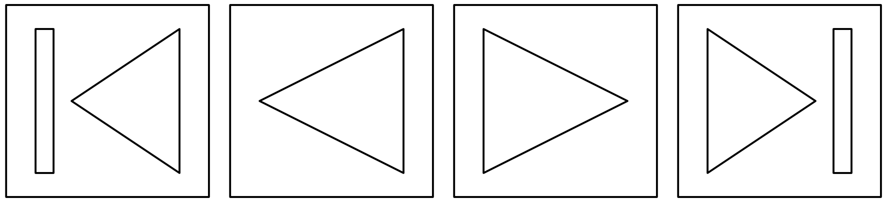
Make users can grasp the correspondence between the point where they operate and the point where the results are reflected.

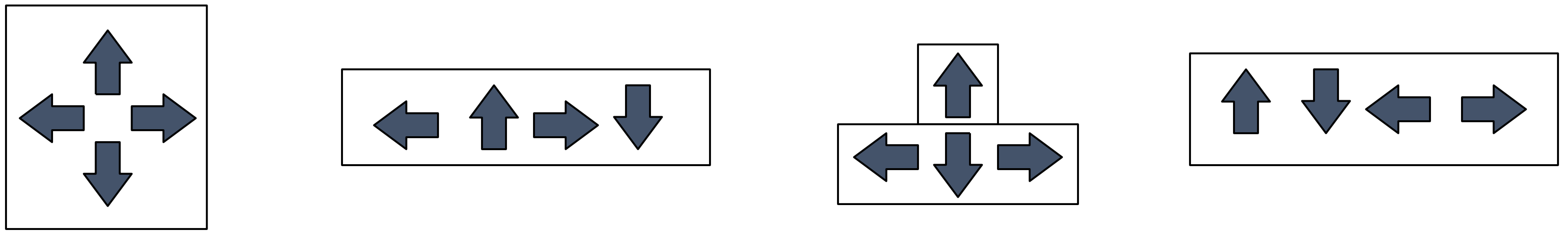


Which is better?



or





- This slider also has a strong mapping, since it's clear moving it to the right will increase it's value versus moving it to the left will decrease it.

- the arrangement of lightswitch that corresponds to the order of the lightbulbs gives us the intuition and ease of control for ourselves.
- Labels are important and often necessary, but the appropriate use of natural mappings can minimize the need for them

- Norman explains, “*when mapping uses spatial correspondence between the layout of the controls and the devices being controlled, it is easy to determine how to use them*”.

Constraints

- constraints are powerful clues, limiting the set of possible actions, in order to let people to readily determine the proper course of action
- Constraints limit the ways in which something can be used
- Helps prevent user from selecting incorrect options
- Constraints can be
  - Physical- when playing with Lego you immediately notice that different blocks match and connect with each other based on physical constraints, which prevents you from matching the wrong pieces together.

Semantic- Semantic constraints are those that rely on upon the meaning of the situation to control the set of possible actions.

As an example, if you are building a car with Lego blocks you will know where to position the wheels, the driver seat, etc because you have knowledge of the situation from the real world.

Stop user from putting head backward on a body

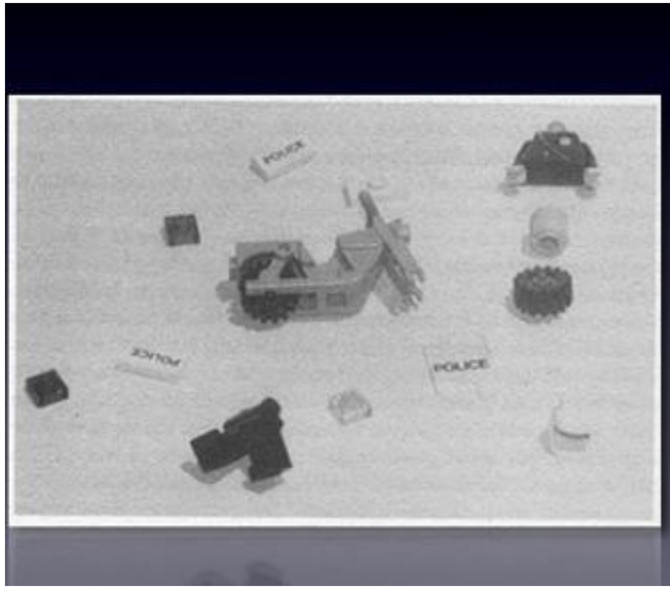
- Cultural- One example of cultural constraint, is the taxi colors. Each country had very well defined car colors for taxis and therefore you would know exactly which car is a taxi and which one is not.

- Logical-Logical constraints are those which use logical relationships to force actions

Eg: such as if you have two lights to control, place two switches and use natural spatial mappings to make them easy to be interpreted.

Example for Cultural Constraints

- only one way you can insert a key into a lock
- batteries

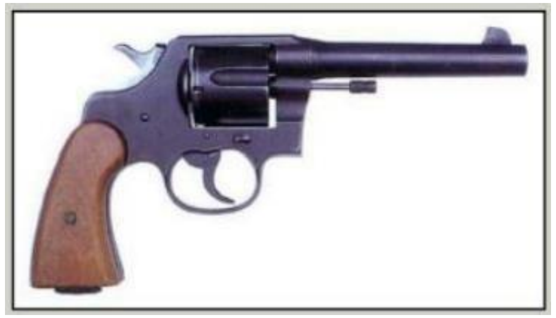


4.1 Lego Motorcycle. The toy is shown assembled and in pieces. The thirteen parts are so cleverly constructed that even an adult can put them together. The design exploits constraints to specify just which pieces fit where. Physical constraints limit alternative placements. Semantic and cultural constraints provide the necessary clues for further decisions. For example, semantic constraints stop the user from putting the head backward on the body and cultural constraints dictate the placement of the three lights (the small rectangles, which are red, blue, and yellow).

Constraint-property of a device that limits its usage

Example:

- The trigger guard of a pistol constrains the number of fingers that can be used to pull the trigger to one (or perhaps two)
- The physical relationship between the grip and the trigger constrains which finger(s) can be used to pull the trigger(eg.not the thumb)
- The engineering of the trigger constrains the direction it can be moved(backward)



- Computer ports are a perfect example of how constraints help identify the possible action

Feedback

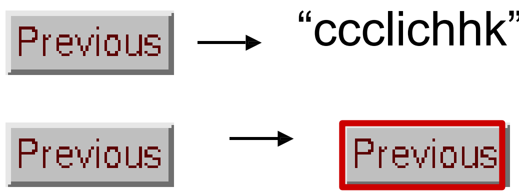
- Feedback is sending back to the user information about what action has actually been done
- Visibility of the effects of the operation tell you if something worked correctly
- Systems should be designed to provide adequate feedback to the users to ensure they know what to do next in their tasks
- Includes sound, highlighting, animation and combinations of these

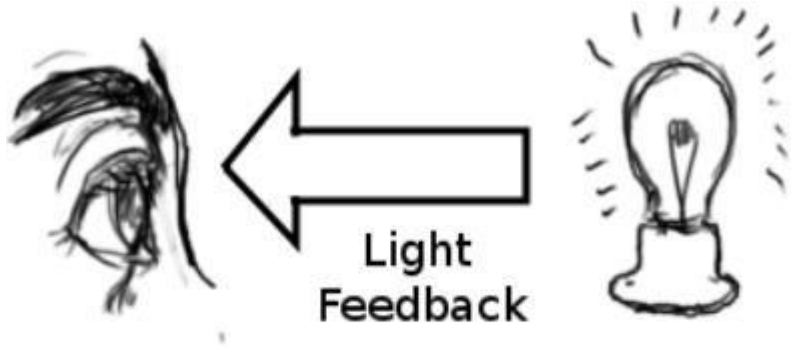
Feedback Examples

- Telephone button press tones
  - Telephone clicks
- Animated icon while waiting for a web page to load

Feedback

e.g. when screen button clicked on provides sound or red highlight feedback:




Light
Feedback


Copying...
cartoon_program.jpg
From 'TK2093' to 'pics'
Cancel

Elevators buttons clearly give feedback about which floors they're going to stop

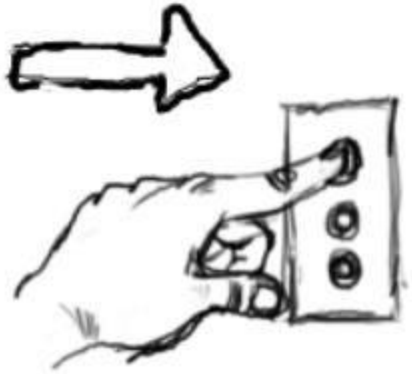
Affordance

- The term affordance refers to the relationship between a physical object and a person (or for that matter, any interacting agent, whether animal or human, or even machines and robots).
- An affordance is a relationship between the properties of an object and the capabilities of the agent that determine just how the object could possibly be used.

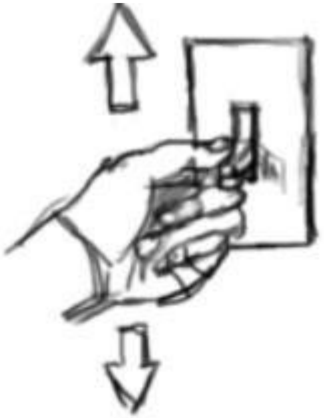
Affordances

- Perceived and actual properties of an object that determine how it could be used
- The affordances of an object determine, naturally, how it can be used
  - Button affords pushing
  - Handle affords grasping
  - Chair affords sitting
  - Knob affords turning
  - Slots are for inserting things into
  - Icon is for clicking

- Describes the perceived function of an object based on our cultural understanding of that object
- Refers to an attribute of an object that allows people to know how to use it – e.g. a mouse button invites pushing, a door handle affords pulling
- A well-designed control gives clues about its purpose
- Eg.: different shapes of door knobs indicate different ways to operate them
- Just by looking at the object, a user should know how to use it



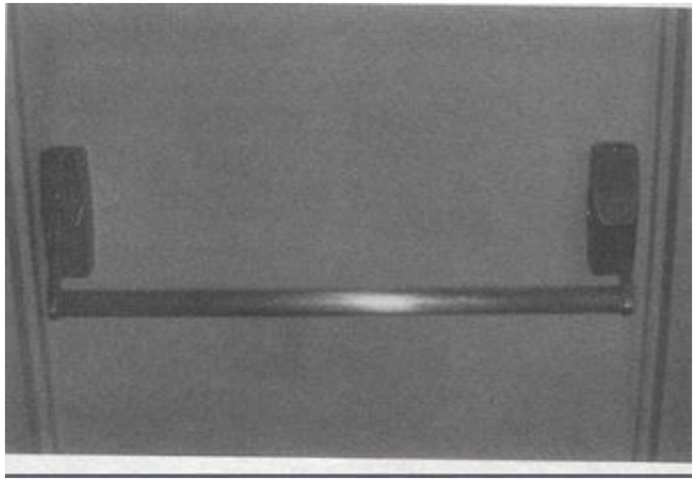
Button - Push

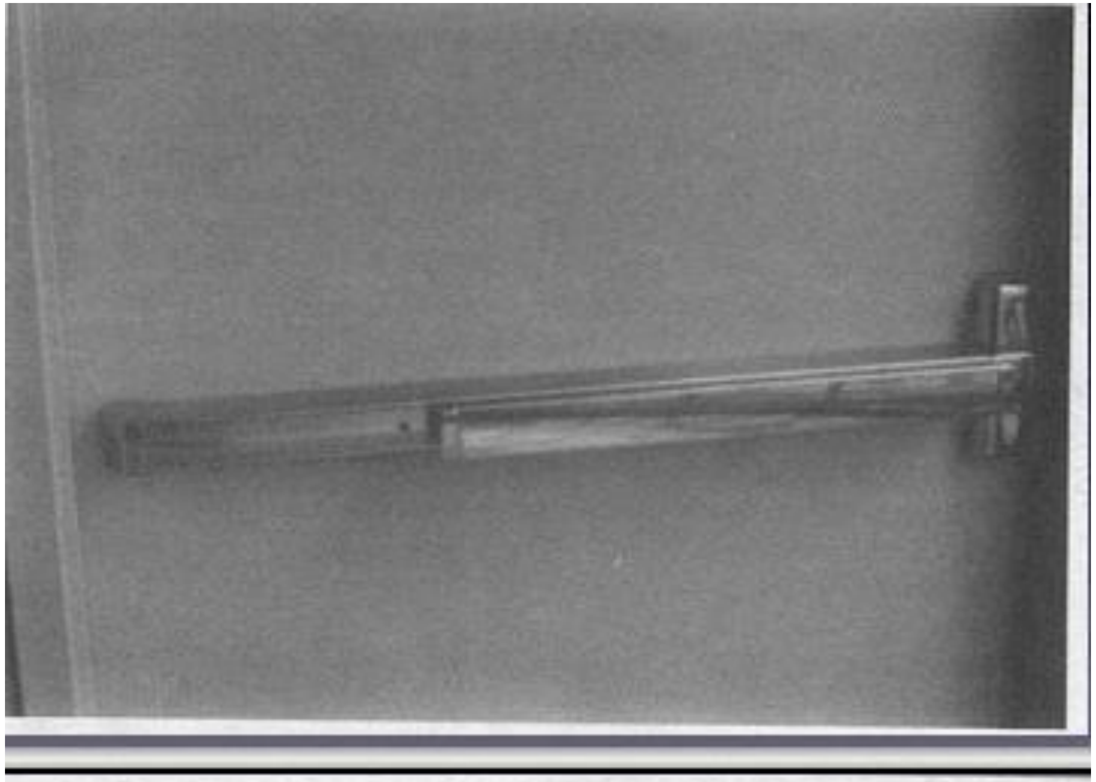


Switch - Flip

Knob - Rotate

- Affordance is influenced by the physical characteristics of an object.
- The door handle *affords* pulling and the push plate *affords* pushing.
- This door exemplifies good affordance because how you think the door opens (perception) matches how the door actually opens (function).
- Products with good affordance enable users to intuitively understand how it should be used.





4.3 **Doors in Two Commercial Buildings.** Pushing the bar opens the door, but on which side do you push? Bar *A* (above) hides the signal, making it impossible to know on which side to push. A frustrating door. Bar *B* (below) has a flat plate mounted on the side that is to be pushed; this is a naturally interpreted signal. A nice design, no frustration for the user.

Affordances

- It should be noted that affordance relies on knowledge in the head (what we already understand) and cultural relevance. Without these properties, then the desired action of an object will be harder to perceive.
- Perceived affordances help people figure out what actions are possible without the need for labels or instructions.
- the signaling component of affordances-> signifiers

- Complex things may need explanation, but simple things should not
  - If a simple thing requires instructions, it is likely a failed design

Signifiers

- SIGNIFIERS signal the presence of affordance
- perhaps a glass window or door has markings on it so you don't run into it.
- The words Push, Pull or Slide can help you know how to use a door correctly.
- Affordances determine what actions are possible. Signifiers communicate where the action should take place.

- People need some way of understanding the product or service they wish to use, some sign of what it is for, what is happening, and what the alternative actions are.
- People search for clues, for any sign that might help them cope and understand.
- Designers need to provide these clues. What people need, and what designers must provide, are signifiers.
- Good design requires, among other things, good communication of the purpose, structure, and operation of the device to the people who use it. That is the role of the signifier

FIGURE 1.2. **Problem Doors: Signifiers Are Needed.** Door hardware can signal whether to push or pull without signs, but the hardware of the two doors in the upper photo, A, are identical even though one should be pushed, the other pulled. The flat, ribbed horizontal bar has the obvious perceived affordance of pushing, but as the signs indicate, the door on the left is to be pulled, the one on the right is to be pushed. In the bottom pair of photos, B and C, there are no visible signifiers or affordances. How does one know which side to push? Trial and error. When external signifiers—signs—have to be added to something as simple as a door, it indicates bad design. (Photographs by the author.)

A.

B.

C.

FIGURE 1.3. Sliding Doors: Seldom Done Well. Sliding doors are seldom signified properly. The top two photographs show the sliding door to the toilet on an Amtrak train in the United States. The handle clearly signifies "pull," but in fact, it needs to be rotated and the door slid to the right. The owner of the store in Shanghai, China, Photo C, solved the problem with a sign. "DON'T PUSH!" it says, in both English and Chinese. Amtrak's toilet door could have used a similar kind of sign. (Photographs by the author.)

A. B. C. D.

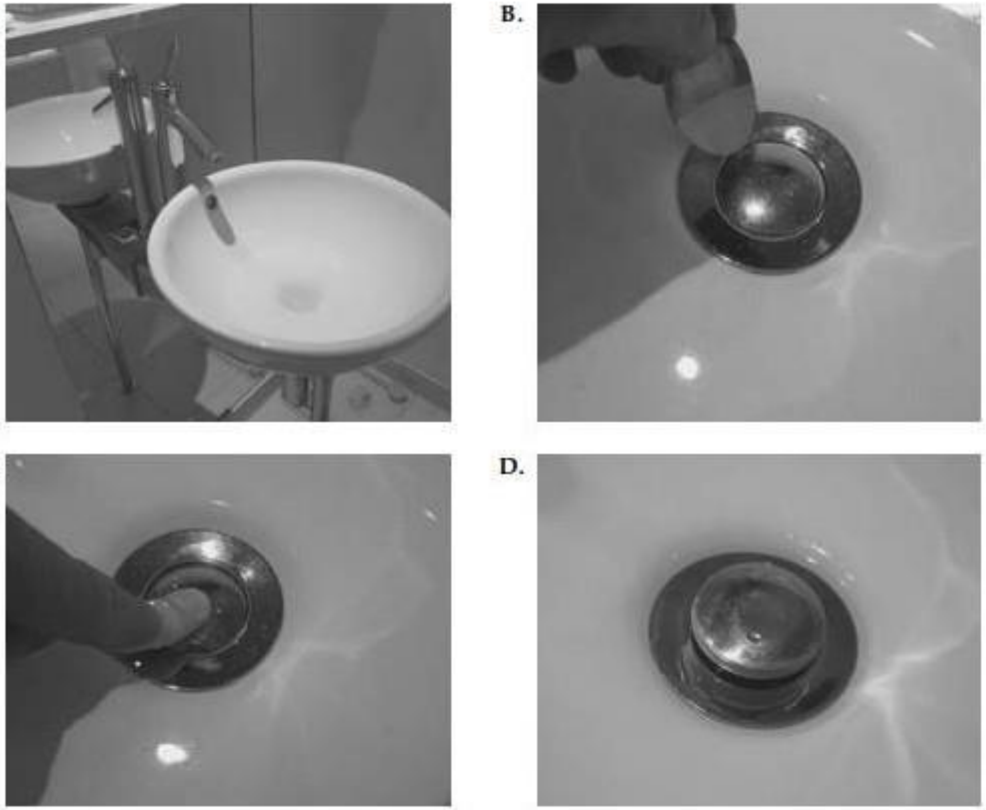


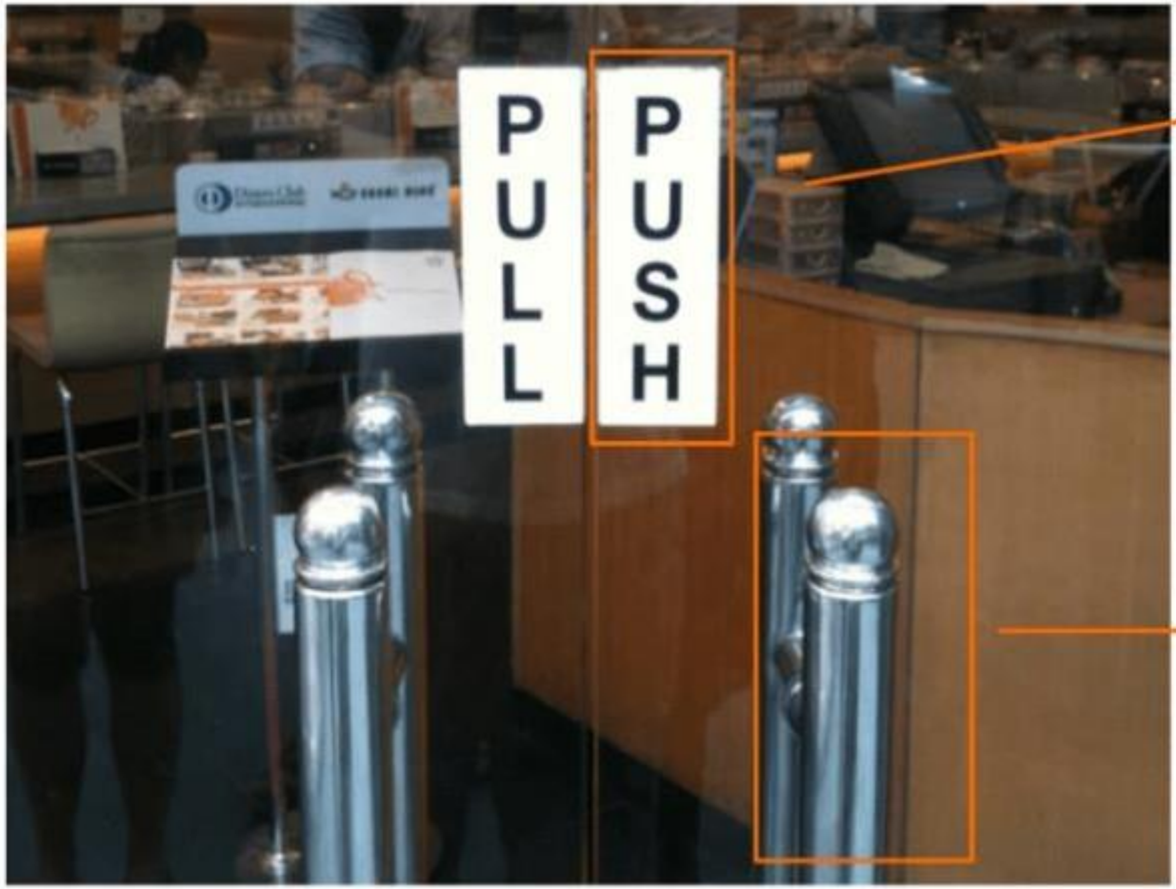
FIGURE 1.4. The Sink That Would Not Drain: Where Signifiers Fail. I washed my hands in my hotel sink in London, but then, as shown in Photo A, was left with the question of how to empty the sink of the dirty water. I searched all over for a control: none. I tried prying open the sink stopper with a spoon (Photo B): failure. I finally left my hotel room and went to the front desk to ask for instructions. (Yes, I actually did.) "Push down on the stopper," I was told. Yes, it worked (Photos C and D). But how was anyone to ever discover this? And why should I have to put my clean hands back into the dirty water to empty the sink? The problem here is not just the lack of signifier, it is the faulty decision to produce a stopper that requires people to dirty their clean hands to use it. (Photographs by the author.)

FIGURE 1.6. Signifiers on a Touch Screen. The arrows and icons are signifiers: they provide signals about the permissible operations for this restaurant guide. Swiping left or right brings up new restaurant recommendations. Swiping up reveals the menu for the restaurant being displayed; swiping down, friends who recommend the restaurant.

- A signifier communicates to us where the action should take place. Norman explains, *“The term signifier refers to any mark or sound, any perceivable indicator that communicates appropriate behaviour to a person”.*
- For example, a button label tells us exactly the kind of action the corresponding control does.
- we design *easily findable* labels, arrows, icons, sounds and other signals to lead people to take the right actions to use our digital and physical products.
- Affordances are *possible interactions*; signifiers are *design properties that announce* affordances.

Signifier
- Icons showing locked and unlocked states

Affordance
- Thumb-shaped button for opening lid
- Sliding lock for locking coffee mug



Signifier
- Sign to explain what to do (because the affordances are confusing)

Affordance
- Handle to physically grasp

Good Conceptual Model

- A conceptual model is a simple and useful explanation of how something works.
- A good conceptual model allows us to predict the effects of our actions
- Without a good model we operate blindly
  - Simply follow rules without understanding a reason
  - No understanding of cause or effect
  - No recourse when something breaks

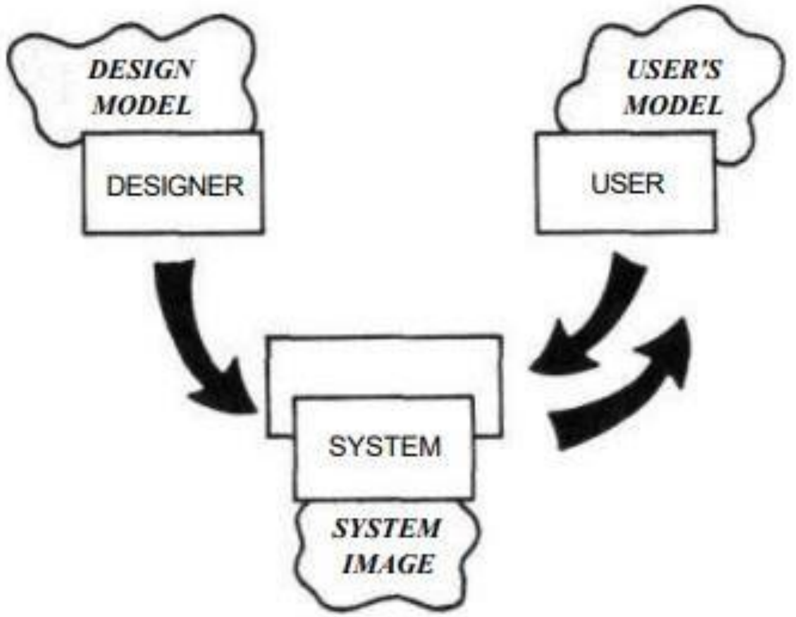
conceptual models

- Conceptual Model: A mental image of how a device works
- There are two types of conceptual models
- Design Model
  - The designers mental image, emerges from designing the device
- User’s model
  - The user’s mental image,emerges from interacting the device
- In general,the closer the user’s model is to the design model for a device, the more understandable the device is for the user
- The design and user’s model for a pistol are very similar: a pistol is a device that shoots bullets at target
- The models diverge to some extent when it comes to details: how to load the bullets,how to use the safety, how to minimize recoil etc

System Image

- The system image is the visible part of a device (including the physical structure, the documentation, instructions, etc)
- The designer only talks to the user through the system image
- If the system image doesn't make the design model clear, then the user will create a different model through their interaction.

1.10 Conceptual Models. The *design model* is the designer's conceptual model. The *user's model* is the mental model developed through interaction with the system. The *system image* results from the physical structure that has been built (including documentation, instructions, and labels). The designer expects the user's model to be identical to the design model. But the designer doesn't talk directly with the user—all communication takes place through the system image. If the system image does not make the design model clear and consistent, then the user will end up with the wrong mental model. (From Norman, 1086.)



Example-Scissors

- Affordances - Insert something into holes
- Constraints - Bigger hole for several fingers, small for thumb
- Mapping - How to insert fingers into holes suggested by visible appearance
- Conceptual model - Suggested by how parts fit together and move

- Consider a pair of scissors: you can see that the number of possible actions is limited. The holes are clearly there to put something into, and the only logical things that will fit are fingers. The holes are both affordances—they allow the fingers to be inserted—and signifiers—they indicate where the fingers are to go. The sizes of the holes provide constraints to limit the possible fingers: a big hole suggests several fingers; a small hole, only one. The mapping between holes and fingers—the set of possible operations—is signified and constrained by the holes. Moreover, the operation is not sensitive to finger placement: if you use the wrong fingers (or the wrong hand), the scissors still work, although not as comfortably. You can figure out the scissors because their operating parts are visible and the implications clear. The conceptual model is obvious, and there is effective use of signifiers, affordances, and constraints

FIGURE 1.8. Junghans Mega 1000 Digital Radio Controlled Watch. There is no good conceptual model for understanding the operation of my watch. It has five buttons with no hints as to what each one does. And yes, the buttons do different things in their different modes. But it is a very nice-looking watch, and always has the exact time because it checks official radio time stations. (The top row of the display is the date: Wednesday, February 20, the eighth week of the year.) (Photograph by the author.)

- Conceptual models are valuable in providing understanding, in predicting how things will behave, and in figuring out what to do when things do not go as planned.
- A good conceptual model allows us to predict the effects of our actions.
- Without a good model, we operate by rote, blindly; we do operations as we were told to do them

Provide a good conceptual model

- The most important of a successful design is the underlying conceptual model-Norman
- Because good conceptual models enables users:

o To mentally simulate operation

o To predict effect of their action

o To incorporate existing knowledge

o To use metaphors-metaphorical reasoning is an iterative process through which designers gradually increase their knowledge of a design situation.

- **Visibility** The correct parts must be visible and they must convey the correct message
- **Feedback** communicates the response to our actions.
- **Conceptual models** are a simple explanation of how something works.
- **Affordance** is the perceived action of an object.
- **Signifiers** tell us exactly where to perform an action.
- **Mapping** is the relationship between the controls and the effect they have.
- **Constraints** help restrict the kind of interactions that can take place.

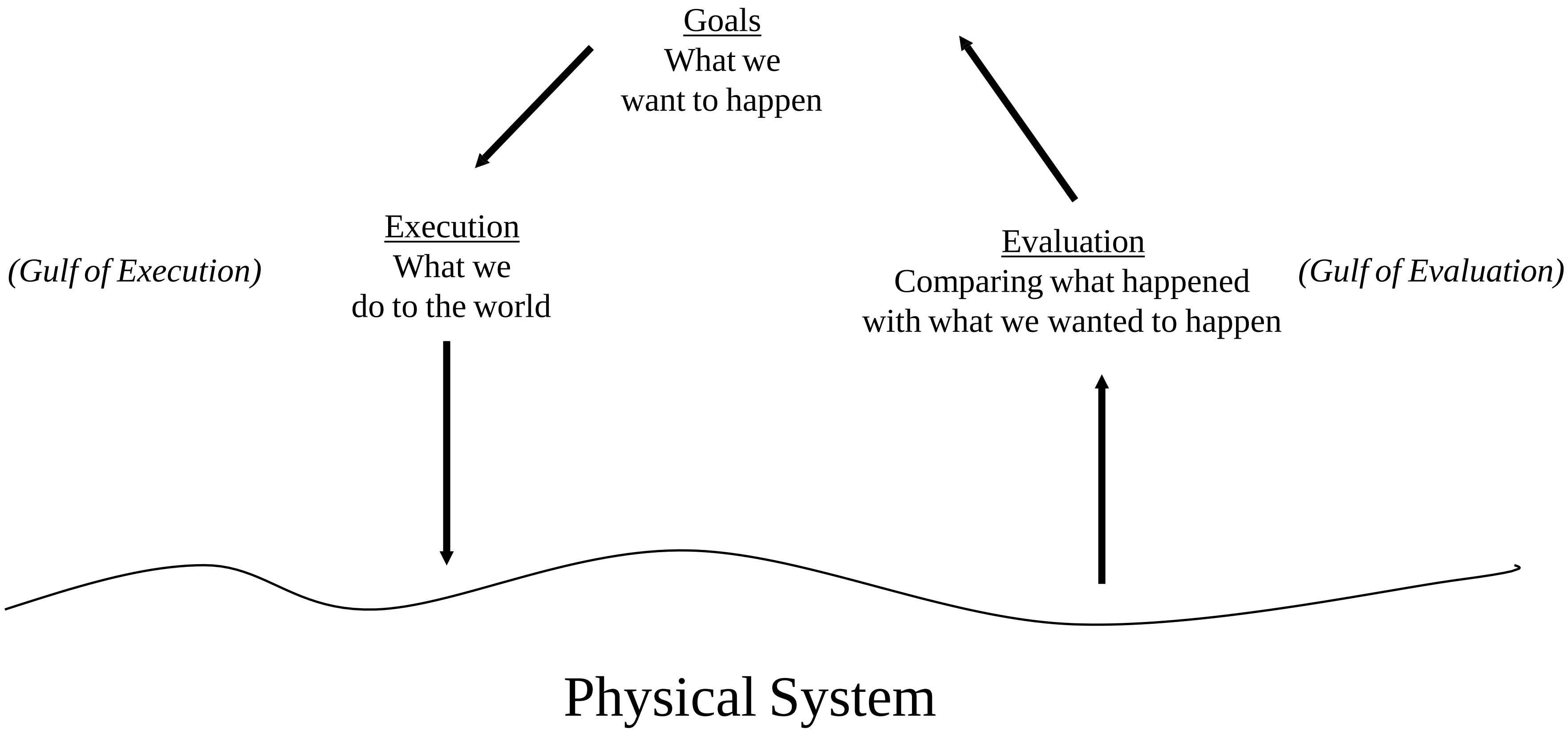
- Visibility- can is see it?
- Feedback - what is it doing now?
- Affordance - how do I use it?
- Mapping - where am I and where can I go?
- Constraint - why can't I do that?

How people do things

How people do things

- To get something done, you have to start with some notion of what is wanted—the goal that is to be achieved.
- Then, you have to do something to the world, that is, take action to move yourself or manipulate someone or something.
- Finally, you check to see that your goal was made.
- So there are four different things to consider: the goal, what is done to the world, the world itself, and the check of the world.
- The action itself has two major aspects: doing something and checking. Call these execution and evaluation

Goals, Execution, Evaluation



Execution

<u>Goals</u>
What we
want to happen

↓

An intention to act
so as to achieve the goal

↓

The actual sequence of actions
that we plan to do

↓

The physical execution of that
action sequence

↓

Physical System

Evaluation

Goals
What we
want to happen

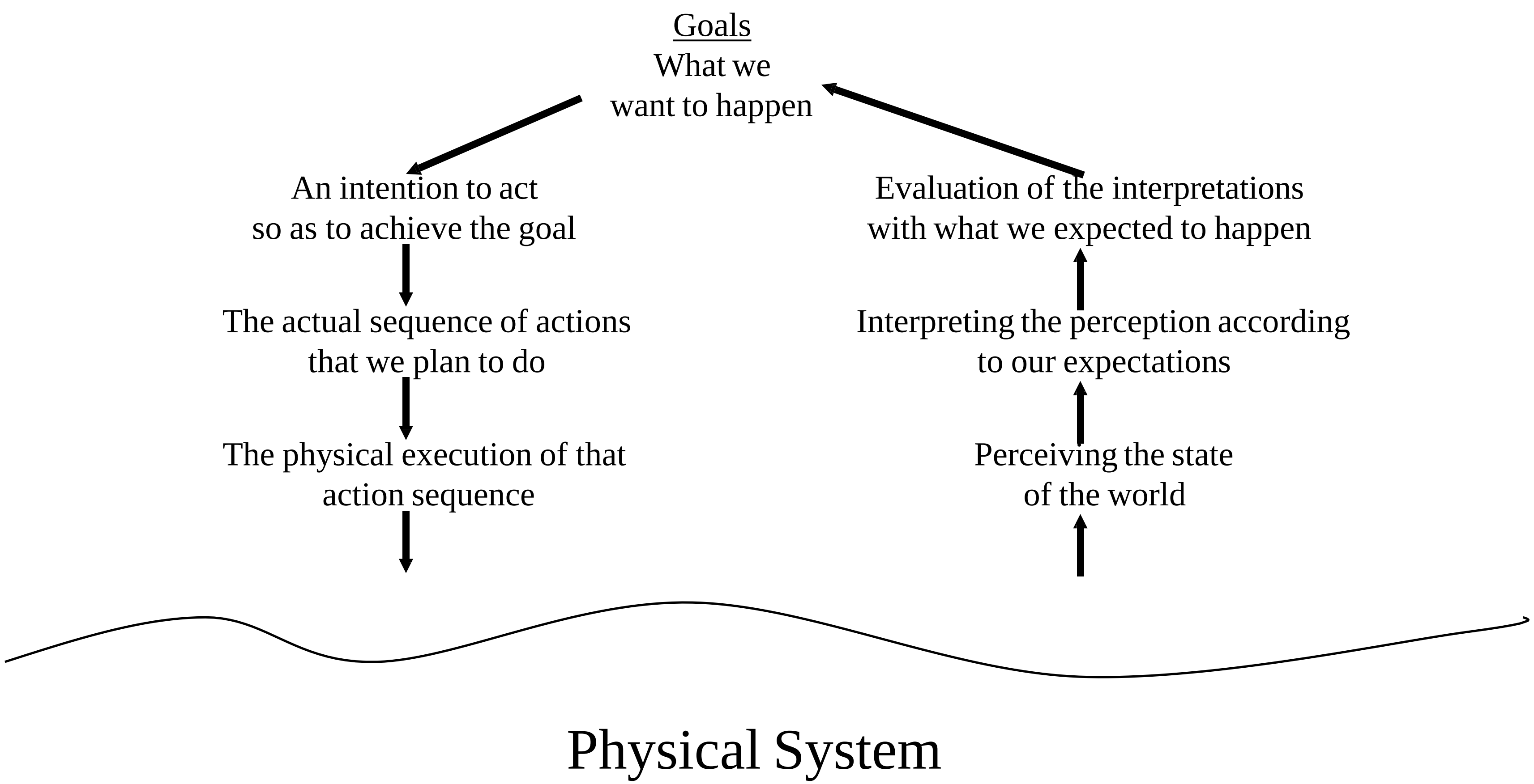
Evaluation of the interpretations
with what we expected to happen

Interpreting the perception according
to our expectations

Perceiving the state
of the world

Physical System

Seven Stages - All Together



- Forming the goal - state to be achieved (often ill-formed)
- Forming the intention - goal translated into intention to perform some action
- Specifying an action - translate intention into set of internal commands
- Executing the action
- Perceiving the state of the world
- Interpreting the state of the world
- Evaluating the outcome

Example

❑ Forming a Goal

- I can’t read my book because the room is dimly lit. I need more light in order to read my book.

❑ Intention to Act

- There is a light next to my chair. Turning on the light would allow me to read my book.

❑ Planning the Action

- I need to reach over and turn on the light.

❑ Executing the Action

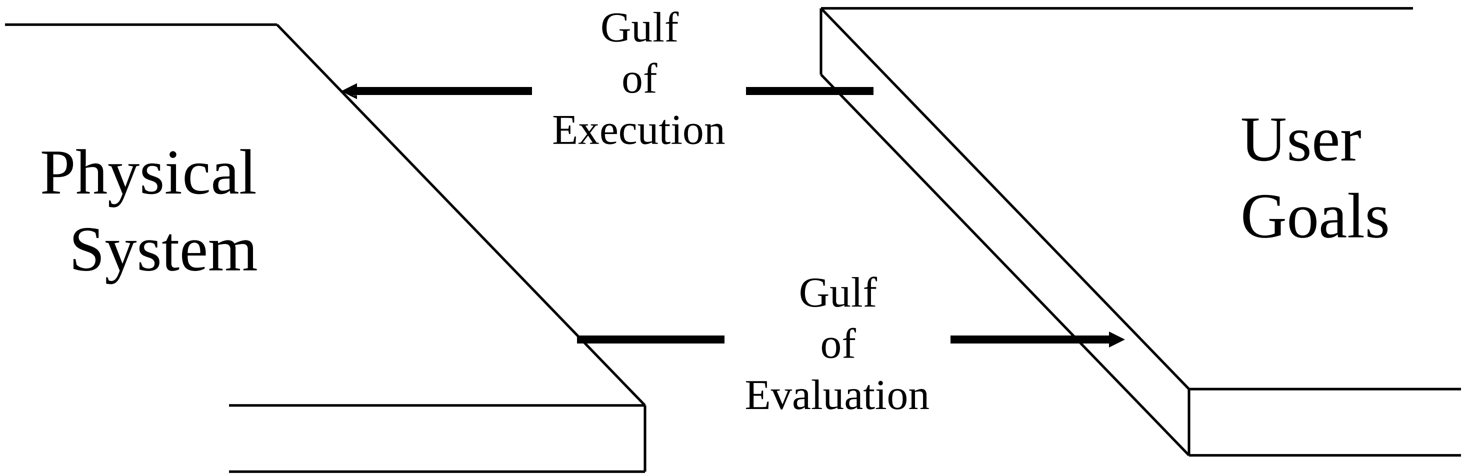
- I reach over to turn on the light.

Example

- ❑Feedback from the Action
- The light turns on.
- ❑Interpret the Feedback
- I am now able to see the text and can read my book.
- ❑Evaluate the Outcome
- **Positive** – I’m able to read my book. No further action is needed. **Negative** – The light doesn’t work. The Action Cycle is either repeated or a new goal is formed.

Execution-Evaluation cycle

Norman (DOET, p. 46)



Gulf of Execution

- The difference between the intentions and the allowable actions is the Gulf of Execution
- How well does the system allow someone to do their intended actions directly
- Do the affordances provided by the system match the actions intended by the person
- Bad if not clear what actions need to be done to accomplish the intention

Gulf of Evaluation

- The Gulf of Evaluation reflects the amount of effort that the person must exert to interpret the physical state of the system and to determine how well the expectations and intentions have been met.
- How well does the system provide a visible state that can be directly perceived and that is interpretable in terms of the intentions and expectations of the user

7 stages as design aid

- The seven-stage structure can be a valuable design aid, for it provides a basic checklist of questions to ask to ensure that the Gulfs of Evaluation and Execution are bridged.

How Easily Can One:

Determine The Function of the Device?

Tell What Actions Are Possible?	Tell if System is in Desired State?
Determine Mapping from Intention to Physical Movement?	Determine Mapping from System State to Interpretation?
Perform the Action?	Tell What State the System is In?

Applying to Design

- Visibility - User can tell the state of the device and the alternatives for action
- Good conceptual model - User given consistent in presentation of operations and results
- Good Mappings - easy to determine relationships between actions and results, controls and their effects, system state and what's visible
- Feedback - User receives full and continuous feedback
- Affordance-provide good affordance

- Make current state and action alternatives visible
- Need good conceptual model with consistent system image
- Interface should include mappings that reveal relationships between stages
- User should receive continuous feedback
- Provide affordances

- **The Gulf of Execution**
  - How do I work this thing? What can it do? What can I do with it?
  - Bridged through signifiers, constraints, mappings and a conceptual model.
- **The Gulf of Evaluation**
  - What happened? Is this what I wanted?
  - Bridged through feedback and a conceptual model.

Knowledge in the head and in the world

- Not all of the knowledge required for precise behavior has to be in the head.
- It can be distributed—partly in the head, partly in the world, and partly in the constraints of the world.

- Precise behavior can emerge from imprecise knowledge for four reasons:
  1. Information is in the world.

     World: Person can derive how to perform a task from things and the environment.
  2. Great precision is not required.
  3. Natural constraints exist in the world.
  4. cultural constraints present
- “Because behavior can be guided by the combination of internal and external knowledge and constraints, people can minimize the amount of material they must learn, as well as the completeness, precision, accuracy, or depth of the learning.

- “Whenever knowledge needed to do a task is readily available in the world, the need for us to learn it diminishes.”
  - Example: We don’t memorize phone numbers as readily in the smartphone era.
  - Example: We know generally what a particular coin looks like, but cannot provide the features exactly.

3.1 Which Is the U. S. One Cent Coin—The Penny? Fewer than half of the American college students who were given this set of drawings and asked to select the correct one could do so. Pretty bad performance, except that the students, of course, have no difficulty using the money: in normal life, we have to distinguish between the penny and other U.S. coins, not between several versions of one denomination. (From Nickerson & Adams, *Cognitive Psychology, 11,* © 1979. Reprinted by permission of Academic Press.)

- Two kinds of knowledge:
  - **Declarative knowledge** (“knowledge of”)
    - Knowledge of facts and rules.
    - Easy to write down and teach.
    - Example: New York is east of Chicago.
  - **Procedural knowledge** (“knowledge of how”)
    - Knowledge that enables a person to perform music, return a serve in tennis and move the mouth/tongue properly when saying a tongue twister.
    - Procedural knowledge is taught by demonstration and learned through practice.
    - Procedural knowledge is largely subconscious.

- Normally, people do not need precision in their judgments. All that is needed is the combination of knowledge in the world and in the head that makes decisions unambiguous.
- People store only partial descriptions of things that need to be remembered.
- Constraints can reduce the number of things or possibilities that need to be learned or remembered to a reasonable number.
  - Example: Epic poetry relies on conventions of meter and rhyming. Rhyming limits possible word choices.

- Two major classes of memory:
  - **Short-term memory** or **working memory** (STM)
    - Retains the most recent information being thought about.
    - STM storage capacity is limited.
    - Interruptions and distractions can result in loss of thoughts.
    - Many techniques can aid or prevent STM loss: writing things down, use of mnemonics, use of different modalities (e.g. audio and touch feedback to prevent distracting visual activities).
  - **Long-term memory** (LTM)
    - Memory for the past.
    - LTM storage capacity is massive.
    - Retrieval is the challenge for LTM.

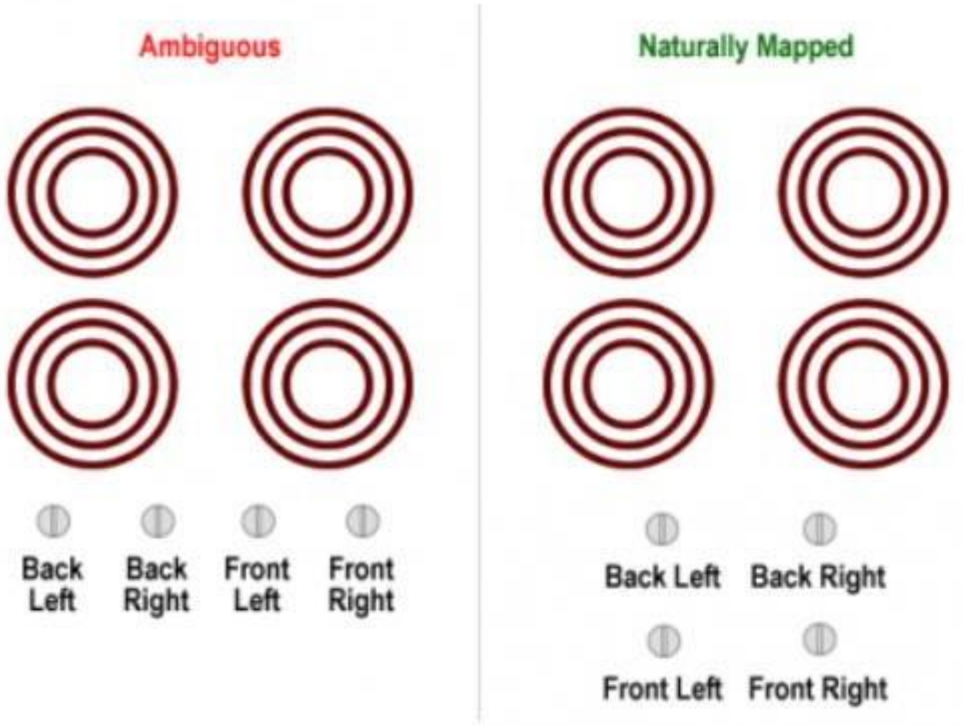
Knowledge in the head

- Knowledge in the head is memory. Knowledge in the world is everything else — external information.
- If we examine how people use their memories and how they retrieve information, we discover a number of categories: memory for arbitrary things, for meaningful relationships, and for explanation.

1. Memory for arbitrary things. The items to be retained seem arbitrary, with no meaning and no particular relationship to one other or to things already known. It is straight memorization. Learning is difficult and takes time and effort to retain. It is inapplicable to situations different from that what was memorized. For simple things such as the alphabet, it works.
2. Memory for meaningful relationships. The items to be retained form meaningful relationships with themselves or with other things already known.
3. Memory through explanation. The material does not have to be remembered, but rather can be derived from some explanatory mechanism. It creates strong mental models that lend to figuring out novel situations and problems in others

Knowledge in the world

- Reminders are used to put knowledge into the world.
- A good reminding method is to put the burden on the thing itself.
- There are two different aspect to reminder: the signal and the message.
- Reminders combined with the power of natural mappings reduce the need for information in memory. Take the stove and its arrangement of controls for example. The row one has many possible combinations and is therefore confusing.



Stove example

- *If a design depends upon labels, it may be faulty. Labels are important and often necessary, but the appropriate use of natural mappings can minimize the need for them. Whenever labels seem necessary, consider another design.*

The Tradeoff between Knowledge in the World and in the Head

PROPERTY	KNOWLEDGE IN THE WORLD	KNOWLEDGE IN THE HEAD
Retrievability	Retrievable whenever visible or audible.	Not readily retrievable. Requires memory search or reminding.
Learning	Learning not required. Interpretation substitutes for learning. How easy it is to interpret information in the world depends upon how well it exploits natural mappings and constraints.	Requires learning, which can be considerable. Learning is made easier if there is meaning of structure to the material (or if there is a good mental model).

Efficiency of use	Tends to be slowed up by the need to find and interpret the external information.	Can be very efficient.
Ease of use at first encounter	High.	Low.
Aesthetics	Can be unaesthetic and inelegant, especially if there is a need to maintain a lot of information. This can lead to clutter. In the end, aesthetic appeal depends upon the skill of the designer.	Nothing need be visible, which gives more freedom to the designer, which in turn can lead to better aesthetics.

Knowing what to do

Knowing what to do

- When encountering new objects, how do we know what to do?

➢ KITH
  - We have learned how to use a similar object
  - We take a course to learn how to use it

➢ KITW
  - The object teaches us: instructions, labels, manuals, a popup help etc

➢ The design of the object can help us figure out what to do with it
  - By intelligent or effective use of affordances and natural constraints
  - Affordances-suggest range of possibilities of what to do
  - Constraints-limit the number of choices of what to do

Classification of everyday Constraints

4 types

- Physical
- Semantic
- Cultural
- Logical

Physical constraints

- Physical limitations constrain possible operations.
- Thus, a large peg cannot fit into a small hole
- they rely upon properties of the physical world for their operation; no special training is necessary.
- With the proper use of physical constraints there should be only a limited number of possible actions—or, at least, desired actions can be made obvious
- Physical constraints work best (at helping us what to do) when they are easy to see and interpret

Physical constraints

- To close a screw top bottle, you must turn the cap clockwise; to open it –you must turn it anticlockwise
- To insert a key in a lock you must push the correct end into the keyhole. To open the lock , you must turn the key (counter)clockwise
- Design of batteries and battery compartments

Semantic Constraints

- They rely upon the meaning of the situation to control the set of possible actions.
- They rely upon our knowledge of the situation and the world.
- In the case of the motorcycle, there is only one meaningful location for the rider, who must sit facing forward. The purpose of the windshield is to protect the rider's face, so it must be in front of the rider

Cultural constraints

- They rely upon cultural conventions to limit the users set of possible actions
- Each culture has a set of allowable actions for social situations.
- Because there are no universally accepted conventions or customs for dealing with culture, we often have many problems with designing new machines
- Which side of the road to drive on?
- Guidelines to cultural behavior are stored as schemas
- Schema- a memory based knowledge structure that contains rules and instructions for interpreting situations and guiding behavior

Logical Constraints

- Constraints which have 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.


POLICE


POLICE
POLICE

4.1 Lego Motorcycle. The toy is shown assembled and in pieces. The thirteen parts are so cleverly constructed that even an adult can put them together. The design exploits constraints to specify just which pieces fit where. Physical constraints limit alternative placements. Semantic and cultural constraints provide the necessary clues for further decisions. For example, semantic constraints stop the user from putting the head backward on the body and cultural constraints dictate the placement of the three lights (the small rectangles, which are red, blue, and yellow).

Remember the LEGO example?

The blue light presented a problem, as many people had no knowledge that would help, but after all the other pieces were assembled, there was only one place for it to go—it was logically constrained.

Name that Constraint!

- What type of constraints help us to know what to do in these situations:
- Stop at red light. Go at green
- Fill your brake fluid reservoir
- Don’t make sudden movements if someone is pointing a gun at you
- Don’t start eating dinner until an opening prayer has been said
- Choose D in a multiple choice exam if A,B and C are wrong
- Change a bike tyre (for the first time) without any instructions
- Stand and bow to the Japanese executive you’re having lunch with

Applying affordances and constraints to ETs

- Applying affordances and constraints to everyday things can dramatically increase their usability
- Doors and light switches are good case studies

Visibility and feedback

- Along with affordances and constraints, visibility and feedback also contribute a great deal to knowing –or not knowing –what to do with a device
- Visibility- Make relevant parts visible.
- Feedback- Give each action an immediate and obvious effect.

Making visible the invisible

- Many systems are vastly improved by the act of making visible what was invisible before
    - Handles on cabinets distract from some design aesthetics, and so they are deliberately made invisible or left out.
    - Electric switches are often hidden: many electric typewriters have the on/off switch hidden underneath; many computers and computer terminals have the on/off switch in the rear, difficult to find and awkward to use
    - the switches that control kitchen garbage disposal units are often hidden away
- Nothing succeeds like visual feedback, which in turn requires a good visual display.

Using sound for visibility

- When things can’t be made visually visible, designers should consider making them sonically visible
- It would be difficult to visually inform (quickly,efficiently,all at once)1000 people in a big building of the outbreak of a fire
- But a sonic alarm does the trick nicely
    - Except for deaf people
- A fire alarm is an extreme example of sonic visibility, more subtle:
    - The change in tone when a vacuum cleaner hose is clogged
    - Cell phone ring tones
    - The whistle of a tea kettle when the water is boiling

Using sound for visibility

- The presence of sound can serve a useful role in providing feedback about events
- the absence of sound can lead to the same kinds of difficulties we have already encountered from a lack of feedback.
- One big challenge with using sound for visibility:
    - Sound, unlike visuals, extend beyond the user’s border
    - Unless the user is wearing headphones or has volume set very low, the sound emanating from a device can be heard by anyone in earshot
        - This can be very annoying and disruptive

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 mappings between intentions and the required actions; between actions and the resulting effect; and between the information that is visible and the interpretation of the system state.
- In other words, make sure that

(1)the user can figure out what to do, and (2) the user can tell what is going on.

Seven Principles for Transforming Difficult Tasks into Simple Ones

1. Use both knowledge in the world and knowledge in the head.
2. Simplify the structure of tasks.
3. Make things visible: bridge the gulfs of Execution and Evaluation.
4. Get the mappings right
5. Exploit the power of constraints, both natural and artificial.
6. Design for error.
7. When all else fails, standardize.

Use both knowledge in the world and knowledge in the head

- “Knowledge in the World” refers to information that exists in the world that we don’t need to memorize to utilize.
  - Don’t need to be able to recall every distinctive feature of a penny to be able to identify one and use it.
- “Knowledge in the Head” refers to memorization
- Using the knowledge that’s already in the user’s head combined with what the user can see in the world, (i.e. what is literally in front of them) can hopefully bridge any gaps and create a full understanding.
- THREE CONCEPTUAL MODELS
- THE ROLE OF MANUALS

Simplify the structure of tasks

- Make tasks simple in structure
- Minimize problem solving or planning required to execute tasks.
- Pay close attention to the psychology and limits of the end-user
  - Short-term memory
  - Long-term memory
  - Attention
- Four major technological aspects

1. Keep the task much the same, but provide mental aids.
2. Use technology to make visible what would otherwise be invisible, thus improving feedback and the ability to keep control.
3. Automate, but keep the task much the same.
4. Change the nature of the task.

Don’t take away control

- One problem is that overreliance on automated equipment can eliminate a person's ability to function without it
- A second problem is that a system may not always do things exactly the way we would like, but we are forced to accept what happens because it is too difficult (or impossible) to change the operation.
- A third problem is that the person becomes a servant of the system, no longer able to control or influence what is happening.
- All tasks have several layers of control. Sometimes we really want to maintain control at the lower level. At other times we want to concentrate on higher level things.

Make things visible

- Make things visible: bridge the gulfs of Execution and Evaluation.
- Things should be visible so that people know what is possible and how to do them.
- People should know what is currently going on and what to do next

Get the mappings right

- make sure that the user can determine the relationships:
  - Between intentions and possible actions
  - Between actions and their effects on the system
  - Between actual system state and what is perceivable by sight, sound, or feel
  - Between the perceived system state and the needs, intentions, and expectations of the user.

Exploit the power of constraints

- Exploit the power of constraints, both natural and artificial.
- “Use constraints so that the user feels as if there is only one possible thing to do – the right thing of course” - Don Norman

Designing for Error

- Understand the cause of error and design to minimize those causes
- Make it possible to reverse (undo) actions, or make it harder to do what cannot be reversed
- Make it easier to discover errors that do occur and make them easier to correct
- Think of an object's user as attempting to do a task, getting there by imperfect approximations, Don't think of the user as making errors, think of the actions as approximations of what is desire

When all else fails, standardize.

- Standardization is essential only when all the necessary information cannot be placed in the world or when natural mappings cannot be exploited.
- Standardization is a way to deal with things that cannot be designed without arbitrary mappings.
  - Keyboard layouts
  - Traffic signals
  - Units of measurement
- Useful as long as everyone uses the same system


12
1
11
2
10
3
9
4
8
5
6
7

- Standardize and you simplify lives: everyone learns the system only once. But don't standardize too soon: you may be locked into a primitive technology, or you may have introduced rules that turn out to be grossly inefficient, even error-inducing. Standardize too late and there may already be so many ways of doing the task that no international standard can be agreed on; if there is agreement on an old-fashioned technology, it may be too expensive to change. The metric system is a good example.

Deliberately Making Things Difficult

- "How can good design (design that is usable and understandable) be balanced with the need for 'secrecy' or privacy, or protection?
- That is, some applications of design involve areas which are sensitive and necessitate strict control over who uses and understands them

7.4 A School Door, Deliberately Made Difficult to Use. The school is for handicapped children; the school officials did not want children to be able to go in and out of the school without adult supervision. The principles of usability espoused in POET can be followed in reverse to make difficult those tasks that ought to be difficult.

Deliberately Making Things Difficult

- Security systems, designed so that only authorized people will be able to use them.
- Dangerous equipment, which should be restricted.
- Dangerous operations, such as life-threatening actions. These can be designed so that one person alone can't complete the action.
- Secret doors, cabinets, safes: you don't want the average person even to know that they are there, let alone to be able to work them
- Cases deliberately intended to disrupt the normal routine action Examples include the acknowledgment required before permanently deleting a file from a computer storage system, safeties on pistols and guns, pins in fire extinguishers.
- Controls deliberately made big and spread far apart so that children will have difficulty operating them.
- Cabinets and bottles of medications and dangerous substances deliberately made difficult to open to keep them secure from children

Deliberately Making Things Difficult

- Many things need to be designed for a certain lack of understandability or usability.
- The rules of design are equally important to know here, however, for two reasons.
- First, even deliberately difficult designs shouldn't be entirely difficult. Usually there is one difficult part, designed to keep unauthorized people from using the device; the rest of it should follow the normal good principles of design.
- Second, even if your job is to make something difficult to do, you need to know how to go about doing it

Deliberately Making Things Difficult

- Hide critical components: make things invisible.
- Use unnatural mappings for the execution side of the action cycle, so that the relationship of the controls to the things being controlled is inappropriate or haphazard.
- Make the actions physically difficult to do.
- Require precise timing and physical manipulation.
- Do not give any feedback.
- Use unnatural mappings for the evaluation side of the action cycle, so that system state is difficult to interpret.