Consciousness : the key of the living. Limits of artificial intelligence.

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Abstract :

The consciousness which opens us to a representation of a world otherwise closed on itself, is a fundamental attribute of nature, an essential operator in the genesis of living structures and the cognitive processes associated with them. Consciousness is the key to life. In its absence no life would have appeared on Earth or on any exoplanet.

The 'computational theory of the mind' where the human mind would function as a computer machine is totally unfounded.

A robot built only on the basis of the relationship between technical components managed by physical laws cannot be fundamentally autonomous, self-organized, like human beings are. It is only a more or less efficient automaton operating in an environment that has been specifically defined by his manufacturer who is naturally endowed with a consciousness which is formally irreducible to any physical interaction.

Summary :

Introduction

Many are the researchers who assert that the artificial life which that is inspired by living systems is for tomorrow. That humanoid robots will soon have similar capabilities and even higher than those of humans in terms of intelligence and developed forces. In our image, these robots, *autonomous*, will adapt to the current constraints by inventing new strategies. They will be *conscious* and have *emotions*. To ensure their durability, their 'life', these robots will be able to intelligently decide what actions to make in response to the useful or harmful stimuli induced by the infinite diversity of objects they perceive.

These physico-chemical structures which would be artificially *living* and therefore endowed with capacities similar to those of living beings in terms of the decisions they would take to ensure their perenniality in all circumstances, would thus be strictly *autonomous*. They would not receive any human assistance in terms of *actions* they should take to ensure the perenniality of their structure and the functionalities attached to it.

The understanding of the decision-making mechanisms that these robots should have to be *autonomous*, artificially *alive*, is therefore essential. Robotics and artificial intelligence techniques allow a formal approach to the logic of these mechanisms such as *connectionism*, *rewards learning*, *dissipative structures*, *evolutionary selection*, which we will analyze successively.

A living definition. The 'theorem of indistinguishability'

To ensure the durability of an artificially intelligent robot, the functional analysis shows that for each perceived object, its controller (its 'brain') have to *choose coherently* the actions to be achieved by the actuator (locomotion system, manipulating arm).

That is how a land exploration robot sensitive to any high temperature that can destroy it must always do the following to stay 'alive' : *escape* from molten lava, *escape* from a forest fire, *escape* an oil slick inflamed,... In other words, the controller of this *autonomous* robot must be able to create a *coherent category* of objects perceived by its sensors, in this case the *category* {*escape* all hot objects}. Whereas there does not exist any physico-chemical affinity of these objects with the controller that could explain this type of perennial action :

> The ability to create *coherent categories* of perceived objects is thus an operational definition of artificial life. Hence, it is also the definition of *living* beings who must also ensure their survival given the constraints of the environment that can only destroy them.

From the point of view of the decision-making mechanism with which the robot controller must be so endowed, this ability to create *coherent categories* logically implies that the different objects perceived by the system are *distinguishable* from each other. Otherwise these decisions will be taken at random which would certainly be antithetic from the expected ability to form *coherent categories* on which the *autonomy* of the robot is founded.

That the objects of the world perceived by the robot sensors are physically *distinguishable* so that the robot can, for example, systematically escape from hot objects and move towards supposedly cold energy sources, seems naturally self-evident. But this actually raises a major epistemological problem :

- Based on the formal theory of 'pattern recognition'[1], which concerns the identification of shapes of objects based on their characteristic parameters in order to make decisions depending on the categories assigned to these shapes, we can demonstrate the following essential property :

> **The different shapes of objects that are perceived by a physical (or physico-chemical) system during a measurement process are physically indistinguishable by its operating part or actuator (locomotion system, manipulator arm).**

Applied to our terrestrial exploration robot, this implies that in a quite paradoxical way given the manner we perceive the world, objects such as 'molten lava' or a 'block of ice' that are perceived by the robot's sensor (a camera, for example) are in fact physically *indistinguishable* from the point of view of its controller which is the 'brain' of the robot.

[1] Satosi Watanabe - *Pattern recognition, human and mechanical*, John Wiley & Son, 1985.

This ‘theorem of indistinguishability’ for short, is applicable to all levels of materiality – macroscopic or microscopic/quantum – regardless the physical laws that govern these fields. It can be established[2] by analyzing the nature of the physical connections that must be established between the sensor and the display of a measuring device whose primary function is to determine the specific properties of objects with which a physicochemical system interacts.

This primordial state of *indistinguishability* of material entities has until now been completely ignored by researchers for whom the *distinguishability* of macroscopic or microscopic objects perceived/measured was self-evident and that it was therefore not necessary to question the validity of such an affirmation. The ‘indistinguishability theorem’ is to be compared with the Ludwig Wittgenstein’s analysis of the truth of propositions in the language domain :

- In his book ‘Tractatus Logico-philosophicus’[3], Ludwig Wittgenstein affirms, by declining the set of all possible propositions constructed from elementary descriptors that we cannot differentiate between a state of a thing and a completely different state of this same thing like the fact that a stone is heavy or light. In other words, that the different states of this stone from which we commonly discuss are strictly *indistinguishable*, like the objects ‘molten lava’ and ‘ice block’ perceived by the exploration robot.

Since the infinitely variable *forms* of objects perceived by the robot during its movements in space are strictly *indistinguishable*, it follows that no *coherent categorization* of these forms can be performed except *randomly*. Which is statistically a very unlikely event by the fact that the perceived forms vary continuously over time. As such, a robot that would be built from only the technical components managed by physical laws (mechanical, electronic, computer, chemical,...), could not be *autonomous*, artificially *living*, in an multiform constantly changing environment.

Connectionism - neural networks

There are many researchers in the fields of robotics and artificial intelligence, for whom it is definitively established that there are self-learning ‘connectionist networks’ which are therefore, by definition, able to *self-classifying* into the same *category* the different forms of objects perceived by a robot. As such, the controller of an exploration robot must so naturally have the ability – without any human assistance – to create *coherent categories of actions* such as {*flee* all hot objects}, which must make this robot totally *autonomous* like living beings are.

These ‘connectionist networks’ are composed of artificial (or formal) neurons that are inspired by the functioning of biological neurons. These artificial neurons have several inputs (‘dendrites’ of biological neurons) and only one output (‘axon’ of biological neurons).

As experimental evidence of the validity of *unsupervised learning* of artificial neural networks, the following computer devices are very often mentioned : ‘Uttley's Informon’, ‘Kohonen's self-organizing maps’, ‘Hebb's networks’, as well as the recent technique of « deep learning » which uses ‘connectionist networks' with a very large number of layers of artificial neurons.

Considering the extraordinary efficiency of the ‘deep learning’ machine to *recognize*, *classify*, without a ‘teacher’, the objects that are subjected to its input retina (a camera, for example), ‘deep learning’ would be this long-awaited information processing that would naturally base our *cognition* and thus that of future *autonomous* robots. *Cognition* being understood as the set of mental processes that allow human beings to acquire knowledge from the perception of different objects of the world.

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[2] Annexe

[3] Ludwig Wittgenstein – *Tractatus Logico-philosophicus* - articles 5.101, 5.135, 5.15, 5.151

But what about the *unsupervised learning* capacity of these different networks that we have just mentioned, given the negative arguments we have developed against them about an *autonomous* terrestrial exploration robot :

— 'Uttley's Informon' is a neural network that is described by the physicist Henri Atlan[4] as certainly *self-organized*, *self-learning*. As such, given the existence of this self-learning process, he hypothesizes that this network could provide a plausible model of brain mental activity. For roboticians, this could therefore also be the basic element of a controller with a truly *autonomous* artificial intelligence.

According to H. Atlan, this network is thus able to learn and then recognize without the help of an operator the different objects (apples and oranges, for example) that are presented to it successively in the form of two dissimilar sets : a set A made up of more apples than oranges, a set B made up of more oranges than apples.

But the functional analysis of the 'Informon' shows that the *self-learning* that is supposed to develop spontaneously can only be achieved to the extent that the operator, insufficiently attentive in establishing the experimental protocol, carefully *prepares* the experiment. It thus constitutes two sets two distinct sets A and B of learning in which apples and oranges respectively predominate. In the absence of this precise preparation of learning sets, experience and calculation show that the subsequent *recognition* of apples and oranges into two distinct categories can only be *random*.

The self-learning of this network is therefore not logically founded. The operator in charge of the network have to ~~who~~ prepare the experiment according to the statistical calculations that he himself has implemented in the network modules.

— Kohonen's 'self-adaptive/self-organizing maps'[5] are neural networks developed by the physicist Teuvo Kohonen. These maps are also very often mentioned by researchers as being based on *unsupervised* learning methods. Thus, neurobiologist Gerald Edelman[6] refers to this type of 'self-adaptive maps' to justify the existence in the brain of human beings of what he calls 'neural maps', which would explain the development of *self-organization* processes that form the basis of *cognition.*

These 'self-adaptive cards' would be able to spontaneously gather in three distinct areas of their output device (a video screen, for example) each of the three founding elements of short sentences – 'subject', 'verb', 'complement' – such as « monkey likes bananas », which are successively shown to his input retina (a video camera, for example).

However, the functional analysis of this device shows that it is a technician, and not a physical device (mechanical, electronic), who, observing the output screen of the network, states that there are distinct groupings of 'subjects, 'verbs', 'complements', elements in three different areas of this screen. While in reality these elements are physically *indistinguishable* on account of the 'indistinguishability theorem' (cf. § A definition of the living – the 'indistinguishability theorem').

But these *clusters*, or *categories*, into three distinct areas of the screen actually only exist in the mind of the operator. Without his participation, this network only transposes the order relationships from the object domain (all sentences) to the network domain (output screen) without creating *categories*. The learning of these 'self-adaptive cards' therefore implies, here too, the supervision of an operator without whom no *coherent action* can take place.

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[4] Henri Atlan – *Biological organization and information theory* – Hermann

[5] Kohonen – *Algorithm of Kohonen : classification and exploratory data analysis* – CNRS Samos Université Paris1

[6] Gérard Edelman – *Bright air, brilliant fire : on the matter of mind* , p. 109 – Odile Jacob

The operator has the empirical capacity to gather, for his ‘pleasure’, the images relating to the ‘subjects’, ‘verbs’ and ‘complements’ that appear in different places on the output video screen. Whereas these images are physically *indistinguishable* and as such they do not have an intrinsic physical existence as sources of differentiated actions.

— ‘Hebb's networks’ are also reported as networks able to learn in an *unsupervised* way. Starting from the idea, derived from the observation of the functioning of the neurons in our brain, that two neurons in activity at the same time create or strengthen their connections, we successively propose to the network whose synaptic weights have been properly adjusted, different objects belonging to a learning database.

If for a given object, the output of the network is conform to the predetermined value entered in the database, the algorithm goes directly to the next instruction and another object can then be submitted to the network. If, on the contrary, the object that is submitted to the network induces an output value that is not in accordance with the one entered in the database, the algorithm automatically corrects the synaptic weights of the network according to the Hebb *reinforcement* law, then we move to the next objects. This learning phase, which is called *unsupervised*, is eventually repeated until, for each object submitted, the corresponding output is in accordance with the value entered in the database.

Hebb's network learning is described as *unsupervised* because it is left free to converge to any end state when presented with a given object. Whereas for a traditional supervised learning, a determined value is imposed at the output of the network for each new object that is submitted to it. This designation is however completely inappropriate, because in reality the network has been carefully *prepared* by an operator who has implemented an algorithm such that if for a given object the end state of the network differs from that corresponding to the learning base, an appropriate instruction automatically corrects the synaptic weights of the network according to the Hebb reinforcement rule until the end state is identical to that of the base.

Contrary to what is always claimed, Hebb's network is fully *supervised* by an external operator.

— ‘deep-learning' is a self-learning technique implemented on a computer equipped with a very large number of artificial neurons distributed in multiple layers (up to a few hundred layers).

After a long period of so-called *unsupervised* learning, during which it was presented with a multitude of images including all kinds of objects, like cats, this machine is said to be able to discover the *concept* {chat} by itself. This is due to the fact that among the N output neurons, only the Nc neuron is spontaneously activated when a real cat is shown to its ‘retina’ (camera).

But like the images ‘subject’, ‘verbs’, ‘complements’, that were displayed on the output screen of Kohonen's ‘self-adaptive cards’, the N outputs of the ‘deep learning’ machine, including the output Nc that a technician reports as activated, are in fact physically *indistinguishable* from any hardware device producing an *action.*

To say that the ‘deep-learning’ machine has discovered the {cat} *concept* is therefore completely irrelevant. It is only the technician who simultaneously observes the cat in front of the machine and the Nc output which is activated only then evokes his own knowledge about chat.

This strong assumption never discussed that ‘connectionist networks’ can *self-organize*, i.e. create *coherent categories* in the absence of any operator, is therefore totally unfounded.

Learning by rewards

In addition to the various connectionist networks in which a large number of elementary components such as artificial neurons are interconnected, it is also worth mentioning these other control mechanisms which are based on what are known as « learning by rewards (Q learning algorithms) ». These mechanisms seem to have this essential virtue in terms of cognition and artificial life, to allow the realization of autonomous robots which, without any human assistance, are for example able to move not in a zigzag, but always in forward motion.

This technique of monitoring which is inspired by Nature (*biomimetism*) is as follows : the robot controller receives a positive digital 'reward' each time the robot moves forward and a negative 'reward'' each time the robot moves backward.

For instance, consider a small four-wheeled mobile robot that is powered as follows : an articulated arm with two degrees of freedom consisting of two movable parts, one of which ends in a claw, moves the vehicle in a straight line on a short distance when the claw is hooking onto the ground. The task that the researcher assigns to the robot in terms of a learning algorithm implemented into the controller, is that ultimately the robot only moves in forward motion.

For this purpose, the robot controller receives a positive digital 'reward' each time the robot moves forward and a negative 'reward' when the robot moves backward. All these successive 'rewards' are the added together and the movements that are retained are then those that maximize the sum of the 'rewards'.

The experience shows that whatever the nature of the soil (rough, dry, damp), the robot always ends up moving only in forward motion. And the technician concluded : the robot learned to move only in forward motion while no information on the nature of its environment had been supplied to it. The robot would thus have self-learnt to move preferentially forward in an environment of which it had no prior knowledge.

But this analysis is totally unfounded, this robot is only an *automaton* that obeyed only the precise numerical instructions of the algorithm that had initially been implemented in its controller by a technician. The final forward displacement was predictable. Without a technician, no information processing mechanism can calculate the 'rewards' which are a function of the positive or negative variable distances travelled by the robot, since owing to the 'theorem of indistinguishability' the different descriptors of the robot states (varied positions of the articulated arm, varied distances travelled by the robot) are strictly *undistinguishable*.

Contrary to appearances, the *learning* of the small robot is therefore totally *supervised* by the technician, in the absence of whom the movements of this robot would be strictly *random* regardless of the duration of the experiment.

This mechanism of 'learning by rewards and punishments', which is at the very basis of human education, does not therefore allow the creation of fully *autonomous*, artificially *living* robots.

Dissipative structures

There are some strange objects studied by Illya Prigogine (Nobel Prize in Physics), these are « dissipative structures far from equilibrium » which would have the essential property of self-organizing. Thus creating *coherent categories* in the absence of any human operator which would clearly go against what we have just argued about 'connectionist networks' in terms of *self-organisation*. A system being said to be dissipative when it exchanges energy or matter with its environment.

The case is of particular significance, since the existence of such objects explains for some researchers the *automatic* appearance of living beings and their cognition.

As a *dissipative structure*, the object « Bénard's vortices (or cells) » is very often mentioned by biophysicists. Such a *self-organized* object can easily be made by heating paraffin in a

cylindrical container until it is completely melted. Then after a few minutes we turn off the heating. When the paraffin is frozen, which is a state corresponding to a photograph of the phenomenon, we then discover that the container is occupied by hexagonal convection cells. These are the famous « Bénard's vortices » which stunningly evoke structures created by living beings such as the honeycombs made up of hexagonal wax cells. This could justify their qualification as *self-organized* structures.

But this is not a *self-organized* object as always stated, which would be the expected answer to the issue of the autonomy of artificially or naturally living structures. It is only an ordered object in the sense that it is the obligatory fruit of stereotypical interactions between the components in accordance with physical laws. If the heat source changes position in relation to the container, the initial conditions being modified, the 'Bénard vortices' will disappear immediately. The object will 'die'.

For the 'Bénard's vortices' object to be truly self-organized, artificially living, and not just ordered, it would be necessary that following the fortuitous displacement of the heat source in relation to the container with the paraffin, the object in question would itself be able to perform a corrective action such that the heat source would again be in a good position in relation to the container in order to ensure the durability of the cells. But this mechanism would imply that the object would be able to *distinguish*, in order to be able to operate, the different positions of the heating source in relation to the container. What we know is not feasible given the fundamental 'indistinguishability theorem'.

The same thing can be said for the very spectacular 'Belousov-Zhabotinsky oscillating reaction' which occurs in a solution of bromate ions acidified by citric acid which periodically changes colour with great regularity. But it is similarly an ordered fluid structure and not self-organized.

Whatever their complexity, *dissipative structures* are *ordered* and not *self-organized*. To argue that dissipative structures are at the base of the self-organization process is thus completely unfounded.

Evolutionary selection

For other researchers, a pragmatic way to make an *autonomous* robot is not to analyze the nature of all events, in infinite number, with which a *solitary* robot can be confronted, but to be guided by the mechanism implemented in the 'Darwinian natural selection' which explains the emergence of animation features with which certain physicochemical structures are provided then described as *living*, so highly *autonomous*. This is the so-called 'evolutionary robotics'.

It should be recalled that the *darwinian evolutionary selection* is primarily based on the transmission between successive generations of living *beings*, of the features which are recorded in *genes*. The mechanism of natural selection is therefore essentially rooted in the *functional reproduction* process « mother → son ».

To perform an experiment of 'evolutionary robotics' we built a flotilla of several robots that are each equipped with an artificial neural network as a controller, whose the synaptic weights (values of the physico-chemical binding forces that exist between neurons), initially all different (*randomly* distributed), are the artificial *genes* of these robots.

Robots are then subjected to a given task, such as reaching a target in minimum time while the test field is strewn with obstacles that can block their moving.

After a first test, one keeps the robot which is the winner of the event having avoiding by chance several obstacles. Then we copy, by deliberately making some mistakes (accidental mutations), its different synaptic weights (values and positions) to the neural networks of the 'losing' robots that did not reach the target. This operation is repeated several times by keeping at each trial the robot that has won the test.

Finally, we note that there is a (or several) robot which has reached the target in avoiding all obstacles. In other words, this robot seems to have created alone the function {avoid all obstacles to reach the target} that makes it *autonomous* in such an environment.

But what no researcher has seems before, not even the physicist von Neumann with his theory of *self-reproducing* systems[7], is that the *functional process of reproduction* « mother → son » that would allow the copy of the synaptic weights (values and positions) of the win robot toward the neural network of the loser robots, is logically prohibited due to the 'theorem of indistinguishability'.

On the other hand, a 'imprint' type reproduction, such as the stamping of the different depressions and bumps of a DVD tracks, is quite legal with regard to the 'theorem of indistinguishability' (cf. § A definition of the living - the 'theorem of indistinguishability').

Due to the prohibition which thus concerns the feasibility of *functional reproduction* « mother → fils », the copying of synaptic weights from the 'winning' robot to the neural networks of the 'losing' robots can only be *random*. This, in turn, invalidates the evolutionary selection process as a mechanism for the incremental creation of *coherent categories* that would base the basis the robot *autonomy*.

Recent *evolutionary robotic* experiments relating to successive generations of robots, seem to show that a number of these robots can spontaneously *self-organize*, that is to say become *autonomous*. Whereas this is not possible for *solitary robots* taking into account of the 'theorem of indistinguishability'. *Solitary robots* means they do not interact with other robots and that the formation of *coherent categories* that should make them *autonomous* only depends on their own capacity.

But if some robots have effectively become *autonomous*, knowing e.g. to move away from all sources of heat that could destroy them, it is because their designers, insufficiently vigilant, have, as *living beings*, injected their own ability for *autonomy*. They thus unconsciously *prepared* the various mechanisms of *functional recopy* « mother → son » by selecting different memory areas otherwise physically *indistinguishable* (memory areas corresponding to the various synaptic weights of neural networks of the robot controller).

By being able to rely only on reproductions of the 'imprint' type – *functional reproductions* being thus prohibited – the 'darwinian natural selection' that we know to be constantly at work in nature by creating a multitude of new species, would only select from the various possible forms of already *autonomous living* systems those that would be best suited to survive the environmental constraints. This theory, without therefore explaining the *living*, having however the immense virtue of explaining the natural appearance of all the *forms of life* that have appeared on Earth.

Finally, neither the *connectionism* nor the *evolutionary selection mechanism*, nor the *dissipative structure*, nor the *learning by rewards and punishments*, are therefore possible answers to the question of self-creation of *coherent categories* that underlie *autonomous*, artificially *living* systems. A robot built from the only relationships (mechanical, electronic, computer, chemical,...) of technical components managed by physical laws, cannot thus be *autonomous*, artificially *alive* in a protean environment, infinitely changing. This robot remains an *automaton* more or less efficient in an environment that has been specifically defined by its manufacturer.

[7] John von Neumann – *Theory of self-reproducing automata* – University of Illinois Press (1966)

« And yet it moves… »

Empirically, we do know that to ensure its own survival a technician – a complex physico-chemical system – is able to escape naturally different hot objects like molten lava, a forest fire, a burning oil slick, so creating a *coherent category* of objects with which it interacts, in this case {escape all hot objects}.

Due to this property, unintelligible according to the 'theorem of indistinguishability' which applies without distinction to any physico-chemical structure, this same technician can then supervise the robot controller by establishing *coherent* links between the sensor and the actuator of the robot so that this one can automatically flee from all the hot objects that could destroy it.

A robot that would be prepared in this way by a technician would be *autonomous* as long as the technician supervised his controller. And so it is that a car, a complex physico-chemical device, becomes *autonomous*, artificially *alive*, from the moment a driver takes control of the car.

Without the technician, the robot is nothing more but one efficient automaton in a world limited to the hostile objects specified by the technician. For new environmental constraints, it would be necessary the technician intervenes once again in order that old *coherent categorizations* be extended to these new constraints .

In view of this physically insurmountable obstacle of the self-creation of *coherent categories* on which the *autonomy* of the robot is based, then one must ask the following basic question :

What then differentiates the robot controller from the technician's brain knowing that the technician can adjust the robot controller to his convenience in order to create *coherent categories* while these categorizations are physically impossible given the 'indistinguishability theorem'.

Consciousness

There is a possible experimental answer to this paradoxical situation : what differentiates the controller of a robot from the technician's brain. Is the *consciousness* possessed by this technician. This faculty that we all have which opens us to the sensible and colorful representation of the world with which we interact.

Experience shows that *consciousness* has this singular property to discriminate objects like 'molten lava' and a 'piece of ice' which, given the 'theorem of indistinguishability', are nevertheless physically *indistinguishable*.

This discrimination of the world objects comes it is « painful » or « pleasurable » for the technician according to the state, current or memorized in his nervous system, of his physical structure. Thus having one day a tooth ache in his childhood – before any learning from his parents in this matter –, the technician had quickly consulted a dentist instead of going to see a florist… two destinations – as objects – which were nevertheless physically *indistinguishable* in the same way the various objects of the world that are perceived by the robot.

The *consciousness* is therefore not an epiphenomenon, an accessory phenomenon which would accompany the mechanical irritation of the technician's tooth. Empirically operative, the *consciousness* choose the technical solutions – designed and stored in the subject's brain – that are associated with some *pleasure* or to its equivalent a *pain reduction*, for having fortuitously ensured in the past the perenniality of the subject. In this case, the *pleasure* or the *pain reduction* that 'labels' the dental technical solution would thus result from the rapid reduction in dental pain that the technician had experienced in the past when, *by chance*, he had been cared by a dentist.

Although being empirically operative, the *consciousness* is formally *irreducible* to any neuronal physicochemical interaction owing to the 'theorem of indistinguishability'. As a result, it is of a *non-physical* nature : if *consciousness* were indeed of a material nature, it would therefore be reducible to particular physico-chemical interactions and as such could be then defined by

complementary dual attributes such as hot/cold, white/black,...like any particle or wave subjected to a measurement. Under these conditions, the predicate (or descriptor) calculation applied to the new system {sensor + consciousness} would show that adding this *consciousness* to the sensor system, whose states were originally *indistinguishable*, would only increase the number of states perceived by the sensor system without reducing the *indistinguishability* of its states. *Consciousness* is well therefore of a *non-physical* nature.

This hypothesis of the non-materiality of *consciousness* is not physically irrelevant as one might at first think with the assumption adopted by the scientific community that the 'material dimension' is the only possible 'dimension' of the universe. The 'material dimension' is not actually an 'object' that can be observed through measurements. It is only a *concept*, and therefore results from a process of *coherent categorizations* which, as we have seen, implies the existence of *consciousness* which is necessarily *irreducible* to any physical interaction because of the 'indistinguishability theorem'. As such, this hypothesis of the *non-materiality* of consciousness would therefore be legitimate.

The function of *consciousness* would therefore essentially be *to choose* the technical solutions that ensure the durability of the subject with which it is associated, among all those – physically *indistinguishable* – that are spontaneously developed during the physico-chemical interactions between the neurons of our brain-computer. *Consciousness* would thus not work out any technical solution, it would not possess any prior knowledge about the objects of the world.

The nature of the decision process that develop in the technician's brain by means of the *consciousness* which he is empirically equipped, is in accordance with the paradoxical results of the neurobiologist Benjamin Libet's experiments :

> […] The *consciousness* may oppose its 'veto' to the technical solutions previously elaborated of some 500 milliseconds by the brain-computer [technical solutions resulting from interactions between entities having a specific physicochemical affinity][8]

In short, to be truly *autonomous*, artificially *alive* – which was our initial question – a robot built only on the basis of the interconnections (mechanical, electronic, computer, chemical,...) of technical components, should also be equipped with a *consciousness*.

More generally, it follows that the emergence of *living beings* would imply that they each have a *consciousness*. *Consciousness* would thus be the key of life. The analysis of the animation of the E. coli bacterium, an elementary *living* being, will illustrate this thesis.

Contrary to what is often claimed, « synthetic biology » does not answer the fundamental question of creating living structures from inert matter. With a first attempt to build a living system de novo[9], biologists have only combined, synthesized, already functional organelles such as *ribosomes*. Elementary components present in the cells of any organism, which have the essential role of deciphering the RNA code that induces protein synthesis through *functional recopy* (cf. § Evolutionary selection) and as such, already possessing the physically paradoxical ability to discern, for perennial actions, otherwise *indistinguishable* entities.

From bacteria to humans

For a physico-chemical structure to be alive or artificially alive as an *autonomous* robot would be, it must therefore be directly or indirectly (a technician continuously supervises a robot)

[8] Libet Benjamin – *Unconscious cerebral initiative and the role of conscious will in voluntary action. Neurophysiology of Consciousness,* pp. 269-306 – Contemporary Neuroscientists 1993.

[9] J. Craig Venter – *Life at the speed of light* -2014

endowed with a *consciousness* that, fundamentally, ensures the durability of the structures with which it is associated.

What allows the animation of a bacterium like E. coli, as an eminently *living* elementary physicochemical structure, will illustrate this point.

The 'chemotactic' function that has the bacterium is fundamental, it leads the bacterium toward areas where there is a high concentration of nutrient molecules (glucose) required to insure its dynamism. But also by removing the bacterium from areas where there are molecules such as phenol that would alter its structure.[10]

For short, the 'chemotactic' chain is composed of the following : *membrane sensors* MCP (proteins) which calculate the glucose gradient in the medium (local variations in concentration), a *flagellum* linked to a molecular motor that can rotate in retrograde or direct way (direct rotation : the bacterium moves in a straight line - retrograde rotation : the bacterium tumbles and thus changes direction), a *control protein* CheY which determines the direction of rotation of the flagellum depending on the glucose gradient in the medium measured by *sensors* MCP attached to the membrane.

Functional analysis of the *chemotactic function* of the bacterium shows that to be animated, its flagellum must rotate *counterclockwise* (direct) whenever glucose *gradient* in the medium is positive and *clockwise* (retrograde) when on the contrary it is negative

Indeed, the *retrograde* (counterclockwise) direction of rotation of the flagellum leads the bacterium to naturally continue its rectilinear movement and thus to move towards areas where there are more and more glucose molecules, since the measured variation in glucose concentration in the environment during the movement of the bacterium – or glucose gradient – is positive. As for the *direct* direction (*clockwise*) of rotation of the flagellum, it leads the bacterium to tumble over itself (by ruffling the filaments that constitute the flagellum), hence a possible subsequent change of direction to be explored.

But according to the 'indistinguishability theorem' which prohibits the control protein CheY from differentiating between positive or negative values of the gradient of glucose molecules measured by sensors MCP, it follows that the 'chemotactic' process of searching for glucose molecules can only be *random*, and as such totally inefficient.

Sensor proteins MCP do not have any particular physico-chemical affinity with the control protein CheY which could spontaneously lead to the emergence of differentiated actions such as those required to ensure the effective capture of glucose molecules. If, despite all expectations, such affinities could nevertheless exist, all the resulting actions (direct or retrograde rotations of the flagellum) would then necessarily be recurrent, stereotypical, and therefore logically incompatible with the formation of *coherent categories* that underlie the *bacterium* activity. In conclusion, the bacterium cannot therefore be autonomous, alive !

However, there is a possible empirical solution to this paradoxical situation where the bacterium is nevertheless an *autonomous*, *living* physical structure, whereas no technician comes to supervise it, as it was possible with the robot : the 'controller' of the bacterium, the protein CheY, must be specifically equipped with a *consciousness* that will allow the creation in situ of *coherent categories* that form the basis of its animation.

It is because the bacterium is « suffering » when its energy state (number of glucose molecules available) is very low, and on the contrary « have fun » when its energy state is high, that the bacterium could efficiently capture the glucose molecules dispersed in the environment. In the absence of a *consciousness*, the capture of glucose molecules could only be *fortuitous* since for its controller, the protein CheY, the different values of the glucose gradient would be

[10] Sept 25 Biochemical Networks – *Chemotaxis and Motility in E. coli*.

indistinguishable with respect to the 'indistinguishability theorem' (cf. § A definition of the living - the 'indistinguishability theorem').

Reasoned hypothesis, the *consciousness* which is logically irreducible to any physicochemical interaction between molecules (cf. 'theorem of indistinguishability'), would be induced by the specific *form* of the protein CheY. At least with regard to the E. coli bacteria for which this protein CheY has an essential role in controlling the chemotactic function.

As such, some proteins (or pseudo-proteins) with an adequate *shape* could be the first living structures to appear on Earth because they were equipped with a *consciousness* and naturally possess sensors (specific sites) as well as a certain motility by deforming their globular configuration. Wouldn't *prions* ('malformed' proteins that do not reproduce but cause the 'deformation' of healthy proteins with which they are in contact – see *Creutzfeldt-Jakob* disease) be an illustration of this hypothesis ?

A consciousness would therefore only be associated with the physico-chemical structure of the bacterium if there are certain specific material configurations of its components, in this case at the level of the protein CheY in the chemotactic chain. Thus, although essential to the emergence of all living beings, *consciousness* would not necessarily be present throughout the universe as the philosopher David Chalmers[11] suggests :

> «[...] consciousness would be universal. It would be found everywhere in the universe, from elementary particles to stars and galaxies. In the field of terrestrial biology, it would also be present from bacteria to humans. »

Consciousness being thus empirically located at the level of the proteins that constitute the basic element of all living cells, in particular neurons that are the elementary functional units of the nervous system that form the basis of cognition, we can then formulate the following hypothesis : *consciousness* that underlies the animation of human beings would result from the fusion both *spatially* and *temporally* of a large number of elementary *consciousness* with which their brains would be equipped.

The operative nature of the consciousness

The crucial role of the *consciousness* being considered, an essential question arises : the presumed interactions between the operator *consciousness*, irreducible to any physical interaction between molecules given the 'theorem of indistinguishability', and the neuronal physico-chemical structures of the technician's brain or the protein CheY of the bacterium, are lawful ?

We can assume that the alleged interactions between the operator *consciousness* and the physico -chemical structures of the technician's brain or the protein CheY of the bacterium, must all be solved at the 'quantum level' by the *oriented reduction* of the superposition state of the « wave functions » (probability waves) which represent the quantum states of these physico-chemical structures.

Essential issue, during the *reduction of the wave function* or quantum transition, which leads to the emergence of a singular state (called *standard*), the one we observe, there is only a simple reorganization of existing energies and therefore there is overall « conservation of the impulse-energy »[12], this fundamental physical law among all.

As a result, through the process of reducing wave function, although the conscious operator is strictly irreducible to any physical interaction and thus escapes any physical measurement, could nevertheless control the physico-chemical structures of the technician's brain or the bacterium protein CheY.

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[11] David Chalmers – *The Conscious Mind: In Search of a Fundamental Theory* - Ithaque 2010

[12] O.C. de Beauregard – *The second principle of time science*, p. 98 – Edition du Seuil, Paris

The operative capacity of the operator *consciousness* would therefore be lawful with regard to physical laws, contrary to what the philosopher of science Daniel Dennett states in his book 'Consciousness explained'[13]:

> How can Casper the sweet ghost [child's story], both pass through walls and catch a falling towel ? How can mental substance [consciousness] both escape physical measurement and control the body ? A ghost in the machine is no help to us for our theories if he can't move things around him - like a noisy hitting spirit that can knock down a lamp or slam a door. But anything that can move a physical thing is itself a physical thing.

The existence

Consciousness would therefore only make *choices* – based on the *pleasure* of being alive – that would ensure the perenniality of the physico-chemical structures with which it would be associated. They would not carry any a priori knowledge about the world, they would be « raw », without object, such as *pain*, *pleasure*, *red*, *salty*... *Consciousness* would thus never be consciousness of something as Husserl[14] assumed.

So that we can then speculate that the *consciousness* of the world would be similar for all *living beings*, from bacteria to man.

The fabulous variety of mechanical *actions* carried out by man, compared to the elementary activities of bacteria, would ultimately result only from the fantastic growth in the number of various potential solutions generated by his central nervous system thanks to the *generalization* and *associativity* properties of neural networks. As for the bacterium, it has only a few proteins associated in networks to calculate the possible mechanical solutions to ensure the perenniality of its structure. The greater or lesser richness of the *actions* carried out by a living being would therefore not be significant in terms of what this living being « feels ».

The « existence » of a living being would essentially result from the *representation* of the world through the *sensitive qualities* (pleasure, pain, color, sound,..) whose nature would be common to all. As such, there would be a « bacterial existence » just as there is a « human existence »

What would distinguish the « bacterial existence » from that of man is that the former would be very elementary because it would consist of only a few proprio or extroceptive descriptors of the world « observed » by its *sensitive qualities* (pleasure, pain,..). Whereas the « human existence » would be of extreme complexity, involving a very large number of descriptors of this world by virtue of the extraordinary computing power of the nervous networks of the human brain.

« Existence » would be, to varying degrees, shared by everything that lives, cognitive processes would be of the same nature for all living beings.

The transhumanism

For *transhumanist* thinking, the functionality of living beings and the *cognition* with which they are equipped must all be reduced to 'algorithms'. That is to say, sets of operating rules, instructions, applying to the development of more or less complex physico-chemical interactions such as oxygen and hydrogen gases that combine to form water.

As such, we would only be *machines*, certainly very sophisticated, which would have spontaneously built themselves by having the physically paradoxical capacity, given the entropic degradation of the universe, to ensure the durability of their structure in all circumstances, which

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[13] *Consciousness explained* p. 52 – Odile Jacob 1993

[14] Edmund Husserl – *An idea of Husserl's phenomenology: intentionality - Situations I,* p. 32 - Paris, Gallimard, 1947

would characterize them. Over time, these *living* machines would have acquired a more or less developed intelligence thanks to *self-learning* information processing systems.

Consciousness that we all naturally possess, which has the essential virtue of opening us to the colourful and sensitive perception of a universe otherwise closed on itself in its minerality, would therefore only be an *epiphenomenon* that would not play any functional role in the construction of living beings.

Transhumanist thought is thus only interested in living beings from a mechanical or computational point of view. Essentially: repair, improve, these so-called living structures as rockets and computers are built, with ever-increasing technical performance. And since these various technical processes will certainly be mastered in the future, we should then one day be able to free ourselves from the physical and mental limitations acquired during our evolution. This is why human beings could become much more intelligent and even almost immortal.

Since the ultimate goal of the mutation to the transhuman is to eliminate all mechanisms of *pain*, both physical and mental, the downloading of the mind to a supercomputer could thus be the final solution to all our worries. To do this, it would be sufficient to copy the different neurons states of our brain to a 'key' of high capacity and then transfer them to the memory of a supercomputer.

The *transhumanist* thesis is thus a dream for some but a terrible nightmare for others. But is this thesis well founded ?

We have shown that far from being an epiphenomenon, *consciousness* is the key to the existence on Earth of living beings and their cognitions. These are the *consciences* of living beings that determine how we act on the world to ensure our sustainability, in other words, to be alive. Far from being an epiphenomenon, *consciousness* is an essential term without which no life would have appeared on Earth.

This *consciousness* which has the physically paradoxical capacity to make *choices* among objects of the world which are physically *indistinguishable*, implies logically that this *consciousness* is strictly irreducible to any physical process. And this is how *consciousness* cannot result from an algorithm, however complex it may be. This is clearly contrary to the *transhumanist* thesis since it is then strictly impossible to repair or create a *consciousness* as one builds a computer or grafts a piece of reconstituted heart tissue onto a failing heart.

So that even if the progress of science is such that one day we can build adequate physico-chemical structures which, experimentally, would prove to possess the capacity to induce *consciousness*, nevertheless, given the fundamental irreducibility of *consciousness* to any physical interaction, we will never be able to control the physically paradoxical capacity that *consciousness* has to select « for its pleasure to be alive » technical solutions which are otherwise physically *indistinguishable*.

Moreover, for a human being to become more intelligent, he would have to be able to create a large number of new *concepts* which. By definition, *concepts* are *coherent categorizations* of the objects of the world that a living being perceives with his sensors in order to act in an appropriate way that ensures his perenniality. Such as, for example, the *coherent categories of actions* or *concepts* {‘flee’ for all temperatures above 30°} and {‘move forwards’ for all temperatures below 30°} which must make it possible to ‘intelligently’ avoid all hot objects.

But to create new *coherent categories* it would not be enough to simply increase the capacity of his memory as the *transhumanist* thesis suggests. It would also be necessary to fully control the *operative properties of consciousness*. Otherwise, the information processed by the brain, as a computer, could only be loaded into memory at *random*, since this information would then be strictly *indistinguishable* with regard to the ‘indistinguishability theorem’, and therefore without any subsequent possibility of ordered readings.

The *transhumanist* thesis of asserting that the only increase in the computational capacity of our brain should make it possible to increase human beings' intelligence in an unlimited way is therefore unfounded.

The only thing that one day will undoubtedly be achievable, will be to modify or even suppress, by acting mechanically or chemically on our brain, the *induction* of certain 'sensitive qualities' or constituents of *consciousness* such as 'pleasure', 'pain', 'colour', 'sound',... But without controlling the decision-making capacity of the *consciousness* that underlies the state of life and thus the existence of all the objects that are constructed by *living* beings.

As such, the *transhumanist* proposal to build an artificial brain capable of *creating* – as we naturally know how to do it – only from mechanical, computing, interactions between technical components, is equally unfounded. All creation implies a *consciousness*. The solutions to a problem posed by a human being which can be produced by a machine equipped with artificial intelligence are only *random* combinations produced from processes previously implemented by human operators. Only these human operators with their *conscience* can then decide, in order to ensure their perenniality, on the relevance of some of the possible technical *operating* solutions proposed by the machine.

Creativity is not so much the power to elaborate new *forms* (cf. § Evolutionary selection) as to associate these *forms* in a *coherent way* – while they are physically *indistinguishable* – so that resulting actions ensure the perenniality of physico-chemical structures then called *living structures* in response to the generally degrading solicitations of their environment. Inert structures do not suffer from being destroyed, a rock does not take any specific *action* in order not to be broken into two pieces.

Computer machines thus only blindly create digital objects resulting from obliged interactions that spontaneously develop with regard to physical laws. It is the subject's *consciousness* who chooses a particular object among all those elaborated by the machine, because this technical object ultimately ensures its durability in view of the infinitely variable constraints of the environment. The machine being, for its part, unconcerned about the durability of its structure.

Thus, the 'deep learning machine' did not invent, create, the concept of {chat} no more than a 'Kohonen self-adaptive card' create the categories *subject*, *verb* and *complement* (cf. § Connectionnism). They are the operators in charge of experiments who have created these different *concepts* through the ability of their *consciousness* to adequately select objects – physically *indistinguishable* – that must ensure their perenniality.

As well as there is no real creation of the digital moulding machine that produces LEGO plug-in elements. It is only a young child who later by combining for his 'pleasure' several elements of a box that has been offered to him, will really *create* what he will call a car as it can move on a table. While these different elements such as a wheel and a plate are in fact strictly *indistinguishable* by any device that should fit them together. LEGO boxes are in this case only containers of various shapes that have no operational value in terms of *life* and *autonomy*.

Another significant example : as we have previously analysed (see § From bacteria to humans), a flagellum associated with a molecular rotating motor allows a bacterium like E. coli to 'intelligently' move towards the glucose sources on which it feeds. But this extraordinary molecular motor composed of several proteins arranged in rings results only from obligatory interactions between proteins with regard to physical laws. As such, this is not as well a *creation* of inert nature in terms of life.

Creativity is not so much the emergence of new forms such as the so-called molecular engine, as to associate these *forms* in a *coherent* way – even though they are physically indistinguishable – so that the resulting actions ensure the durability of a physico-chemical structure like the E. coli bacterium then facing the ever degrading pressures of its environment. The « creativity of the bacterium » is that this molecular motor is *coherently* associated with a glucose sensitive sensor – an membrane protein MCP, so that this bacterium can effectively capture glucose molecules. It is

the *consciousness* that, as we have shown, must necessarily be associated with the bacterium, which will choose for its « pleasure to be alive » the appropriate physico-chemical links between the membrane sensor MCP and the molecular motor associated with flagella.

As for the hypothetical transfer of our mind to a supercomputer by simply copying the different states of activation or non-activation of neurons in the brain assimilated to a computer machine, i.e. by ignoring the existence of *consciousness*, is just as impossible. We would only build a super-automaton like the 'Automaton' of neurobiologist Wilder Penfield[15]. An 'Automaton' is a human being deprived of *consciousness*, therefore of any *sensitive qualities* (pleasure, pain, color, sound,..) because of a major dysfunction or surgery, and having therefore totally lost the ability to *create*, to adapt to an environment different from that which he had known when he was in good health.

It is undoubtedly true that the tremendous technological advances in biology and neuroscience suggest that most diseases will disappear and that all or almost all parts of the body can be repaired or replaced. But this purely *computational* approach to life proposed by the proponents of *transhumanism*, which would lead to an infinite increase in our mental capacities and the elimination of all *pain* mechanisms, is therefore not scientifically founded.

Conclusion

The construction of an *autonomous* robot, *alive* artificially, made up of technical elements resulting from physicochemical interactions, is formally unfeasible. We can build only *automaton* robots having tools whose performance may far exceed those of living beings as regards developed forces, computing capacities and memorizing. But these robots remain unable to adapt to the infinitely variable constraints of their environment, create new tools as can do it all *living beings* that these robots should emulate.

Sharing the same criterion of existence that the *autonomous* robots should have, namely to ensure at any cost the durability of their structure, living beings therefore should not exist !
It turns out that *living* structures with their *cognitive* abilities owe their existence to *consciousness* with 'sensitive qualities' such as *pleasure* or *pain*, which they are empirically endowed with. *Consciousness* having the essential ability to select the objects of the world – all physically *indistinguishable* – with which these structures interact in order to ensure their durability at all costs. *Consciousness* is the key to the existence on Earth of living beings and their cognitions.

The 'computational theory of the mind', in which the human mind functions as a computer machine following the *transhumanist* thesis in which the functionality of living beings and their cognitions must all be reduced to 'algorithms, which would entail the possible transfer of our 'mind' to an indestructible supercomputer, is therefore totally unfounded. As a result, computer machines have no *creative* power. All *creation* implies a *consciousness*.

Since the *actions* we perform on the objects of the world are derived only from the *choices* made by our *consciences* endowed with *sensitive qualities*, these *actions* that are emanating from our thoughts are all fundamentally « irrational ». In the sense that the *actions* that are selected from all those possible ones resulting from physical interactions between neurons, do not result in any case from *logical operations* based on the laws of physics. These *perennial* actions are essentially based on the *pleasure* perceived by the *consciousness* as they unfold, and not on spontaneous calculations that develop in the neural networks of our brain as a computer.

The *consciousness* with its *sensitive qualities*, which chooses – and not builds – particular technical solutions developed by a more or less efficient brain, would thus possess no a priori

[15] Wilder Penfield – *The Electrode, the Brain and the Mind* - Z. Neurol. 201, 297-309 (1972) Springer Verlag 1972

knowledge of the world. As such, the nature of the feeling provided by *consciousness* could be qualitatively similar for everything that lives. The 'sense of existence', the « living in the certainty of the world » according to Husserl, would then be, to varying degrees depending on the richness of the technical description of the world, naturally shared by all living beings.

- Annex -

'Theorem of indistinguishability' :

To measure an observable **O** (temperature, weight, length,...) on an object **A**, this object must interact with a given technical device that has the particularity to put in a single specific end state **E** when the interaction is complete.

Let us consider a thermometric measuring device consisting of the following elements: a *sensor* (a thermometer), a *display* (a screen on which the measurement results can be read), physical *connections* between the sensor and the display. The world to which the thermometric measurements relate is assumed to consist of only two objects **A** and **B**, the first of which is, for example, molten lava, it is *hot*, and the second a piece of ice, it is *cold*. The measurements are thus related to the only observable **P**, the temperature.

Generally, if **P** is the number of observable, there are $\mathbf{N} = 2^{\mathbf{P}}$ possible properties. In this case, with the only observable temperature, let **P** = 1, it follows that there exists $N = 2^{\mathbf{P}} = 2^1 = 2$ different properties. Namely, the properties 'hot' and 'cold' that characterize the objects **A** and **B** respectively

For a given state (*hot or cold*) of the entity **A** or **B** which is the subject of the measurement must correspond to a unique state of the temperature sensor. Thus, with a thermometer as a sensitive element **Ap** to the observable temperature, this state is represented by the length of the mercury column that is a function of the temperature of the object which is measured.

Two photoelectric cells $\mathbf{C_A}$ and $\mathbf{C_B}$ – only sensitive to the specific shape of the mercury meniscus in the capillary tube – are positioned at two points on the capillary corresponding to the two possible positions reached by the meniscus depending on whether it is object **A** or **B** that is being measured.

When object **A** is in front of the bulb of the thermometer and the measurement is complete (the mercury column is stabilized, the transient positions are ignored), only the photocell $\mathbf{C_A}$ is activated, i.e. an output signal $\mathbf{S_A} = 1$, with $\mathbf{S_B} = 0$. For object **B**, only the cell $\mathbf{C_B}$ is activated, i.e. an output signal $\mathbf{S_B} = 1$, with $\mathbf{S_A} = 0$.

The question that arises is the following : what are the physical connections that can be established between the two outputs $\mathbf{S_A}$ and $\mathbf{S_B}$ of the sensor and the input of the display (read-out screen) in order to take into account all the information that comes from the sensor.

Logically, there are 3 and only 3 possible physical combinations between the two outputs $\mathbf{S_A}$ and $\mathbf{S_B}$, i.e. : $\mathbf{S_A}$, $\mathbf{S_B}$, $\mathbf{\{S_A}$ ***or*** $\mathbf{S_B\}}$. We ignore the combination $\mathbf{\{S_A}$ ***et*** $\mathbf{S_B\}}$ (operator « and »), because being logically always equal to 0 since the photoelectric cells $\mathbf{C_A}$ and $\mathbf{C_B}$ cannot be simultaneously activated when objects **A** or **B** are in front of the thermometer.

In all generality, there are **M** = 2^{N}-1 possible operative combinations established from the **N** possible properties (these are the **N** rows that result from the different possible combinations of 0 and 1 in a table with **N** columns).

In this case, the fact that there are **N** = 2 *hot* and *cold* properties corresponding respectively to objects **A** and **B**, means that there is **M** = 2^{N}-1 = 2^{2}-1 = 3 possible combinations, i.e. : **S_A**, **S_B**, **{S_A** or **S_B}.**

In view of the experimental context, an operator then establishes in an exhaustive way the following 3 possible links between the sensor and the display:

- a link **L_1**, attached to the **S_A** output.
- a link **L_2**, attached to the **S_B** output.
- a link **L_3**, attached to the compound output **{S_A *or* S_B}** – as lawful as the links **L_1** et **L_2**

The 3 connections **L_1**, **L_2**, **L_3** between the sensor and the display being established, the following tasks are then performed:

(1) object **A** is placed in front of the bulb of the thermometer sensor: only the **A_C** photoelectric cell is then activated, hence **S_A** = 1 and thus **{S_A *or* S_B}** = 1. The **L_1** and **L_3** links are therefore simultaneously activated, which is indicated by the display which also stores this result.

(2) object **B** is placed in front of the bulb of the thermometer sensor : only the photoelectric cell **C_B** is activated, hence **S_B** = 1 and thus **{S_A or S_B}** = 1. The **L_2** and **L_3** links are simultaneously activated, which is indicated by the display, which also stores this result.

Finally, the display screen appears to the operator as follows :

objet **A**	**L_1**	**L_3**
objet **B**	**L_2**	**L_3**

Since the operator has no a priori knowledge of the objects that we initially named **A** and **B**, he must conclude from reading the second column of the table that **A** = **L_1** and **B** = **L_2** and that as such these two objects are *different*.

But reading the third column of the same table also informs him that **A** = **L_3** and **B** = **L_3**, which means that these two objects are also *identical*.

Being both *different* and *identical*, objects A and B perceived by a sensor are physically *indistinguishable* from the point of view of the *actuator* with which this sensor is associated.