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СОЗНАНИЕ КАК МЕНЕДЖЕР КОГНИТИВНЫХ РЕСУРСОВ. ЭВОЛЮЦИОННАЯ ГИПОТЕЗА О ПРАВИЛЬНОМ ФУНКЦИОНИРОВАНИИ СОЗНАНИЯ

Аннотация: Для любого биологического признака разработка хорошего эволюционного объяснения представляет значительные трудности в связи с принятой методологией или определением адаптации [1] и частой нехваткой эмпирических данных [2; 3]. Кроме того, в том, что касается психических явлений, некоторые философские теории, такие как Сознательный несущественный подход [4] или Взгляд на случайность как побочный продукт [5], отрицают, что свойство быть сознательным могло дать организмам какое-либо реальное избирательное преимущество, что делает его эволюционное объяснение еще более затруднительным. Тем не менее, сознание можно разумно рассматривать как полезный инструмент, который с какого-то момента филогенеза и далее каким-то образом способствовал приспособленности его носителей. Таким образом, основная цель этой статьи состоит в том, чтобы предложить эволюционную гипотезу о правильной функции сознания. Сначала мы определим понятия надлежащей функции и адаптивной ценности. Затем мы рассмотрим, почему наличие чего-то вроде ядра сознательного управления, каким бы базовым или минимальным оно ни было, может быть адаптивно ценным, и мы сделаем это с помощью аналогии между этим ядром и менеджером цифровых ресурсов (операционная система современных цифровых электронных устройств). И наконец, в заключение, мы сформулируем нашу гипотезу, которая предполагает, что в какой-то момент филогенеза возникло когнитивное единство, а без него никакое управление сложностью, равно как и выработка целенаправленного поведения, были бы невозможны.

Ключевые слова: сознание; функции сознания; минимальное сознание; модель поведения; окружающая среда; приспособляемость; диспетчер ресурсов.

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CONSCIOUSNESS AS A COGNITIVE RESOURCE MANAGER. AN EVOLUTIONARY HYPOTHESIS ON THE PROPER FUNCTION OF CONSCIOUSNESS

Abstract: For any biological trait, developing a good evolutionary explanation presents remarkable difficulties in relation to the adopted methodology, or definition of adaptation [1], and the frequent scarcity of empirical data [2; 3]. Furthermore, as far as mental phenomena are concerned, some philosophical theories such as Conscious Inessentialism [4], or the By-product Accident View [5] deny that the property of being conscious could have conferred any real selective advantage to organisms, making its evolutionary explanation even more arduous. Nonetheless, consciousness can reasonably be viewed as a useful tool that, from some point of phylogenesis onwards, contributed in some way to the fitness of its bearers. The main purpose of this paper, therefore, is to propose an evolutionary hypothesis about the proper function of consciousness. We will firstly define the notions of *proper function* and *adaptive value*. Then we will examine why having something like a conscious control core, no matter how basic or *minimal*, could be adaptively valuable, and we will do so through an analogy between this core and a digital resource manager (the operating system of advanced digital electronic devices). Finally, and in conclusion, we will formulate our hypothesis, which suggests that at some point of phylogenesis, cognitive unity emerged, and without it, no handling of complexity — and production of goal-directed behaviours — would appear to be possible.
Key words: consciousness; functions of consciousness; minimal consciousness; behaviour; environment; adaptivity; resource manager.

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1. Proper functions and adaptive values

For many people, ears fulfil several useful functions, such as carrying pencils or cigarettes. Similarly, for many of us, wrists seem the best place to wear a smartband or a watch, and what are noses for if not to hold up spectacles? Nonetheless, carrying pencils and cigarettes, holding up spectacles, and so on, cannot be considered the proper functions of our body parts.

The question is what justifies these judgments. It is necessary to understand why the proper functions of ears are to hear and provide balance, and not to carry small cylindrical objects. Moreover, we should ponder the reason why the former are defined as proper functions, while the latter are not, to such an extent that we consider the latter *derived* or *additive*, rather than real, functions. The reason which permits this distinction is that the first kind of functions have *adaptive value*, while the others do not.

In evolutionary biology, adaptive value measures the ability of a trait to enhance the adaptability and fitness of its bearer[1]. To illustrate this point, let's look at the famous case of "Darwin's finches", a group of passerine birds that the father of evolutionary theory discovered on the Galapagos Islands during his voyage on the *Beagle*.

As it is well known, during his five-year-long journey, Darwin studied the geology and biology of the regions reached by the expedition, and collected a great number of fossils, plants, and

[1] It might seem that we are adopting the definition of adaptation given by Sober: "A is an adaptation for task T in population P if and only if A became prevalent in P because there was selection for A, where the selective advantage of A was due to the fact that A helped perform task T" [6. P. 208]. Our idea is similar, but we are not talking about adaptation, only about adaptive value, which is nearer to the concept of *adaptedness*. A trait might be able to enhance the fitness of its bearer, but still fail to be selected (and became prevalent) for many reasons. The definition of adaptive value is functional; it does not imply any (potentially controversial) ontological commitment to biological entities identifiable as "adaptations".

animals that brought back to London at the end of his trip. Among that great collection was a group of finches which, despite their strong similarities, presented clear differences in the form and dimension of their beaks. Darwin, with the help of the famous English ornithologist John Gould, noticed that these differences were consistent with an adaptation of the beaks to the kind of food the birds ate. This process, called adaptive radiation[2], gives rise to different species in virtue of their specific biological traits, which allow them to successfully occupy different ecological niches. To put it another way, the form of the beak performs a certain function, and that function permits the bird to successfully adapt to its environment. The key point to highlight here is that it is the function that the biological trait performs which authentically enhances the fitness of the bird. That is to say, the adaptive value of the trait is *embedded* in its function, and that function determines its spread — the trait is selected and spread *because of* its performing that function. In conclusion, the proper function of a trait is the function which gives it an adaptive value, causing the trait to be selected and reproduced[3].

All things considered, and, following Bjorn Marker [8] looking at consciousness as a core control system able to control and determine living beings' behaviours, we should examine whether it could have a proper function, and what its proper function might be. But before that, we shall also determine what an evolutionary explanation can really tell us about consciousness.

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[2] "Adaptive radiation is the evolution of ecological and phenotypic diversity within a rapidly multiplying lineage. It involves the differentiation of a single ancestor into an array of species that inhabit a variety of environments and that differ in the morphological and physiological traits used to exploits those environments" [7. P. 10].

[3] "The teleological properties of proper functions are thus explained in a naturalistically acceptable manner. Traits are *for* their proper functions because they were selected for their performance of these functions" (Griffith, 1992, p. 112).

Natural selection cannot explain the *origin* of biological traits/entities, but only their *spread,* their *distribution*, and, sometimes, their development (Griffith 1992) [1]. A trait emerges by chromosomal combination, *or* by random mutation, and the matter of whether consciousness emerged in one way or in another does not explain its functions. Novelties somehow emerge, that is a fact, but then it is their adaptive success or failure which accounts for their usefulness.

The contemporary debate in philosophy of mind has given rise to theories such as eliminative materialism [9], or epiphenomenalism [10], which consider consciousness a *naive* notion belonging to a kind of non-scientific defective theory — so called "folk psychology" — which in the near future will be replaced by better neuroscientific theories. In this framework, consciousness has no function at all, and should be considered a misleading concept, or just an epiphenomenon with no causal efficacy.

In my opinion, however, these views lose sight of certain data provided by evolutionary biology, such as the fact that traces of cognitive unity can be detected in most, if not all, vertebrate species, and its steady presence seems too regular to be a useless accident or an epistemological misunderstanding. Moreover, it seems that although many cognitive processes do not require consciousness to be performed, consciousness «is required for some specific cognitive tasks, including those that require durable information maintenance, novel combinations of operations, or the spontaneous generation of intentional behavior» [11].

2. An analogy between the conscious control core and a digital resource manager

I would like to begin with an analogy that can help shed light on the problem of whether *something like* a control core could be practically useful, bearing in mind Fiddick and Barrett's observation that, "In general, the principles of adaptive design are similar to the principles of good engineering: efficiency, precision, reliability, and so on" [12. P. 4998].

Since the 1950s, one of the main features of the history of the development of advanced digital electronic systems[4] has been the operating system (OS).

An OS can be defined in two different ways in relation to the two fundamental functions it performs [13. Ch. 1]. On the one hand, we have a top-down definition which highlights its ability to extend the machine; on the other, a bottom-up description, which underlines its power in managing resources.

The first definition describes an OS as a user-friendly interface which facilitates interaction between the user and the electronic device. In the 1980s, for instance, the first personal computers had a "command-line" OS, which means that commands could only be given by typing strings of code on the keyboard, without the help of icons, windows or other devices like mouses, to which we are now all so accustomed. The evolution of the OS enabled the development of those intuitive tools which together form the *graphical user interface* (GUI), which provided a simple interface for people who are not experts in computers.

What is interesting for us, however, is the second definition, which describes an OS as a fundamental structure which performs a crucial function in a complex system, i.e., the digital electronic system. Every digital system is composed of hardware, an OS, and several pieces of software running on it, whether actively or in the background. The OS efficaciously arranges and controls the machine's resources (the hardware) in order to cover all the software requests, and such an arrangement is realized according to *priority* and *importance*. This last point is of particular interest, as the complex

[4] By "advanced digital electronic systems" we mean devices with a multitasking OS which enables "context switching". This feature is the ability of the processing unit (the CPU) to switch from one process to another, as necessary. See: www.linfo.org/context_switching.html

environment which the OS handles presents many similarities with the natural and social environment in which living beings live and act. Those similarities depend on a characteristic which both environments share, namely their concurrent (or complex) nature.

When we use a personal computer, we can write while listening to music, and have our email and calendar applications open in others windows at the same time: this is concurrency, meaning the simultaneous presence of independently executed, overlapping processes. The opposite of concurrency is sequentiality, where a sequential system is a system in which each process must be completed before another one can start. In other words, a sequential system executes each process one at a time, without overlaps, thereby avoiding the problem of interference between them. In concurrency cases, on the contrary, interference is a very real problem, and a whole field of study exists dedicated to concurrency control, understood as "the activity of coordinating the actions of processes that operate in parallel, access shared data, and therefore potentially interfere with each other" [14. P. 1].

The aim of concurrency control is, therefore, to establish a proper order for processes, so as to handle in a consistent way the overlapping complexity of the digital environment. A multitasking OS is a good candidate to do that. It is in that sense that an OS can be compared with cognitive unity, for the latter has to manage, in the very much the same way, a concurrency of stimuli and decision-making processes, providing them with a higher or lower priority and avoiding interferences and inconsistencies. Let's analyse on what terms it does so.

3. Handling concurrency through a conscious self

It might be objected that an OS successfully handles concurrency while being unconscious or having no self at all. However, an OS handles concurrency by virtue of rules defined by a programmer, who is (presumably) conscious. What I would like to suggest is that beyond a certain level of complexity, a kind of sentient unity is required, as the complexity of environment-organism interaction becomes such that is too difficult to be managed deterministically.

But perhaps we need to take a step back here. What does it mean, in biology, for interaction between the environment and organisms to be complex or concurrent? The point is addressed in an interesting paper by Bjorn Merker, who clearly explains:

> "The evolution of higher animals leads not only to increased complexity of single sensory and motor systems, but produces a diversification of such systems in the equipment of a given species. Vision, hearing, touch, pain, smell, taste, enteroception, proprioception, and vestibular system are some of those on the sensory side, while a great variety of locomotor, orienting, grasping, and manipulatory appendages […] proliferate on the motor side. […] Such sensory, motor, and behavioral diversity brings with it a rich and intricate set of issues in logistics, control, and resource utilization. These involve multisystem coordination, sharing of and competition for common resources, ranking of behavioral priorities, and decision-making, *because behavior*, the ultimate outcome of the operation of the many systems, *must remain coherent, unitary, and organized* [my italics]" [8. P. 92].

Like an OS, which has to regulate the functioning of a complex digital system, every living being — especially once the terrestrial environment was colonized[5] — has to handle a huge number of stimuli, inputs, and different ongoing sub-systems.

Hence, at this point, we need to consider whether it is possible for a concurrent complex system to exist and persist in its integrity without such a synthetic resource management unit.

In my view, the most reasonable answer to this problem should be negative, for at least two reasons. Firstly, because such a system could exist and persist in theory, but in practice it does

[5] As several studies have proposed, the origin of such cognitive unity can be traced back to the early Amniotes, which present features that suggest the emergence of an affective dimension of cognition. See: [15; 16; 17; 18].

not, for all vertebrates seems to possess cognitive unity — and perhaps not only vertebrates, as recent studies have suggested [8; 19; 20; 21; 22]. Secondly, because cognitive unity facilitates in a consistent way the ranking of stimuli and the selection of *adequate* response behaviours.

The usual strategy available to animals to adapt to their environment is the stimulus-response mechanism, which is highly useful, but as a strategy it presents major problems in explaining higher level mental phenomena. To give an illustration of what I mean, let's think of homeostasis, the tendency of an organism to maintain internal equilibrium. In summer, external temperatures rise, while in winter they fall, but our body temperature must remain constant. Our body maintains its equilibrium thanks to its ability to respond constantly and automatically to external stimuli, so that according to the stimulus received, we shiver to raise our body temperature, or perspire to lower it. At a higher level, such an elementary stimulus-response system becomes stimulus-response *association*, whereby:

> "[…] a system of neurons that fires in response to sensory changes in the environment, produces a cascade of firing patterns through the brain, and terminates with a behavioral response. The behavioral response then elicits a change in the environment that ultimately produces a positive or negative outcome, which in turn strengthens or weakens that particular cascade of connections from input to output" [23. P. 51].

Understood this way, stimulus-response association could produce more or less adaptive outcomes that by strengthening or weakening an association could modify stimulus-response connections to obtain increasingly better outcomes. Even in such a case, however, we still could not expect goal-directed behaviour to be performed (*ivi*: 53), as stimulus-driven systems work in a deterministic way and handle stimuli in order of arrival, which means *sequentially*. But as we highlighted earlier, the environment presents a high degree of concurrency, and what really matters for biological preservation is the ability to recognize the priority and the importance of certain stimuli and of certain information at the expense of others. A stimulus driven system which focuses on the order of arrival of the stimuli, and responds in a rigidly fixed way, on the basis of regular past associations alone, and therefore independently of the new context, would fail at that task.

Teleologically speaking, what was "needed" instead was a unitary[6] centre of control for both the requests of the environment, and the resources available, which could bear in mind, at one and the same time, the goals and consequences of possible behaviours, on the basis not only of past experiences, but also future expectations. Even in cases of a "minimal consciousness"[7], the cognitive structure is remarkably complex, as it implies the acquisition of a model of the world, in which another model of the organism itself needs to be nested. Moreover, this nested structure is updated in real-time, which in turn implies memory and learning abilities.

My hypothesis, therefore, is that at some points of phylogenesis[8], the simple automatic mechanisms of stimulus-response were

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[6] "Although the brain operates with multiple parallel anatomical and functional networks, the emerging consciousness of the intact brain is an experience of self-unity" [16. P. 35].

[7] "Minimal consciousness refers to the most basic form of sensory phenomenal experience, such as seeing red (and experiencing redness), or feeling pain. This (basic) form of consciousness is distinct from high-order consciousness, which includes, in addition to the phenomenal experience itself, self-referential, or reflective (usually linguistic) content, such as the awareness of the thought that one is experiencing a red colour" [19. P. 8].

[8] As far as the presumed uniqueness of human (or mammal) consciousness is concerned, Bronfman, Ginzburg and Jablonka [19. P. 19] make the interesting observation that "There is […] a small but growing convergence on the view that minimal consciousness first evolved, in parallel, during the Cambrian era in two different phyla". See also Godfrey-Smith: "Cephalopods are an island of mental complexity in the sea of invertebrate animals. Because our most recent common ancestor was so simple and lies so far back, cephalopods are an independent experiment in the evolution of large brains and complex behaviour" [22. P. 9]. Finally, see: [20].

no longer sufficient, and a kind of cognitive unity spontaneously emerged as a consequence — one that was able to centralize, and therefore process more efficiently and flexibly, the abundant information provided by interaction with the environment.

So conceived, having consciousness, no matter how basic or minimal, gave its bearers a great adaptive advantage, which was the ability to select the right behaviour — and not just the usual behaviour — for the right environmental conditions, keeping in mind the right goal.

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