ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Cognitive psychology for everyday objects

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Introduction

Here we discuss:

- Using objects
- Errors in human beings
- Knowledge in the head and the world
- Designing everyday things

Topics from Donald Norman's book, “The psychology of everyday things”, 1988, 1990, 2002 (ed. it. *La caffettiera del masochista*, Giunti ed.) and its more recent edition "*The Design of Everyday Things*", 2013.

Everyday objects

Adults use and can recognize at first sight more than 20.000 objects

Some we use every day, so we have gained a clear model of their working.

Others are simple to use because they offer clear clues of their working

Others are irremediably complex and obscure. Why?

Design to simplify

Good design of objects must help discovery and understanding:

- Discovery: can we imagine or guess which actions are possible, and when and where to execute them?
- Understanding: what does it do? How do you expect me to use it? What are all these commands and settings for?

Design deals with deciding how objects work, and the nature of the interaction between people and technology.

Machines have a limited number of behaviors, set by the designer during the early design stage. If users do not follow these behaviors correctly, machines fail and the operator is blamed.

- If it is an everyday object, the result is frustration
- If it is a complex object, or an industrial machine, the result can include economic losses, accidents, even deaths.

The logical user

Designers have homogeneous mental characteristics and are all provided with logical minds, attention to detail, and eagerness to learn new things.

Designers believe that people are as logic and attentive to details as they are.

When watching non-designers use their objects, they often think:

- What are they doing?
- Why are they using it in this way?

We have to design our artefacts for how users are, not how we wish they were. We have to assume that people will make mistakes, and plan against them.

Fundamental principles of interaction

Interaction generate experiences, and experiences must be pleasant

Experiences are fundamental because they determine

- How we will remember the interaction
- How we will approach a new interaction
- What we will expect from future interactions

Lack of understanding generate confusion, frustration, rage or lack of interest

Understanding generate sense of control, mastery, satisfaction and pride

Cognition and emotions are strongly connected, and we cannot have one without the other.

Some basic concepts

- Affordance and signifiers
- Conceptual models
- Mapping
- Feedback
- Knowledge in the head and in the world
- Constraints

Affordance and signifiers (1)

Affordance in objects are the perceived interactive properties of the objects showing object:

- Slabs (piastre) are pushed,
- Knobs (manopole) are turned
- Slots (fessure) receive objects.

Affordance and signifiers (2)

Example:
British rail station platforms

- glass panels afford breaking
- Wood panels afford painting

Example:

There is only **one** way to insert a 3.5" floppy disk


cm
1 2 3 4 5 6 7 8 9

Affordance and signifiers (3)

Sometimes the affordance is not clear enough

- Glass allows for transparency, and is used for windows, light bulbs, etc.
- But it also allows for blocking air and objects from passing. This is not perceivable, and we learn it with experience, and sometimes we do not learn it.

If the affordance is not perceivable, design must signal its existence: this is the ***signifier***

- A signifier is a construct of the design to make visible or explicit the affordance of an object
- An arrow in a sign, a slab on a door, are signifiers for the existence of an affordance.

Affordances determines which actions are possible, and signifiers tell where the action should take place.

Conceptual models (1)

We create naturally the conceptual model of the working of an object

We use naturally constaint, affordances and spatial correlations

For instance:

- On a bicicle, the seat, the handlebars, the pedals individually and together afford only ONE right position.
- Scissors: the cutting edge, the finger holes, with different dimensions, all conjure for only one use, there is no possibility of error

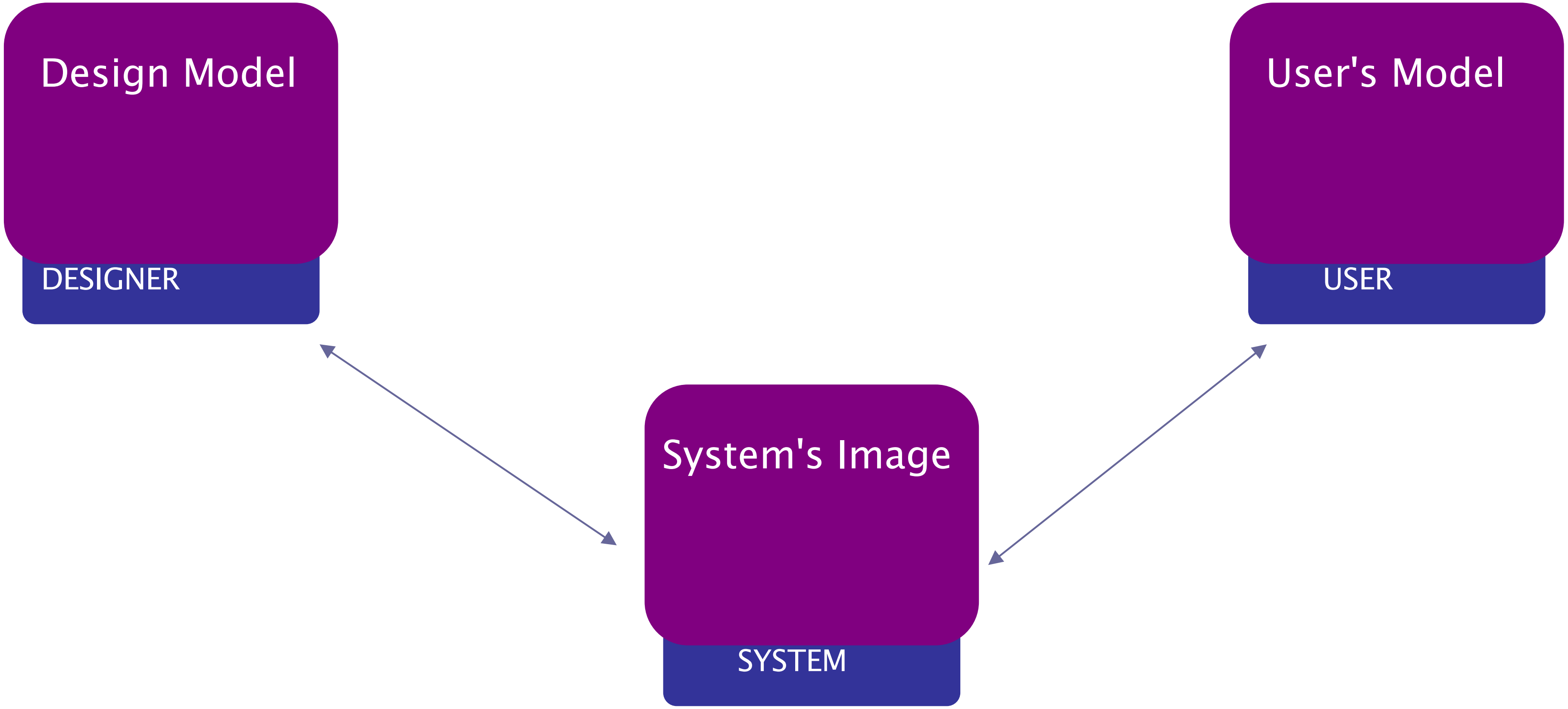
Conceptual models (2)

Counter-example:

- A thermostat in an apartment control the final temperature, not the intensity of the heating elements:
- Raising the temperature does NOT increase the speed of heating up a cold house

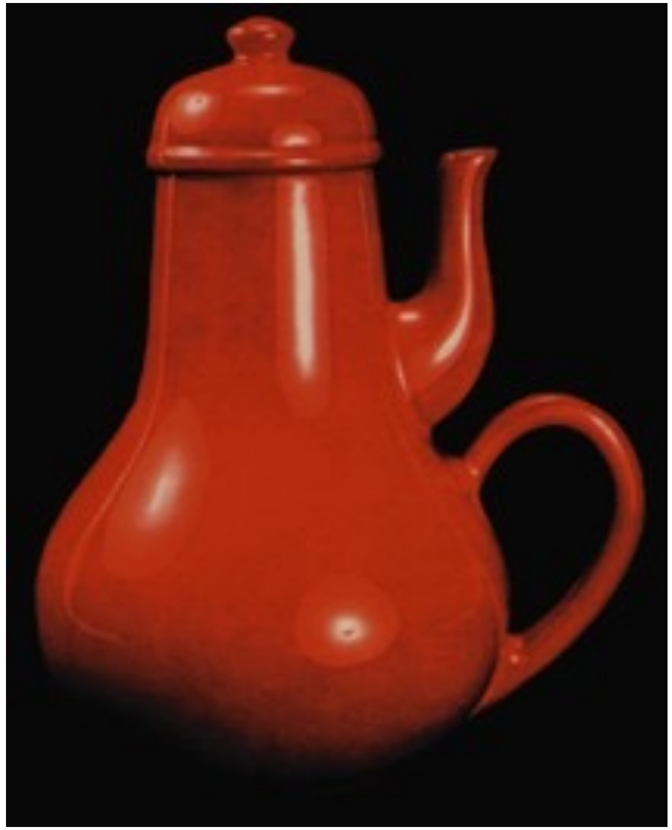
Conceptual models (3)

The designer has a duty to provide the best conceptual model



Conceptual models (4)

What conceptual model do these objects transmit?



Mapping (1)

Mapping is the relationship between commands and their working.

Some objects have a very natural mapping: the exploit physical analogies, cultural and biological models. That's why they are easier to learn

Example: the seat positioning controls for two luxury cars:

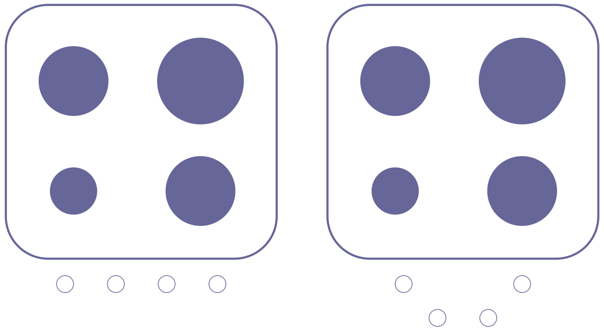
Hyundai Equus Mercedes E320

Mapping (2)

Additional examples:

Car wheel

Volume of a stereo



Arbitrary mapping

Natural mapping

Kitchen burners and their commands

Counter-example:
Complex task on a traditional phone

Feedback (1)

Feedback is returning information, allowing the user to understand which action were performed and what result was reached

If it is clear, not ambiguous and non oppressive the feedback is, we do not worry about the correct use of an object.

- Is the machine on or off?
- Did it complete the task or it jammed?
- Is everything ok or are there problems?

The feedback is the way the machine provides information about its state.

- Feedback must be in the language of the received, not the transmitter
- Feedback must be rapid, especially for remote or slow processes (e.g., a light bulb taking time to switch on or off).

Feedback (2)

A bad feedback is not a feedback at all, but an anxiety generator.

- In some control centers the same warning sounds are generated by fundamental control machines and by secondary machines

Feedback can be excessive

- The "Crying Wolf" effect: too many warnings may cause users to ignore them all, includng the important ones

Feedback can be unintelligible

- A green light means "ok", a red light means "bad", ok. What about a yellow light? A blu light? A double rapid flash followed by three slow ones, an increase in intensity, and decrease, what do they mean???

Lights and buzzers are standard methods for generating feedback, they cost very little. But there are too many machines and they are too similar to each other

Declarative and procedural knowledge

Declarative knowledge is explicit and conscious

- Laws, conventions, facts, relations, people, roles

Procedural knowledge is implicit, non describable with words, automatic

- Speaking, playing tennis, playing a musical instrument

Declarative knowledge is easy to explain, easy to write down, difficult to learn and use

Procedural knowledge is hard to explain (both practice and examples), impossible to write down and easy to use.

Knowledge in the world, Knowledge in the head (1/3)

There is an enormous amount of concept we know of and we know that we know.

Some are shared with others of our circles, other we learnt personally and are only ours.

For instance peculiar idiosincracies of our personal objects are well known to us, but hard to explain to others.

Knowledge in the world, Knowledge in the head (2/3)

Precise behavior out of imprecise knowledge

Constraints and mappings are the key

Moving the retention of declarative knowledge to the external world allows us to free up some memory

- Coins
- Numerical keyboards

Knowledge in the world, Knowledge in the head (1/3)

Arbitrary facts and data

- Passwords
- Codes: ATM, credit cards, car plates, health or tax codes, timetables

Meaningful relationships

- How to use the shift in a car
- How to tune a guitar
- How to install a printer

Explanation-oriented memories

- Mental models to understand the behavior of an object

A comparison

Property	Knowledge in the world	Knowledge in the head
Retrievability	Easy if visible/audible, impossible otherwise	Not easy. Requires search or recall in all cases
Learnability	Not necessary. Replaced by interpretation. Dependent on constraint and mapping	Can become intensive. Helped if supported by a good mental model
Efficiency	Slowed down by continuous interpretation	Can become fairly high
Ease of use	High	Low
Aesthetics	Dependent on the ability of the designer. Can lead to overcrowding	The lack of visibile parts gives free hand to the designer

Constraints in objects

Physical constraints

- Small parts interacting with each other: little screws go in little holes, linchpins (perni), hooks, etc.

Semantic constraints

- Meaning of individual parts and their purpose in the overall object

Cultural constraints

- Cultural meaning of each part, and the role of their positioning.

Logical constraints

- Rational analysis of the purpose of the parts and identification of logically acceptable sequences of construction of the object.

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Actions

Actions

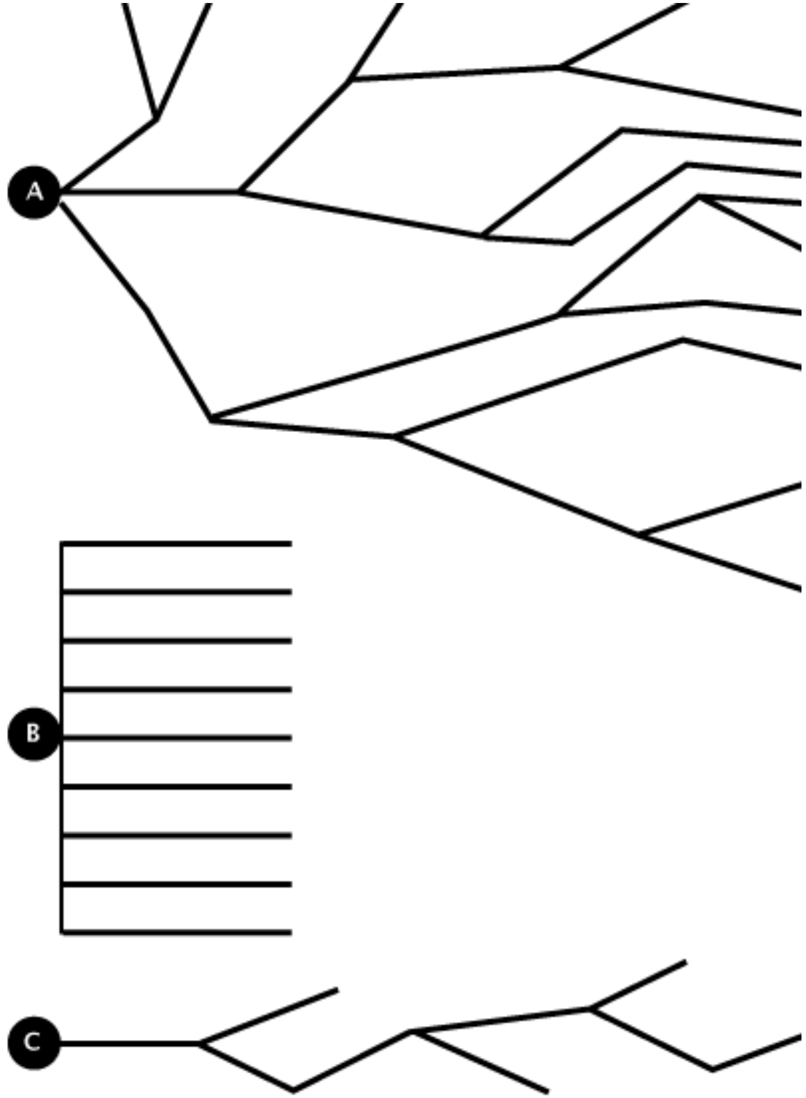
- The structure of a task
- The seven stages of an action
- The gulfs
- Errors in human beings
  - Slips
  - Mistakes
  - Lapsus
- Fallacious explanations
- Learned (and taught) helplessness

Structure of tasks

Daily tasks are usually rather simple

Tasks are trees of sequences of actions requiring exclusive choices at every junction

A. Difficult tasks: wide and deep structures (e.g., chess)
B. Simple tasks: wide and flat structures (e.g., menu of a chinese restaurant)
C. Simple tasks: narrow and deep structures (e.g.: sequence of steps in a recipe, instructions on reaching a known place, etc.



Carrying out an action

What happens when we carry out an action? Donald Norman has a classification in seven stages

- We have a goal (generic description of the desired result)
- We convert that into intentions (specification of the process taking to the result)
- We carry out some operations
- We evaluate the result

There is a schema called the "seven stages of the action"

The seven stages of action (1)

1 Form the goal

2 Form the intention

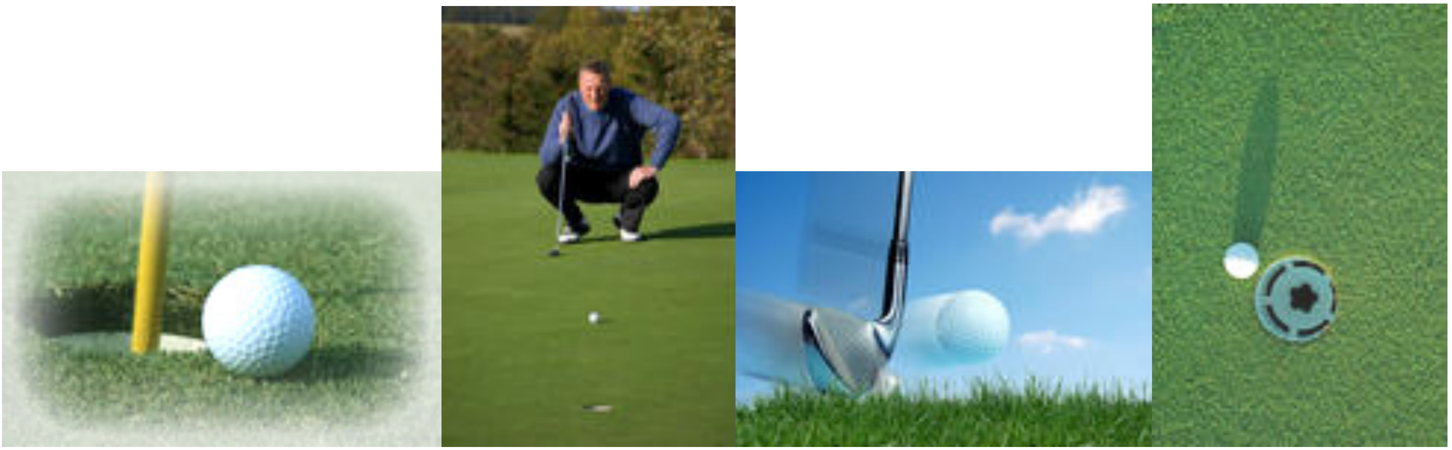
3 Specify the action

4 Execute the action

5 Perceive the state of the world

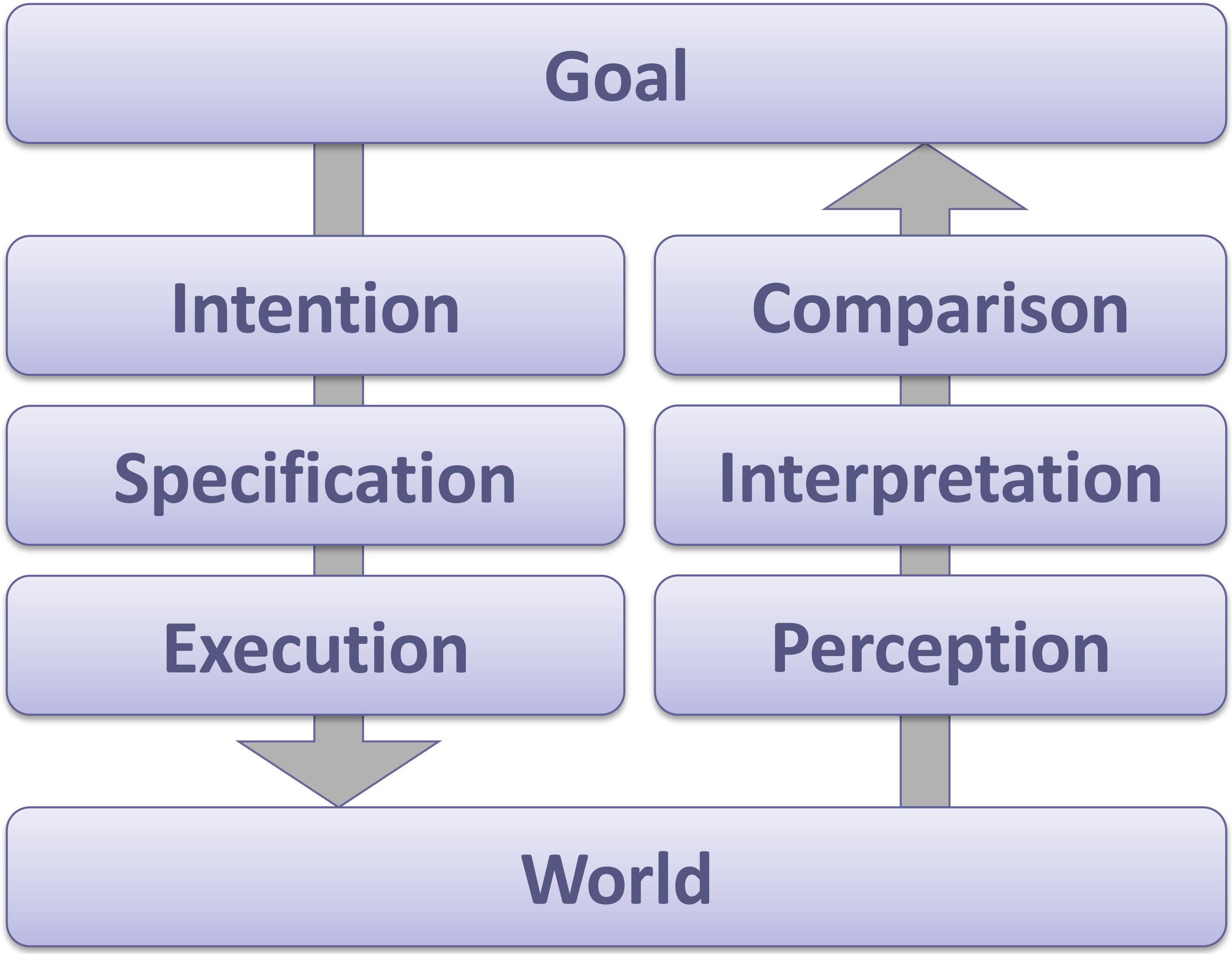
6 Interpret the state of the world

7 Compare the result to the goal



GOAL INTENTIONS EXECUTION EVALUATION

The seven stages of action (2)



The seven stages of action (3)

This is an approximate model. In the real world, the approach is opportunistic, not planned.

Opportunistic actions require less mental effort, less discomfort and greater interest (newness)

In addition, the process can start at any stage, and our goals are often vagues and ill defined

We more likely show a data-driven behavior, rather than a planned and designed behavior

Conscious and subconscious actions

Most human actions are *subliminal*, i.e., below the threshold of consciousness (soglia della coscienza). We are not aware of the mechanics of our actions.

For instance, close your fists and:

- Raise your thumbs. Close it back (Alzate il pollice. Richiudetelo)
- Raise your index finger. Close it back (Alzate l'indice. Richiudetelo)
- Explain in words the differences in the command given to the fingers.

Hard?

Subconscious actions	Conscious actions
Fast	Slow
Automatic	Controlled
Learned activites	New situations and experiences we have no good competencies.

Conscious and subconscious actions

Overlearning: learning so deeply that its competence becomes automatic, effortless, often unaware.

Non only mechanical competencies:

- What is the capital of France?
  Qual è la capitale della Francia?
- What is the capital of Lithuania?
  Qual è la capitale della Lituania?
- What is the capital of Azerbaijan?
  Qual è la capitale dell'Azerbaijan?
- What was Napoleon Bonaparte's telephone number?
  Qual era il numero telefonico di Napoleone Bonaparte?

Which came first? The answer, or the reaction of disbelief, or the amusement, or the explanation of why this is impossible to know?

Cognition and emotion (1)

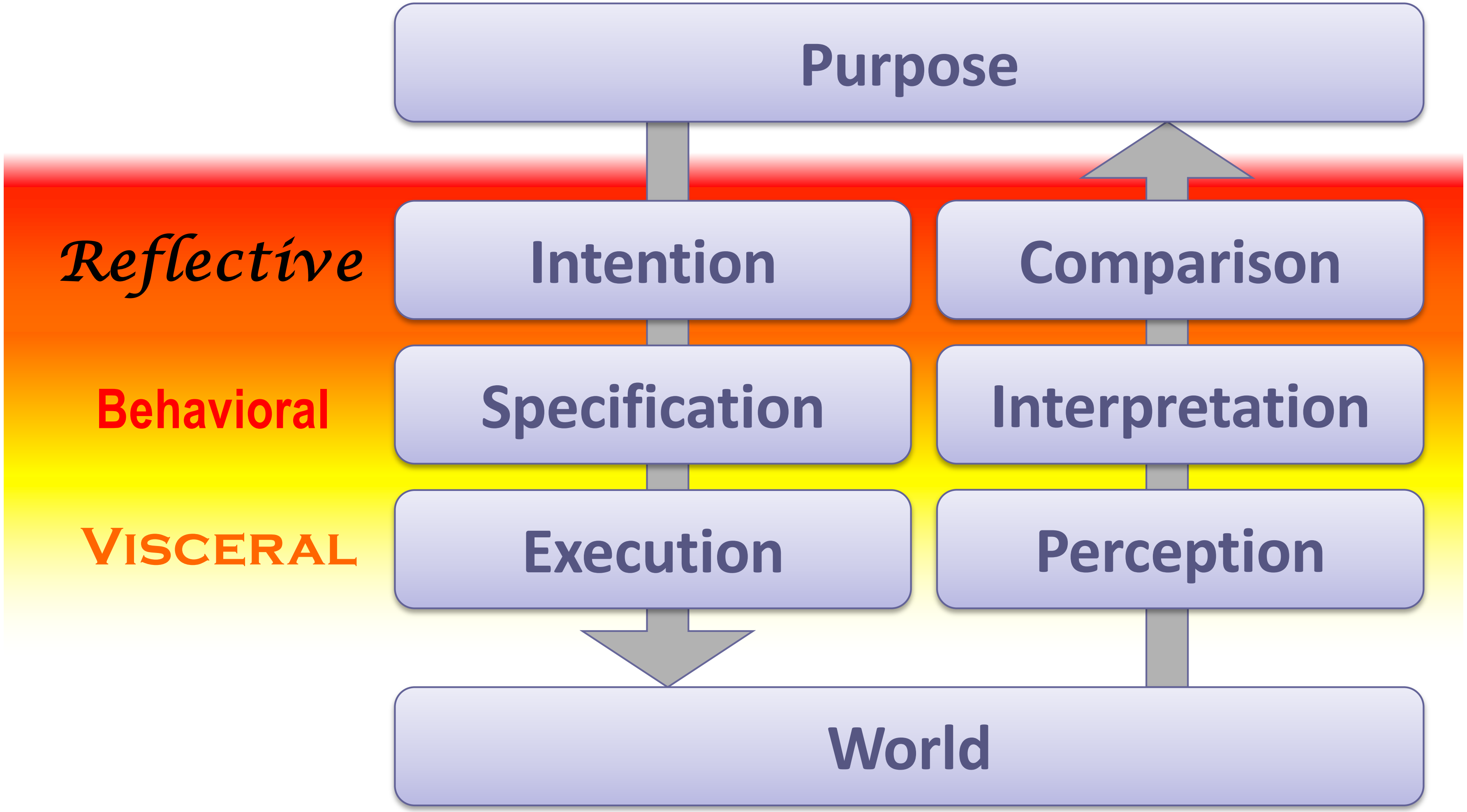
Important aspects of cognition pass through the filter of emotion (affective system). Norman proposes three levels:

1. ***Visceral level***
   - Also known in literature as the "reptile mind", controlled by the amygdala. We share it with all vertebrates.
   - Part of the fundamental system of the affective system protecting us against the dangers of the external world.
   - It responds quickly, without control or consciousness.
   - It handles the basic fears such as of physical aggressions, falling, annoyance of loud noises, appreciation of sweet and disgust of bitter, etc.
   - The reaction is influenced by repetition and conditioning (e.g., Pavlov's dogs).
   - Closely linked to the external nervous system that controls muscles, which we discover directly (instinctive reaction to assault) and indirectly (we realize that we are worried because the muscles are tense).

Cognition and emotion (2)

2. ***Behavioral level***
   - It is the place of the learned competencies: talking, writing, cycling, playing tennis, playing an instrument, driving, etc.
   - Actions and analysis are fundamentally subconscious.
   - Each action combines an expectation (that can generate anxiety or tension before action), and satisfaction (for a positive conclusion) or frustration (for a negative conclusion).
3. ***Reflective level***
   - It is the place of conscious reflections: counting, thinking, deciding, remembering, reflecting.
   - The emotions associated with this level are related to the association of causal relationships with events, such as guilt (colpa) and pride (orgoglio) (when we are the cause) or praise (lode) and accusation (accusa) (when the others are the cause).

The seven stages and the three levels



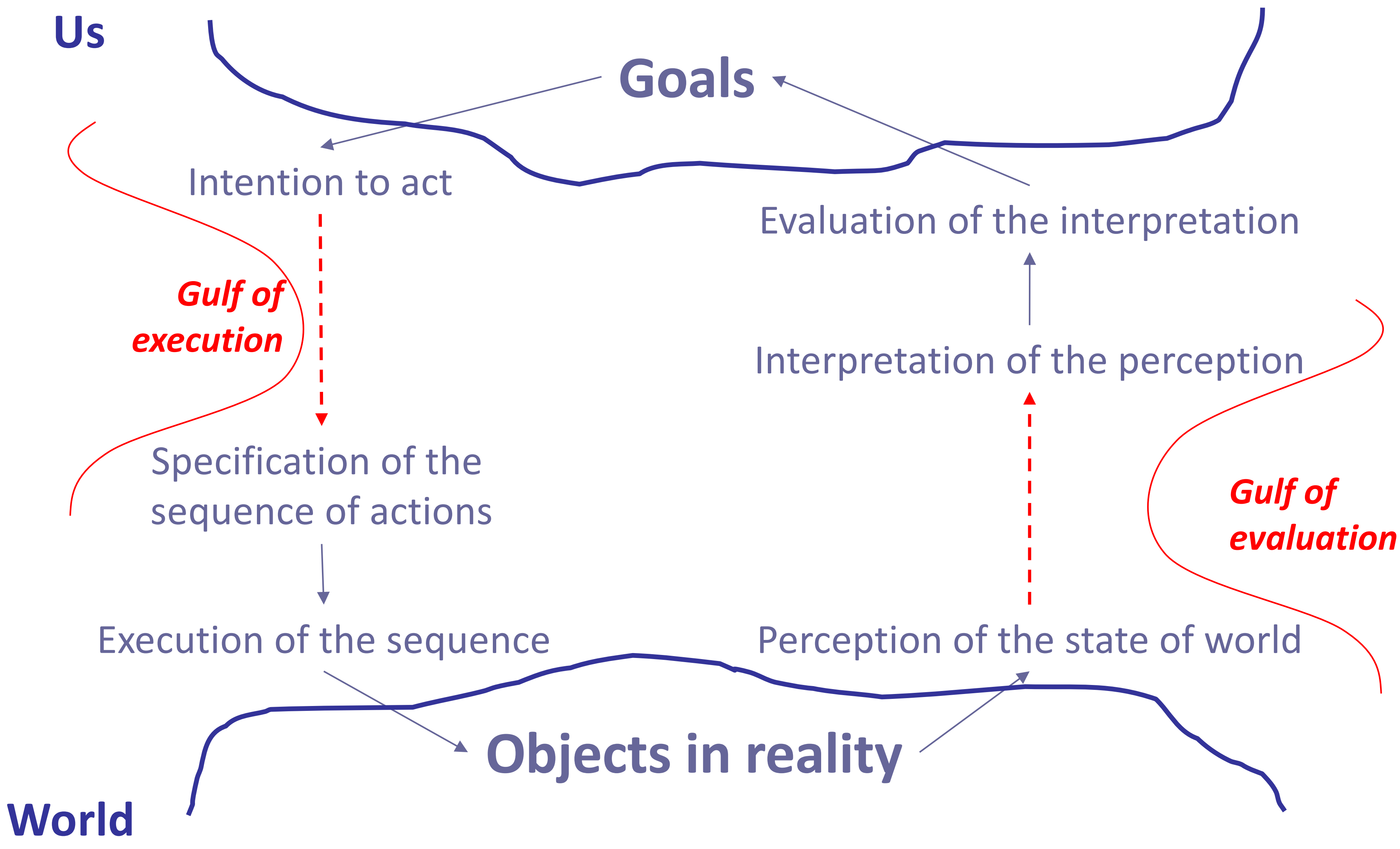
The gulfs of execution and of evaluation (1)

Errors in actions are sometimes due to the distance between the user's mental model and the real world of the objects we act on. These distances are called *gulfs* (*golfi*):

The theory of the seven stage of actions identifies two points where one can make errors, two major gulfs:

- The *gulf of execution* is the distance between the intentions shown by an object and the actions concretely possible with it (the distance between the affordance and the actions)
- The *gulf of evaluation* is the effort needed to assess the final state of the system AFTER the action, (the distance between the state of the system and its feedback)

The gulfs of execution and of evaluation (2)



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Errors

Errors in human beings: terminology

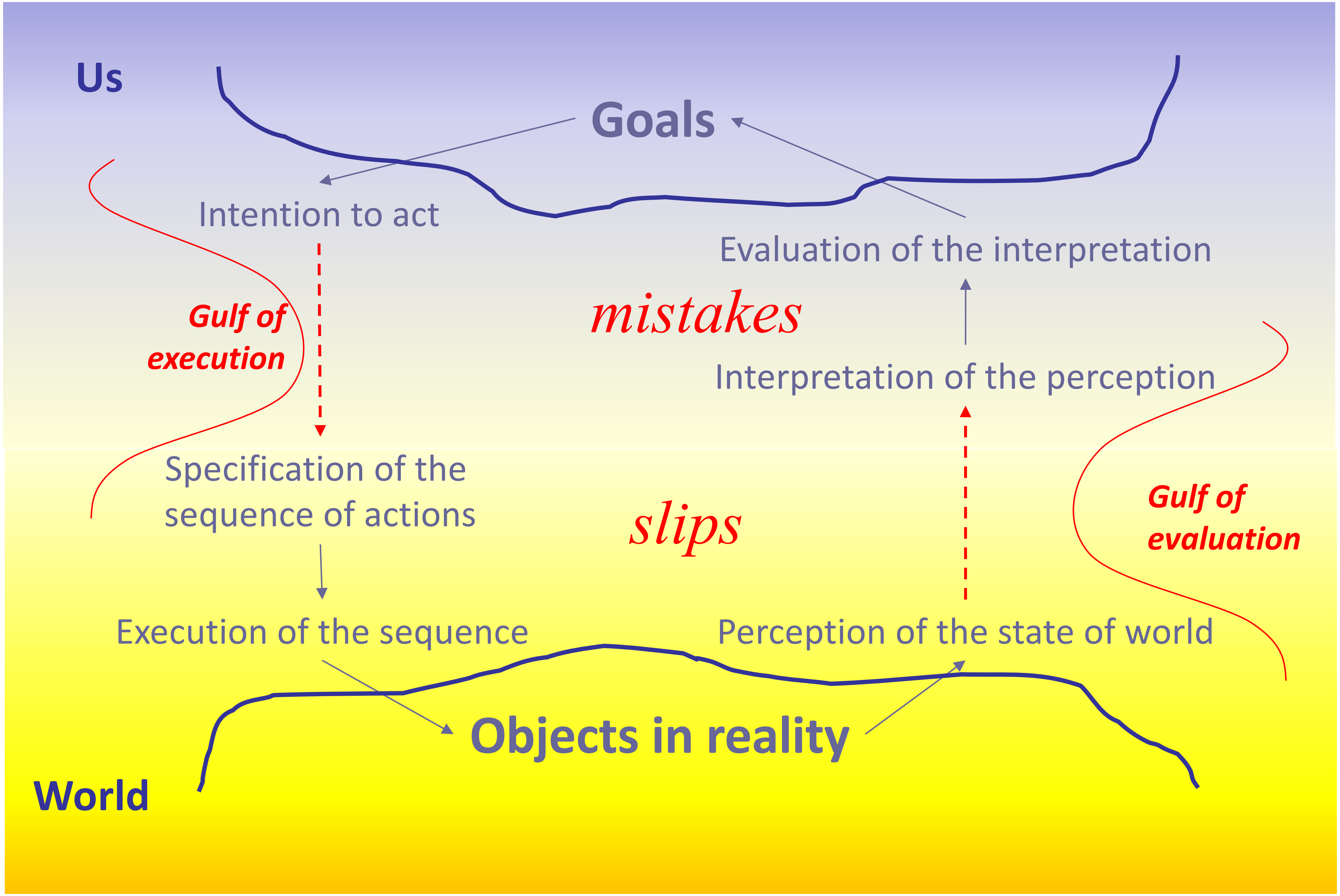
Mistake

- wrong intention
- cause: incorrect understanding
  - people create mental models to explain behavior
  - If incorrect, errors may occur

Slip

- correct intention, but incorrect execution
- cause: poor ability, inattention, and so on.
- unexpected changes in an aspect of the system
- Also known as lapsus
- Proper intention, correct execution but "deviated" from a similar and predominant intention

Mistakes and slips in the seven stages



Mistakes

Objects designed for humans that do not provide the possibility of mistake are unusable objects.

There are many causes of mistakes by humans:

- fallacious explanations,
- sense of helplessness,
- problems in executing or interpreting the actions.

Human beings as explaining beings

Humans are creatures that explain

- The explanation is often based on incomplete analysis and evaluations
- Often also on a mythological and anthropomorphic conception of external events (my computer hates me)

Naive Aristotelian Physics

- Reasonable conceptions (common sense) denied by physics
- Eg: push a heavy box (an object we stop pushing will stop)
- Ex .: shotgun fired vs. dropped (a shot projected horizontally will touch the ground after a dropped bullet).

Learned and taught helplessness

Learned helplessness

- Tendency to blame themselves
- A perception of global inability, which is then no longer put to test
- One just stops trying

Taught helplessness

- Bad explanations, system images, books or teachers convince us that we are not made for a given task
- Ex .: Mathematics

Self-fulfilling prophecies (*profezie auto-avverantesi*)

- Failing an exam

Slips

The *slip* (Latin *lapsus*, ita scivolata) correspond to a failure to realize a clear intention

They are not due to inexperience or misunderstanding, but to psychological phenomena that take over for various reasons

We can identify some types:

- Capture slips
- Description slips
- Memory-lapse slips
- Mode-error slips

Capture slips

A frequent activity takes over a rarer, but similar activity

The initial part of the action sequence needs to be identical to the more frequent one, and the capturing needs to be much more familiar than the captured one.

- Ex: sing a familiar motive
- Ex: go to your bedroom and go to bed
- Eg, drive someone to his/her home and finding yourself at your home

Description slips

The action to be performed is described in terms of intentions and actions in a similar way to a more common task.

The two descriptions are sufficiently similar to be confused.

- Eg: throw dirty clothes in the toilet
- Eg: Pour oil into a glass instead of the salad, or put salt in the cake mix
- Ex: Hang the wrong phone

These are typically correct actions on the wrong objects

Memory lapse slips

Humans are imprecise executors. Even a well described sequence of actions can lead to an error if an interruption halts momentarily the execution.

These are slips caused by the wrong or partial restart of the original execution.

For instance:

- Forgetting the original in a copy machine
- Leaving the pen somewhere, and forgetting it there
- Getting cash from an ATM machine, and forgetting the card inside the machine.

Modality slips

A technological, not a psychological slip: it exists since modes have been invented (same commands for different functions).

It happens when we forget or ignore that the same commands have different functions in different modes

- Ex: light and reset the stopwatch in a digital clock
- Ex: setting the current time and the alarm time in a alarm clock
- Ex: "d" in vim

Other causes of errors

Minimization

- Eg: Silence your dog right when there is a thief

Rationalization

- Provide rational explanations that ex post are obviously wrong

Selective attention

- Conscious reasoning is concentrated, slow and serial, reductive: we can not react with sufficient speed to the inputs
- Automatic reasoning is fast, holistic, associative: in the effort to concentrate on doing something, we lose sight of the consequences

Social and economic pressure

- Sometimes social pressure, the desire to not look bad, the costs associated with a change of program, may lead us to avoid things that would be right to do.

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Design

Designing everyday objects

- Visibility and feedback
- Managing the error
- Forcing functions
- The aesthetics
- Things deliberately difficult

Visibility and feedback

Visibility

- Make relevant parts visible and emphasize them in some way.
- Reduces the gulf of execution.

Cover in complex remotes

Feedback

- Make sure that every action has immediate and obvious effect.
- Reduces the gulf of evaluation.

High beam indicator

Managing errors

- Understand the causes of errors and design in order to minimize it
- Make all actions reversible
- Make irreversible actions very difficult
- Help the discovery of errors and help their correction
- Consider that the user makes mistakes, and indeed uses trial–and–error approaches.

Forcing functions

They are physical constraints that prevent certain actions to be executed in the wrong moment or in the wrong way

- *Interlock:* a part blocks the operation of another part. Ex .: Sliding door and tank cap of a van
- *Lockin:* the functionality of an object is guaranteed even in the event of accidental interruption (eg .: the hooks of a telephone, a soft switch in a computer, the "Cancel" button after the quit command)
- *Lockout:* the operation of an object is made deliberately difficult so as to ensure the user really wants to activate it (ex .: security stairs to the basement, dangerous options for an application, the safety lock of a gun)

Aesthetics and usability

Remember that the designer is not the typical user:

- its system model is precise regardless of the clarity with which the system makes it manifest
- His knowledge is specialized and uncommon
- Often with intelligence, preparation and age different from the end users

The customer may not be the end user

- He is more interested in functionality or cost than usability
- He is less aware of specific tasks and procedures
- He may well be deluded about the technical capabilities of the users

The problem of excessive functions: *featuritis*

The problem of false ideals: aesthetics, efficiency, portability

Designing deliberately difficult objects

Sometimes difficulty is required, the user's explicit attention is required before performing a special action:

Video games

Switches and lockouts

Two-hands controls on industrial appliances

Conclusions

Today we have talked about how to deal with everyday objects design:

- Understanding how the user works
- Understanding how wrong the user is
- Knowing how the user learns and remembers

References

Donald Norman, "The Psychology of Everyday Things", 1988

Donald Norman, "The Design of Everyday Things", 2013. (ed. it. "La caffettiera del Masochista", Giunti ed., 2015).