Methods in Psychology/ Methods in cognitive ergonomics

Several methods have been developed in Cognitive Ergonomics, which are largely based on Psychological methods.

- Personas e scenarios
- Observation, interviews, surveys, questionnaires
- Case-study
- Thinking aloud, probes, card sorting
- Task analysis
- Heuristic evaluation
- Cognitive walkthrough
- Participants based evaluation

- The starting point in the study of the interaction between humans and "the world", and consequently of the interaction human+artifacts+environment (context), is the knowledge of how humans get informations from the outside.

What the senses are for?

All the available informations from both the external world and our internal state results from our sensory processes.
A memory, for example, derives from a past experience that we lived through our senses.
And a memory could be triggered after another sensorial experience (a voice, a word, a parfume…)

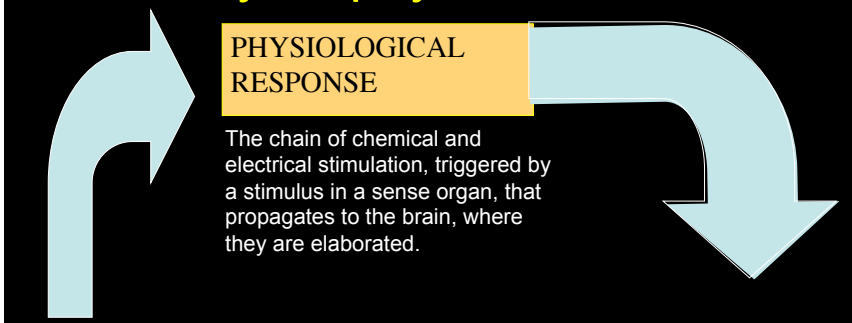
Could we state that we have a DIRECT knowledge of the world?

Stimulation and information

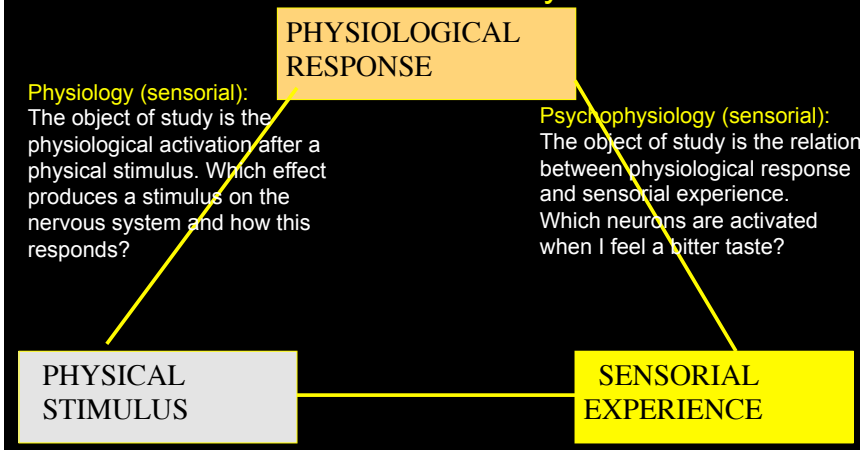
We get informations from the external world through our sense organs (eyes, ears, skin etc) which are sensitive to specific forms of energy (sound waves from 20 to 20000 Hz, electromagnetic waves from 400 to 700 nm), or to specific mechanical stress (as cutaneous receptors), or to chemical input (as taste and smell).

The information coming from the outside should be processed to different levels in order to assume a meaningful valence for the organism.

Psychophysical Chain



Fields of study



Psychophysics: the object of study is the relation between the physical stimulus and the sensorial response, thus deliberately ignoring the physiological response which mediated this response. If I change something in the physical stimulus, how the response change?

If we consider the stimulation of a sense organ and the consequent experience, we should consider two aspects, which could be translated into the following questions:

1) Which is the minimum level of a stimulation necessary to elicitate a sensation?

2) Which is the minimal difference necessary to make two stimulations of the same nature as one different from the other (for example one higher)?

1) Which is the minimum level of a stimulation necessary to elicitate a sensation?

The first question introduces the concept of absolute threshold of the physical stimulation, that is the minimal (or maximum) amount of energy required by the sensorial system to generate a sensation along a given sensorial continuum in an observer. For example, for a given dimension and a given spatial distance between a light source and an observer, which is the minimal intensity for the light source to be seen?

2) Which is the minimal difference necessary to make two stimulations of the same nature as one different from the other?

The second question introduces the concept of differential threshold between two physical stimuli, that is the amount of energy that a stimulus B should have in order to be perceived as different (more or less intense) from a stimulus A. For example, given a light source, how much should I descrease or increase its intensity in order to notice a difference in its perceived lightness?

Absolute and differential thresholds have a common characteristic: they could be determined only with approximation, because they vary not only from an individual to another, but also for the same individual from a situation to another (and sometimes from a moment to another).

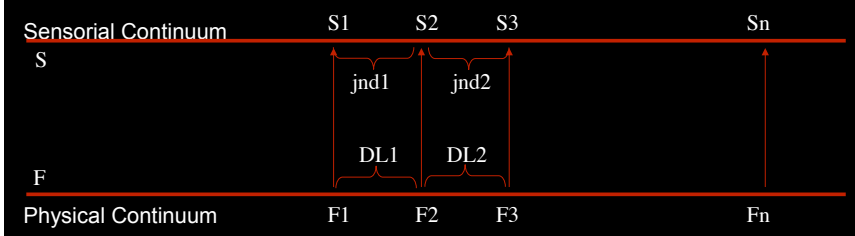
For this reason their definition is probabilistical:

•Absolute threshold (Absolute Limen - AL) is defined as the value of it that could elicit a response in the 50% of presentation.

•Differential Threshold (Difference Limen - DL) is defined as the minimal difference in intensity that could be detected in the 50% of the presentations of two comparable stimuli.

It should be clear that the concept of threshold refers to an intensity related with the PHYSICAL nature of the stimulus.

Then, the differential threshold between two stimuli gives place to a Just Noticeable Difference (jnd) that represent the MENTAL EVENT which CORRESPONDS to the increase in the physical intensity.



- How do you think we could measure a threshold?
- Think about a possible experiment to measure a threshold (absolute or differential).

Ernst Weber (1795-1878), physiologist, was the first to try to formalize differential threshold in terms of a universal law. Weber law is the following:

$\Delta F = kF$; then $\Delta F/F = k$

ΔF = DL, that is the increment one should add to a stimulus to obtain a jnd;

k = is a constant, named Weber ratio.

Let's consider a room with 50 candles. Now, we add one (51). If we do not see an increment in the luminosity in the room, this means that the increment brought by the 51th candle is BELOW THRESHOLD (DL). We then blow out the 51 candles and light up other two candles, so to have 52 candles on. Let's go on like that, blowing out n candles and lighting up n+1 until a change is seen in the illumination of the room. That change is a jnd, and the number n+1 is the DL (the Weber's ΔF). If we suppose that 5 candles (ΔF) are necessary to see an illumination difference in a 50 candles illuminates room, this means that Weber ratio (k) = 0.10

$\Delta F/F = 5/50 = 0.1 = k$

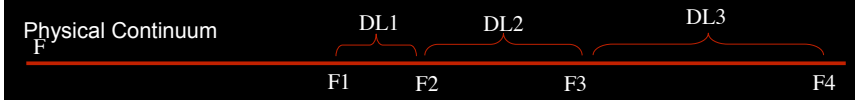
In our "candles" example, we have $\Delta F = 0.1 \times F$.

Then we have: $\Delta F1 = 0.1 \times 50 = 5$;

$\Delta F2 = 0.1 \times 55 = 5.5$;

$\Delta F3 = 0.1 \times 60.5 = 6.05$;

$\Delta F4 = 0.1 \times 66.55 = 6.655$



As clear, according to Weber law, differential thresholds grow as stimulus intensity grows. Indeed, to let k constant, the numerator should increase proportionally to the denumerator.

K=(F1-F2)/F1=(F3-F2)/F2=(F4-F3)/F3

Weber law is concerned only with physical continua.

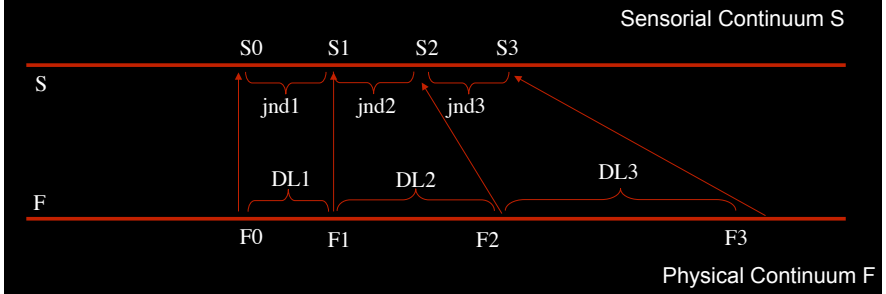
Fechner was the first to formulate a law which gave a strong impulse to pshychophysical research. He linked physical continua to sensorial continua, assuming that, for each physical continuum, a given DL always corresponds to an identical sensorial difference, whatever is its value along the physical continuum.

In other words, according to Fechner, along a given sensorial continuum all jnds are equal.

The equation for the Fechner's law is logarithmic, because it places in relation a scale of regular intervals (the one of jnds) with a scale of constant ratios (the one of DLs, that we know follows the Weber's law):

$$S = c \log F + A$$

c = constant = 1/log(1+k); A = integration constant



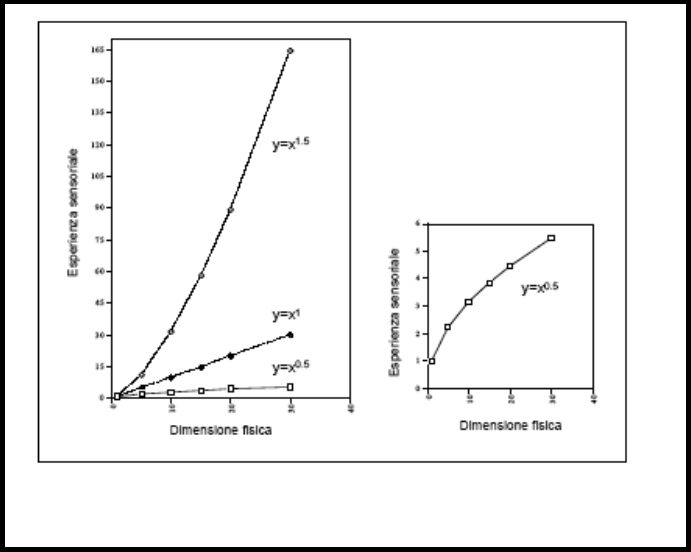
Already during the 30s of XX century it has been noticed that Fechner's law is valid only for intermediate values. Jnds are not always constant: they have the tendency to grow as a function of stimulus intensity.
According to Stevens (1957) the function the better ties a physical continuum with the corresponding sensorial continuum is a power function, as:

$$S = c F^b$$

c = constant
b = esponent changing depending on the continuum

Continuum	Esponent	Stimulus
Squares	.70	Visual area
Lines	1.00	Visual length
Weights to be lifted	1.45	Weights
Thickness of blocks	1.30	Touch
Salt	1.40	Taste
Sucrose	1.30	Taste
Visual Flash	0.50	Lightness
Signal 3150 Hz	67	Sound Volume

An esponent less than 1 produces a negatively accelerated curve, while an esponent more than 1 produces a positively accelerated curve.
In other words, some sensorial systems are attenuators of stimulus intensity (b<1) while others are enhancers (b>1).
Adaptively, is better to expand the sensorial continuum (diminishing differences so to detect even the smaller) of that stimuli that give us useful informations on our behavioural environment, so to collect detailed info.
On the contrary, is better to detect immediately (amplifying differences without detecting minimalia) of that stimuli which could be potentially dangerous, such as electricity (b=3.50), potentially poisoniing food, weight of objects (b = 1.45).



First psychophysicals were perfectly aware that thresholds were fluctuant values. However, they attributed that fluctuations to stochastical nature of stimuli mediating physical stimulation and sensorial experience.
Only later they became conscious of the existence of at least another continuum which should be considered, the one of judgements.

In other words, a given physical stimulation elicits a correlated internal process which is properly represented through a judgement. An additional problem is thus that of understanding tthe rules that subjects use to make judgements.

A second problem that they had to face, expecially after the development of telecomunication and technology, was that of detecting the presence of signals between “fields of noise”.

To this aim the Theory of Signal Detection (TSD) was determinant.
The theory postulates that each stimulus (i.e. energy) which is significant to the subject should be detected not only among other stimuli, but also below the background noise (an unavoidable element of transmission and reception, a non relevant disturbance).
It becomes then necessary to develop a theory of decision, which concerns the conditions in which subject, uncertain whether a signal is present or not in the noise, make a positive or negative judgement on the actual presence of the signal.
With this theory the interest is moved from the physical stimulus to the response.

Signal Detection

	Perceived	Unperceived
Signal present	*Hit*	*Misses*
Signal Absent	*False Allarm*	*Correct Rejection*

In TSD, four factors are crucial:

1. The ratio between signal intensity and noise: the detection of signals become easier as a function of this ratio
2. Subject's personality (gamblers vs. conservative)
3. Subject's expectation. If for example we inform subject that the signal will be present the 80% of times, then the number of positive responses ("Yes, I feel/see/hear the signal") will increase.
4. Subject's motivation. This is connected with a function of costs and benefits. If for example, for each true positive signal (hit) subject receives money, then we should expect many false alarms, where subjects state a signal is present even if it is not.

Think to possible psychophysical experiments for a (Cognitive) Ergonomist.

Think to possible psychophysiological experiments for a (Cognitive) Ergonomist.

How you would apply theTDS to a real situation?

Direct Perception and Cognitive Ergonomics

- In visual perception one of the most influential school was the so-called "Gestalt School".
- For many years they were the reference point in Psychology, but when the mainstream moved from Germany to America, the behavioural/cognitive/HIP approach became the most important (and probably the only one) way of studying and interpreting psychology.

Direct Perception and Cognitive Ergonomics

- Gibson was maybe the only American scientist supporting the idea of "direct perception".
- We won't enter in details of his theory (even though I would like to…), but what is imporrtant for us is the concept of AFFORDANCE.

Gibsonian Affordance

According to Gibson, natural objects and substances (such as water, woods, fire, and natural shapes) directly “comunicate” their function.

Affordance

- To denote this perceptual quality of objects Gibson created a new word:

THE AFFORDANCE OF AN OBJECT.

- The concept of affordance becomes crucial in Cog.Erg, and is one of the “rules for good design”.

Affordance

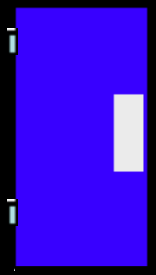
- In Cog.Erg “affordance” became a more sophisticated concept, and in a circular way also in psychology now, when we talk about the “affordance” of an object, we refer more often to its “visible” functional properties.

- It is important to undereline that already the european school of Gestalt had the concept of affordance (obviously not with the same word) many years before. Maybe if in America they would be aware of this, the HCI would arrive before in considering emotions as an itegrate part of humans as “systems”.

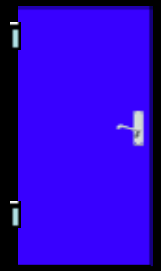
The concept of affordance in Cog.Erg.

- With “affordance” we refer to functional properties of things, spontaneously emerging from their appearance, without any cognitive intervention of categorical nature.

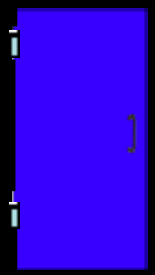
- Examples of affordance are the fact that a surface could be seen as a support (or not), or the fact that an object is graspable with only one hand, that it could be filled, that it cuts etc.



The metal plate “invites” to push



This type of handles “invites” to press down, but then you do not know whether to pull or to push (information given by hinges)

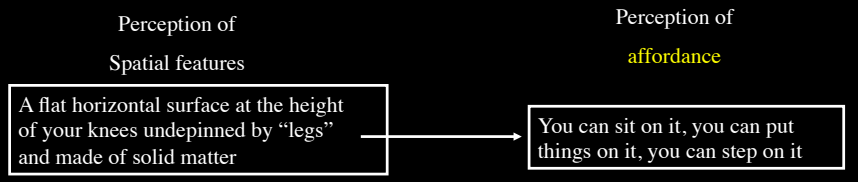


This type of handles “invites” to pull, but is often used on doors where you are supposed to push

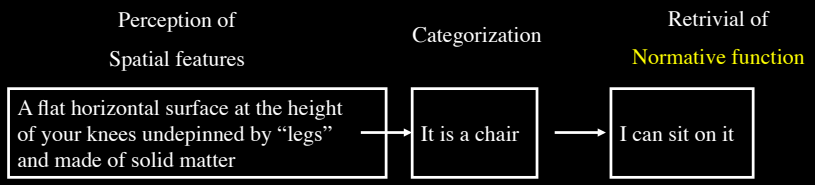
- Direct perception of functional properties allow to understand, without any particular cognitive elaboration, which objects of our environment are useful to reach a given goal.

- What is the difference between direct perception of functional properties and categorical processes for the retrivial of functional properties?

Direct perception of functionalities



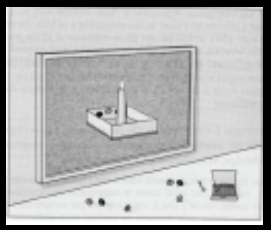
Mediated perception of functionalities



Categorical process has, as a possible consequence, that of functional fixedness.

A crucial example to see how functional fixedness works is to propose this practical problem:

you have a candle, matches and a box of drawing pins: your task is to fix the lighted up candle to a wooden wall.



- The concept of affordance could be understood as intrinsecal properties of objects that an organism could directly perceived as usable opportunities, without any categorical process.
- According to Gibson, an observer is capable of directing perceiving an object to sit on it, grasp it, step on it or to stab it without using categorical process, which implies that we can use objects for uses different from their supposed (normal) use.
- This capacity could be seen also as a"physiognomical" properties of object (Gestalt psychology)

Objects with a specifical normative function (learned function) could convey other perceptual functions not related with the normative ones (thus non cultural), according to oberver's specific needs (a book under an unstable chair; ice sketting as knives; recent studies on reaction times for objects recognition show interactions between affordance and all levels of recogntion – even with verbal labelling).

- Structure similarity is a strong clue for perceptual function, and then we should avoid to design objects with similar structures and different functions (or at least to avoid to put them one close to the other, because this could generates errors).

- Do you have some examples?

Gibson put in evidence two important conditions for direct perception of functional properties (affordances):

1) Functional Shape. The relations between the shapes of an objects and its affordances should be "transparent" (the object should have visible relevant properties). In other words, visible combination of properties should be such to determine if a surface has, for example, a given affordance so to give a safe support for my body, in terms of both height and structural stability. Then a given functional property could not be arbitrarly attributed to an object: perceived functionality is a consequence of the shape.

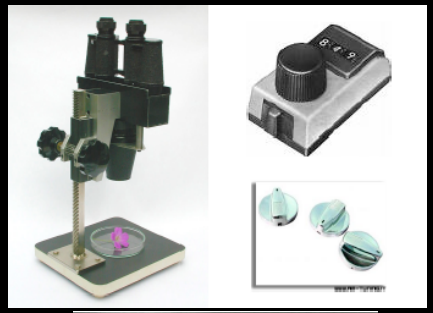
2) Oberver Relativity. Affordance is a perceived functional property of the object in relation to an observer and a given context.

For example a m. 1.50 stump, which "invites" an adult to sit on it, could not be seen as such by a 2 years old child, who instead could see the same stump as an opportunity to climb it.

Normative functionality and perceived functionality do not necessarily coincide. This is extremely important when we consider the design of objects with specific functions, both as complex systems and as interaction human-machine-environment.

Perceived functions (affordances) are usually the first to be seen when we are in front to a new technological object. The designer could take advantage of this, but if he undervaluates this fact in the designing process, this could cause problems during the interaction.

When we should interact with a new technological product, usually our first actions are driven by visual-mechanical affordances, based on the visible structure of the artifact.



Today the use of the word affordance is more peculiar: “perceived functionality” (affordance in its original meaning) is often sobstituted with“normative functionality” (cognitive affordance), so to define affordance in terms of usability.

Affordance in Cog.Erg.

	Subject Interface SI	Object Interface OI
Cognitive Affordance CA	CA-SI: degree of difficulty in use. *Understand how you should use the object*	CA-OI: Degree of difficulty of comprehension of the action. *Understand what the object is doing*
Material Affordance MA	MA-SI: degree of handledness of the artifact. *How the artifact let be used.*	MA-OI: Degree of effectiveness of the object. *What the object is really doing.*

From Arielli, 2003

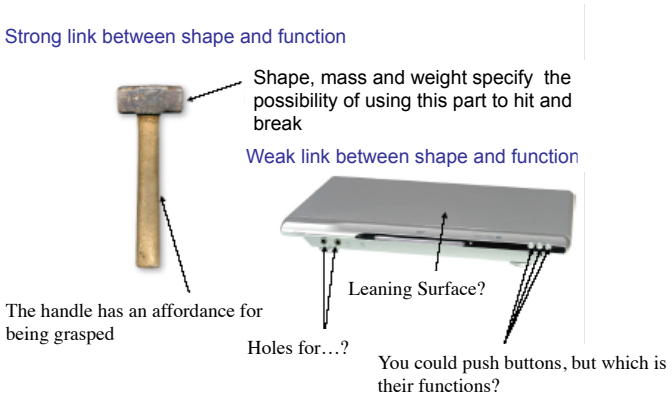
Indirect perception of functionality through categorization

- The process of categorization implies a first stage in which the intrinsic properties of an object are perceived to determine its belonginess to a given class of objects, and a second stage in which that class is retrieved from memory storages.
- Virtually, there are no limitations concerning which functional information on an object should be learned in this way, given that the link between the category of an object and its function is potentially arbitrary, being independent on the associations established with prior experience with the object.

Now, one could ask which of the two kind of information gives a major contribution to the perception of functionalities: affordances or categorical knowledge?

Indeed, there is no a cut edge between the two kind of "knowledge" on objects' functionalities. In everyday tasks, such as walking, opening doors, drinking a coffee, we don't need categorical knowledge on the functions of objects and surfaces. For more complex actions, such as starting a computer and write something with it, affordances are not enough, given that we should know the sequence of required actions, which is determined by the functionality of different commands.

The difference between situations is partly dependent on the complexity of the interaction, and partly on the relation between the shape and the function of objects, which could vary along a continuum that goes from "very high" (as leaning surfaces) to "very low" (as a laptop).



The process of visual categorization comprised four phases:

1) Object's representation. Relevant features, which should be categorized, should be perceived and represented in the visual system;

2) Categories' representation. All possible categories should be represented in memory in a way accessible to the visual system;

3) Comparison process. There should be a way in which represented objects are compared with represented categories;

4) Decision making. There should be some decisional criteria based on the result of the comparison process, to decide which is the category that the object belongs to (and that consequently inform us on how to usefully use it).

It is apparent that the more a technology is complex, the higher the need to resort to processes of retrivial of functionality through categorical processes.

A good design (a good interface) reduces to the minimum the efforts to resort to memory, for example by using semplification. But even an high semplification could result as critical for the naive user (or for the user with different expectation).

- The concept of affordance is very similar to what european Gestalt defined as “expressive qualities” or “physiognomical features” or, also, “tertiary qualities” of an object.
- Analyzing this concept it is possible to see how features that were classically considered as “cognitive/rationale” and emotional features are in fact often perceived as a defining quality of the object of our perception.

Expressivity (Animacy)

- According to philosophical tradition, qualities of objects could be divided in three categories:
- **Primary Qualities**⇒ they look as independent on the observer (weight, width, shape, etc.);
- **Secondary Qualities** ⇒ they look as somehow dependent on the observer (colour, taste, emotional value/significance, etc.);
- **Tertiary Qualities**⇒ they look as entirely dependent on the observer, they concerne feelings and emotional and affective values expressed by objects and events.

Animacy (Expression)

Animacy

Primary Qualities⇒ ?
Secondary Qualities ⇒ ?
Tertiary Qualities⇒?

Top-down or bottom up? “Social perception” and clinical aspects. Affordance as a tertiary quality (emotions and functions)

- Tertiary qualities are also called “expressive” or “physiognomic”. The english literature is more about “animacy” (more appropriate for events’ perception).

  Scientific studies in cognitive sciences are not yet well developed, because of the intrinsic difficulties in defining the relevant variables to be changed, so to correlate changing in perceived expressivity with changing in the stimulus.

- However, there are many experiments in the so-called “social perception” or “person perception” related with some aspect of expressive qualities conveyed by how people (not objects) is looking .

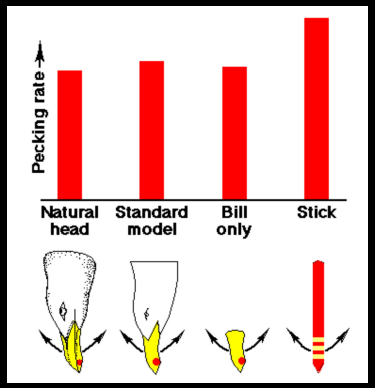
- Without entering in details of a too “psychological” research (which I hope you will be told in other courses), I just want you to reflect on two main topic in this area: baby schema and superstimulus. Both concepts come from ethology.

- Baby-Schema.

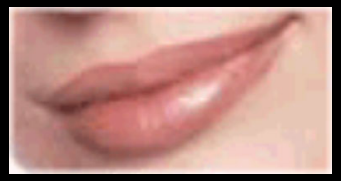
- Baby-Schema.

- Baby-Schema.

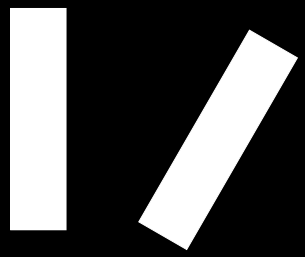
- Superstimulus



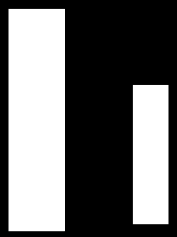
- Superstimulus



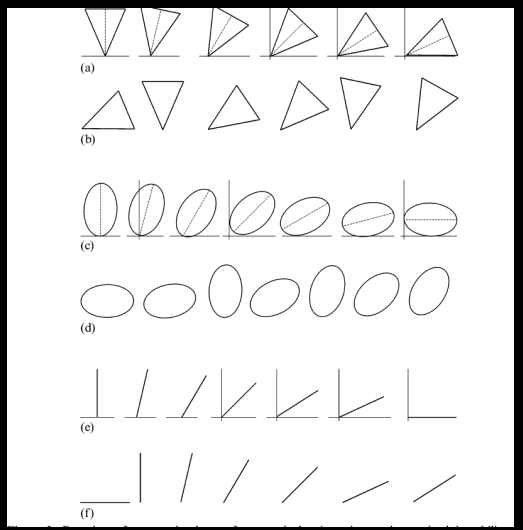
- The only experiments which I was able to find with static objects are by Marigonda (1972) and Sokolov e Pavlova (2005).
- However, in Marigonda the expressivity refers to TWO objects, a sort of social expressivity: the distribution of static objects in the visual field could convey intrpersonal relations between that objects ⇒ dominance/ submission with rectangles which differed in heigth, width, tilt and position (i.e. distance).



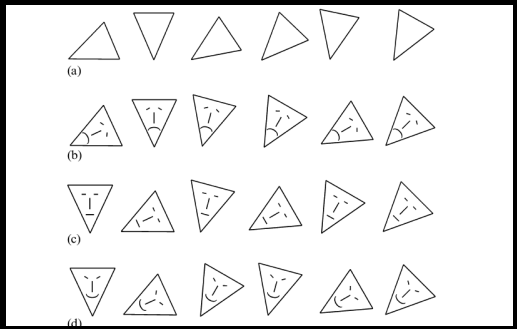
WHO IS THE BOSS?



- Pavlova, Sokolov & Sokolov, 2005



- Pavlova, Sokolov & Sokolov, 2005



- Marigonda: expressivity of an object towards another
- Pavlova, Sokolov & Sokolov: expressivity of an object in comparison to the same object with explicit emotion.

Social perception and emotions

- Marigonda was thus referring to the expressivity of TWO objects, a sort of social expressivity: the spatial distribution of static stimuli in the visual field could convey interpersonal relations between those stimuli.
- Pavlova Sokolov & Sokolov directly link the expressivit conveyed by geometry (i.e. shape and orientation) with EMOTIONAL FACES.

- In event perception there are more influential and numerous studies on expressivity, which in this case is properly dubbed animacy ⇒ they follow research by Michotte, who put in evidence the way in which activity and passivity are features that “express” a “way of being” of perceived events.

- Certain combinations of movements are not perceived as successions of phases, but are instead globally integrated, giving to the whole event a meaning which is not physically present in each single phase (i.e. animacy)⇒ in the auditory domain the classical example of this kind of integration is the one of melodies.

Perception of causality

- **Launch effect**⇒ the observer perceives a causal relation between the two movements: the first square “hit” the second (active movement), whose motion is passive (i.e. caused by the first).

Perception of causality

- **Launch effect**⇒ the impression of a causal relation is spontaneous and depends from spatial, temporal and kinetic conditions (is thus STIMULUS DRIVEN).

- By slightly change those conditions, other “structure” are obtained, equally evident and “stimuls diriven), as the triggering effect ⇒ **“expressive” configurations (i.e. animacy).**

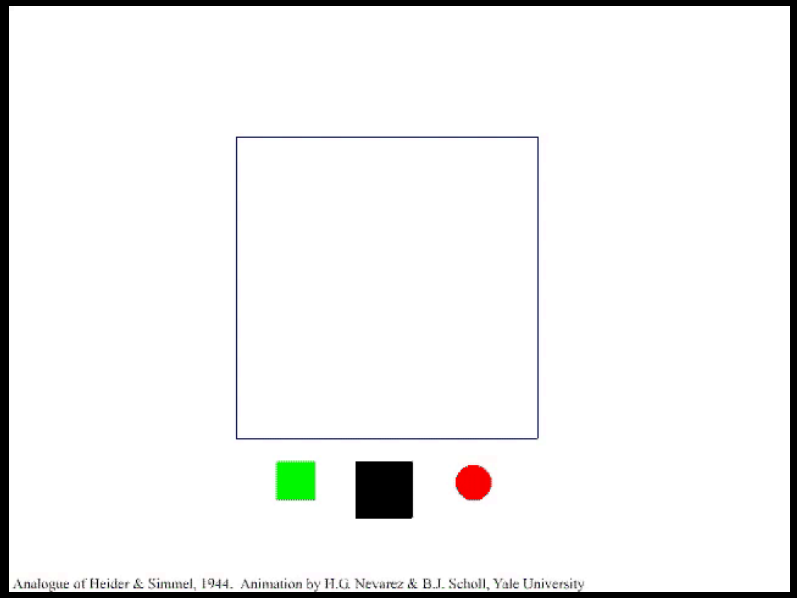
Several studies confirmed Michotte’s idea:

- Movements have an high degree of expressive or tertiary qualities;
- each expressive quality emerges (i.e. is driven by) with determinate spatio-temporal conditions.

Social perception and expressive qualities

- Already in 1968 Kanizsa and Vicario presented an effect (“intentional reaction”) in which they ideally link Michotte’s and Heider e Simmel’s (1944) observations.

- Heider e Simmel (1944) showed an animation in which two triangles, a disk and a bar were moving ⇒ subjects **congruentelly** describes movements “as” human actions (all subjects but 1!): moving configurations conveys emotional and social qualities.



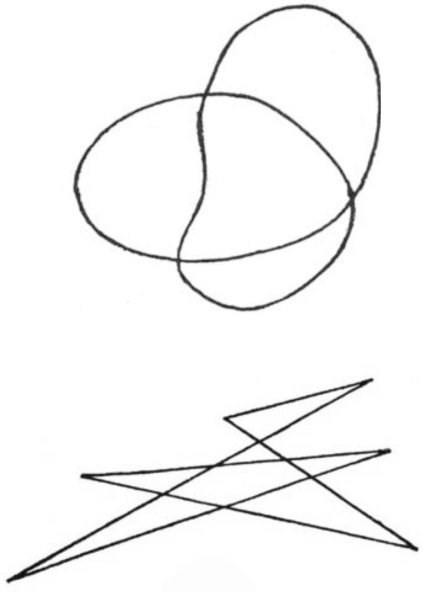
- Kanizsa and Vicario (1968) put together those results, proposing that all these effects are part of a continuum that goes from “unification” (at one pole) to indipendence (at the other pole of the continuum).

Top-down or bottom up?

- Results of these experiments could be interpreted as a transposition of past experience with “real” actions done by humans or animals (i.e. a sort of generalization).
- But…:

1) If some expressive qualities are tied to precise physical conditions, this means that they are stimulus driven, not related with our willness of “interpreting” events.

2) Expressive qualities are intermodal. This means that we perceive the same affective value in different sensorial domains ⇒ Köhler experiment with TAKETE and MALUMA



Takete e Maluma

Here there is no past experience, because geometrical figures are seen for the first time, and their “names” are meaningless words ⇒ the explanation stands on the identity in structure of visual and acoustical events.

In conclusion..

- Many different data force us to believe that tertiary qualities are so immediate as secondary and primary ones.
- This is something to keep in mind with our relation with objects and interaction in general, because it could affect not only UX but also usability.

- This has important consequences both for experimental psychology and for design.
- If you start considering affordance as an expressive quality (and not as a “cognitive” feature) we could develop interfaces which immediately convey what we want them to convey: emotions, actions, social relations.