# Elements on cognitive theories

HCI-Patras

Cognitive Ergonomics course

Dimitris Nathanael

# Historical evolution of theories on cognition (1)

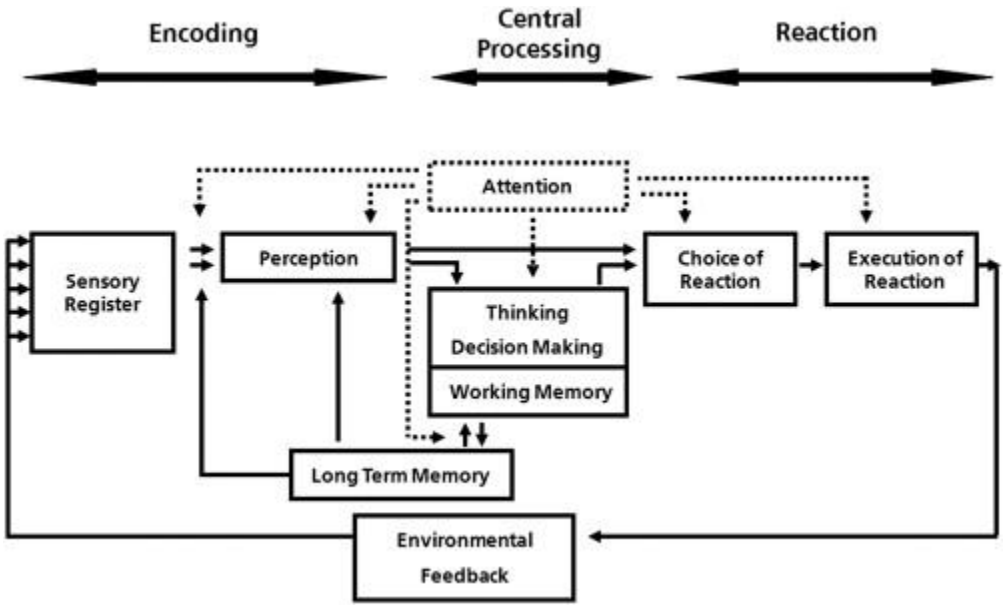
- Before 20th century → Philosophy and specifically **metaphysics** (Plato, Descartes, Hegel, etc). How we internally structure the world to understand it.
- Beginning of 20th century → **behaviorism** the bipole «stimulus – response», tries to explain intelligent behavior as a system of conditioned reflexes that builds through repetition
- 1930s. The rise of **cognitivism** after the inadequacy of behaviourism to encompass higher level cognitive processes in its theory. Cognitivism acknowledges the autonomy of the human thought and tries to model it through formal logic predicates.

# Historical evolution of theories on cognition (2)

- 1940s. The rise of **Information theory** and later computer science supports the cognitivist project and pushes it to model human cognition as digital computation.
- 1970s. The computational model o the human mind becomes widespread and promises to simulate the human mental processes through **Symbolic Artificial Intelligence** (S-AI).
- Late 1980s. The so called “Symbolic AI” and strong cognitivism, receives heavy criticism, in terms of its underlying hypotheses that information processing is a good candidate for modeling human cognition
- 1990s, Hybrid **connectionist** and **philosophical** approaches gain support (e.g. situational, phenomenological, sociological)

# Wickens model of Human Information Processing

(Wickens 1992)




**Sensory processing** – The input (called stimuli) comes from all the human sensory systems. Each sensory system includes a mechanism which prolongs any stimulus for a short time after the stimulus has occurred.

**Perceptual encoding** – The stimuli are assigned to a single perceptual category. This is also known as detection, recognition, identification, categorization, pattern recognition, etc.

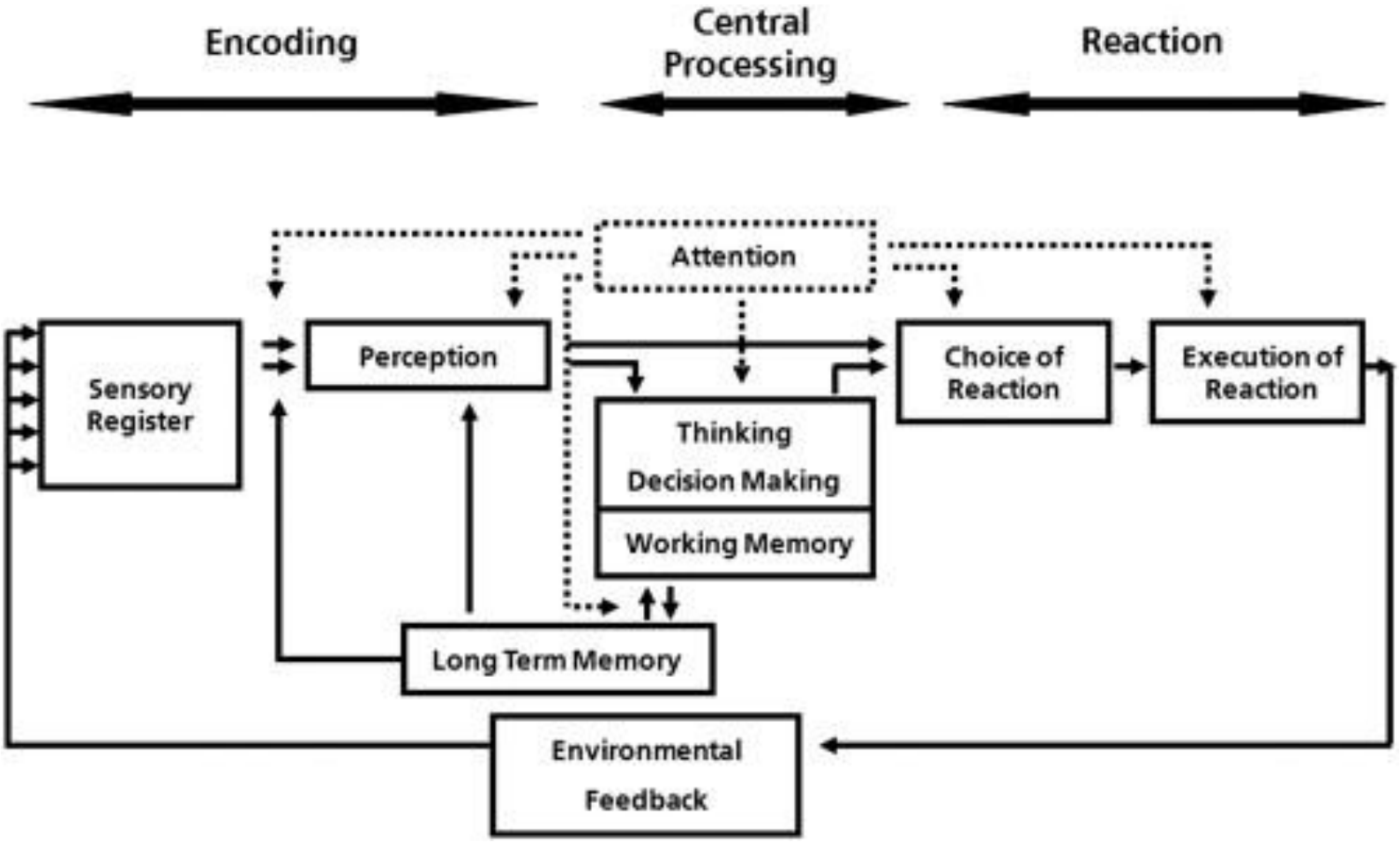
**Cognitive processing/Decision making**– After categorizing the stimulus, you must decide what to do with it. This involves conscious processing (Working memory) as well as recollection –conscious or not (Long Term memory)

**Response execution** – The response (physical action) is executed.

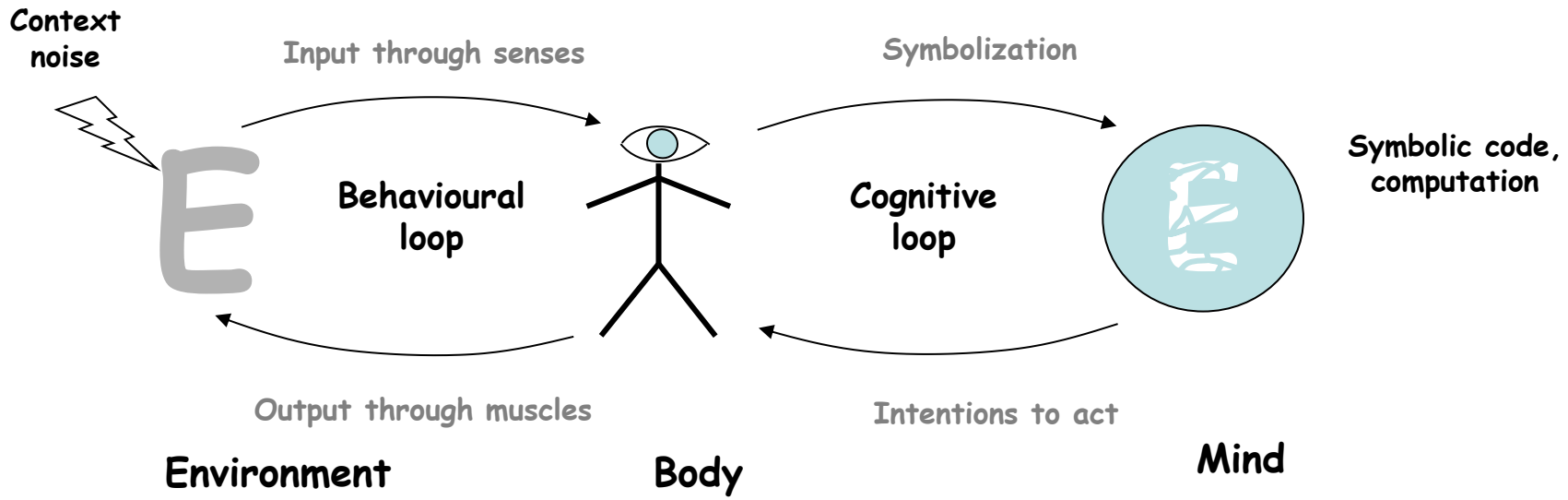
**Feedback and information flow** – You monitor the consequences of your action.

**Attention** – How attentive you are to diverse external stimuli or internal processes (For example, when you hear a suspicious sound, you decide to pay more attention to your hearing than to your eyesight.)

# Wickens model of Human Information Processing



# The distinction between matter and mind in classical cognitive psychology



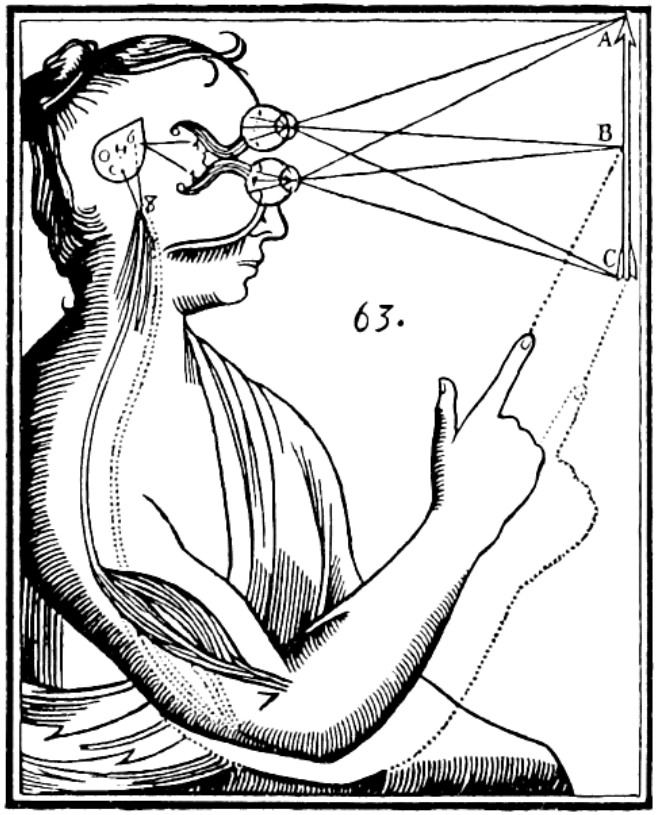

- Environment – Body – Mind treated as independent entities
- Environment is objective (not influenced by the subject)
- The body is an input-output device connecting Environment with mind
- Mind builds symbolic representations of the Environment, performs logical computations and responds via the body
- Context is treated as a source of noise

## Challenging to model:

- The role of emotion in thinking
- The role of consciousness and self-reference
- The role of the environment in thinking
- The role of bodily activity in thinking
- The moderating role of social phenomena in shaping thinking
- The fact that the human mind is cultural rather than logical
- That the mind does not equate the brain, it is not matter but process.

To understand human experience we need to address the mind – body problem : how are mind and brain related?

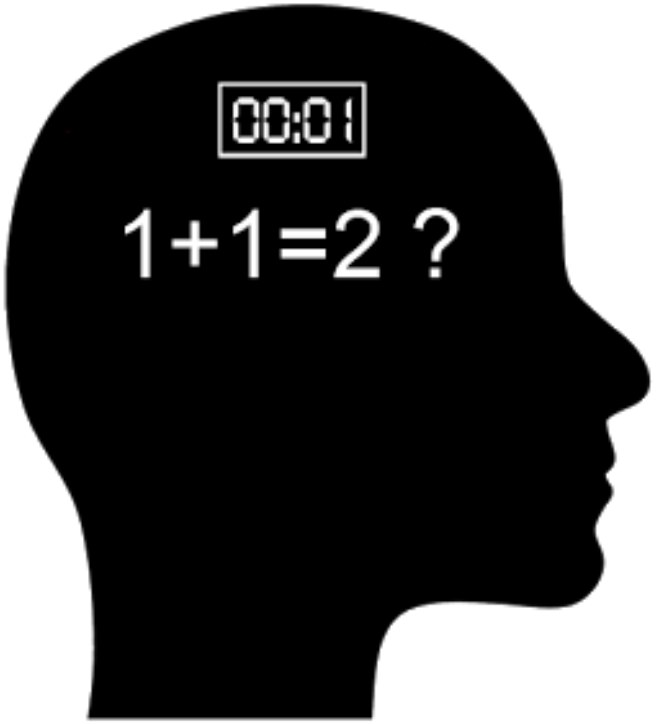
- The mind – body duality - Spirit vs Matter – Neurophysiology vs Psychology




**A circular causality: brain and adaptive mechanism, mind an evolving process taking place in the brain transforming it as it evolves**

*René Descartes's illustration of dualism. Inputs are passed on by the sensory organs to the epiphysis in the brain and from there to the immaterial spirit.*

To understand human experience we need to make a shift from well-established ideas such as:

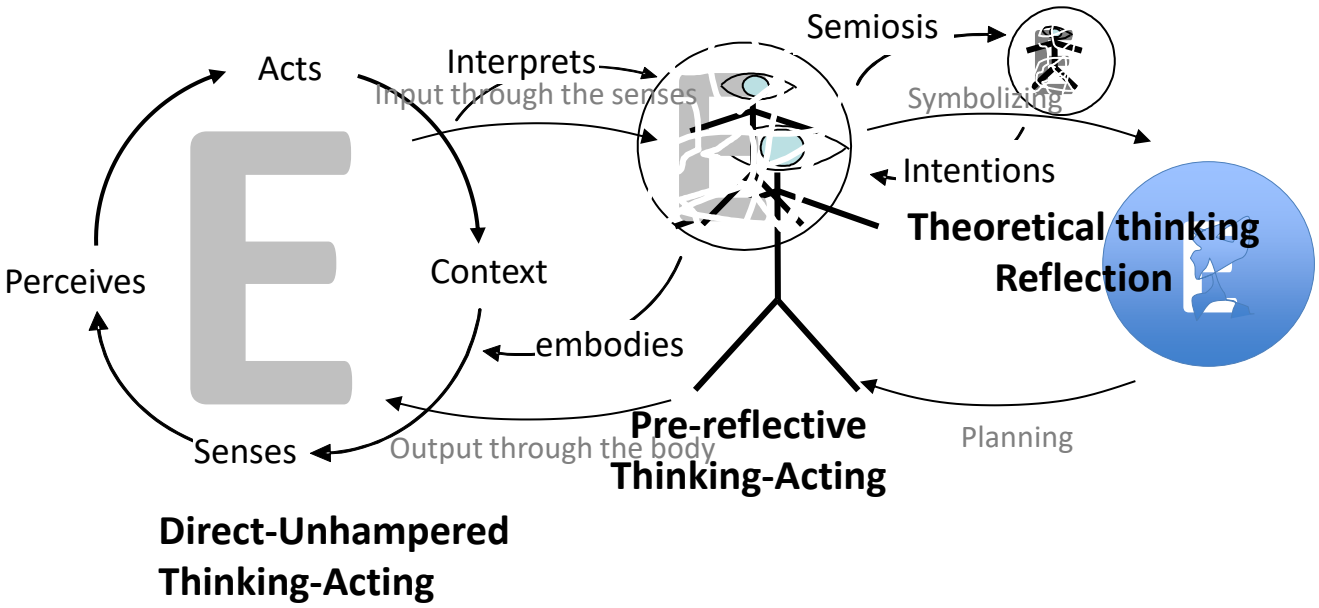



- The mind as a numerical / symbolic machine
- Biological memory as an information storage device

To understand human experience we need to make a shift from well-established ideas such as the independence of the animal from its environment

***Where does our functional body and sensory organs end?***

# Phenomenological View




- Humans
- Context
- Cognitiv
  EXPERIE
- Through
  reflecti

- The Cartesian body - Mind dichotomy
- Body as a machine receiving signals and following plans
- Mind as symbol manipulator / computer
- Environment uninfluenced by body or mind

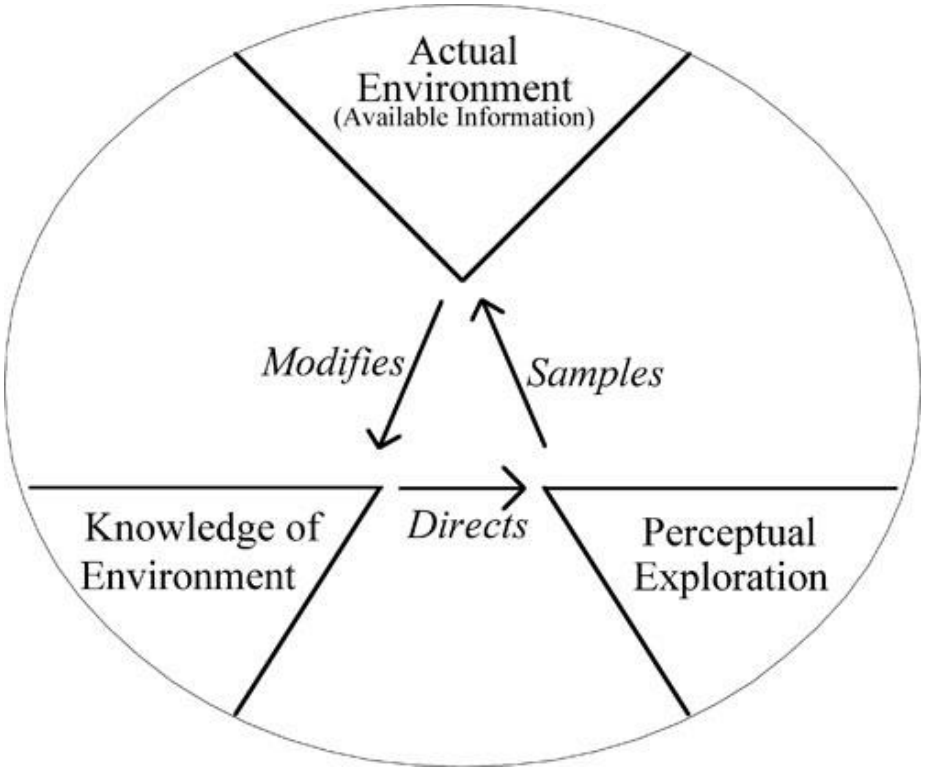
bodied as

own

# The Perceptual Cycle

(Ulrich Neisser, 1976)

However, Humans are not just processors of information,–whether they like it or not – they are both animals and autonomous (responsible) actors



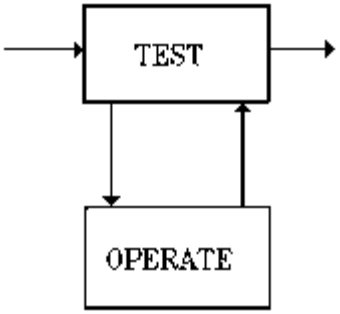

Perceived reality is a *construction*, a perpetual cycle between:

- Searching information from the outside
- Modifying our internal state
- Deciding on where to search next

# The Test – Operate – Test – Exit model

(Miller, Galanter & Pribram, 1960)

## A primitive cognitive interaction model: the TOTE unit



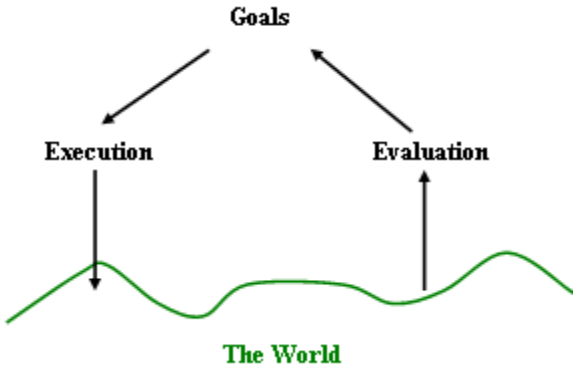

1.Test to obtain some representation of the problem state

2.Operate - intervene in some way

3.Test again to see if the desired result has been achieved. If it has not, loop back to operate. If it has:

4.Exit - problem solved

## A reformulation of TOTE unit: the Action Cycle




1.Form a goal

2.Execute goal

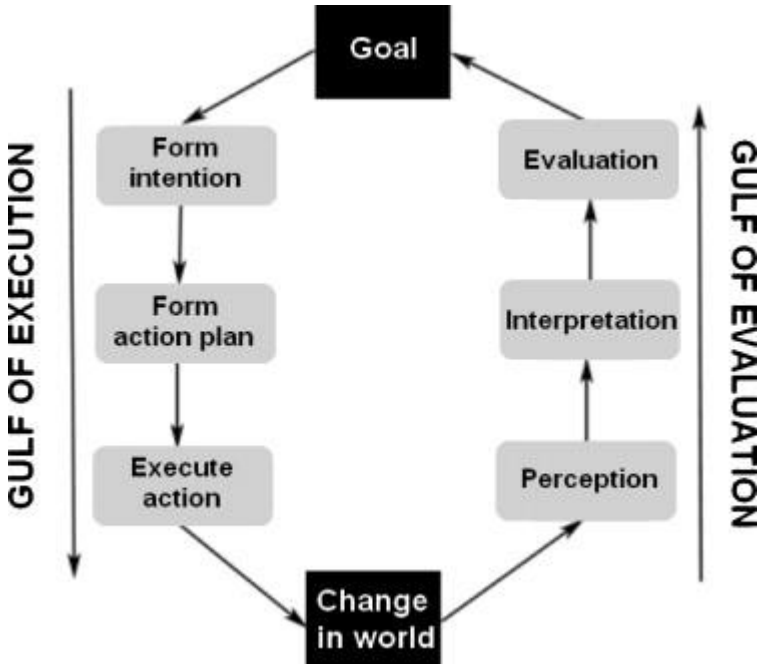
3.Evaluate world state vis-à-vis goal

4.Form a new goal

https://www.youtube.com/watch?v=yY96hTb8WgI

# The Action Cycle model

(Donald Norman 1988)




http://www.interaction-design.org/tv/action_cycle_explained.html

**Goal formation stage**

1. Goal formation

**Execution stage**

2. Translation of goals into a set of unordered tasks required to achieve goals

3. Sequencing the tasks to create the action sequence

4. Executing the action sequence

**Evaluation stage**

5. Perceiving the results after having executed the action sequence

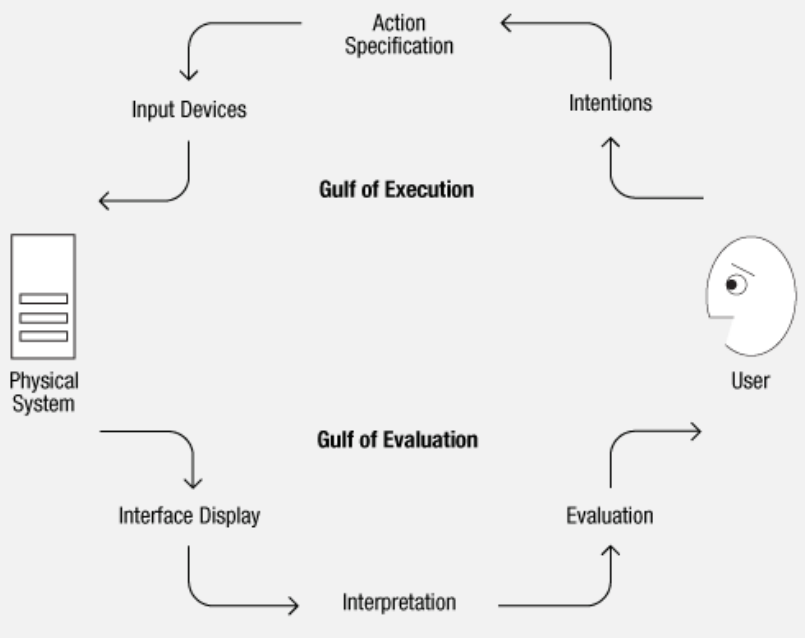
6. Interpreting the actual outcomes based on the expected outcomes

7. Comparing what happened with what the user wished to happen

# The Action Cycle: gulfs of execution & evaluation

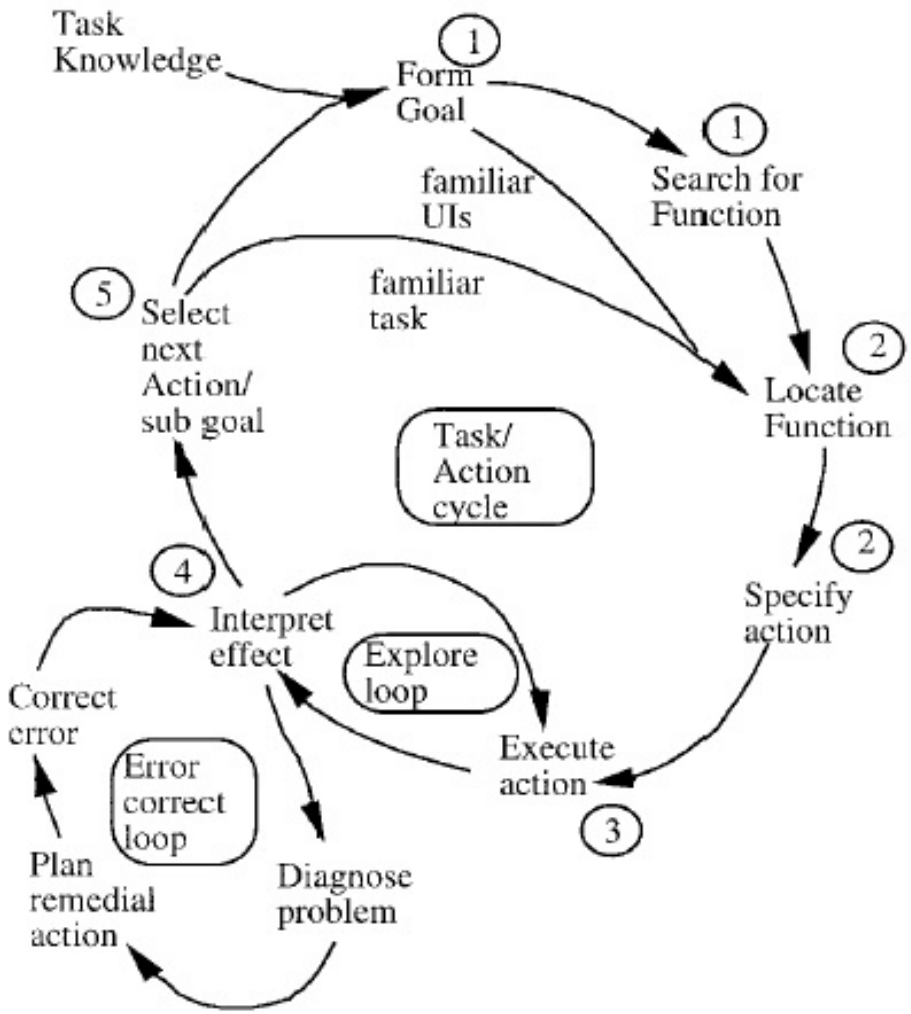
Difficulties in the use of technological artifacts can be divided in:

- Difficulties in intention - execution
- Difficulties in evaluation




- The **gulf of execution** is the degree to which the interaction possibilities of an artifact, a computer system or likewise correspond to the intentions of the person and what that person perceives is possible to do with the artifact/application
- The **gulf of evaluation** is the degree to which the system/artifact provide representations that can be directly perceived and interpreted in terms of the expectations and intentions of the user

# The Action Cycle model: shortcuts in real life




We do not always consciously act upon all stages. We may directly execute an action upon perception or select an new action without forming a new goal.

Shortcuts are our primary means of cognitive economy and contribute to our cognitive performance

However, they are also at the basis of Human Error!

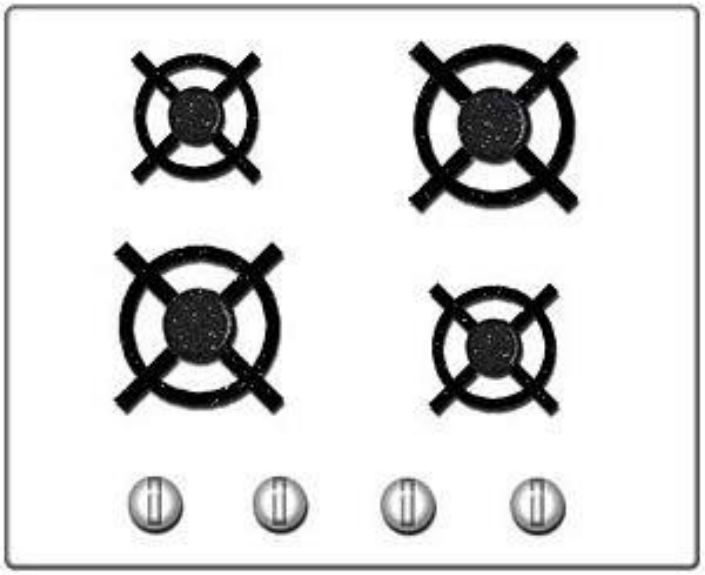
# Small and large gulfs of execution (1) - Mappings

adjusting the driver's seat with the control above offers a very small gulf of execution

adjusting the front and rear speakers with the above control introduces a large gulf..

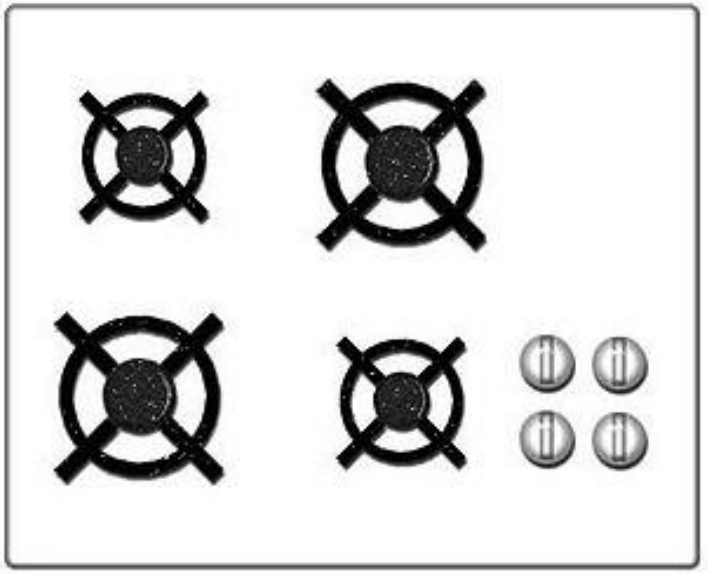
# Small and large gulfs of execution (2) - Mappings

Poor mapping



A common stovetop design with no natural mapping between burners & knobs (controls)

Good mapping



An improved design with unambiguous mapping between burners & knobs

# Compatibility of interface controls to the user goals

**Mapping of physical actuators to the user goals (e.g. flow & temperature control)**

- **Left: indirect (need to manipulate both knobs to control temperature and flow**
- **Right: Direct (vertical control -> flow, horizontal → Temperature )**

# Compatibility of control action with the target effect

- Mapping of goals to controls
- Directional compatibility of control displacement
- Topological compatibility of control position
- Functional compatibility of control physical action (e.g. discrete vs. continuous, upper –lower limit, cyclical)
- Semantic compatibility (e.g. size, force exertion, color, shape)
- Cultural?

How about the controls of home faucets?.....Fast?... Accurate flow?... Hot / warm or temperature control? … ?

Compatibility ultimately depends on users' goals !

# Small and large gulfs of execution (2) – Affordances - Signifiers

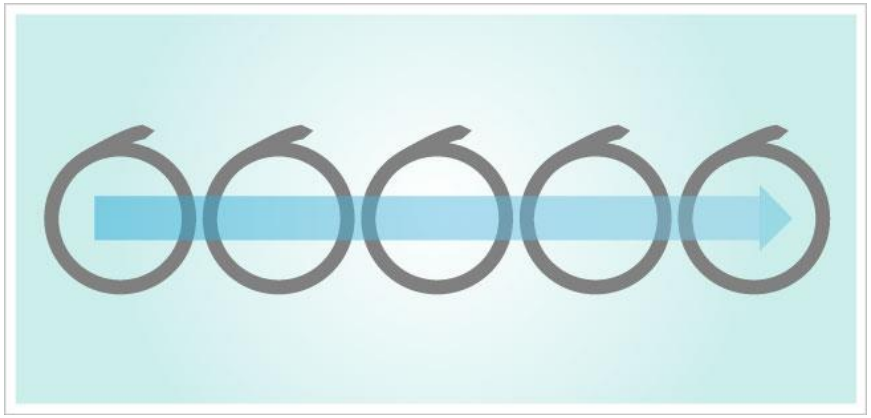
The handles above offer small gulfs because they “invite” the hand to manipulate them in the most predictable way

Where do the roots of our expectations lie?

# The Action Cycle : a perpetual spiral of planning, acting, perceiving, interpreting… and planning again

We may model complex interactions with the use of successive action cycles.

We may also model multilevel cognitive processes with nested hierarchies of such cycles



Not only interaction with technological artifacts but many every day activities, e.g. Car driving, can be usefully modeled with this versatile tool

# Checklist for design

**How easy will it be for the user of a technological artifact**:

- To perceive its main functions. e.g. what goals can he fulfill through it?
- To understand what actions are possible i.e. to decide through what actions he may fulfill his set goals?
- To define the sequence and the way of realizing the above actions?
- To physically realize the actions?
- To perceive the state of the artifact once he acted upon it?
- To interpret and signify correctly the perceived state of the artifact?
- To advance his goal to the next needed action(s)?

End of Lecture on Action cycle

# Signals

# Signals

# Signals

**Ferdinand de Saussure**
**1857–1913**

***"The sign is binary; It is comprised of two parts; the signifier (eg. sound pattern) and signified (concept)"***

**Ferdinand de Saussure**
**1857–1913**

***sign***

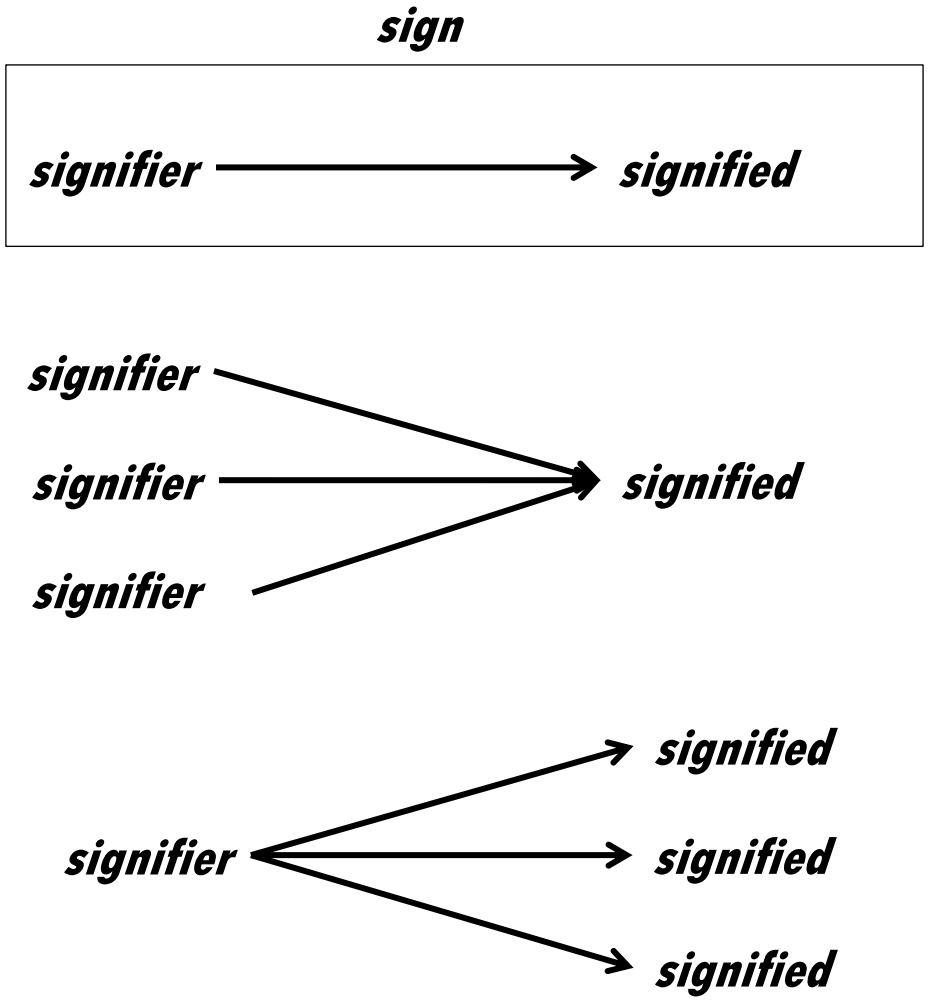
***signifier*** → ***signified***

**"Apple"** → **The concept of apple**

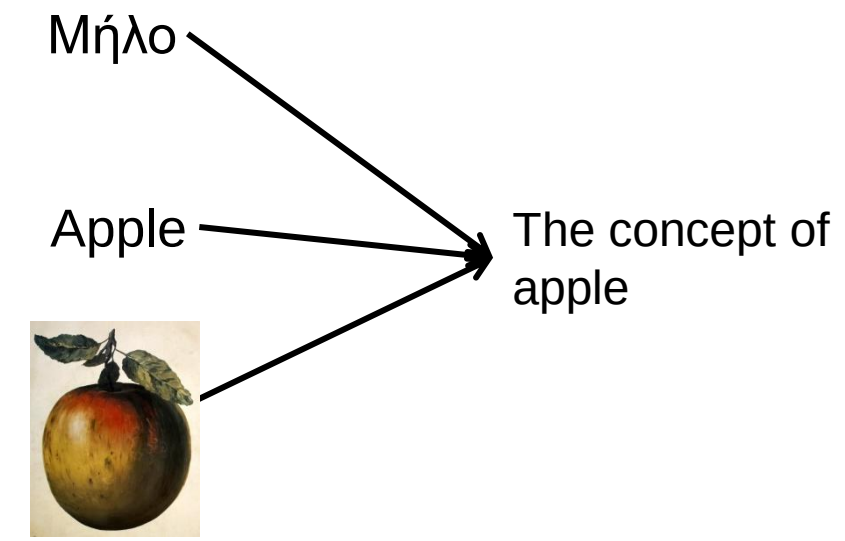
**"Violence"** → **The concept of Violence**

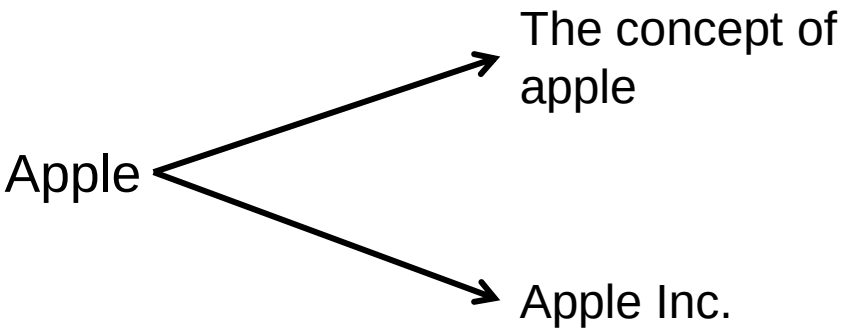
**Smoke** → **Fire**

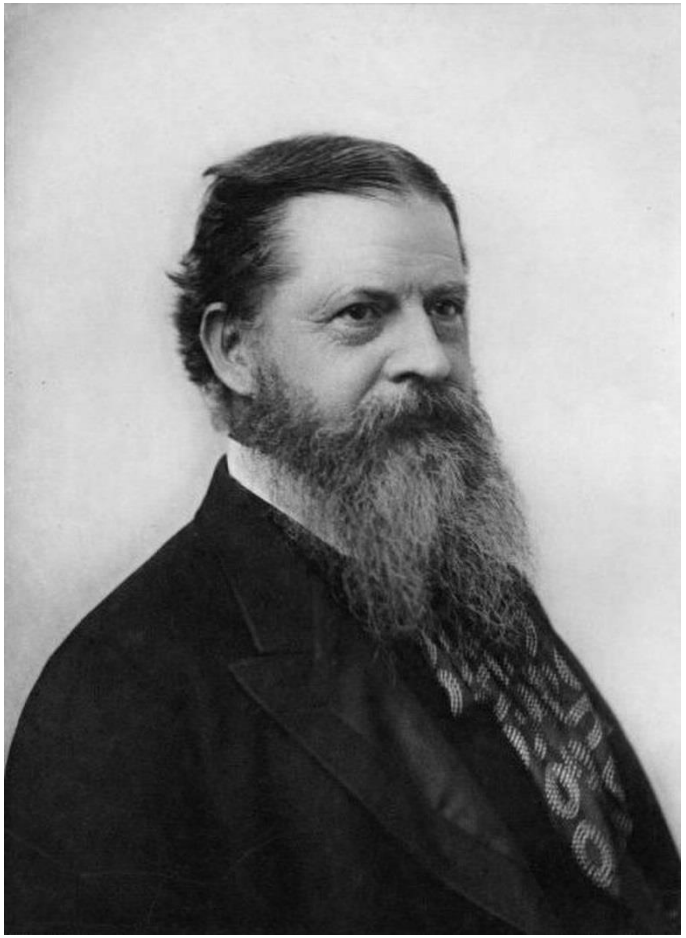
**Ferdinand de Saussure**
**1857–1913**



**Ferdinand de Saussure**
**1857–1913**

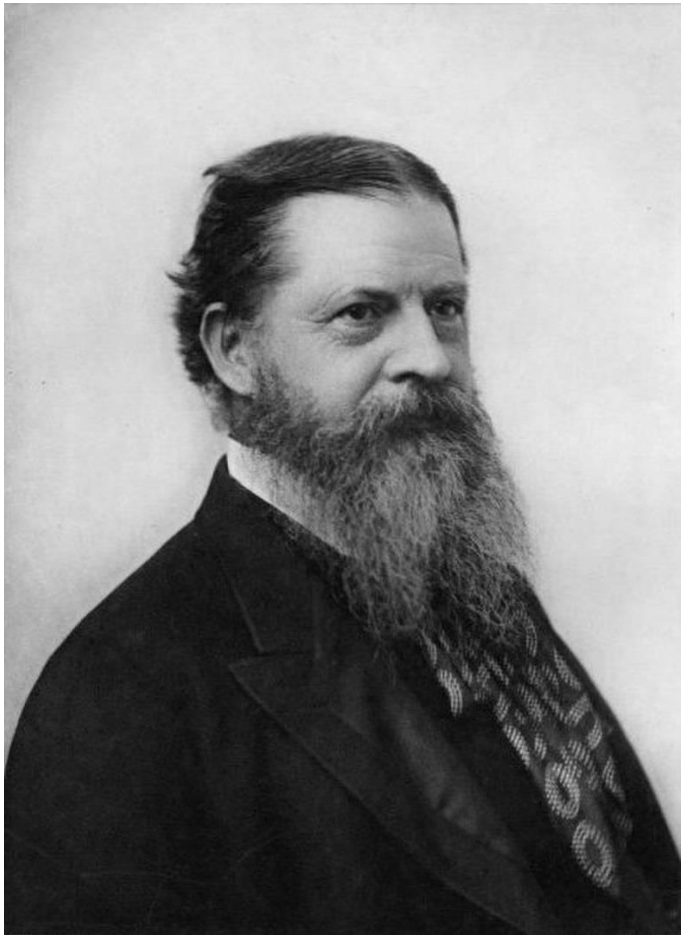


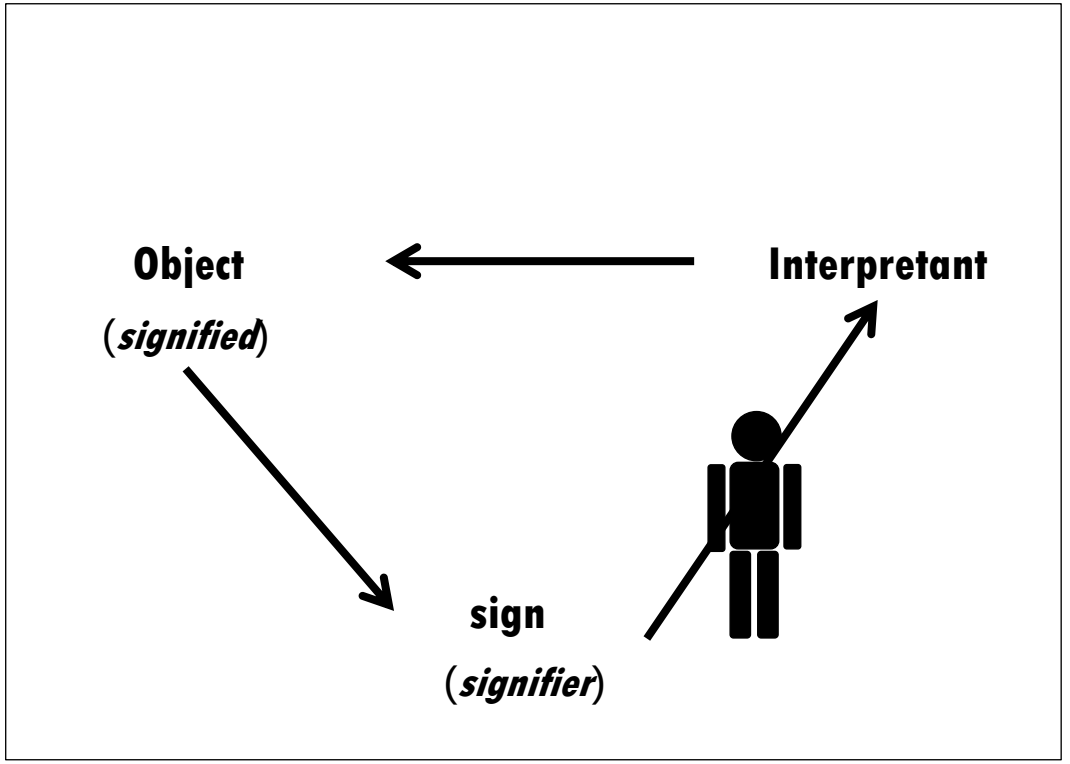


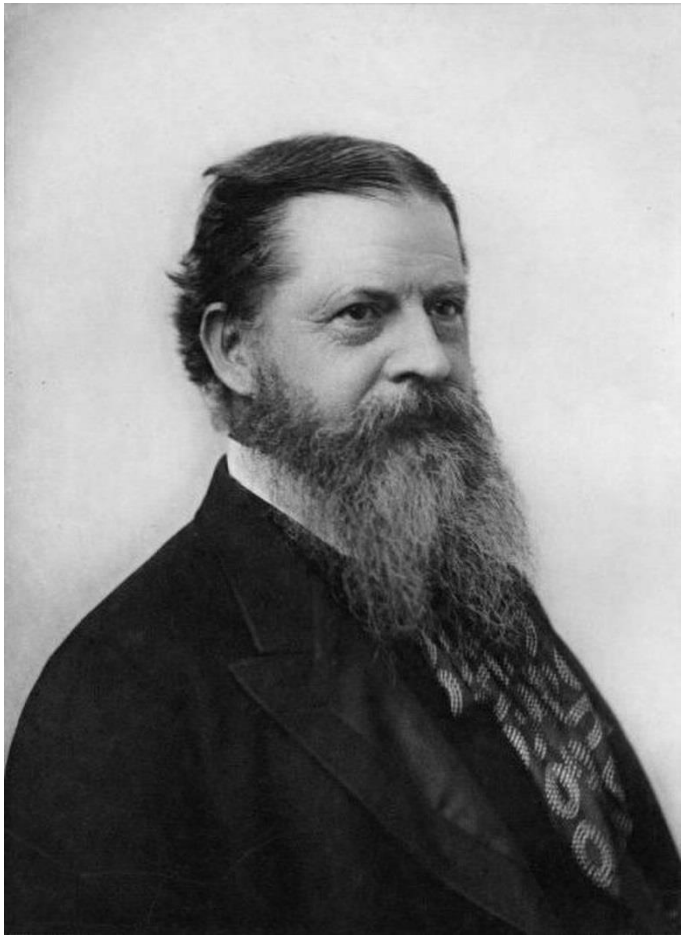
Charles Sanders Peirce
1839 - 1914

**I define a "sign" as anything which is so determined by something else, called its Object, and so determines an effect upon a person, which effect I call its Interpretant, that the later is thereby mediately determined by the former.**



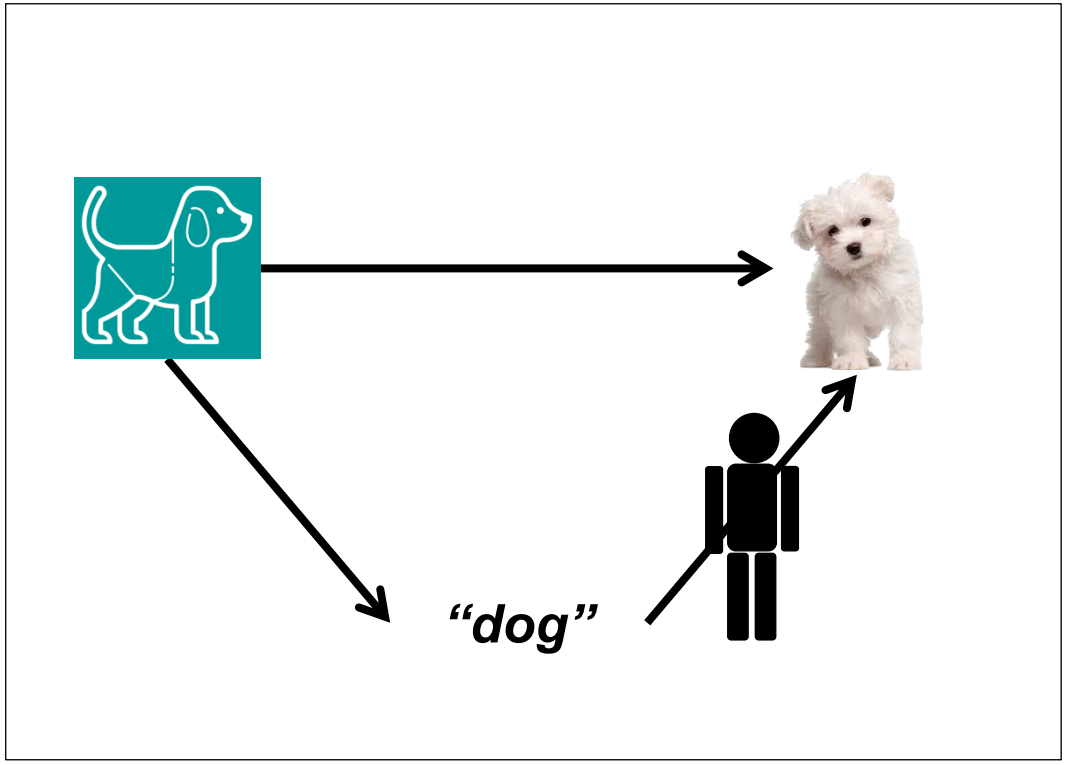
**Charles Sanders Peirce**
**1839 - 1914**





Charles Sanders Peirce
1839 - 1914

# Σημείο / Σημείωση



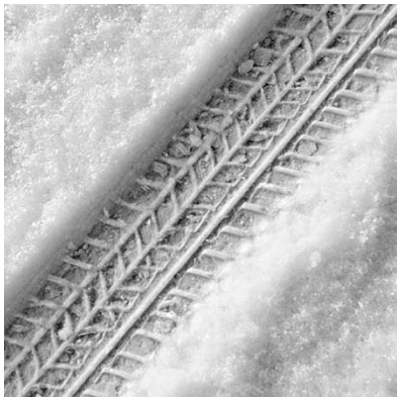
# The types of Signs

**Symbol**

relation by convention to its object

**Icon**

similarity to its object



**Index**

factual connection to its object

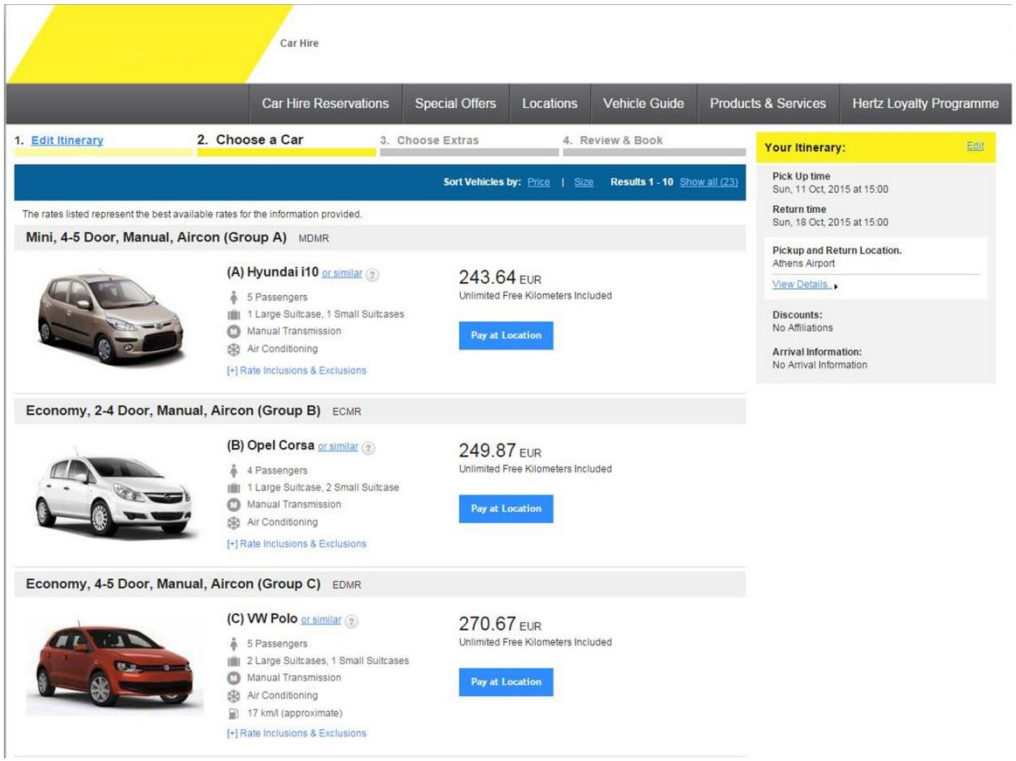
# Signs

# How does the ecology of the receiver affect the Interpretation?

The ecology of the receiver affects the Interpretation mechanism in many ways:

- previous experiences of the receiver
- the cultural context in which he is located,
- the context in which he is located at the time of receiving the signal
- his available perceptual resources at that time

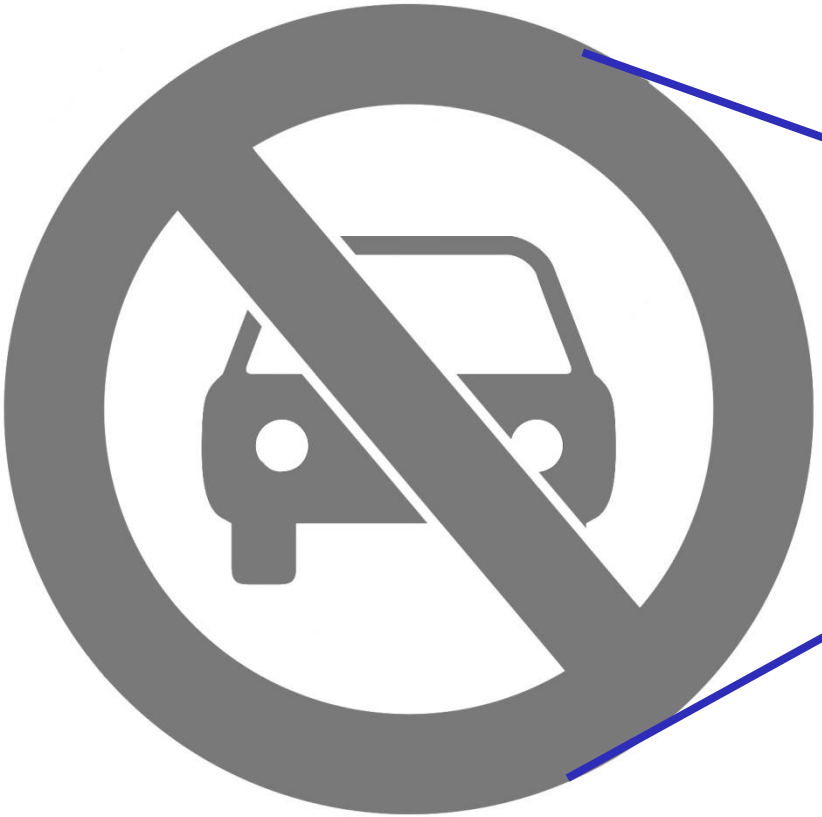
C-Zero
C1
C1 airscape
C3
C3 Picasso
C4
C4 Cactus
C4 Grand Picasso
C4 Picasso
C5
C5 Tourer
Dispatch
Dispatch Combi
DS3
DS3 Cabrio
DS4
DS5
Nemo
Relay
DACIA LEASING
Logan MCV
Sandero
Sandero Stepway
DELOREAN CAR LEASES
DMC-12
FIAT CAR LEASING
500
500 Convertible
500L
500L MPW
Doblo Estate
Fiorino Combi
Panda
Panda 4x4
Punto
Qubo Estate
Scudo Combi
Scudo Panorama
FORD LEASE CARS
B-Max
C-Max
EcoSport
Fiesta
Volkswagen Up
1.0 i (59bhp) Take
Hatchback 3dr 999cc
3+35 3 year lease
£118.80
more info
Fiat 500 1.2 i 8v
(69bhp) Pop [Start Stop]
Hatchback 3dr 1242cc
3+47 4 year lease
£118.92
more info
Nissan Micra 1.2 i
12v (78bhp) Visia
Hatchback 5dr 1198cc
3+23 2 year lease
£131.04
more info
"Great car, great service, great deal" - Paul Nolan, BL9 5QL ...1528 letters HERE
Fiat 500 1.2 i 8v
(69bhp) Pop [Start Stop]
Hatchback 3dr 1242cc
3+35 3 year lease
£138.00
more info
Fiat 500 1.2 i 8v
(69bhp) Lounge [Start Stop] Hatchback 3dr 1242cc
3+47 4 year lease
£151.38
more info
Nissan Juke (new shape) 1.6 i 16v
(93bhp) Visia Hatchback 5dr 1598cc
3+35 3 year lease
£162.68
more info
"After 3 hours of trawling the net, I am glad that I found you" - Rob Baker, OX16 9NR ...1528 letters HERE
LINGsCARS.com
CLICK! See 226 clients live in LINGO!
Live!!
CLICK to VIEW!
Online Service Response Times
Quote > Proposal > Order > Delivery
75 CLIENTS IN 'PROPOSAL'
...LING REPLIES IN: 0:03:49
HRS : MINUTES sec
151 CLIENTS IN 'ORDER'
...LING REPLIES IN: 0:07:08
HRS : MINUTES sec
Lingscars.com Limited (gb)
Customers use my secure LINGO management system.
Response times above based on last 4 hour period between 9am - 6pm, Mon to Fri -Ling
WOW!
UK's BEST service times!
No Waiting
LINGsCARS.com


Car Hire
Car Hire Reservations
Special Offers
Locations
Vehicle Guide
Products & Services
Hertz Loyalty Programme
1. Edit Itinerary
2. Choose a Car
3. Choose Extras
4. Review & Book
Your Itinerary:
Edit
Sort Vehicles by: Price | Size
Results 1 - 10 Show all (23)
The rates listed represent the best available rates for the information provided.
Mini, 4-5 Door, Manual, Aircon (Group A) MDMR
(A) Hyundai i10 or similar
5 Passengers
1 Large Suitcase, 1 Small Suitcases
Manual Transmission
Air Conditioning
[+] Rate Inclusions & Exclusions
243.64 EUR
Unlimited Free Kilometers Included
Pay at Location
Economy, 2-4 Door, Manual, Aircon (Group B) ECMR
(B) Opel Corsa or similar
4 Passengers
1 Large Suitcase, 2 Small Suitcase
Manual Transmission
Air Conditioning
[+] Rate Inclusions & Exclusions
249.87 EUR
Unlimited Free Kilometers Included
Pay at Location
Economy, 4-5 Door, Manual, Aircon (Group C) EDMR
(C) VW Polo or similar
5 Passengers
2 Large Suitcases, 1 Small Suitcases
Manual Transmission
Air Conditioning
17 km/l (approximate)
[+] Rate Inclusions & Exclusions
270.67 EUR
Unlimited Free Kilometers Included
Pay at Location
Pick Up time
Sun, 11 Oct, 2015 at 15:00
Return time
Sun, 18 Oct, 2015 at 15:00
Pickup and Return Location.
Athens Airport
View Details
Discounts:
No Affiliations
Arrival Information:
No Arrival Information

“Please close all the open windows”

# How the implementation of the Sign Affects its Interpretation

The implementation of the Sign is carried out within a cultural context. This inevitably assigns additional elements to it which convey their own references and hence are also subject to Interpretations by the receiver, affecting the purity of the Interpretation of the Object.



ΕΛΛΗΝΙΚΟ
100%
ΚΡΙΘΑΡΙ
ΠΕΡΙΕΧ. 0,33L e
ALC. 5% VOL.
18+
5 201261 031030

# The Investment Bank

The Investment Bank

i will always find you
I WILL ALWAYS FIND YOU
FONT MATTERS.