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Semantic Biology and the Mind-Body problem
The theory of the Conventional Mind

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ABSTRACT

The mind-body problem is about the relationships that exist between mental phenomena such as *feelings and perceptions*, and brain phenomena such as *neuron firings*. The models that have been proposed for the solution of the problem can be divided into three major groups that are referred to as the *computational theory*, the *connectionist theory*, and the *emergence approach*. Here it is shown that a new theoretical framework is provided by the idea that the mental world is based on *natural conventions*. More precisely, by the idea that there is a mental code at the origin of the mind as there is a genetic code at the origin of life. This is the *theory of the conventional mind*, and its basic idea is that mental objects are assembled from brain components according to conventional rules, which means that they are no longer *brain objects* but *brain artifacts*. Such a mechanism implies that feelings and perceptions are not spontaneous side-effects of neural networks (as in connectionism), that they do not come into existence spontaneously by emergence, and that they are not the result of computations but of real manufacturing processes. In the framework of the conventional mind, in short, feelings and perceptions are *manufactured artifacts*, whereas according to the other theories they are *spontaneous products* of brain processes. This is relevant to the mind-body problem because if the mind were made of spontaneous products it could not have *rules of its own*. Artifacts, on the other hand, can have such autonomous properties for two different reasons. One is that the rules of a code are conventions, and these are not dictated by physical or chemical necessity. The second is that a world of artifacts can have *epigenetic* properties that add unexpected features to the coding rules. The autonomy of the mind, in short, is something that spontaneous brain products cannot achieve whereas brain artifacts can.

Introduction

Semantic Biology (or *Biosemantics*) is a view of life that underlines the key role played by organic codes in the origin and evolution of living systems (Barbieri, 1985; 2003). The starting point of the theory is the concept that genes and proteins differ from inorganic molecules not because they have different structures and functions but because they are *produced* in a totally different way. All inorganic molecules are made by self-assembly and their structure is determined *from within*, i.e., by *internal* factors. Genes and proteins, instead, are produced by molecular machines that physically stick their subunits together in an order provided *from without*, by *external* templates. They are assembled by molecular robots on the basis of outside instructions, and this makes them as different from ordinary molecules as *artificial* objects are from *natural* ones. Indeed, if we agree that objects are natural when their structure is determined from within and artificial when it is determined from without, then we can truly say that genes and proteins are *artificial molecules*, that they are *artifacts made by molecular machines*. This in turn implies that all biological objects are artifacts, and we arrive at the general conclusion that *life is artifact-making*.

The second key point of the semantic theory is that genes and proteins are manufactured by very different mechanisms. Genes are made by a process of *molecular copying* and their machines can be referred to as *copymakers*. Proteins are manufactured by a translation apparatus based on the genetic code, i.e. by a process of *molecular coding* and their molecular machines can be referred to as *codemakers*. Copying and coding are both essential to life but do not work according to the same principles. Copying ensures the transmission of *linear information* and is the mechanism that in the short run leads to *heredity* and in the long run to *natural selection*. Coding requires not only the linear information of a template, but also the rules of a code, rules that creates a correspondence between the objects of two independent worlds, in this case between codons and amino acids. Copying and coding, in short, are distinct mechanisms because copying is involved in *organic information*, and coding in *organic meaning*.

The third key point of the semantic theory is that the genetic code is not the only organic code that exists in living systems. Proteins synthesis is the paramount example of *codified assembly*, i.e. of an assembly based on a code, but many other biological processes have the characteristics of codified assemblies. This is documented by the presence of molecules that perform two independent recognition processes, because these molecules, called *adaptors*, are the qualifying features of the organic codes. Signal transduction, for example, creates a correspondence between first and second messengers, but it has been shown that any first messenger can be coupled with any second messenger, and this means that without the rules of a code there would be no biological specificity. The molecules of signal transduction, in fact, have the structural properties of true adaptors and are the effective agents of a *signal transduction code* (Barbieri 1998). Molecular adaptors have also been found in many other biological processes, thus pointing to the existence of *splicing codes*, *cell compartment codes*, *cytoskeleton codes*, and *apoptosis codes* (Barbieri, 2003). Other organic codes have been discovered with different criteria. Among them, the *sequence codes* (Trifonov, 1989; 1996; 1999), the *adhesive code* (Redies and Takeichi, 1996; Shapiro and Colman, 1999), the *sugar code* (Gabius, 2000; Gabius et at., 2002), and the *histone code* (Strahl and Allis, 2000; Jenuwein and Allis, 2001; Turner, 2000; 2002; Gamble and Freedman, 2002; Richards and Elgin, 2002).

According to modern biology, the genetic code is the only organic code of the living world and this implies that evolution went on for four billion years, almost the entire history of life on Earth, without producing any other organic code after the first one. According to semantic biology, on the contrary, the genetic code was only the first of a long stream of organic codes that appeared during the history of life and their appearance gave origin to those great events that have been referred to as the *Major Transitions* in evolution (Maynard Smith and Szathzmàry, 1997). The origin of the mind was certainly one of them, but the mechanism that brought it into existence is still a mystery. Most biologists assume that the mind evolved only by natural selection, but it may be worth considering also the alternative point suggested by the semantic theory, the idea that the mind, like the first cells, evolved by two distinct mechanisms, *by copying and coding* , i.e. *by natural selection and by natural conventions*.

Three groups of theories

The mind-body problem is about the relationships that exist between mental phenomena such as *feelings and perceptions*, and brain phenomena such as *neuron firings*. Today it is generally assumed that the mind is a natural entity and that mental events are produced by brain events. More precisely, it is widely accepted that *"the mind is made of higher-level brain processes that are produced by lower-level brain processes"*.

At the lower level, the functional units are usually identified with *neurons and synapses*, but it has also been suggested that they could be groups of neurons (columns or areas) or even subcellular structures like microtubules. In a similar way, the units of mental life are normally identified with feelings and perceptions, but it has been pointed out that those could be intermediate agents and that the functional unity of the mind could be realized at a higher level. Whatever is the actual number of brain states, however, we can divide them into two great classes, or levels, and our problem is to understand what happens between them. The scientific version of the mind-body problem, in other words, is: *"how does the brain manage to produce the higher-level brain processes that we call mental phenomena from lower-level processes such as neuron firings?"*.

Today the models, or theories, that have been proposed for the interpretation of the experimental data can be divided into three major groups.

(1) The *computational theory* is the idea that lower-level brain processes are transformed into feelings and perceptions by neurological processes that are equivalent to *computations*. Brain and mind are compared to the hardware and software of a computer, and mental activity is regarded as a sort of data processing which is implemented by the brain but is in principle distinct from it, rather like a software is distinct from its hardware (Fodor, 1975; 1983; Johnson-Laird, 1983).

(2) The *connectionist theory* states that lower-level brain processes such a neuron firings are transformed into higher-level brain events by neural networks, i.e. by complex webs of synaptic connections that are not the result of computations but of biological interactions with the environment. The reference model here is not the computer *per se* but the computer-generated neural networks that simulate the growth of the synaptic connections in a developing brain (Hopfield, 1982; Rumelhart and McClelland, 1986; Edelman, 1989; Holland, 1992; Churchland and Sejnowski, 1993; Crick, 1994).

(3) The *emergence theory* states that higher-level brain properties emerge from lower-level neurological phenomena, and the mind is therefore dependent upon but also distinct from the brain, because any emergence is accompanied by the appearance of unique properties (Morgan Lloyd, 1923; Searle, 1980; 1992; 2002).

The conventional mind

A new theoretical framework for the study of the mind is provided by the idea that the mental world is based on *natural conventions*. More precisely, by the idea that there is a mental code at the origin of the mind as there is a genetic code at the origin of life. This implies a deep parallel between the products of the two codes, i.e. between proteins and mental objects, and at first sight such a parallel may seem unlikely because proteins are assembled from chains of nucleotides, which are sequences in space, whereas mental objects are made from neural firings, which are sequences in time. Proteins, in short, are *space-objects*, whereas mental structures are *time-objects*, and yet, despite this outstanding difference, they do have something in common. They are both assembled from linear sequences, and we already know that the assembly mechanism is based on codes not only in the world of proteins but also in the world of language.

The theory of the conventional mind, in short, is merely extending to the mind what we already know to be true in organic life and in language. Its basic idea is that mental objects are assembled from brain components *according to conventional rules*, and this means that they are no longer *brain objects* but *brain artifacts*. Such a mechanism implies that feelings and perceptions are not spontaneous side-effects of neural networks, that they do not come into existence spontaneously by emergence, and that they are not the result of computations but of real manufacturing processes. In the framework of the conventional mind, in short, feelings and perceptions are *manufactured artifacts*, whereas according to the other theories they are *spontaneous products* of brain processes.

The evidence from epigenesis

Embryonic development has been traditionally defined as an epigenesis because it is a step-by-step generation of new structures, but today the concept of epigenesis has acquired a more precise meaning. A clear distinction has been made between the genetic and the epigenetic components of development and epigenesis has been restricted to the processes that take place after the expression of genes. All embryonic structures arise therefore by a sequence of steps that start with the expression of genes and are followed by epigenetic processes of assembly. Proteins synthesis is a typical example of epigenetic assembly and also an example of codified assembly, but the evidence has shown that this is true of many other biological processes. The defining characteristic of codified assemblies, i.e. the presence of adaptors, has been found in processes like cell adhesion, cell movement, cell compartments, cytoskeleton assembly and programmed cell death, and all these phenomena play crucial roles in embryonic development, particularly in the development of the brain. The mechanisms by which neurons and synapses start and stop their movements, for example, are based on cell-adhesion and substrate-adhesion molecules that behave like true adaptors and work according to phenomenological rules that have all the characteristics of coding rules (Edelman, 1988).

The experimental study of brain development, in short, has brought to light many molecules that behave like adaptors and many empirical rules that have the characteristics of natural conventions, all of which suggests that the development of the brain, like the development of any other anatomical organ, is largely based on the rules of organic codes. This is what gives credibility to the theory of the conventional mind: if the development of the brain is based on organic codes, it is likely that the same is true for the development of the mind. We have therefore a new theoretical framework before us: *feelings and perceptions are manufactured artifacts, and the brain assembles them from neuron firings with a mechanism that is based on codes and codemakers*.

The unexpected properties of artifacts

The idea that feelings and perceptions are brain artifacts can be qualified by saying that "artifacts", in this case, means "objects that are assembled from components according to the rules of a code". This however does not make us understand what the properties of artifacts are, and whether there is anything special about them. In order to find this out, let us start from the special case of those particular human artifacts that we call "numbers". There is little doubt that numbers arose by counting, and that counting was favored by natural selection because it had practical advantages. The process of counting, however, produces exclusively *natural* numbers, but then we have discovered the existence of prime numbers, of rational and irrational numbers, of real and imaginary numbers, and of an endless stream of mathematical theorems. All these additional entities were not produced by counting, and this is why some mathematicians say that natural numbers were *invented* by man but that all other rules of mathematics could only be *discovered*, as if they had an existence of their own. In practice, this is equivalent to saying that the world of mathematics was generated by the "genetic" rule of counting and gradually developed into an increasingly complex system that has additional, or "epigenetic" properties. A world of artifacts, in short, may not be completely described by the coding rules that generate the artifacts. It may well have unexpected *rules of its own*, rules that we may call *epigenetic* because they were not present at the beginning and appeared only during a process of development.

Can we extend this conclusion to other artifacts? Today similar properties seem to exist in the world of language, because it has been discovered that children learn to speak by using only a limited number of inputs from their environment. Chomsky has pointed out that this suggests the existence of a *universal grammar*, a mechanism that has the ability to retrieve the countless rules of any particular language from a limited sample of them. It is as if the brain of a child "explores" the world of language and "discovers" an unlimited number of new rules simply by applying the basic algorithm of the universal grammar.

Language and mathematics have different properties and are generated by different strategies, but deep down there is something in common between them. They both have (1) a "genetic" algorithm that starts producing the objects of a potentially unlimited new world of artifacts (numbers or words) and (2) an exploratory procedure that discovers additional or "epigenetic" properties of the new world that were not present at the beginning.

This is highly relevant to the mind-body problem, because if the mind were made of spontaneous brain products it could never have *rules of its own*. Artifacts, on the other hand, can have such autonomous properties, and for two different reasons. One is that the rules of a code are conventions, and these are not dictated by physical or chemical necessity. The second is that a world of artifacts can have "epigenetic" properties that add unexpected features to the coding rules. The autonomy of the mind, in short, is something that spontaneous brain products cannot achieve whereas brain artifacts can. It could be argued that the autonomy of the mind is only an illusion, but for what we know it could also be a genuine phenomenon, and in this case it may be useful to remember that artifacts provide a very rational explanation for it.

Diversity or dualism?

The mind-body problem has been at the heart of philosophy ever since Descartes, but Cartesian *dualism* has long been abandoned. The dominant paradigm, today, is the idea that there is only one world (*monism*) and that everything in it can be explained in terms of physical quantities (hence *physical monism* or *physicalism*). A notable exception to this widespread consensus is Karl Popper, who has declared himself "a Cartesian dualist" and has proposed that there is a dualism not only between body and mind (World 1 and World 2) but also between mind and culture (World 2 and World 3). The surprising thing is that Popper puts physical and biological objects all together, in the same World 1, which suggests that he doesn't see any dualism between matter and life.

Biologists, on the other end, in general take the opposite view. Ernst Mayr, for example, has argued that the genetic code divides matter from life, but that no dualism exists in the living world. This is because natural selection makes new objects by gradually transforming previous ones, and produces objects that belong necessarily to the same world because they are all related by descent. Natural selection, in short, is a mechanism that creates endless diversity but not dualism. This has led to the idea that there is only one living world, a paradigm that can be referred to as *biological monism* and that Ernst Mayr has championed under the name of *organicism*.

According to this paradigm, there may well be a dualism between matter and life but there can be no dualism in life, and in particular no dualism between body and mind. Today this is by far the dominant approach to the mind-body problem, because it is taken for granted that the mind evolved *only* by natural selection. And yet there is, in principle, a perfectly natural alternative. The origin of the mind could have been an event similar to the origin of life, an event produced by the twin mechanisms of copying and coding, i.e. *by natural selection and by natural conventions*. This is equivalent to saying that there has been a mental code at the origin of the mind just as there has been a genetic code at the origin of life, and in this case there would be a divide between body and mind as there is between matter and life.

We realize in this way that the mind-body problem cannot be separated from the greater problem of the mechanisms of evolution, because natural selection can only transform existing objects whereas natural conventions can bring *absolute novelties* into existence. The origin of the mind, however, is a not only a phylogenetic problem but also an ontogenetic one. Body and mind come into existence by embryonic development, and if there is a divide between them it must arise anew in every individual embryo. It is likely therefore that we will have an answer to the mind-body problem only when we discover how the mind comes into being during the embryonic development of the body.

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