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BRIEF REPORT

The Brain, a Living and Thinking Machine

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Living beings can be classified into four categories: those without a nervous system, such as bacteria, which respond to physic-chemical forces; those which have a rudimentary nervous system with limited thoughts if any, such as the worm; those which have a more developed nervous system, such as mammals, which can produce elaborated thoughts; finally, those with a sophisticated brain, which is the case of *Homo sapiens*. Why do we *Homo sapiens* have such an advantage compared with other animals? The answer is our brain at the head of the nervous system. Not only can humans produce thoughts and emotions, but also in addition, we can have thoughts about our thoughts (what can be called "meta-consciousness"). One way to understand that our brain can produce thoughts is by accepting that the brain is a machine, but a particular machine—a "living and thinking machine."

The brain is a "machine" in that it can transform information entering the brain (a perception) into a different information leaving the brain (a behavior). In that sense, the brain can be defined as a machine which is nothing more than a sophisticated computer. But a machine is inert, servile, just providing what you are expecting. In contrast, from an inert machine, the brain is alive. It is made of biological matter, which means that the brain can modify itself and is therefore adaptable to the outside world. Not only this machine is living, but also, in addition, this living machine is thinking.

The question then becomes: what do we mean by thinking? How to define a thought? We will assume that a thought is simply a type of information. Not any kind of information, however, is a type of information that is coded into a specific language. After all, this is no more than what a computer is doing: transforming information that is going in the computer into a new information that is going out.

Then, you may argue that since our brain is a machine made of an inert biological matter (the brain weighs almost 3 pounds and contains around 200 billion cells), how can this brain composed of inert material produce thoughts, which, as far as we know, are immaterial. They are invisible, tasteless, odorless and you cannot touch it; the only thing you can do with thought is to say it.

This leads to a second question: how can the living, thinking brain process all the information? What are the biological mechanisms eliciting an inert material such as the brain to produce immaterial thoughts and emotions?

The brain alone is not able to produce thoughts and emotions. Let us imagine a crazy scientist putting a naïve brain (which so far has never received any information) into a vessel so that it survives normally thanks to sophisticated machinery. Is it able to think? The answer is "No" because that brain is totally isolated, receiving no information. In French we say "il n'a rien à moudre–it has nothing to grind. That brain is like a car engine without a body and wheels, it does not make the car move—how then is it possible that the brain can think?

The answer is: the brain can produce thoughts if it is connected to the environment. The brain needs to be fed by information originating from the outside world through sensory nerves (our five senses: vision, hearing, smell, taste, and touch). This information is processed within the brain using a specific physical–chemical code, currently an enigma and in the domain of research. The brain is then able to modify the environment by return, using motor nerves, which activate different muscles, thereby eliciting the production of movements (e.g., gestures, elocution) leading to the behavior. The same is true for our viscera using specific nerves and hormones (Figure 1).

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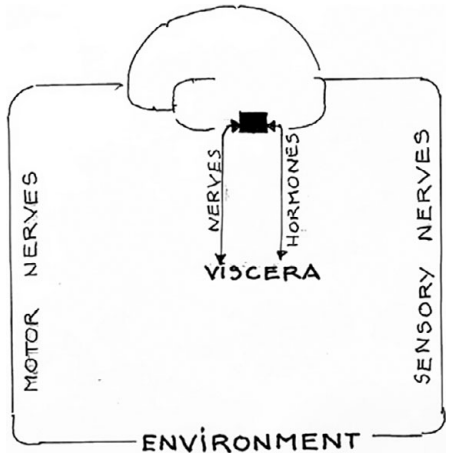


Figure 1. The brain can think consciously because it is in contact with the environment from which it receives information and to which it sends novel information, thereby modifying the environment, and so on. The viscera are controlled unconsciously by the hypothalamus (in black) through nerves and hormones.

How is this possible? As far as we know, the environment does not think. For instance, the surface of the moon does not think. If the brain alone does not think and if the environment alone does not think, how can the brain think? It follows that you need both your brain and your environment to think. Thinking therefore depends on a selective relationship between the brain and the environment. Our thoughts are only produced if the brain is connected to the environment. This conclusion leads to two observations:

First observation: the brain can think but not the body. Our brain can elicit a behavior adapted to the outside world (a motor response made of gestures, elocution …), but our body, through the spinal cord and peripheral nerves, only provides information to our brain from the environment (for instance, if you burn your hand on the oven), and execute the orders decided by the brain (in that case, you remove your hand). The conclusion is that we are not thinking with our body, we are exclusively thinking with our brain. The brain is thinking, but not the body. This does not mean that the body is useless. On the contrary, the body is essential to think, as it is mandatory to connect the brain to the environment, thereby providing information from the environment and modifying the environment by return.

Second observation: metabolic and electrophysiological measurements show that our brain is working continuously, day and night. Since the role of the brain is to produce thoughts and emotions, it follows reasonably that thoughts and emotions are produced continuously. However, we are not thinking permanently. How much time do we spend thinking per day? A few hours? To be aware that we are thinking implies that we are conscious. What happens when we are not conscious? For instance, at night? Since our brain is working continuously, and since the role of our brain is to think, it follows that our brain is thinking continuously, but without us being conscious. *Conclusion*: most of our thinking activity is unconscious, thus stressing the importance of our unconscious life. Consciousness corresponds to the tip of the iceberg, most of our unconscious thinking is under the water.[1]

Having accepted that the brain is a living and thinking machine, it remains to be understood how it works? The functioning of the brain can be divided into three steps: the input, that is, the information perceived at the posterior part of the brain; the processing of these perceptions within the brain

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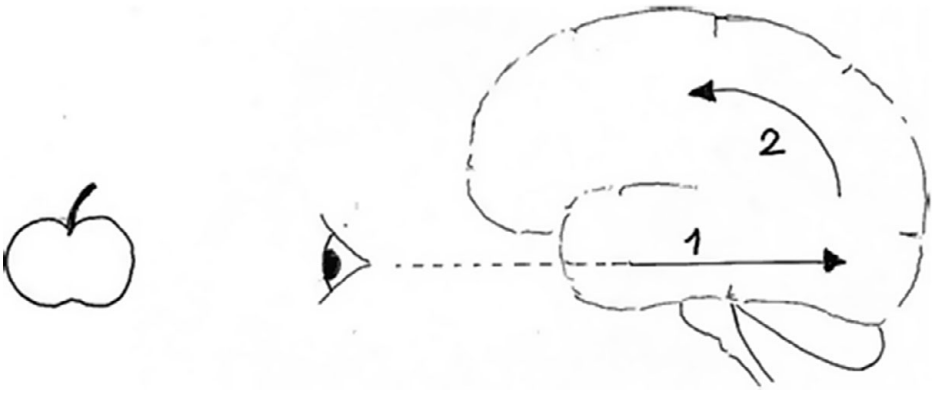


Figure 2. When we see something, for example an apple, the image of the apple is forwarded toward the retina of the eye where the photons are transformed into electric impulses. The latter are targeted through the optic nerve to the posterior part of the brain (<2/10 second) where our brain can perceive the apple but not us (1). To recognize consciously the apple takes half a second, that is, the time necessary for the visual stimulus to reach the frontal cortex (2).

producing the main mental functions such as attention, motivation, reasoning, emotions, language, memory, decision, consciousness; the output of the information in the form of movements resulting in motor behavior.

The brain perceives the information from the outside world through the five senses. Here is the example of vision[2] (Figure 2).

Part of this information is stored into memories, like books that are titled in a library, to be used later. But the information can be processed immediately, allowing us to have a representation of the outside world. Here is the example of emotions[3] (Figure 3).

Finally, using our perceptions and stored memories, our mental functions can be expressed by making movements, essentially through elocution (spoken language), but also by making various gestures (moving our eyes, our hands, etc.). The result of the production of movements is the implementation of behavior, that is, what others can see of us. This explains that just by looking at someone, the way he is talking, walking, and making gestures, provides an indirect reflection of what he thinks and what he feels. To produce our behavior, we need to decide, to prepare, and to execute decided movements (Figure 4).

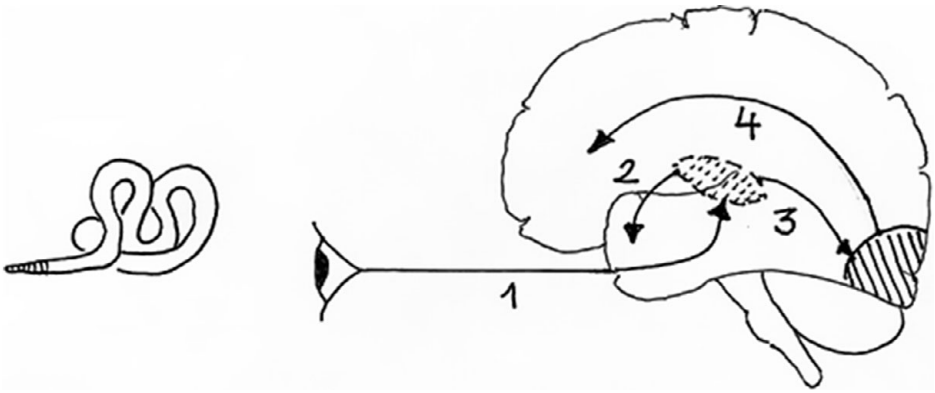


Figure 3. The image of the snake is transported to both the amygdala (1, 2), where it triggers a sensation of fear (allowing us to escape rapidly), and the posterior part of the brain (3) where the snake is recognized by our brain (but not yet by ourselves). From there, the information is targeted to the frontal cortex (4) where we become conscious that it is a snake.

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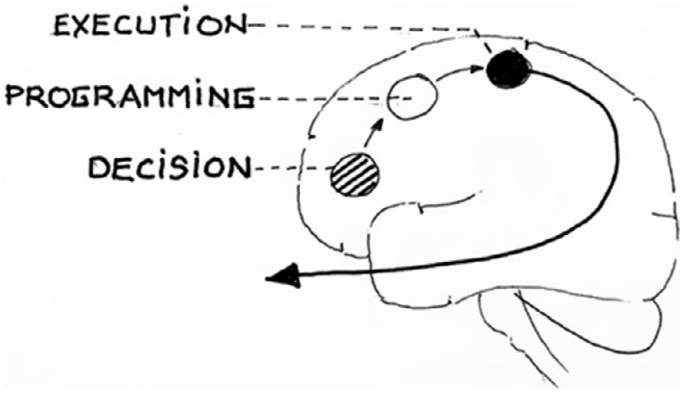


Figure 4. To decide a given movement takes place in the frontal part of our brain. The information is then targeted to the premotor cortex where the different sequences of movements are programmed before being executed in the motor cortex.

Finally, to produce a given behavior, our brain can behave in two ways. Usually, our brain produces a servile behavior, like a machine making the same things in the same way, repeatedly. The result is an automatic stereotyped behavior, such as walking, washing our hands, or driving our car. These automatic non-conscious behaviors are controlled by the basal ganglia[4]. Sometimes, however, we are confronted with a new situation. In that case, we can adapt consciously our behavior to the unexpected situation. Our brain can even become conscious of being conscious (meta-consciousness), that is, having a thought about our thoughts, about what we are doing, about what we feel, eventually about who we are (our identity). Our brain is therefore responsible for what we are, as it can control all our mental functions, including who we are—our identity. What makes us unique and different from all others is our brains. But the identity of someone is oneself. The conclusion is, therefore, that our brain is ourselves. We are our brain.

Notes

1. Agid Y. Consciousness and scientific discovery, the iceberg effect. *Cambridge Quarterly of Healthcare Ethics*. Great Britain; 2024;**33**(4):1–3.
2. Naccache L. *Le Nouvel inconscient. Freud, le Christophe Colomb des neurosciences*. Paris: Odile Jacob; 2009.
3. Ledoux J. *Le Cerveau des émotions*. Paris: Odile Jacob; 2005.
4. Agid Y.*Subconsciousness. Automatic Behavior and the Brain*. New-York: Columbia University Press; 2021.

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