
**ADAPT**
***IST–2001-37173***
***Artificial Development Approach to Presence Technologies***

# Deliverable Item 2.2
# The "theory of intentionality" after some experiments

**Delivery Date: September 1st, 2005**
**Classification: Public**
**Responsible Person: Riccardo Manzotti and Giorgio Metta – UGDIST**
**Partners Contributed: ALL**

**Short Description:** This deliverable describes how D2.1 and the experimental plan of Adapt complement each other.


**Project funded by the European Community under the "Information Society Technologies" Programme (1998-2002)**

## Table of contents

## 1. Introduction

The problem of consciousness is traditionally conceived as the impossible task of justifying the emergence of an inner world of experiences, qualia and/or mental representations out of a substratum of physical things conceived as autonomously existing. We argue that an alternative approach is possible but it requires a conceptual reconstruction of consciousness and existence, the two being different perspectives on the same underlying process. On this basis, we present a view of direct (conscious) perception that supposes that there is unity between the activity of the brain and the events of the external world. The outlined process is here referred to as *onphene*. We will use the example of the rainbow as an intuition pump to introduce the new perspective. Eventually, the same approach is used to explain other kinds of consciousness: illusions, memory, dreams, and phosphenes. The view presented here shares some elements with neo realism and can be considered as a form of radical externalism. The deliverable contains also a tentative unified view that includes the experiments performed by the Adapt consortium. With respect to D2.1 that presented the theory of the *onphene* (see later) at the beginning of the project, this deliverable contains a wider comparison with other philosophical approaches to the study of consciousness.

*That reality is constituted by the things. Could anything else do the job?*
*Ted Honderich (Honderich 2000)*

Do we really live in a private, subjective experience concocted in real time by our brains? Since Descartes' evil genius hypothesis, many thinkers have been fascinated by this suggestion. Notwithstanding the formidable obstacles it faces, the idea that consciousness is in the head has gained respectability in the recent past disguised in different variants: quantum waves in microtubules, central workspaces, neural coding, NCC (for a comprehensive review see (Koch 2004)). However no clear solution has insofar been presented and the problem of the emergence of conscious experience out of neural activity is as "hard" as ever. One of the reasons is substance oriented thinking that biases most of the discussion about the mind. Let us make an example (Figure 1).

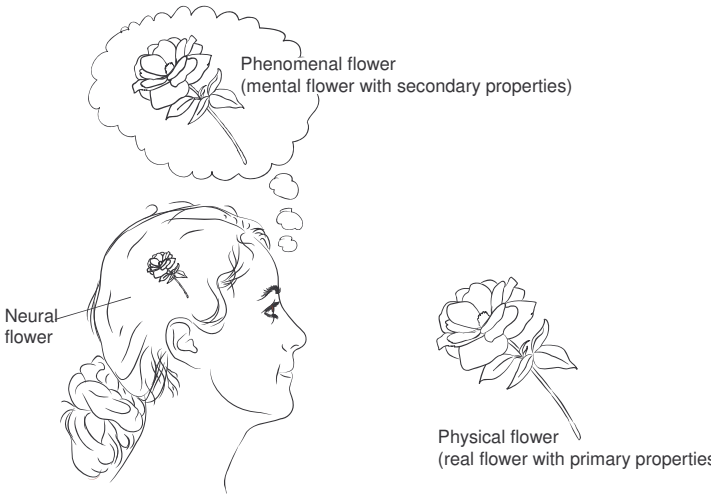



Figure 1 Traditional approach (substance oriented) to the problem of consciousness. According to the dualistic framework the phenomenal object has different properties from the physical

object. However the phenomenal object must be instantiated by a neural object (or activity) which is doomed to have only physical properties and thus it cannot have any phenomenal qualities.

Sabrina is sitting in front of a flower. The flower has physical properties like shape and colors. Sabrina has an experience of shapes and colors. However where are these experienced shapes and colors located? Are they in the brain? As all neurologists know, in the brain there is nothing like that (Place 1956): the properties of brain processes are completely different from the properties of the supposed correspondent conscious processes. On the other hand, it is doubtful whether the experienced properties are in the flower itself. The famous difference between primary properties explored by physics and secondary qualities resulting from psychological activity is there with all its strength. The color Sabrina perceives is not necessarily there. Upon the surface of the flower, there is a reflectance spectrum which seems to be not exactly Sabrina's experience of the color. What then? Against this view argued, with characteristic elegance, William James saying that "It supposes two elements, mind knowing and thing known, and treats them as irreducible. Neither gets out of itself or into the other, neither in any way *is* the other, neither *makes* the other. They just stand face to face in a common world, and one simply know, or is known unto, its counterpart." (James 1890/1950), p.218.

We claim here that the problem just outlined is so hopeless because it is based on a false hypothesis that we try to emphasize in the following. The position we develop here is related to three different and yet connected viewpoints: externalism (Rowlands 2003), process philosophy (Whitehead 1927/1978; Griffin 1998), and Neorealism (Holt, Marvin et al. 1910; Holt 1914; Tonneau 2004). We will explain the relation between our theory and these three positions at greater length in the following.

In the next chapter we will analyze the historical causes that shaped the actual game yard of consciousness. As we will see, the problem of consciousness is made so awkward not by the properties of consciousness itself but by the supposed properties of the physical world.

The rationale of this proposal is simple, albeit radical. It can be summarized as follows. It is traditionally assumed that there is a world of things and there is an experience of such a world of things: the two being different and separate. This standpoint is based on the common belief that the world is made of things which seem to exist autonomously and without any need of being in relation with the rest of their environment. We will start challenging this belief and showing proof of the fact that in order to exist something needs to interact with something else. Thus we will claim that the existence of things (objects and events) should be re-described as their taking place. A different ontology must here be sketched: a process based ontology. Having reframed in this way the world of things, we will proceed to the next step: how does the experience of things fit in this new picture? Our bet is that – as soon as we drop the belief in a world of things existing autonomously and as soon as we conceive the world as made of processes extended in time and space – experience (and thus consciousness) does not need to be located in a special domain (or to require the emergence of something new): experience is just made of those processes that make up our behavioral story. Experience becomes no more constrained to the activity taking place inside our cranium: experience becomes an extended collection of processes comprehending all those events that are part of our conscious experience. Many concepts – like those of representation or mental causation – get a twist and develop a new perspective.

## 2. An historical and ontological perspective on the problem of consciousness

Childhood is as important for science as it is for individuals. The framework of the contemporary controversy on the nature of the mind was shaped in XVII century. Most of current literature on this issue (Minsky 1985; Dennett 1991; Chalmers 1996; Tye 1996; Kim 1998; Manzotti 2002) is inscribed inside the playground chosen in the first half of XVII century by Galileo Galilei. Very often the settling of the modern version of the mind-body problem is traced back to René Descartes or to John Locke: but they were both influenced by the inventor of the modern scientific method. Galileo defined the modern playground for the discussion on the mind in one of the most influential book of XVII century, "the Assayer", in 1623, 14 years before the publication of the much more often quoted Descartes' "Discourse on the Method of Rightly Conducting the Reason, and Seeking Truth in the Sciences" (1637). Descartes started writing a draft in 1629, after the publication of Galileo's masterpiece and heavily influenced by the Italian Scholar's writings. Locke's work was completed much later (mostly between 1662-1700).

This historical introduction is necessary in order to understand the reasons behind the current and contemporary ontological framework: to understand what has been defined the impulse to "etherealize" or "cranialize" consciousness (Honderich 2000). Galileo put forward three crucial issues in his book:

1) the experimental method that founds knowledge on empirical proofs and not on the authority of past scholars;
2) the suggestion to read nature in mathematical symbols;
3) the suggestion that the "real" world is made only of quantitative aspects while all the other empirical aspects like quality and form are just something created by the "mind".

While the first two issues were mainly methodological, the latter was an ontological claim with no empirical basis, heavy with metaphysical and ontological implications. New historical data have recently connected Galileo's indictment to this claim and not to the much more famous but probably much less theologically dangerous Copernican theory (Redondi 1983/2004). Of course there are differences between Galileo, Descartes and Locke on the matter of primary and secondary qualities, especially with regard to whether secondary qualities only exist in perceiving minds. We recognize this point, but we will mainly discuss the view of Galileo as the founder of the doctrine in the 17the century cosmology. Here it is important to emphasize that the first two issues raised by Galileo, which are at the root of modern science, do not entail the third issue, which is a metaphysical claim about what the world is made of. These are Galileo's words:

> "Therefore, I am inclined to think that these tastes, smells, colors, etc., with regard to the object in which they appear to reside, are nothing more than mere names, and exist only in the sensitive body; insomuch that when the living creature is removed all these qualities are carried off and annihilated; although we have imposed particular names upon them (different from those other and real accidents), and would happily persuade ourselves that they truly and in fact exist. But I do not believe that there exists anything in external bodies for exciting tastes, smells, and sounds, but size, shape, quantity, and motion, swift or slow; and if ears, tongues, and noses were removed, I am of the opinion that shape, quantity, and motion would

> remain, but there would be an end of smells, tastes, and sounds, which, abstractedly from the living creature, I take to be mere words." (Galilei 1623)

This lengthy passage is the first outline of the modern framework in which the mind was discussed. It contains: 1) the distinction between primary and secondary properties (or "qualities" which is a misleading name); 2) the link between primary properties and quantity and secondary properties and quality; 3) the claim that the former are *real* while the latter are "mere words" which "exist only in the sensitive body". On the basis of an epistemological difference – what can be described by quantities and what cannot – Galileo put forward an ontological difference. In short this is the classic dualistic view which later scholars tried to specify without substantial changes. Although nowadays the role of the soul is taken by the brain plus the body, the way in which the problem is framed is still the same (for instance in (Dennett 1991; Chalmers 1996; Kim 1996; Edelman and Tononi 2000)). So far, this view led to many unsolved problems. The most important of which are (as shown in Figure 2a):

- if secondary properties (or qualities) are separate and different from primary properties, how can secondary properties arise out of primary ones (*hard problem*)?
- if secondary properties (or qualities) are separate and different from primary properties, how can secondary properties produce effects on them (*mental causation*)?
- if secondary properties (or qualities) are separate and different from primary properties, how can secondary properties represent any properties of the external world (*representation and intentionality*)?

In sum, the three previous problems can be seen as the problem of what is a secondary or mental property, how does it act on primary properties and how do primary properties act on it. We don't know what they are, how to get inside and how to get out of them: quite a desperate situation!

Interestingly enough, all these apparently unsolvable problems are dependent on the aforementioned metaphysical assumption of the separation and difference between the domain of secondary properties and that of primary properties. Is that assumption well founded? Can it be questioned? Instead of keeping the assumption, in this manuscript we will analyze it and we will see if dropping it leads to a better view of consciousness.

Let us sketch briefly the contemporary version of the mind-body problem as it has been shaped by its historical origin. It is a fact that the body of a subject is physically separate from the bodies of the objects of its experience. It is similarly a fact that a subject has an experience of something. It is also a fact that its experience consists of qualities like smell, color, shape, and other phenomenal content. Finally, it is a fact that the external world, *as it is described in mathematical terms*, does not possess these qualities, but it seems to be made by particles and waves moving and interacting in different ways. Whitehead expressed his uneasiness about this view of nature by writing that "Nature is a dull affair, soundless, scentless, colorless; merely the hurrying of material, endlessly, meaninglessly. However you disguise it, this is the practical outcome of the characteristic scientific philosophy which close the seventeenth century." (Whitehead 1925), p.80. What is crucial here is that the separation between the ontology of qualities and that of quantities led to the distinction between primary and secondary properties and, subsequently, to the separation of existence and consciousness.

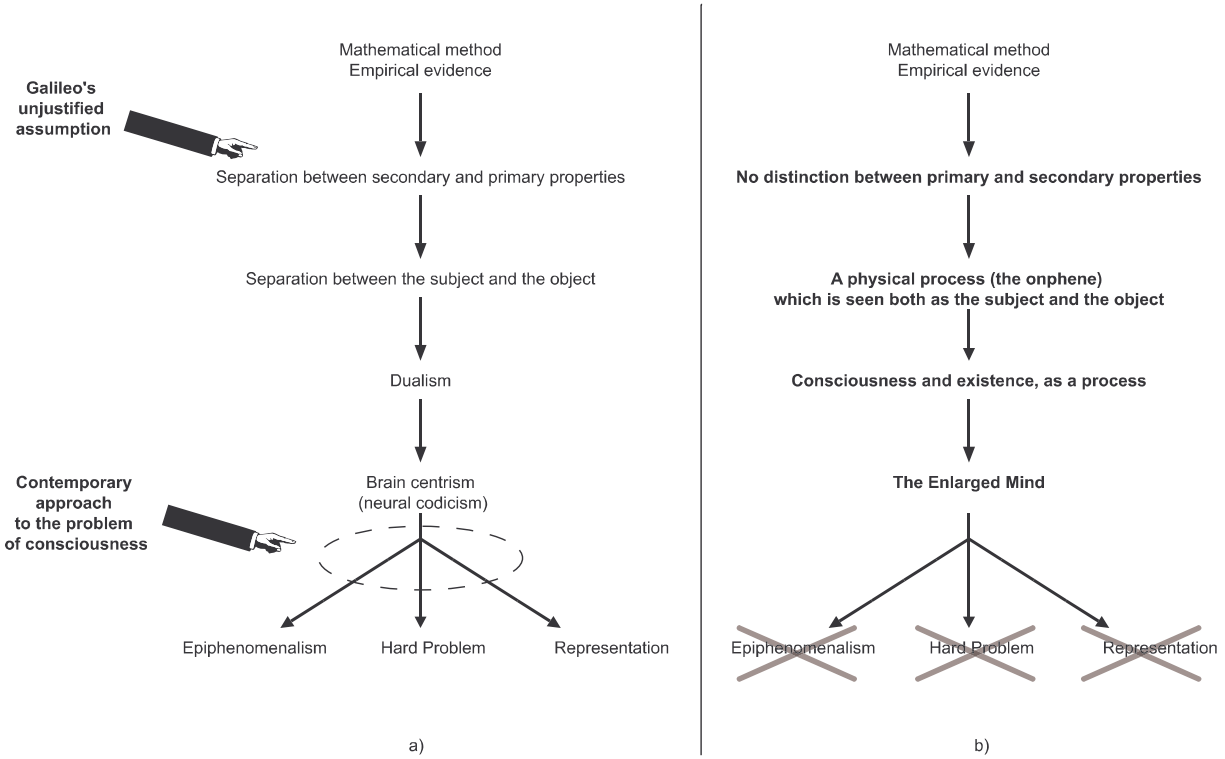



Figure 2. The conceptual path leading from the assumption of secondary and primary properties to the hazards of dualism: a) the standard approach; b) the approach attempted in this document.

Galileo suggested an epistemological tool capable of systematizing empirical evidence in order to derive knowledge. The mathematical approach was his answer to this problem. Yet, nothing entailed that such a tool should carry an ontology: namely leading to the hypothesis that only those properties that could be expressed as quantity should be real. We can simplify Galileo's claim in this way:

- I will use mathematics to organize empirical evidence;
- Mathematics deals only with quantitative aspects of reality;
- Only quantitative aspects of reality would belong to my ontology.

It is evident that the final conclusion is unjustified: "in general, it is unadvisable for philosophers to try to make ontological points by using epistemological arguments" (Fodor 1976) p. ix. Most of contemporary discussions on consciousness implicitly accept it. Once the unity of the empirical world is split in a subjective domain (made of secondary properties) and an objective domain (made of primary properties), there is no way to put the two together again.

The accepted standpoint is showed in Figure 1. There is a subject, physically made of entities like neurons and cells, interacting with external entities (a flower). The subject has an experience of something. There are two options: 1) the experience is representing the external object or 2) the experience is independent of the object. In both cases, experience must be different from the activity going on in her brain since it is known, through neurological analysis, that the primary properties of what is going on in her brain (the neural flower) is completely different from what she has an experience of. Assuming, as it seems reasonable to

do, that in her experience of the world there is something correlated with the external object, it should be concluded that the phenomenal flower somehow represents the external flower. How this could happen is the so called problem of representation interwoven with the so called "hard problem". Insofar, it has received no explanations whatsoever. With respect to the conscious experience of the world, the brain carries the same burden of XVII century soul. The brain is supposed to be able to interpret the electric signals or information and to produce a conscious experience of the world by means of some neural coding (Metzinger 2000; Koch 2004). Unfortunately, it is not clear how this happens and how something can be a re-presentation of something else (Goodman 1978; Fodor 1981; Honderich 2000; Lehar 2003).
A dualistic view of perception cannot be avoided once the hypothesis of the separation between the subject and the object (between the brain and the external world) is made. The dualistic approach leads to the issue of re-presentation. Given the number of problems this approach entails, and its strong resistance to solution, it is worthwhile questioning such an hypothesis (Rorty 1979; Searle 1980; Fodor 1981; Millikan 1984; Dretske 1993; Dretske 1995; Tye 1996; Clark 1997; Bickhard 1999; Metzinger 2003).
The discovery of the separation and difference between secondary and primary properties (and of the separation and difference between subject and object), seen as the foundation of the modern world view, could be mistaken; this is the main reason why it is impossible to develop a scientific theory of consciousness. This is the view we will challenge. As Whitehead makes the point: "The false idea we have to get rid of is that of nature as a mere aggregate of independent entities, each capable of isolation. According to this conception these entities, whose characteristics are capable of isolated definition, come together and by their accidental relations form the system of nature …" (Whitehead 1926), p. 141.

## 3. Natural unities: the rainbow and other remarkable objects

In order to make as clear as possible our rationale we emphasize a principle that we will apply consistently: *something, in order to exist, has to produce some effects*. It is a principle that has been advocated by most of Galileo's epistemological descendants.
If something would not produce any effect, there would be no difference between its existence and its absence: in either case what would happen would be the same. Here, we are not going to enter into the debate of the existence of logical entities and abstract concepts. We will keep our feet on the ground of physical reality. Ether, phlogiston, and epicycles were dismissed as being incapable of making a real difference. We will use this principle to show that the separation between the subject and the object is unfounded.

*The rainbow*. The rainbow is perhaps an example in which the separation between the observed object/event and the observing object/event is not evident. When the sun is sufficiently low on the horizon and projects its rays at an appropriate angle against a cloud with a large enough volume of drops of water suspended in the atmosphere, an observer can see an arch with all the spectrum of colors. All drops of water reflect the sunlight in the same manner, yet only those which have a particular geometrical relation to the observer, due to his position, and due to the orientation of the sun rays, are seen as part of the rainbow. The position of the rainbow seen thus depends on the position of the observer.
An important caveat is here needed. By observer of a phenomenon, we do not refer to a human being, or a conscious subject, or an agent with a mind. We refer to a physical system that is capable of "recognizing" an occurrence of that phenomenon. By recognizing we refer to the

capability of selectively producing an outcome of some kind in response to the presence of that phenomenon. For instance, an observer of a rainbow is a system which can produce an outcome whenever it is in front of a rainbow. According to this definition, which has no pretension of being used outside of the scope of this manuscript, a digital or film camera is not an observer since it records all the visual information without being able to recognize explicitly anything. On the contrary, a human being, most animals, artificial pattern recognizers are observers.

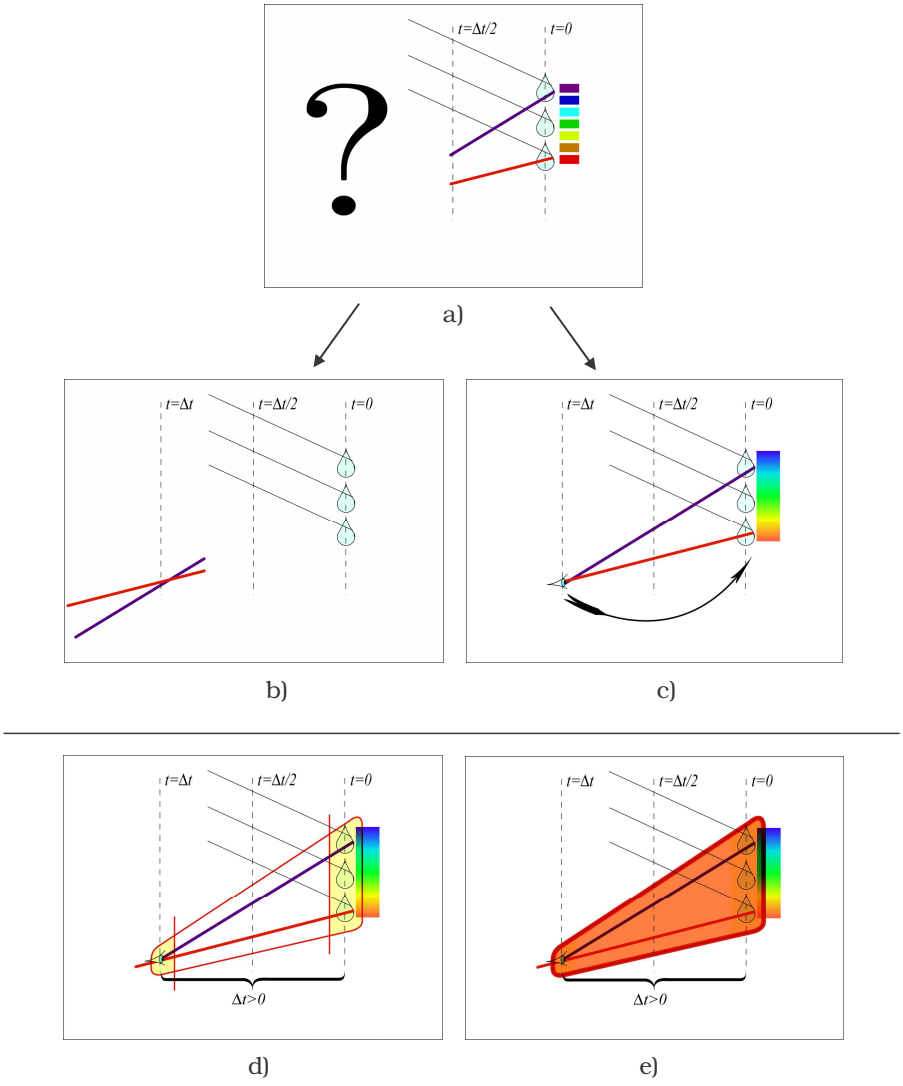



Figure 3 A rainbow (see text).

Let us consider a simplified version of a rainbow as that shown in Figure 3. A one-dimensional column of drops is floating in the air. A stream of parallel white rays of light collides with them. As a result, each drop reflects a divergent stream of colored rays of light. Is there a unity? a whole? No. The rainbow as a unity, as a whole, is not there yet. Nevertheless, as soon as an observer would select a given combinations of drops, a rainbow would take place. If no observer were there, would the rays produce an effect as a whole? No, they would not, because

they would continue their travel in space without interacting and eventually they would spread everywhere. Their opportunity to produce a joint effect would be lost. As William James wrote "In the parallelogram of forces, the 'forces' themselves do not combine into the diagonal resultant; a *body* is needed on which they may impinge, to exhibit their resultant effect" (James 1890/1950), p. 159. Therefore their cause (the supposed rainbow) would not have produced any effect and as a cause would not have existed. It was only a theoretical existence. We assumed that there must have been a rainbow, but there wasn't. On the contrary, if an observer were there, the converging rays of light would have hit his/her photoreceptors and a fast but complex chain of physical processes would have continued from the retina to the cortical areas up to a point where the recognition of the rainbow as a whole (a colored arch) would have taken place. Thanks to the existence of the physical structure of the observer, the drops of water of the rainbow have been able to produce a joint effect.

As it is shown in Figure 3a, until the whole process is concluded, there is no actual rainbow as a whole. Something could happen at the very last moment in order to interfere with the completion of the process. There are two possible outcomes (Figure 3b and Figure 3c). In the former, a perceiver is missing and the rays of light would loose their chance to produce an effect as a whole. In the latter, an observer allows the rainbow to take place as a process and as a whole. The cause seems to exist only thanks to the occurrence of its effect (Figure 3d): the cause of the cause is the effect and the effect of the effect is the cause. This is paradoxical. Yet the paradox disappears once we conceive the unity of the underlying process (Figure 3e).

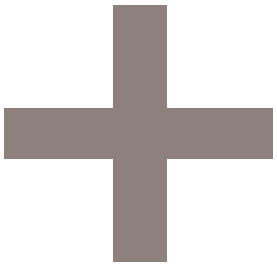
If we apply the principle, mentioned at the beginning of this paragraph, we must conclude that the rainbow remains a possibility, an abstraction, until the rays of light interact with something with the proper capability.

Thus the answer to the question: "Does the rainbow exist independently of the act of observation?" is obviously "No". Even from a logical point of view, to define the position of a rainbow, an expert physicist would need to know the precise point of view of the observer. Thus the rainbow is not a thing: it is *a process*, in which there is an entanglement between a physical complex and an observer. The drops of water do not constitute a distinctive whole (the rainbow) unless and until they produce an effect. The point is that the effect cannot be split from the cause, nor can the cause and the effect be split from their relation. The effect is responsible for the existence of the cause. Further, the existence of the rainbow depends not only on the presence of the physical conditions given above and the observer, but on a causal continuity between the two. This continuity consists of rays of light at the right location actually hitting the retina of the observer and setting up a continual discharge in the brain, as long as the physical relationships are maintained. Once these physical relationships are broken, the rainbow as – a process and as a whole – ceases to exist.

In the cloud there are almost infinite possible rainbows. Yet only a very limited number of them are actually able to produce an effect as a whole: those that are interacting with the proper kind of physical systems (normally human beings' visual systems).

The concept of a "possible rainbow" is misleading because it entails the existence of something, while it would be much more precise something like "some of the conditions necessary to the occurrence of a rainbow". The physical conditions of the drops are only half of the story: the other half is in the observer's eyes and brains. The whole story is the occurrence of the process as a whole (which we call a rainbow).

*The sun's reflection over the sea*. It is a glorious sunset. The sun is not yet sunken behind the line of the horizon. A small breeze is caressing the sea surface producing countless small waves. By looking towards the sun, we see the familiar sight of a vertical row of glittering lights going from us to the horizon limit. From a physical point of view, there is a row of light stretching many miles on the sea surface that, because of the chance of interacting with your brain, is producing an effect as a whole. The phenomenon is similar to that of the rainbow: many separate entities are producing an effect *as a whole* because of the existence of the proper system. The separate waves reflecting the sun rays have no unity all together, until the reflected light produces an effect. By standing on a beach and looking at this phenomenon, we can naively believe that only that part of the sea shines because of the sun light. It is not so. The entire sea surface shines in the same way. The position of the observed column of light depends on our properties (position in space, and properties of our visual system).



| | | | | |
|---|---|---|---|---|
| *u* | *u* | *n* | *u* | *u* |
| *u* | *u* | *n* | *u* | *u* |
| *n* | *n* | *n* | *n* | *n* |
| *u* | *u* | *n* | *u* | *u* |
| *u* | *u* | *n* | *u* | *u* |

| | | | | |
|---|---|---|---|---|
| *30* | *8* | *17* | *25* | *28* |
| *18* | *15* | *11* | *9* | *14* |
| *31* | *3* | *5* | *23* | *29* |
| *10* | *22* | *19* | *4* | *20* |
| *16* | *8* | *7* | *6* | *12* |

Figure 4 Three crosses: do they exist in the same way?

*Patterns*. The three crosses in Figure 4 provide another example. They seem to have different degrees of autonomous existence. The grey cross seems to be the most autonomous. The other two are more arbitrarily created by the perceiver (a cross of characters 'u' and a cross of prime numbers). If our eyes were equipped with hard-wired receptors for prime numbers (something easily achievable in a machine using a Character Recognition System and a mathematical rule), we would see the last cross as easily as the first one. The perceived difference is based on the difficulty that the brain has in viewing them. The crosses exist because they interact with the brain. Conversely, the brain can interact with them because they exist.

What about the famous Lincoln's face in Salvador Dalì's painting or the "Dalmata Picture"? In both cases the unity of those dots and patches on a screen or on a piece of paper takes place thanks to the observer in front of them.

Countless similar examples can be derived from other kind of patterns. A well known one is Kanisza's triangle (Figure 5). The three black shapes do not produce any effect *as a whole* until they interact with someone with the proper cognitive and perceptual category: namely that of the triangle. It is often assumed that the triangle is the only possible outcome. It is not so. For instance, during the Eighties there was a popular videogame called "Pacman" whose main character had the shape of one of the three elements of Kanisza's figure. When confronted with the figure, students often failed to see the triangle. Instead they claimed to recognize three separate Pacmans.

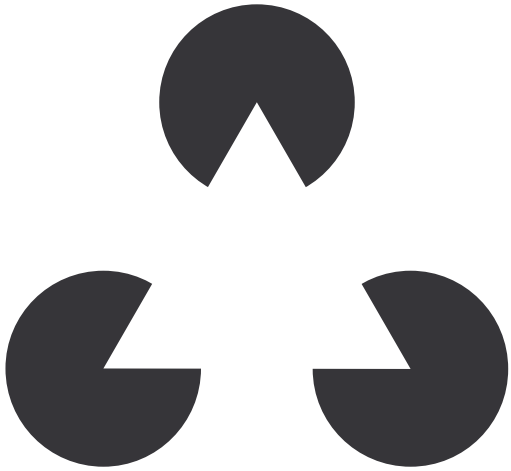


Figure 5 Kanisza's triangle: how many objects is made of? One, three or four?

*Constellations*. We can choose to connect one star to a constellation or to remove it. There are no fixed rules based on their magnitude or position and the historical choices are what they are: we are fond of conventional choices, for sentimental reasons. Nelson Goodman wrote: "Has a constellation been there as long as the stars that compose it, or did it come into being only when selected and designated? In the latter case, the constellation was created by [us] … a constellation becomes such only through being chosen from among all configurations … As we thus make constellations by picking out and putting together certain stars rather than others, so we make stars by drawing certain boundaries rather than others. Nothing dictates whether the skies shall be marked off into constellations or other objects" (Goodman 1978), p.36. On the same subject, William James stated that "wholes are not realities, parts only are realities. […] The 'whole', be it a bird or constellation, is nothing but our vision, nothing but an effect on our sensorium when a lot of things act on it together. It is not realized by any organ or any star, or experienced apart from the consciousness of an onlooker" (James 1908/1996), p.194. A more recent development of the same stream of thought is represented by Brain Smith (Smith 1996; Smith 1998). Constellations produce effects thanks to their capability of interacting with the proper physical systems: human beings.

*Faces*. They exist because the brain has devoted great resources to select them, to the extent that a special cortical has been assigned to the process as testified in several studies (Nachson 1995; Farah, Wilson et al. 1998; De Haan 2001). Patients suffering from prosopoagnosia due to lesions of the relevant cortical area are well aware of this. If all human beings were affected by prosopoagnosia, faces would stop producing effects. The human capability of recognizing faces allows the 'man in the moon' to produce an effect. Thanks to the fact that human beings are trained to recognize faces, a face-like configuration in the moon produces effects as a whole. This is put to good use in children's comics and books where locomotives or airplanes can be given a distinctive facial appearance. Among all possible combinations of patterns, only the face-like pattern exists and this is not the result of a difference in the properties of the face-like pattern, but in the properties of systems that actually interact with these patterns.

*Landscapes.* A landscape becomes a unity only because it is perceived by someone. For instance, take the Hong Kong skyline: buildings that are very distant produce a joint effect thanks to the physical system which is the observer.

*Music and words.* Spoken words and pieces of music are collections of sound waves. Thanks to the existence of listeners, they produce effects; spoken words and music come into existence as discrete unities of sound. Spoken words, speeches, songs, concertos, arias, symphonies all exist because human beings can perceive them as wholes while they are occurring. Here again is an actual physical continuity between the sound waves and the brain mechanisms.

*Colours*. An interesting example, one that has engaged the attention of philosophers and scientists alike, is that of color vision. Isaac Newton expressed the essence of the question when he wrote: "For the Rays to speak properly are not colored. In them there is nothing else than a certain Power and Disposition to stir up a Sensation of this or that Color." (Newton 1704), although the dualism inherent in much 18th century thought is evident in the "stirring up of the sensation". What we know as color is the result of the processing done by the brain, based on a system with a site in the V4 complex (Zeki and Bartels 1998) whose precise implementation is not yet fully understood. Damage to the V4 complex renders a human unable to see the world in color. The neural color processing may be summarized as follows: it is a comparison between the wavelength composition of the light reflected from one part (surface or object) and from the surrounding parts. The comparison is performed by the brain and has two components: the physical one consisting of what surfaces reflect in terms of wavelength composition, and the brain one – the one which affects the comparison. Note that the comparisons are of a very particular kind – a comparison between what one surface and its surrounding surfaces reflect in terms of the energy-wavelength composition of the light. There is no physical rule that dictates that such a comparison should be made – it is only the brain that dictates that this should be so. The perceived color is a unity achieved between the two when there is a physical continuity in terms of the light reflected from the surfaces and the V4 area in the brain.

*Keys and locks*. A lock is a lock only if a suitable key exists. Likewise, a key is a key only if there is a lock that can be opened by it. In reality, the lock and the key are such only when they are actually engaged in the proper kind of relation: when the lock is being locked or unlocked. Let us suppose to have an irregular piece of metal in our pocket. Eventually, a crazy blacksmith molds a special lock which can be opened only by that piece of metal. Instantaneously the causal powers of that piece of metal in our pocket changed and not because of some change in its physical structure but because of a change in the environment. Instead of one piece of metal, we could have two and the blacksmith could have molded a lock that could be opened by the joint use of both pieces. Instantaneously the two separate objects would have gained the status of being a key and only because of a change in the environment. Similarly the drops of water floating in the air inside the colored arch of the rainbow, which were separate and independent one from the other, gained some kind of unity thanks to the existence of a physical system many meters below – made of a retina, optical nerves, and cortical areas – that allowed the projected rays of light to become the joint cause of the recognition of the rainbow.

In summary, all these examples show that the shift from a pure abstraction to an actual entity is based on the occurrence of processes between physical systems. The simple application of the aforementioned principle at the beginning of this paragraph leads to an unavoidable conclusion

that something in order to exist has to interact with something else. Interacting with different systems would lead to the existence of different causes.
All the presented examples – except the last one – required a perceptual system to which we do not assign any special property apart from being able to let a given process to take place as the result of a given cause as a whole. We never resorted to any kind of mental or phenomenal or secondary aspect of the perceptual process.
Furthermore these examples suggest that, from a processual point of view, there is no separation between the object of perception and the perceptual process: the two being different ways of describing the same course of events.

## 4. Consciousness and existence, as a process: the *onphene*

Let us recap the meaning of the previous examples and the core of the proposal. The traditional standpoint conceives reality as made of relatively autonomous objects or relatively autonomous events. This entails that the subject and the object, being both instantiated by autonomous set of objects or events, are irremediably separate in time and in space. Therefore the problem of representation, the problem of mental causation and the problem of the ontology of mental events (secondary properties) arise. On the other hand, we – as human beings – do perceive the world not as an image of the world but as the world itself. Realism basically reminds us that our mental states are about the world. Externalism tries to get out of the boundary of the brain. Finally, a process ontology could be the tool to sustain both views and to overcome the subject/object conundrum. The rainbow and the other examples try to convey this insight: the world is not made of relatively autonomous events; the world is made of intrinsically related processes. Therefore, the subject and the object are not separate and there is no problem of re-presentation, since the experience and the occurrence of the world are identical.
In all previous examples the cause does not exist isolated from its effect. They are both taking place as two different ways of describing a process which cannot be split. Whenever the examples regarded perceptual events (like the perception of a rainbow or a face), the perceived object does not exist in isolation from its perception.
According to Galileo's view the world is made of primary properties (expressed by numeric quantities) autonomous and independent of their being in relation with other systems. Here, this view is challenged. Every property, in order to exist, needs to produce effects. In order to produce effect, it must enter in relation with the proper physical systems: no keys without locks, no rainbows without eyes, no faces without cortical areas, and no constellation without human beings.
In a slightly more formal and Leibnizian way, it is possible to argue that, from an empirical standpoint, each entity is equal to the sum of its causal powers (these being equal to the properties). For instance, the entity X is characterized by having the property A and the property B, the two being equal to say that X is capable of doing As and Bs. Nothing special, up to here. Yet, we suggest that any causal power is not entirely located on X but it is located in the process between at least two interacting systems. For instance, in the fact that X can do As only when interacting with Y and do Bs only when interacting with Z. If this were true, X (as something capable of doing As and Bs) would not be entirely located in the supposed entity but in the relation with Y and Z. By carrying this argument a little further, the conclusion is that neither X, Y nor Z exist in isolation before the process. X and Y are two ways of describing the process "X doing As with Y" which is the real unity and starting point: X, Y and A are just conventional shortcuts to address the process under different points of view.

For example X could be any of the previous objects: a rainbow, a face, a key. Y would be the effect produced by such objects in such a way that they need be the cause *as a whole* (the recognition of the rainbow as a colored arch, the recognition of the identity of a face, the joint opening of a lock). The causal property A would be the action performed to produce the effect. Z could be a different physical system. Let us consider faces. A face is capable of producing effects like being recognized as a whole only if there are human subjects not affected by prosopoagnosia. Without them, there would be no faces since the facial features of people would lack the relevant causal power required to be a face. For subjects that are born blind faces produce completely different chain of effects. By virtue of them the same facial features produce completely different effects and are thus completely different objects. Let us take another example: the Kanisza's triangle. With a standard subject, it has the property of producing an effect as a joint set of figures carving out a triangle. With a videogames addicted teen-ager, Kanisza's figure has the property of producing three separate effects as three different shapes: the triangle as a whole is not there.

The same rationale can be used in more fundamental domain than those of macroscopic perceptual processes. For instance, does an electron have a charge autonomously? We cannot be sure, since the only way to know if an electron has a charge is to make it interact with another charged particle. It could be that, when left alone, the electron has no charge. It could be that only couples or groups of particles have a charge. From an empirical standpoint there is no way to test if an isolated particle has a charge. The same rationale holds for all hard physics primary properties: mass, charge, spin, et caetera. There is no way to consider them in isolation. It is meaningless to talk about them independently of an experiment when they are measured. An experiment is always a physical process from which we *infer* the existence of autonomous entities. However we never see them. We infer them because we trust the Galilean intuition of the existence of a domain of autonomous primary properties. However, it has never been demonstrated empirically. What has been demonstrated is the taking place of physical processes which is a slightly different thing.

We draw a few conclusions.

*Secondary properties and primary properties are not different*. They are two different ways of describing the same processes. Furthermore, the existence of objects is identical with these processes. Objects do not exist autonomously. Objects are a way to provide a timeless description of a recurrent physical process. Since *we suppose* that a key must have a lock somewhere, we label that piece of iron as a key. Since *we cannot but interact visually with the world*, we label the incomplete side of the physical processes – we are continuously constituted by – as faces, rainbows, constellations, and similar.

Therefore existence is a process. Similarly, having an experience of something can be seen as the occurrence of that something as a whole. There is no need to add a phenomenal rainbow and a physical one. Why should we add something to the process carving a rainbow out of the general flow of events? Consciousness (which is the same as representing), existence and being in relation are inseparable: the three being three different ways of describing the same process taking place.

Subjects and the surrounding environment are made of processes: some of them shared by both. The body and the brain are made in such a way that, given the same external systems, the same processes take place. Subjects cannot perceive the world without their brain and their body. This means that subjects are always carrying around their private set of locks in response to which they allow many external combinations of events to act as the keys. Being always

with the same set of locks, subjects concentrate on the keys and, eventually, they end up believing that those keys do exist autonomously. This is not the case.
We propose to call this process – which is constitutive of what there is and what we perceive – an *onphene*, derived from the Greek words *ontos* (what there is) and *phenomenon* (what appears to be) (Manzotti and Tagliasco 2001; Manzotti 2003). It refers to a reciprocal causation in which the traditional distinction between cause and effect, perceiver and perceived, measured and measurer is missing, and is the foundation for viewing reality as a whole. Figure 6 can be seen also as a visual metaphor of the onphene.

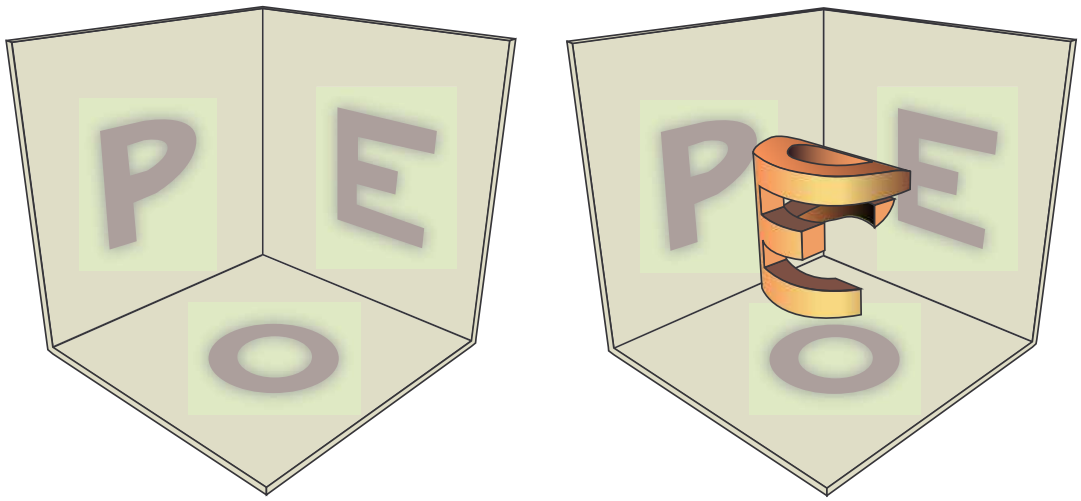



Figure 6 Three different planes: until we consider them separately, there is no connection between the different shadows. However, once we proceed to a higher dimensionality, there is something which can be projected as each of them.

## 5. The enlarged mind

The traditional problems of consciousness are going to vanish once the onphene perspective is adopted. The world in which each subject is living is no longer a private bubble of phenomenal experiences concocted by the brain. Each subject is living in and experiencing the real world: the two being different descriptions of the same process. Each subject lives in that part of the world made by those processes with which s/he is identical with. The subject is those processes. In our own experience, consciousness, existence and becoming cannot be split. As agents, we are part of a physical flow of processes which are possible thanks to our physical structure. These processes have the right properties of our own experiences as well as the right properties of the external world. The need for postulating a noumenal world of primary properties (and their bearer, the object) and a symmetrical world of secondary properties (and their bearer, the subject) arose from the undemonstrated Galilean hypothesis of an a-temporal domain of autonomous entities. By using a processual view such need vanishes.
Adopting a processual point of view a different framework begins to unveil. Consciousness and existence can be explained as two perspectives on the same processes.
The world of the subject's experience is identical with the real world. It is then possible to discard many classical conundrums. In particular it is possible to discard the television view of the mind (see (Dretske 1995)). This is not a complete novelty. Other authors criticized in a similar view the idea that what we have an experience of is an image internally generated of

the external view. For instance James Gibson wrote that (Gibson 1952): "The visual field, I think, is simply the pictorial mode of visual perception, and it depends in the last analysis not on conditions of stimulation but on conditions of attitude. The visual field is the product of the chronic habit of the civilized men of seeing the world as a picture … So far from being the basis, it is a kind of alternative to ordinary perception." In a strikingly similar way, the art historian Jonathan Crary wrote that "The idea of subjective vision – the notion that our perceptual and sensory experience depends less on the nature of an external stimulus than on the composition and functioning of our sensory apparatus – was one of the conditions for a severing of perceptual experience from a necessary relation to an exterior world." (Crary 1992), p.12. Of course, this historical process of reshaping the observer had its theoretical origin with the aforementioned work by Galileo.

With respect to direct perception this approach has the advantage of solving all of the three classical problems outlined in the previous paragraphs: the hard problem, epiphenomenalism and the problem of representation. Let us briefly see how.

The hard problem is solved since there is a candidate for the nature of phenomenal experience: the physical processes engaged between the brain and the external environment. There is no more dualism. The price to pay is to discard the assumption of the separation between the subject and the object as well as the autonomy of the existence of objects. Onphenes are neither objective nor subjective. They are private and public at the same time.

Epiphenomenalism is solved since phenomenal states are no longer separate from the physical world. Every phenomenal state is identical with a physical process that, as all physical processes, has causal powers and exerts its effects on the environment.

The problem of representation is solved since there is no more need to re-produce an internal image of the external world. Phenomenal experiences are identical – they coincide – with the aspects of reality they should represent. More precisely, they do not represent reality: they are the reality. The subject does not perceive *an image* of an object: a process takes place which is constitutive both of subject and objects; a process which can be described or as a subjective experience or as an objective event.

We introduce here the concept of the enlarged mind. If every phenomenal experience is identical with a process (an onphene), the sphere of an individual consciousness is identical with a collection of onphenes. If a subject is conscious of a rainbow plus a face plus some speech to which s/he is listening to, it means that at least three separate processes are taking place. In reality there are almost countless processes going on in an environment. However, only a subset of them becomes entangled in that flow, which is the conscious experience of a given subject. The mental life of a subject is no longer constrained inside the cranium, compelled to the creation of a theatrical replica of the external world: the mental life is literally enlarged to the processes constituting everything that mind is conscious of. There is not a mental life and a physical life: there is only a life.

The mind is identical with everything the subject is conscious of; everything being a process and not an a-temporal static object. Furthermore, the existence of what the mind is conscious of is possible because of the occurrence of those processes that are identical with the mind itself. This is only apparently paradoxical. For instance, the fact that the subject is conscious of the rainbow as an arch of colors does not entail that the subject is responsible for the existence of the sun and the drops of water. Yet, without the subject's brain, the drops of water would have remained each by its own. No rainbow as a whole would have occurred. Their unity, as a

colored arch, is the result of the process occurring. The rainbow, as a unity, does exist thanks to the same process which is identical with the observer.
We consider the physical process that begins in the external world and ends in the brain as a unity since it provides a unique framework for the description of physical reality and mental reality. If the hypothesis proves to be correct, it is no longer necessary to look for a neural implementation of conscious activity. A conscious mind is the set of processes that have as causes the object of experience and as effect the recognizable events of the cognitive activity. Such causal processes named onphenes (achievable thanks to the brain structure, to the agent body and to the surrounding environment) constitute the external objects and the internal content of the mind, the two being different ways of describing the same thing. The rainbow is an excellent example of an onphene, in which observation, the observer and the observed entity cannot be split. All occur jointly. They are the same occurrence so this is coherent with the fact that they must constitute a unity. But the example of the rainbow, though a very compelling one, is not unique in leading to this conclusion. We propose that most perceived objects (if not all) exist insofar as they take place. The relevance of this argument lies in the fact that the brain is not self-sufficient with respect to mental events. We envisage the brain as the end part of a larger network of physical processes.

## 6. The variable causal geometry of consciousness: memory, dreams, illusions, imagination

Up to here, we have focused attention on the case of direct perception. What should we make of memory, dreams, hallucinations, and mental imagery? The hypothesis of the onphene states that in a given instant the content of a particular conscious mind is the collection of all those physical events (in the external world) that, thanks to the brain of a particular subject, actually produce effects. The conscious mind is the collection of physical processes going from the physical events to the brain neural areas. The brain is not a special place in the sense of having emergent or mental properties. The brain is like the valley in which the stream – of the processes we are – is flowing through. It is a collection of processes that spans considerable time and space (Figure 7, Figure 9). It is well known that conscious experience is not confined to direct perception. Other possibilities include illusions, memory, mental imagery, and the perception of fixed entities usually referred to as object constancy. If the hypothesis of the onphene is sound, a direct continuity with an external object has to be proven in all of these instances. We propose to redefine the above mental activities as instances of perception with a variable causal geometry while maintaining the continuity between the external events and the brain.

*Direct perception*. It is the kind of perception we have examined so far. Since the mind is extended to include, physically, that part of the world of which it is conscious, there is no need to posit a mental representation separate from what is represented. When something is perceived, there is a physical process partly in the brain and partly in the external world. That process (named onphene because of its role in forming a mind and what the mind perceives of the world) defines (and unifies) a part of reality and a part of the mind. Mind and reality are not separated phenomena. They are the same process. It is important to emphasize the fact that direct perception is not direct at all, being mediated by countless intermediate physical medium and events. Direct perception spans considerable time and space.

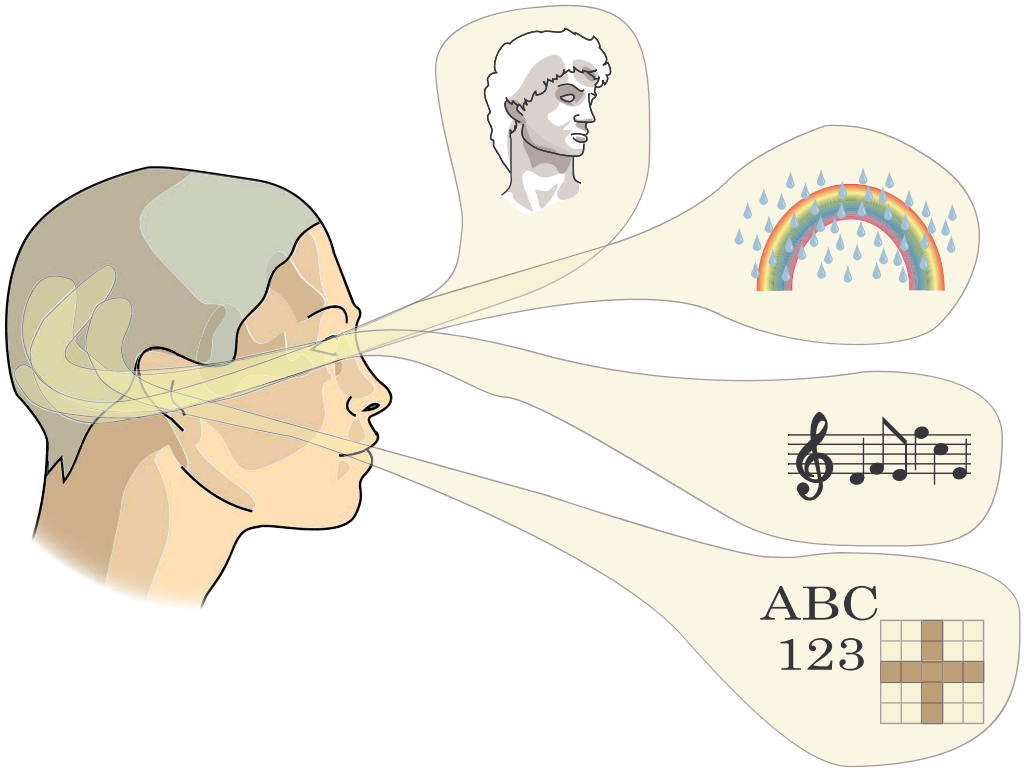



Figure 7 The conscious mind is a process that extends to include external reality which the subject is conscious of. In other words, there are no "external objects" and "internal phenomenal representations": there are just processes originating in the external world. Yet they take place thanks to the existence of a particular brain.

*Object constancy*. Objects maintain their identity when viewed from different angles or distances. Under the dualistic framework (or a derived physicalistic one), it is often assumed that what is perceived as an object has an external autonomous existence (Strawson 1959; Proust 1999). However, other authors have stressed the relation between the existence of objects and their interaction with agents or simply their capability of producing effects (Quine 1960; Davidson 1980). The role of perception becomes that of recovering the assumed pre-existing physical common distal cause (the object) from a multiplicity of proximal phenomenal events. In the present approach, it is the other way round. We apply the usual criterion by which something exists, if it produces effects. *The subject assumes the existence of a common cause because a multiplicity of different proximal percepts produces the same effect (in the same part of the brain)*. We can be misled. We assume the identity of people and things since we have limited conceptual resources. There are several reasons why different phenomenal experiences produce the same effect. The most common one is that different views of the same object produce the same kinds of result. For instance a face, although it can be seen from many different perspectives, will always produce the same effect in the brain. Put more simply, from whatever angle an object is viewed, it will have a physical outcome in a specific part of the brain and would produce the same motor response. A bridge can be crossed independently of how we perceive it and a chair can be used to sit upon independently of how it is perceived. There is no independent criterion to determine the existence of a common cause for a series of

percepts apart from their sharing the same effect. The brain accepts the existence of a common effect as a proof of the existence of a common cause.

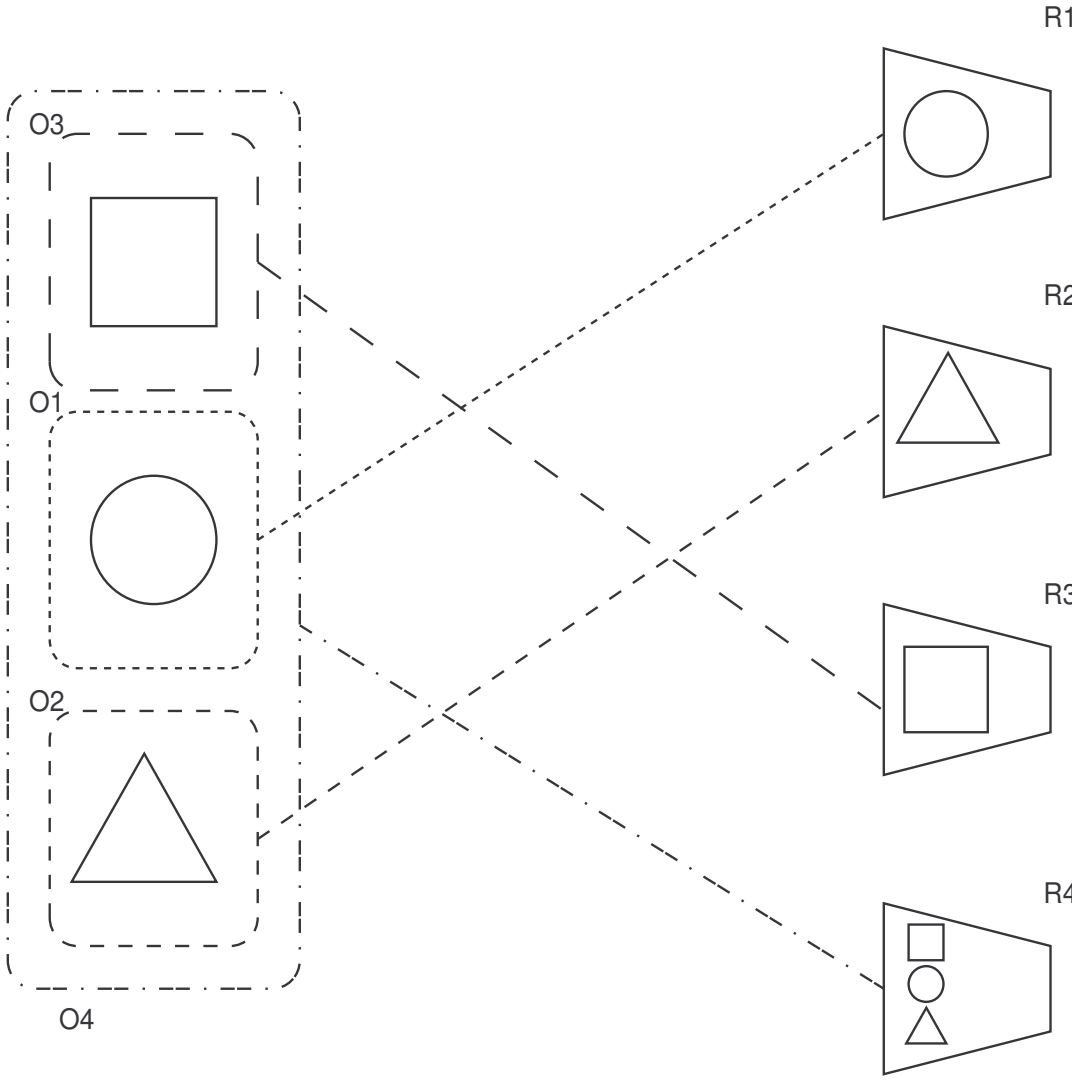



Figure 8 The existence of objects depends on the existence of structures that let them produce effects. The true existence of objects lies in their taking place.

Once again, it is the effect that is responsible for the existence of the cause. Those events, which produce a common effect, are assumed to belong to a common cause, and indeed there are good reasons for this assumption. Previous theories have sought for object constancy, as well as other constancies, in terms of neural activity alone. But according to the argument presented here, the process by which object constancy is achieved is much less one sided than commonly assumed. As we mentioned earlier, the causal properties of objects depends on what they interact with. Many objects and many of their properties take place thanks to the structure of the brain and of the body of subjects.

*Memory, dreams and mental imagery*. There are many situations when apparently the external object is missing. In memory, in dreams, and in mental imagery the brain seems capable of

producing phenomenal experiences without an external object. This is not entirely true. In fact there are strong limits to this, which speak in favor of the thesis presented here. First, no absolutely new phenomenal experience is generated by the brain. Born blind subjects do not dream colors; neither are they able to image them by sheer will. Normal sighted subjects cannot access new sensory modalities (ultrasounds, microwaves, ultraviolet) by an act of imagination or during a dream. Direct acquaintance with the external world is a necessary condition for the experience of something and the subsequent reuse of that particular phenomenal content. This is sufficient for the hypothesis presented here. It means that whenever we remember or dream or imagine something, a causal chain to the external world is concluding. We propose to interpret memory, dreams and mental imagery as perception delayed in time.

Let us consider the case of memory. When a subject remembers the schoolyard of twenty years ago, what takes place is an effect of the event that took place twenty years before: a process that began twenty years ago is still on going as empirically shown by the fact the it is still producing effects. Conceptually, memory is not different from direct perception, except that one must posit additional or different cerebral processes. Such processes, which span considerable time, began in physical continuity with external objects; they span space and time. In memory the time span is much larger than in direct perception. Thus memory is a delayed perception. Yet, in the past, it had a physical continuity with the external world. For instance, something happens. It produces effects in the brain modifying the structure of the brain. Many years later, these modifications will continue to produce effects related to the original cause. In other words, it is not the subject that recalls something. It is what is recalled that, after some time, still produces effects through the brain of subjects (Figure 9b). Instead of assuming a pre-existing and separate subject that recovers something from the past, it is the process of remembering that constitutes the subject. Whenever past events produce an effect, the corresponding process is part of the conscious mind.

Let us consider the case of dreams. Dreams are delayed and asynchronous perception incoherent both in time and space. In dreams, past events, that could have taken place in different times and locations, produce a joint (unified) effect. But dreams are also subject to rigid rules. For example, it is impossible to dream of ultraviolet or infrared light. Equally, with the exception of some interesting pathological states that themselves follow rigid brain rules, it is most unusual for a person to dream of a “face” with the eyes in a different position than usual, the nose outside and the eyelashes indifferently placed with respect to the eyes. In other words, what occurs in dreams is strictly related to past perceptions, although new combinations may arise. One may dream of a beautiful woman in Rome, even if one has never been with that woman in Rome. The difference with reliable memory is that the original coherency between separate events is lost. In fact dreams do not create new phenomenal experiences (for instance, we cannot have a dream of a new color that does not belong to the physical spectrum normally perceived). Dreams are a reorganization of past experiences. They are the result of an actual physical continuity between the brain and the external world, into new combinations. Also dreams are to be interpreted as instances of delayed perception where the physical continuity is with a scattered collection of past external events (Figure 9b). This is not, however, an explanation of why we dream of a certain configuration of events, an explanation which is much more properly addressed by psychologists. This is an explanation of why the activity in a brain disconnected from the external environment is accompanied by a conscious experience of apparently missing physical events.

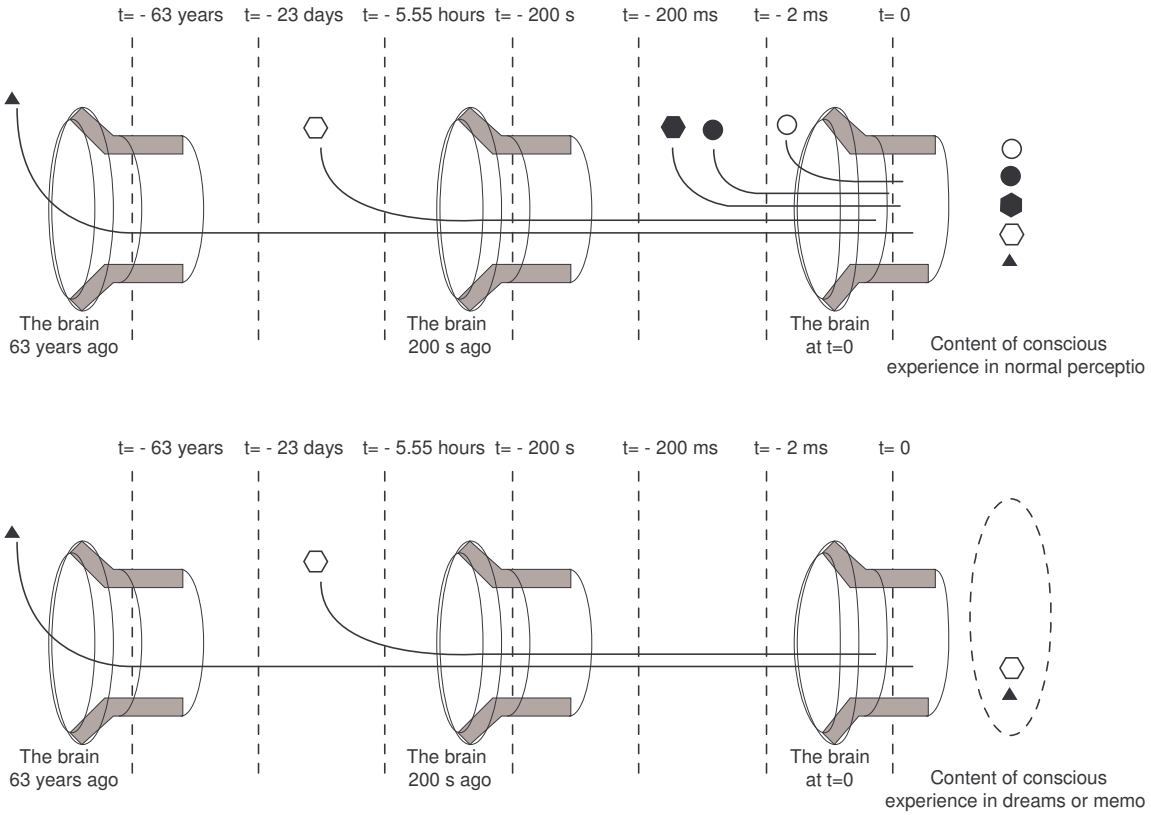



Figure 9 a) Top. Direct perception in time. The brain in three different instants in time. The present content of perception is defined by all those past events that had a relation of circular causation with the brain. b) Bottom. Memory, dreams and mental imagery. Past events still exert their effects on present.

*Non veridical perception (illusions)*. Whenever we perceive something, which is not real (like a Kanisza's triangle, or similar optical illusions), is the continuity still possible? Apparently there is no external object with which to be continuous (the triangle is not there). However, in illusions it is assumed that the perception should be different from what it really is. But why should this be so? Is this assumption really necessary? Illusion is a misnomer. A different interpretation is the following: all physical phenomena, which are perceived as equal, *are* equal. For instance, a Kanisza's triangle and a "complete" triangle share the same property (namely to have three angles with potentially converging lines). They also share a common neural property, in the sense that the cells that are capable of responding to real lines of specific orientation will also respond to virtual lines of the same orientation, even if somewhat less vigorously (Peterhans and von der Heydt 1991). They belong to the same class of entities, both physically and neurally, although they can be classified using different criteria. Since virtual lines produce equal neural effects and therefore are perceived as equal, they are part of the same kind of physical process. Another example is that of the peripheral/drift illusion where motion is perceived from a static pattern (Fraser and Wilcox 1979; Faubert and Herbert 1999). The assumption is that we should not perceive motion since nothing is moving. However, the assumption is pointless. A more satisfying explanation is that moving patterns *and* the peripheral/drift pattern belong to the same kind of physical phenomena, the

phenomenon that is labelled as "perceived motion". This can indeed be shown directly in examples such as the Isia Leviant's Enigma (1984) which can produce a strong perception of fast motion for some viewers. Brain mapping studies showed that the cortical area engaged during this activity is area V5, specialized for motion, which is also active when subjects perceive ordinary motion. The point is that both stimuli produce the same effect, on the same cortical area, and hence the stimulus, even if it is static, is perceived as being in motion by the brain. Since in normal situations this kind of perceived phenomenon is correlated with physical movement, it is assumed that it must always be so. This is not the case. So we propose to see illusions as instances of infrequent correlations among physical events. Slightly more formally, we propose to see illusions as situations where an event C – normally perceived in conjunction with some other event A – is exceptionally perceived in conjunction with some other event B. Using Kanisza's example, the event C is the "perceived triangle", the event A is the "geometrical triangle" and the event B is the Kanisza figure. Since C and A usually occur together, it is assumed that the perception of A is equal to the perception of C. This is not the case. When C occurs together with B, an illusion is supposed to explain the different relation among events: it is supposed that A is perceived instead of B. However it is not the case. What is perceived is, as in normal situations, C. The hypothesis of illusions is unnecessary and the continuity with the external physical world is maintained.

*Phosphenes*. Light is not the only stimulus that can cause a visual response. Try looking off to the side and gently pushing and moving your finger on your eye through your eyelids on the other side. You may notice a spot moving on the opposite side of the visual field from where you are pushing. Here, the pressure on your eye is causing a visual response. A visual response caused by stimuli other that the normal entry of light into the pupil is called a phosphene. If you bump your head, you may see stars; these are phosphenes. You can stimulate V1 with an electrode and see light stimuli; these are phosphenes. People with migraine sometimes see patterns of light; these too are phosphenes. The idea of visual phosphenes is related to an idea in neurophysiology called the Law of Specific Nerve Energies. The idea is that no matter how you stimulate a particular receptor or nerve, the signal it sends depends on where the message goes to in the brain. The rather naïve idea that nerves provide a specific phenomenal quality to signal has been eventually rejected. Afterwards other entities have been proposed as causes of content such as brain areas, states of internal workspaces, specific kinds of coding, sensory-motor mappings (for a review (O' Regan and Noe 2001)). A different explanation is the following. What takes place in the brain as a result of the stimulation of a visual area by a non visual stimulus (pressure on the eyeball, electricity, bumping) is also related with a very long past history of visual stimuli. As a result it maintains a causal continuity with them. On the other hand we could ask a different question. What would be the phenomenal perceived content if the eyes were disconnected from visual stimuli from the very beginning? If the eyes could not access light but were just subjected to pressures, according to the hypothesis of the existence of some structure (nerve, inner workspace, brain area), the perceived phenomenal content should be a visual phosphene. On the other hand, according to the hypothesis of the continuity with the external world, the phenomenal content should be of tactile nature: the eyes should work as poor tactile receptors. Furthermore, if they were eventually exposed to light, by some technical or surgical means, they should elicit "tactile" phosphenes. Interestingly, although the literature is rather poor on cases like them (for a review see (Senden 1932; Gregory and Wallace 1963), there is the famous case reported by William Cheselden of a born

blind patient that, after an operation that partially restored his sight, reported the first visual experiences as having a tactile phenomenal quality: "When he first saw […] that he thought all Objects whatever touch'd his Eyes, (as he express'd it) as what he felt, did his Skin". Of course, more empirical data is necessary to draw a final conclusion.
In all these different situations, a different geometry in the causal relation between the brain and the external world has been used as an explanation for the corresponding conscious experience. Memory, dreams, illusions, object constancy have all been interpreted as cases of perception, though with different kinds of causal relation with the environment. Rather than proposing internal mechanisms capable of creating or recreating internal representations of the external world, we propose to look for direct physical processes (onphenes) linking the internal activity with the physical world. The two, thus linked, constitute the percept.

## 7. Externalism, radical empiricism, neo-realism and process ontology

As we mentioned in the introduction, the view presented here is related with other approaches. We do not pretend to be exhaustive in this section. We will only mention those approaches that seem more closely related with the enlarged mind: externalism, neo-realism, radical empiricism and process ontology.

Externalism is the view "that not all mental things are exclusively located inside the head [or mind] of the persona or creature that has these things" (Rowlands 2003), p. 2. According to Mark Rowlands there are two variants of externalism: content externalism and vehicle externalism. The former corresponds to the "idea that the semantic content of mental states that have it is often dependent on factors […] that are external to the subject of that content" (Rowlands 2003), p. 5. The latter is more radical and suggests that "the structures and mechanisms that allow a creature to possess or undergo various mental states and processes are often structure and mechanisms that extend beyond the skin of that creature" (Rowlands 2003), p.6 The kind of externalism advocated here belongs surely to the variant of vehicle externalism, the onphene being the proposed vehicle. In the recent past, different authors proposed various version of vehicle externalism (Dretske 1995; Chalmers and Clark 1999; Lycan 2001; O' Regan and Noe 2001). The main difference between these approaches and the enlarged mind is the fact that they accept an ontology of the world made of separate and autonomous entities. On the contrary, the enlarged mind criticizes the Galilean notion of autonomous existence of primary properties. For instance, the form of externalism advocated by Kevin O' Regan and Alva Nöe (O' Regan and Noe 2001) evolves towards a kind of functionalism since it does not criticize the fundamental ontology based on autonomous individuals (Manzotti and Sandini 2001). Functionalism has always been compatible with various versions of content externalism and vehicle externalism. If a mental state is defined by its functional role, which includes the relations that the state bears to inputs, outputs and other mental states, it is possible to include the external environment in order to accommodate externalism and functionalism. However in its typical formulation functionalism is based on the traditional ontology. As a result it is compelled to define mental state as relations between phenomenally void events. The troubles of functionalism in explaining the phenomenal side of the mind are very well known. The enlarged mind is different since it suggests a different fundamental ontology.
A related concept has been developed by the Austrian biologist von Uexküll, who called Umwelt that part of the environment which is causally connected with an animal. Each animal

lives, according to this biologist, in what he defined its Umwelt. Von Uexküll's idea derived from his work in the field of zoology where it is possible to observe that, given the same environment, two different specimens of two different species occupy the same physical space but have a completely different experience of the same physical world (Uexküll 1934; Clark 1997). The same rationale can be applied to artificial agents (Emmeche 2001). The main difference between the Umwelt and the Enlarged Mind is twofold: 1) the Umwelt entailed no ontological revision; 2) the Umwelt was mostly an ethological concept. In short, the Umwelt refers to the whole collection of events with which an agent is able to interact. On the contrary, the enlarged mind is a highly dynamical entity being identical with a flow of processes that defines, at every instant, the part of reality which is identical with the subject's flow of consciousness. Apart from these two differences, the two concepts are compatible and we could see the Umwelt as a kind of summary of every occurrence of the Enlarged mind in an agent's life.
Inside the various version of externalism, a very closely related concept to that of the onphene is that of James J. Gibson's affordance. Although the concept of affordance is not completely unambiguous (Jones 2003), Gibson defined an affordance of something as "a specific combination of the properties of its substance and its surfaces taken with reference to an animal" (Gibson 1977), p.77. As in the case of the onphene, the affordance is neither entirely located in the object nor in the subject. Furthermore, an affordance depends on both terms it relates: on one side "the properties of its substance and surfaces" and on the other side "an animal", which is the observer. Gibson wrote that "[…] an affordance is neither an objective property nor a subjective property; or it is both if you like. An affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy. It is both a fact of the environment and a fact of behaviour. It is both physical and psychical, yet neither. An affordance points both ways, to the environment and to the observer" (Gibson 1979), p. 129. The onphene is very similar to an affordance in the sense that both bypass the subject/object distinction.

A similar challenge to the subjective/objective dichotomy has been developed by William James under the name of radical empiricism (James 1907/1995; James 1908/1996; James 1912). James developed the idea that there is no substantial difference between the subjective events of mental life and physical events. They are both constitutive of the more general domain of reality itself. Grouping these events in one way leads to a mental world. Grouping them in a different way leads to a physical world. The flow of events is termed by James *pure experience* in the sense that is neither subjective nor objective (James 1905). James' thesis "is that if we start with the supposition that there is only one primal stuff or material in the world, a stuff of which everything is composed, and if we call that stuff 'pure experience', then knowing can easily be explained as a particular sort of relation towards one another into which portions of pure experience may enter." (James 1905). James does not develop a new kind of idealism. He is trying to avoid falling in the trap set by Galileo and Descartes. The duality between the world of subjective experience and that of objective fact is not inherent to the structure of reality: it is a hypothesis that has a limited practical usefulness. If the hypothesis should prove to be unsuited to explain reality, so much the worse for it.
Significantly, James wrote that: "Experience, I believe, has no such inner duplicity; and the separation of it into consciousness and content comes, not by way of subtraction, but by way of addition" (James 1904). Such an addition is precisely the hypothesis Galileo first suggested.

As soon as the subject/object duality collapses a second hypothesis is immediately challenged: the hypothesis according to which the unity (or wholeness) of object is inherent to them. Radical empiricism is due to criticize such a hypothesis. Hence James noted that the unity of objects is the result of the interaction with subjects. For instance he wrote that "we see on reflection that in the *physical* world there is no real compounding. 'Wholes' are not realities there, parts only are realities. 'Bird' is only our *name* for the physical fact of a certain grouping of organs, just as 'Charles's Wain' is our name for a certain grouping of stars. The 'whole', be it bird or constellation, is nothing but our vision, nothing but an effect on our sensorium when a lot of things act on it together. […] In the physical world taken by itself there *is* thus no 'all', there are only the 'eaches'" (James 1908/1996) and also that "'things', what are they? Is a constellation properly a thing? or an army? or is an *ens rationis* such as space or justice a thing?" (James 1907/1995) p.70 or "We carve out groups of stars in the heavens, and call them constellations, and the stars patiently suffer us to do so – tho if they knew what we were doing, some of them might feel much surprised at the partners we had given them." (James 1907/1995), p.97. If the fundamental stuff of the world is a flow of pure experience, the absence of an autonomous criterion of existence for object is no longer problematic since it is the way in which such a flow flows that makes them.

The third approach which is important to mention is Neo-Realism and the concept of Cross Section developed by Neorealists like E. Holt (Holt 1914). The notion of Cross Section has a strong similarity with that of Enlarged Mind. According to Holt, "Consciousness is extended in both space and time:- in space as actual objects are extended, consciousness being actually such part of the objects as are perceived; i.e. such parts as are consciousness; and in time as a quarter hour, a day, or a week, is extended." p. 210-211 (Holt 1914).
Recently the same concept has been further developed by Francois Tonneau. About the nature of conscious experience he wrote that "The neorealists believed that a person's conscious experience at any instant was the part of the environment acting on this person at this instant and nothing else. We shall see that in order to provide a plausible account of consciousness, this part, or cross-section, of the environment must be conceptualized in a rather abstract and complicated way; in any event, according to Neorealists (e.g., Holt, 1914) consciousness is identical with not the entire environment but only with a part of it." (Tonneau 2004) This part of the environment with which consciousness is identical is defined as a Cross Section. According to Tonneau, "[Given] a reference system and a relation R in which this system and parts of its surroundings could participate. A cross-section is a function of the system state that takes its values in the environment of the reference system. The value of this function at any moment is called the content of the cross-section and consists in the part of the environment that fulfills R." (Tonneau 2004) In other words a subject is conscious of a subset of the environment which is the Cross Section carved out by the function R.
Although Tonneau is a strong Neorealist, since he would assume that the existence of the external world is independent of the function R and the way in which the Cross Section cuts out a part of reality, there is no real incompatibility between his kind of Neorealism and the onphene. The onphene could embody the function R on which the notion of Cross Section is based. The Cross Section would then be equivalent to the Enlarged Mind with the onphene playing the role of the function R.
A related work is that of Ted Honderich about Consciousness as Existence. He rejected all forms of internalism or cranialism, which take the mind as an internal product of the activity of

the brain alone, as being absurd. He developed an alternative view according to which "what it actually is for you to be aware of the room you are in. It is for the room a way to exist." (Honderich 2004). According to him, perceptual consciousness is a way for the world to exist. Therefore, consciousness is literally out of the cranium as in the proposal presented here: "Phenomenologically, what it is for you to be perceptually conscious is for a world somehow to exist" and "Perceptual consciousness itself is literally to be understood as things existing in a way spatio-temporally" (Honderich 2004). As a result, he is lead to identify consciousness with existence the two being different perspectives on the same state of affairs. This is strikingly similar to the onphene. In the onphene too, existence and phenomenal experience are two different ways of looking at the same thing. Furthermore, we got to the same conclusion, that "perceptual consciousness, like consciousness generally, is something to which the distinction between appearance and reality, and thus talk of phenomenology, does not apply" (Honderich 2000).

Then, why should we bother with the onphene? The onphene is a process, not a state of affairs. The onphene is something that takes place, not something that exists. We would like to change Honderich's slogan, which is *consciousness as existence*, with *consciousness as a process* or more precisely with *consciousness and existence, as a process: the onphene*. The onphene aims at capturing the essence of how reality takes place; consciousness and existence are two ways to describe the same flow of events.

Furthermore, the onphene could be helpful also because it could cast some light on the relation between the worlds of the perceptual consciousness of each individual and the world without individuals. Honderich wrote that "the rough idea […] is that a claim as to a person's being perceptually conscious needs to be regarded as no more than a kind of claim as to the existence of things, not exactly standard physical things" (Honderich 2000). If we take "standard physical things" to be the equivalent of static objects, the onphenes are good candidates for the make-up of perceptual consciousness. The biggest difference, which is not an incompatibility, is the emphasis on the processual nature of the world in which each individual lives.

As Honderich wrote "The realist theory necessarily involves not only the physical world but the unclear relation to it." (Honderich 2004). The onphene is the relation, but it is also the physical world and, of course, it is also the experience of it. This manuscipt suggests that the "unclear relation" looked for by the realists is identical with the way in which reality takes place, this being the same as having an experience of it. This is also a good place to make a statement about the baffling relation of intentionality as defined by Franz Brentano (Brentano 1874/1973). If the onphene makes sense, then intentionality as a relation separate from what is being related would disappear. On the other hand intentionality would correspond precisely to the onphene. In some sense we could say that the onphene is pure intentionality and that by embracing the onphene standpoint instead of naturalizing intentionality, we propose of intentionalizing nature (Manzotti 2000).

The onphene should pass all of the five criteria expressed by Honderich (Honderich 2004; Honderich 2004) (which can be traced back to the three problems previously mentioned). In particular we would like to deal here with the criterion about subjectivity. In Honderich's words: "Another criterion, the main one in some sense, is that a good conception has to recognize and give real and unique sense to our conviction of the subjectivity of consciousness. Subjectivity has to be made sense of, not denied, reduced or replaced."(Honderich 2004). The onphene is always a process and, as every process, it corresponds to a unique and specific point of view. In this sense, the onphene plays the role of subjectivity. Let us go back to the example

of the rainbow. There are no two identical rainbows. For each observer, a different rainbow is selected out of the cloud. Two persons side by side would be watching at two different rainbows. The sets of selected drops would be slightly different for each of them. This is extremely coherent with consciousness as "the world seen my way" (Honderich 2000). However the subjectivity of the onphene – as well as its *perspectivalness* (Metzinger 2003) – is not the result of some kind of mental paint, but simply the way in which things take place. However the onphene, as any physical process, notwithstanding its kind of subjectivity continues to participate to the chain of causal events of which it is an active constituent. The onphene allows us to have phenomenal adequacy together with phenomenal causal efficacy.

The fourth standpoint is process or event based ontology. We refer here to the ontological view by Alfred N. Whitehead (Whitehead 1929/1978; Griffin 1998). According to him, current scientific world view is biased by what he called the fallacy of the misplaced concreteness – that is, mistaking the abstract for the concrete. On the basis of this insight, he developed an alternative ontology based on actual occasions or events related by a process called "prehension". According to Whitehead, reality is composed of actual occasions or events that evolve from one to the other by means of a process called prehension. Every prehension transforms one or more actual occasions into subsequent actual occasions. Every actual occasion has an internal dimension; it contains both a subjective aspect and an objective one. From the external world towards our brain there is a progressive increase in the subjective content of every actual occasion up to what we call consciousness. This process gives rise to our experience of reality as well as to reality itself. In many respects, the enlarged mind has a strong similarity with Whitehead's view although there are a few crucial differences. For instance, in Whitehead's work every actual occasion has an internal double nature, while the onphene has no need of positing an internal structure.
A crucial element of similarity between this approach and Whitehead's approach involves the problem of internal and external relations. As Peter Farleigh succinctly stated, "if two entities *a* and *b* stand in some relation R, to one another, such that neither the identity nor the character of *a* depends in any way upon *b*, then *a* is said to be *externally* related to *b*. If *a* could not be the same entity without standing in relation R to *b*, then *a* is said to be *internally* related to *b*." (Farleigh 2004). Regarding the previous discussion about objects, it is evident that according to the Galilean view, all patterns are aggregates of parts linked only by external relations. On the other hand, the onphene plays the role of an internal relation since the two terms that can be used to describe it (the object=the rainbow as a whole and the subject=the observer) would not be what they are independently of the onphene. In this sense the onphene collapses subject, object and their relation in one process, hence its name. By saying that, in the case of the rainbow, the effect of the effect is the cause and the cause of the cause is the effect, we are stating the presence of a symmetrical internal relation between the two terms. A symmetrical internal relation which is solved by the onphene in collapsing the three terms in one process: a move that overcome Bradley's critique of relations (Mc Henry 1992), p. 74.
There is a strong connection between the kind of relations and the dichotomy between the Galilean inspired framework and the process view. Regarding this issue, Birch and Cobb wrote that "As long as the substance thinking is dominant, the relations among the parts are viewed as just as external to the parts as the relation of the machine to what is spatially outside it" (Birch and Cobb 1981), p.88. Here the substance thinking refers to a view based on the existence of entity substance-like, i.e. entities which exist autonomously and separately. This

view is exactly the one challenged here; the onphene aims at being the proper kind of internal relation or process. The aim of the onphene is that of avoiding the Scylla of subjectivism as well as the Caribdi of physicalism. Similarly, according to McHenry, "process philosophy steers a mediated course between two extremes: radical pluralism and radical monism, to formulate what Hartshorne has called, in opposition to new realism, the 'New Idealism' or 'realistic Idealism'" (Mc Henry 1992). The same kind of conceptual equilibrium point which is the target of the onphene and that is the reason why all this terms have such a love for oxymoron.

The onphene shares Whitehead's view of relations (and differently from Bradley and Russell) as essentially temporal phenomena. However, the onphene's asymmetry is different regarding the internal/external aspect. In short, *a* and *b* are externally related if the existence of the relation does not change *a* or *b*. *a* and *b* are internally related if one of the two depends on the relation in order to be what it is. *a* and *b* are related by an onphene if *both* depend on their being in relation in order to be what they are (although they depend in a different way as outlined in the previous sections, one dependences being temporal and similar to the efficient cause and the other one being a-temporal and similar to the formal cause).

The strength of Whitehead's solution to the problem of relation is due to two facts: 1) relations are temporal; 2) relations are asymmetrical. According to McHenry, for Whitehead and Hartshorne, "internal and external relations are grounded in the temporal asymmetry of process where, at each successive moment, the world moves from disjunctive diversity to conjunctive unity." (Mc Henry 1992), p. 92.

Succinctly stated, in the onphene the ontology of the past is internally related to the present. The rainbow as a whole "was there" only after the process took place. The cause took place only after the effect happened: hence the idea that "the effect of the effect is the cause" and conversely that "the cause of the cause is the effect". The onphene is a temporal relation and is a symmetric internal relation: the past depends on the present as much as the present depends on the past, the two being two descriptions of the same process. The apparent paradox that arises from the idea that the effect goes backward in time to modify the past is here avoided by considering the onphene as process that span time and space. The onphene is a unity. Therefore there is no "going backward".

On the other hand, the onphene suggests that all relations should be internal. All the external relations (like those between the different parts of a pattern) are not existent until the pattern takes place as a process (as an onphene) and thus being carried on by an internal relation. In a broad sense in the onphene framework, all external relations are nothing more than projections of internal relations. According to the onphene based standpoint the parts of a pattern have, between themselves, only external relations; however as soon they become involved in a process, they produce a joint effect. Because of this process they constitute a whole, but the whole is the process itself and therefore it spans time. In this sense the internal relation between them and their effect (which is the onphene) can be projected in a set of external relations between them.

Let us use the figure below. Let's suppose that A and B are different parts of a pattern. Let's also suppose that C is the effect of a complex process of recognition capable of detecting the existence of patterns of the (A+B) kind. The Galilean view would suppose the existence of a pattern A+B and of the relation among A and B; the relation would be an external one. According to Whitehead, C is an actual occasion that brings together A and B. A and B are independent of C, while C is internally constituted by its relation with them. The onphene

avoids considering A+B independently of the process the produces C. A+B and C are two different ways of describing the same process – the same onphene – which cannot be further split in different parts. The process, according to the onphene view, is the ultimate starting block. Everything else is just a different way of looking at it, not a real constituent of the process.


Figure 10 Comparison between the internal/external model of relation and the unity of the onphene.

## 8. Motivations and development

Motivations play the key role in the ontogenesis of conscious beings. A motivation is an internally produced criterion for the control of developments. Unfortunately, the relationship between, for example, cognitive development (but also sensorimotor coordination) and motivations has not been studied in greater detail (von Hofsten 2004). On the other hand, dealing with the motives that drive the development is fundamental for the study and implementation of autonomous agents. From our point of view, in fact, a subject can be viewed as the process resulting from the incremental aggregation of onphenes elicited by motivations. We distinguish here between fixed or hard-wired motivations and acquired or ontogenetic motivations. Fixed motivations are a priori coded and hence do not depend on the ontogenetic history of a system. By contrast, acquired or ontogenetic motivations must be the result of the interactions with the environment. In the following we will refer exclusively to the latter. *A (ontogenetic) motivation is here defined as a process whose probability of occurrence is increased* due to its own occurrence, in combination with the existence of certain embedding conditions.

To illustrate the point, let us imagine you see a face and hear that this is Sigourney Weaver. As a result you will be able to recognize her again and again. A process that has happened just once (the perception of a face *as* Sigourney Weaver's face) has produced itself as a future possibility. You are conscious of her because her face has become a part of the processes that are your ontogenetic make-up. Your mind has enlarged itself by incorporating a new process that remains intertwined into what you are. The occurrence of such processes of recognition may be a matter of chance–they happen just in case you happen to see that face. But as soon as the occurrence of your recognition of Weaver's face increases the probability (frequency) of the occurrence of such recognitions, motivation has set it. The process of recognizing Sigourney could become a target for your future action – you might buy cinema tickets to repeat the recognition.

In our interpretation, motivations and phenomenal experiences are very similar in their causal structure. However they play a different role with respect to other onphenes. The crucial difference is that motivations are processes which 'call' for their repetition. A phenomenal experience does not produce a modification in the subject's causal structure, while a motivation propagates its effects through time in the subject's history due to a stable modification in the subject's causal structure. A phenomenal experience (onphene) is an event C whose effect E is the cause of a causal relatedness of a cause of kind of C and an effect of the kind of E. Simplifying we might say, a phenomenal experience is an event Q which generates a causal relation of the kind Q instantiates. Motivations are just that with an additional element of causal structure. A motivation is an onphene which generates *future* occurrence of onphenes of this kind. More precisely, switching to the causal idiom, a motivation is an event C whose effect E is the cause of the causal relatedness of a cause of kind of C and an effect of the kind of E, *and of future occurrences of a causal relatedness of this kind.*

To have a motivation for getting something means to be in relation with an event: the target event (what we want to achieve) becomes the cause of all or most of our action. How we act is not caused by a 'final cause' but by our past, i.e., by the processes which entered a past processual constitution of the subject that we are. However, once the specter of final causation is properly replaced, it is admissible to speak of a system's goals. For instance, assume that the system has been exposed to the presence of Susan, and as a result the system aims at having Susan in its field of view. The system will behave with the goal of repeating as much as possible the process of seeing Susan. It was the process of seeing Susan that modified the structure of the system in such a way that among its goals there is 'having Susan in the field of view'. The occurrence of the process 'seeing Susan' has increased the probability of its own repetition. If Susan would not have come into the system's field of vision, the system would not have modelled its criteria for 'preferred visual object' around her visual appearance. The Susan process became entangled into the ontogenetic history of the observing subject by adding a new motivation.

A caveat: what increases its possibility to happen again is not the appearance of Susan (which depends only on Susan), but the process of Susan's being seen and recognized by the system. Motivation is not a causal reflection of conditions in environment–rather, it is a self-reinforcing activity. Playing tennis is a way to become fond of playing tennis.

The view of motivations we have set out here acquires its full meaning only within the broader process-based approach we have sketched in this document. Without this background, the suggested account of motivations can still be read in purely causal terms, but in doing so its explanatory power with respect to the constitution of a self will be lost.

We can pose the question then: what are the consequences for artificial systems? Current implementations of artificial systems focus mainly on intelligent algorithms to achieve a fixed goal (or a fixed set of goals) with optimal performance. They look for "how" to achieve a given goal. Many biological systems do not only achieve an optimal performance with respect to a given set of hardwired goals, they develop new goals. They must find "what" they want to achieve and not only "how". The development of new goals on the basis of the interaction with the environment is here defined the "what" problem. The goals can be totally or partially dependent on a limited set of phylogenetically determined goals. However, the new ones are the result of the interaction with the environment and can overcome the original ones. Usually artificial systems are designed with an already fixed set of goals that has to be reached.

Therefore, designers focus their efforts to find "how" those goals can be achieved. One of the most sophisticated ways to do that is learning. "Learning is usually defined as a modification in our behavior: a modification driven by a goal" (Arkin 1999). The various learning paradigms focus mostly on this modification of the behavior.
In the neural network field, Supervised and Unsupervised Learning and Reinforcement Learning are examples of the learning paradigms and the brain is hypothesized to be employing these different modalities through different circuits (Doya 1999), and indeed it seems plausible that different problems are solved by the use of specialized computational resources. For example, feature extraction from sensory data is best achieved by "mostly" unsupervised learning (although action might bias the feature generation), sensorimotor coordination on the other hand is best left to a variant of supervised learning, and finally reinforcement learning can be of use when planning a complex course of action.
Sutton and Barto present reinforcement learning as: "[…] learning what to do – how to map situations to actions – so as to maximize a numerical reward signal [the goal]" (Sutton and Barto 1998), p.3. In the following they claim that "the basic idea is simply to capture the most important aspects of the real problem facing a learning agent interacting with its environment to achieve a goal. […] All reinforcement learning agents have explicit goals" (Sutton and Barto 1998), p.4-5. In other words, Reinforcement Learning deals with situations in which the agent seeks "how" to achieve a goal despite uncertainty about its environment: a goal fixed at design time. In this paper we want to address the process by which "what" (the goal) the agent has to achieve is generated. This is the "what" problem.
Using the Reinforcement Learning terminology, the "what" problem is equivalent to look for new reward functions. In Reinforcement Learning systems "the reward function must necessarily be unalterable by the agent", p.8, that is, the goal is fixed. On the contrary, many biological systems are capable of developing partially or totally unpredictable goals. Our ultimate goal should be that of designing systems that develop their own reward functions: systems capable of autonomously developing the goals that have to be achieved.

In conclusion, we made a series of hypothesis here. Let us summarize them:

- presence is due to a series of phenomenal mental events that are contentful and integrated;
- the intentional and phenomenal status of mental events is due to their identity with physical processes that include the external target of these events;
- these processes have a role in shaping both the environment and the subjective experience; for this reason they have been named onphenes;
- a collection of these processes (or onphenes) constitutes a moment of presence
- the unity between separate onphenes is due to the progressive entanglement of causal processes in order to achieve a goal;
- the final unity of separate onphenes (which possess intentionality in the philosophical sense of aboutness) is eventually achieved by their cooperation to reach a given goal thus obtaining intentionality in the psychological sense.

We are aware that the presented theory is much broader and that it is impossible to verify all its implication. Nevertheless we believe it is worthwhile to attempt at presenting a complete description of it. Future work, both experimental and theoretical, will provide the necessary elements for its development.

## 9. Support from robotics

A key distinguishing feature of Adapt is the implementation of our model of multisensory representation in a real robotic artifact (see D5.1). We developed several line of research including both unsupervised and partially supervised learning techniques. They are described in details in D4.4 and D5.4 and D5.5. Our work included both a technological aspect (realization of new robot parts) and a scientific one (implementation of grasping). Complementary to this, morphology and bodily factors that are known to influence manipulation and its development were investigated (D3.3). It is perhaps too early to start linking the robotic experiments and the theory of the onphene, but nonetheless a few general remarks and considerations can be drawn.

The first one is generally speaking methodological. By investing in the implementation of the model we can really single out its details, with an eventual degree of confidence difficult to achieve otherwise. This is common to the approach of developmental robotics (Lungarella et al. 2003). To start with, we comment on the aspects that were not covered in the present implementation. The most important missing component is perhaps a motivational system (apart from the experiment in (Manzotti and Tagliasco 2005)). We already discussed in details the relationship between onphenes and motivations. This is indeed something to be investigated in the future and indeed we can expect a contribution also from developmental psychology (von Hofsten 2004). The other missing component is a complete integration in a coherent fully functional robot where several modules still work off-line with respect to the interacting real time system.

On the other hand, three sets of experiments have been performed on the development of grasping and the initial processing of visual data for extracting affordances, on the development of visual features for the support of grasping and manipulation, and on the analysis of the influence of morphology into the control of grasping.

The most promising though difficult route is the development of representations (visual features) from unlabeled data. The problem here is that of developing efficient representations that are to be used both for recognition (of objects) and control of movement (detecting the robot hand). The neutral approach of unsupervised learning is justified from the theory by trying not to embody our preconception of the final form of the representations. The idea is to develop them out of general principles derived from statistics and information theory and biased (through small amounts of supervised learning) from motor control (see D5.5).

For pure motor control the robot is now equipped with a set of modules that allow reaching and grasping. In a last experiment we enabled the detection of the three-dimensional orientation of the target that is used to form the almost obvious affordance of grasping. The future will see the exploitation of action and motoric information as it has already been proposed by Metta et al. (Metta and Fitzpatrick 2003).

Finally, the last experiments have been directed to complement this implementation with an analysis of the factors of morphology that influence manipulation. In particular, information theoretical means have been employed to investigate the information “self-structuring” induced by sensorimotor coordination.

## 10. Support from developmental psychology

The investigation of the shape and development of representations in humans seems crucial for substantiating the theory of the onphene proposed earlier. The rationale of the experiments (described in greater length in D4.3) is to study the interaction between infants with objects and humans (the mother or a stranger). In particular two aspects were developed further: the nature of representations in newborns (a few hours after birth) and the timing and contingency of multimodal perception in 2, 6, and 12 month old infants. Concerning the former, the preferential looking paradigm was employed; the latter set was carried out instead by using the teleprompter device developed at CNRS (see deliverable D4.2 and D4.1 for details).

In summary, from the first set of exepriments, we derived the notion that shape and texture are two interrelated aspects of the perception of objects and different results are obtained depending on the content of the objects presented (e.g. volumetric vs. flat, texture vs. uniform). Transfer from touch to vision is observed in certain cases only. These experiments show the degree of integration between various modalities at birth. This information is important also for the robotic implementation; in fact, it provides details on the initial state of the system at "birth". In practice we can think of these abilities as predispositions or tendencies of integrating and/or separating different streams of information rather than to full-fledged skills to segment objects (Spelke 2000). These predispositions are useful for bootstrapping and promoting the development of the concept of objects and eventually of affordances. Although it is somewhat puzzling that similar abilities are present at birth, more recent experimental evidence shows that as soon as the fetus starts moving, he/she starts also experiencing the environment and forming sensorimotor maps and links. Vision perhaps is very limited in the womb but tactile, body maps, and sound and their integration thereof start developing links as early as a few months after conception (von der Malsburg and Singer 1988). A crucial aspect of development, that is, the distinction between the body and the external environment, for instance, can develop since both proprioception and touch are available in the womb.

These relations are the first onphenes, the first links to be established, so that even at birth it makes sense to speak about sophisticated skills. They are part of the persona since they derive from the interaction between the environment and the forming brain.

In the second set of experiments we analyzed another aspect of the early interaction between the infant and the external world. In this case, even more interestingly, we were able to look at the timing and contingency intra-modality. The detection of time differences, delays, and contingency is a fundamental component to brain development. The repetitive interaction with the environment clearly contributes to the construction of appreciation of time, and includes various disparate skills ranging from sound localization to predispositions for social interaction and especially the detection of other people as contingent entities (i.e. following certain timing or patterns in responding/interacting).

The relationship between delayed video and sound was investigated in various contexts, including delays, mother vs. stranger interactant, contingent vs. non-contingent behavior. Results are reported in D4.3. Particularly interesting is the result that in 2 month olds, imitation decreases when the adult behaved non-contingently. Already at that age infants detect the non-contingent behavior and change their own response accordingly.

Finally, the last experiment, still ongoing, investigated the development of object affordances in 6 and 12 month old infants. In particular, at 6 months of age we observed a high variability of behavioral responses confirming previous studies (cited in (von Hofsten 2004)). The data will be now further analyzed. It is important to note that the approach of "stimulating" the

infant by testing the spontaneous grasping, the affordant, and the non-affordant action triggered by the experimenter is new. It also links to the vast literature on mirror neurons (Gallese et al. 1996) and it can potentially contribute with a new direction of research on the topic of imitation and action understanding. We analyzed earlier the link between the concept of affordances and the onphene; this line of research can possibly provide new hints into the question of validating the theory of the enlarged mind. Gibson's theory as we already noted is perfectly in agreement with our approach (Metta and Fitzpatrick 2003).

## 11. Relevance for presence research

It is worth stressing that many of the aspects touched in our experimental plan are directly related to the core of presence research. Firstly, a theory spanning perception is clearly of major interest for the comprehension of presence: e.g. answering the question of which part of reality is needed to convey the sense of presence or, in other words, what need to be simulated to make sure the desired onphenes are re-created into the brain of the user. This can have practical (beside the philosophical) consequences on the approach to the study of presence, and psychology eventually (see the link with Gibson for instance). The investigation into the development of multimodal representations is a second element with the potential for exploitation in presence research. A question similar to the previous ones can be framed: what is fundamental for presence vs. what can be neglected? Finally, the development of machines with perceptual capabilities to a certain extent similar to humans can open new avenues into the realization of avatars or mediators of virtual experiences. One last aspect is that if we agree with the notion that action deeply influences perception (Gallese et al. 1996), then the "acting body" is also required in conveying the true sense of presence. Robotic implementation can be useful to investigate it further in details.

## 12. Conclusion

The presented theory brings together externalism, realism and a process based approach in an attempt at escaping from the subject/object dichotomy.

The enlarged mind is related to Realism. Realism means literally that the content of our experience is not concocted by our brain but it is identical with the world. Interestingly enough, this position does not entail any ontological commitment about what the world is made of (objects, events, and processes). With the onphene, experience is not only about the real world, experience is the world in its taking place (a part of it).

The enlarged mind is externalist in the sense that the processes corresponding with the mind are not entirely inside the cranium. They span considerable time and space (from a few milliseconds in the case of "direct" perception, to days or even years in memory, dream and imagination).

Finally, the enlarged mind is based on a process ontology in which there are no separate autonomous entities (objects, primary properties, any kind of substance-based token, individual, types or particular). Everything takes place.

The enlarged mind aims at steering a equilibrated course between physicalism and idealism, between reductionism and antireductionism. A course that is very well expressed by the short poem "Maentwrog" by Gerard Hopkins (1864):

"It was a hard thing to undo this knot.
The rainbow shines, but only in the thought
Of him that looks. Yet not in that alone,
For who makes rainbows by invention? […]"

## 13. References

Arkin, R. C. (1999). Behavior-Based Robotics. Cambridge (Mass), MIT Press.

Bickhard, M. (1999). Representation In Natural and Artificial Agents. Semiosis. Evolution. Energy: Towards a Reconceptualization of the Sign. E. Taborsky. Aachen, Shaker Verlag.

Birch, C. and J. B. Cobb (1981). The Liberation of Life: From the Cell to the Community. Cambridge, Cambridge University Press.

Brentano, F. (1874/1973). Psychology From an Empirical Standpoint. London, Routledge & Kegan Paul.

Chalmers, D. J. (1996). The Conscious Mind: In Search of a Fundamental Theory. New York, Oxford University Press.

Chalmers, D. J. and A. Clark (1999). "The Extended Mind." Analysis 58(1): 7-19.

Clark, A. (1997). Being there: putting brain, body and world together again. Cambridge (Mass), MIT Press.

Crary, J. (1992). Suspension of Perception. Cambridge (Mass), MIT Press.

Davidson, D. (1980). Essays on Actions and Events. Oxford, Clarendon Press.

De Haan, M. (2001). The Neuropsychology of Face Processing during Infancy and Childhood. Handbook of Developmental Cognitive Neuroscience. C. Nelson A. and L. Monica.

Dennett, D. C. (1991). Consciousness explained. Boston, Little Brown and Co.

Doya, K. (1999). What are the computations of the cerebellum, the basal ganglia and the cerebral cortex? Neural Networks 12: 961-974.

Dretske, F. (1993). "Conscious Experience." Mind 102(406): 263-283.

Dretske, F. (1995). Naturalizing the Mind. Cambridge (Mass), MIT Press.

Edelman, G. M. and G. Tononi (2000). A Universe of Consciousness. How Matter Becomes Imagination. London, Allen Lane.

Emmeche, C. (2001). "Does a robot have an Umwelt? Reflections on the qualitative biosemiotics of Jakob von Uexküll." Semiotica 1(4): 653-693.

Farah, M. J., K. D. Wilson, et al. (1998). "What is 'special' about face perception?" Psychological Review 105: 482-498.

Farleigh, P. (2004). The ideal of Mechanism: Its strengths and limitations, Macquarie University.

Faubert, J. and A. M. Herbert (1999). "The peripheral drift illusion: A motion illusion in the visual periphery." Perception 28: 617-621.

Fodor, J. A. (1976). The language of thought. New York, Crowell.

Fodor, J. A. (1981). Representations: philosophical essays on the foundations of cognitive science. Cambridge (Mass), MIT Press.

Fraser, A. and K. J. Wilcox (1979). "Perception of illusory movement." Nature 281: 565-566.

Gallese V., Fadiga L., Fogassi L., Rizzolatti G. (1996) Action recognition in the premotor cortex, Brain, 119:593-609.

Galilei, G. (1623). The Assayer.

Gibson, J. J. (1952). "The Visual Field and the Visual World." Psychological Review LIX: 148-151.

Gibson, J. J. (1977). The theory of affordances. Perceiving, acting, and knowing: Toward an ecological psychology. R. E. Shaw and J. Bransford. Hillsdale (NJ), Lawrence Erlbaum Associates.

Gibson, J. J. (1979). The Ecological Approach to Visual Perception. Boston, Houghton Mifflin.

Goodman, N. (1978). Of Mind and Other Matters. Cambridge (Mass), Harvard University Press.

Goodman, N. (1978). Ways of Worldmaking. Cambridge (Mass), Harvester University Press.

Gregory, R. L. and J. G. Wallace (1963). "Recovery from early blindness: A case study." Experimental Psychology Society Monograph 2.

Griffin, D. R. (1998). Unsnarling the world-knot: consciousness, freedom, and the mind-body problem. Berkeley, University of California Press.

Holt, E. B. (1914). The concept of consciousness. New York, MacMillan.

Holt, E. B., W. T. Marvin, et al. (1910). "The program and first platform of six realists." Journal of Philosophy, Psuchology and Scientific Methods 7: 393-401.

Honderich, T. (2000). "Consciousness as existence again." Theoria 95: 94-109.

Honderich, T. (2004). "Consciousness as Existence, Devout Physicalism, Spiritualism." Mind and Matter 2(1): 85-104.

Honderich, T. (2004). On Consciousness. Edinburgh, Edinburgh University Press.

James, W. (1890/1950). The Principles of Psychology. New York, Dover.

James, W. (1904). "Does 'Consciousness' Exist?" Journal of Philosophy, Psychology and Scientific Methods 1: 477-491.

James, W. (1905). "A world of pure experience." Journal of Philosophy 1: 533-561.

James, W. (1907/1995). Pragmatism: A new name for some old ways of thinking. New York, Dover.

James, W. (1908/1996). A Pluralistic Universe, The University of Nebraska Press.

James, W. (1912). Essays in Radical Empiricism. New York, Longmans Green.

James, W. (1912). The Thing and Its Relation. Essay in Radical Empiricism. W. James. New York, Longmans Green: 92-122.

Jones, K. S. (2003). "What Is an Affordance?" Ecological Psychology 15(2): 197-114.

Kim, J. (1996). Philosophy of Mind. Boulder, Westview Press.

Kim, J. (1998). Mind in a Physical World. Cambridge (Mass), MIT Press.

Koch, C. (2004). The Quest for Consciousness: A Neurobiological Approach. Englewood (Colorado), Roberts & Company Publishers.

Lehar, S. (2003). "Gestalt Isomorphism and the Primacy of Subjective Conscious Experience: A Gestalt Bubble Model." Behavioral and Brain Sciences 26(4).

Lycan, W. G. (2001). The Case for Phenomenal Externalism. Philosophical Perspectives, Vol. 15: Metaphysics. J. E. Tomberlin. Atascadero, Ridgeview Publishing.

Lungarella M., G. Metta, R. Pfeifer, G. Sandini. (2003) Developmental Robotics: A Survey. Connection Science. 15(4), pp. 151-190.

Manzotti, R. (2000). Intentionalizing nature. Tucson 2000, Tucson, Imprint Academic.

Manzotti, R. (2002). "Why Physicalism and Constructivism Will Never be Able to Understand the Mind." Psycoloquy 13(6).

Manzotti, R. (2003). A process based architecture for an artificial conscious being. Process theories. J. Seibt, Kluwer Academic Press. Process Theories: Crossdisciplinary studies in dynamic categories: 285-312.

Manzotti, R. and G. Sandini (2001). "Does Functionalism really deal with the phenomenal side of experience?" Behavioral and Brain Sciences 24(5): 994-994.

Manzotti, R. and V. Tagliasco (2001). Coscienza e Realtà. Una teoria della coscienza per costruttori e studiosi di menti e cervelli. Bologna, Il Mulino.

Manzotti R., Tagliasco V. (2005) From “behaviour-based” robots to “motivations-based” robots, in “Robotics and Autonomous Systems”, 51 (2-3), 175-200.

Mc Henry, L. B. (1992). Whitehead and Bradley: A Comparative Analysis. New York, State University of New York Press.

Metta G. and P. Fitzpatrick. (2003) Early Integration of Vision and Manipulation. In Adaptive Behavior special issue on Epigenetic Robotics. Vol 11 Issue 2 (2003) pp. 109-128

Metzinger, T. (2000). Neural correlates of consciousness: empirical and conceptual questions. Cambridge (Mass), MIT Press.

Metzinger, T. (2003). Being no one: the self-model theory of subjectivity. Cambridge (Mass), MIT Press.

Millikan, R. G. (1984). Language, Thought, and other Biological Categories: New Foundations for Realism. Cambridge (Mass), MIT Press.

Minsky, M. (1985). The Society of Mind. New York, Simon & Schuster.

Nachson, I. (1995). "On the modularity of face recognition: The riddle of domain specificiity." Journal Clinical Esperiment in Neurpsychology 17: 256-275.

Newton, I. (1704). Opticks: or, A treatise of the reflexions, refractions, inflexions and colours of light: Also two treatises of the species and magnitude of curvilinear figures. London, Smith S. & Walford B.

O' Regan, K. and A. Noe (2001). "A sensorimotor account of visual perception and consciousness." Behavioral and Brain Sciences.

Peterhans, E. and R. von der Heydt (1991). "Subjective contours -- Bridging the gap between psychophysics and physiology." Trends In Neurosciences 14: 112-119.

Place, U. T. (1956). "Is consciousness a brain process?" British Journal of Psychology 47: 44-50.

Proust, J. (1999). "Mind, Space, and Objectivity in Non-human Animals." Erkenntnis 51(1): 41-58.

Quine, W. V. (1960). Word and object. Cambridge (Mass), Technology Press of the Massachusetts Institute of Technology.

Redondi, P. (1983/2004). Galileo eretico. Torino, Einaudi.

Rorty, R. (1979). Philosophy and the Mirror of Nature. Princeton, Princeton University Press.

Rowlands, M. (2003). Externalism. Putting Mind and World Back Together Again. Chesham, Acumen Publishing Limited.

Searle, J. R. (1980). "Minds, Brains, and Programs." Behavioral and Brain Sciences 1: 417-424.

Senden, V. (1932). Raum und Gestaltauffassung bei operierten Blindgeborenen vor und nach der Operation (conception of space and gestalt in congenital blind children before and after surgery). Leipzig, Verlag Jd Ambrosus Barth.

Smith, B. C. (1996). "The Foundations of Computing." 1996.

Smith, B. C. (1998). On the Origins of Objects. Cambridge (Mass), MIT Press.

Spelke, E. S. (2000). Core knowledge. American Psychologist. November 2000: 1233-1243.

Strawson, P. (1959). Individuals. An Essay in Descriptive Metaphysics. London, Methuen.

Sutton, R. S. and A. G. Barto (1998). Reinforcement Learning. Cambridge (Mass), MIT Press.

Tonneau, F. (2004). "Consciousness Outside the Head." Behavior and Philosophy 32: 97-123.

Tye, M. (1996). Ten Problems of Consciousness. Cambridge (Mass), MIT Press.

Uexküll, J. v. (1934). A Stroll through the Worlds on Animals and Men: A Picture Book of Invisible Worlds. New York, International University Press.

von Hofsten, C. (2004) An action perspective on motor development. Trends in Cognitive Sciences. 8(6): 266-272.

von der Malsburg C. and W. Singer (1988). Principles of cortical network organization. In P. Rakic and W. Singer, editors, Neurobiology of Neocortex, pages 69-99. John Wiley.

Whitehead, A. N. (1925). Science and the modern world. New York, Free Press.

Whitehead, A. N. (1926). Concept of Nature. Cambridge, Cambridge University Press.

Whitehead, A. N. (1927/1978). Process and Reality. London, Free Press.

Whitehead, A. N. (1929/1978). Process and Reality. London, Free Press.

Zeki, S. and A. Bartels (1998). "The autonomy of the visual systems and the modularity of conscious vision." Philosophical Transaction of the Royal Society of London 353: 1911-1914.