Cambridge Quarterly of Healthcare Ethics (2024), 1–3
doi:10.1017/S0963180124000252

CAMBRIDGE UNIVERSITY PRESS

EDITORIAL

Consciousness and Scientific Discovery: The Iceberg Effect

Yves Agid

Paris Brain Institute, Salpêtrière University Hospital, 83 Boulevard de l'Hôpital, Paris 75006, France
Email: yves.agid@icm-institute.org

> The intellect has little to do on the road to discovery. There comes a leap in consciousness, call it intuition or what you will, the solution come to you and you don't know how or why.
>
> Albert Einstein

Humans have an unquenchable thirst for progress, and history suggests that whether or not a civilization survives depends on its progress—or lack of it. Discoveries in science contribute to that movement toward progress. For that reason, it is useful to recognize the mechanisms that can lead to making a discovery, which, in turn, enables us to work for the betterment of society.

The activity of scientific research is a construction, a long and laborious process that is often discouraging. It is more about constructing useful models rather than discovering the "truth" about an unobservable reality. It is like fishing in murky waters. Sometimes, it is more like searching for the critical puzzle piece that brings the whole picture into focus. Science works as an accumulation of countless experiences spanning over time. However, simply accumulating experiences is not enough. As the French mathematician Henri Poincaré said, "An accumulation of facts is no more a science than a heap of stones is a house."

The question is how does the master stonemason puts those stones together to form an edifice? Within the scientific context, how do those pieces come together to lead to a discovery? In reality, scientific discoveries rest on conscious and mostly unconscious construction. There is a myriad of choices as to what these terms mean. Does consciousness refer to: "Reconstruction of the external world?" "Mental experience of every moment?" "Perception of internal states?" "Representation of one's thoughts?" "A way of relating to oneself?"[1] Whatever the case, the consciousness we have of the world implies perception followed by interpretation, and it is not an isolated mental function.

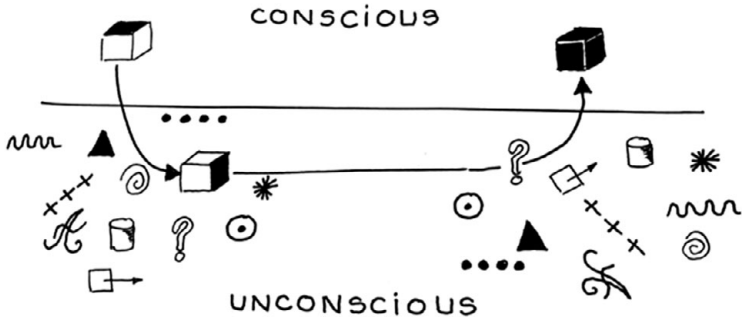
To prevent the constant influx of perceptions from driving us mad, this consciousness has the ability to rest without us needing to pay attention to it. Consciousness is thus in constant interaction with the unconscious, which is the same thing as consciousness but without us being aware of it. A difference from consciousness is that this "unconscious" is permanent. Therefore, most of our life is spent unconsciously. This unconscious is to be distinguished from the Freudian use of the word "unconsciousness," which refers to hidden conflicts buried in the unconscious.

Although this nonconscious part of mental activity, is deliberate, it is triggered by perceptions of the environment or information originating from our memories. Even if the messages from this nonautomatic unconscious may never become conscious, they still leave a trace, and this information may eventually emerge into consciousness.

In terms of process, this form of mental activity starts to develop within the cerebral cortex. We start to perceive information through our five senses without being aware (less than 2/10 of a second) in the posterior cortical areas, which means that our brain is informed without us being aware. Then, it moves to the frontal cortex, responsible for the awareness of messages (about half a second). However, this form of nonautomatic consciousness should not be confused with automatic subconsciousness, which plays a role in various unconscious overlearned behaviors such as walking, driving a car, and so forth. These are behaviors managed by brain structures located in the depths of the brain, the basal ganglia.[2]

In this way, consciousness is only the tip of the iceberg of our thoughts. That the brain is active during conscious activity seems self-evident. That it is the same in the absence of consciousness appears less obvious. However, it can be demonstrated that the brain produces incessant work (days and nights) using a phenomenal intensity (10 times more than any other organs, as shown by several electroencephalographic and metabolic studies). Using electroencephalogram monitoring, the electrical activity of our cerebral cortex recorded at rest is distributed seemingly randomly, which was interpreted as a "background noise" without specificity. However, it is now understood that they serve as the substrate for information (words, images, reasoning, emotions, etc.) circulating within our cerebral cortex, that is, unconsciously.

How can these unconscious pieces of information contribute to generating discoveries? In transitioning from unconsciousness to consciousness they undergo a process, silently enriching each other before becoming conscious. The hypothesis is that these unconscious pieces of information, thoughts or images, interact, combine, and articulate with each other to produce new information that unfolds over time. This incubation unfolds like a film or a chemical reaction, and it hypothesized that this circulating information in the brain has the ability to create others within a vast network of associations. Some of them make sense, and one of particular interest will emerge and become conscious above a given threshold. It is this unconscious deliberation time that allows us to consciously find solutions to the scientific questions we pose.



What makes some people find the solution while others do not? It is sometimes said that a person must have a knack. But having a knack is not really finding the solution; it is what enables a person to find it. Others will say that intuition is necessary. Intuition is immediate knowledge, a judgment all of a piece happening in a moment, as if reasoning had taken place almost instantly. This is characteristic of doctors who make a diagnosis at first glance. By observing the patient, they recognize a clue that gives them access to all the information learned and stored in their memory, and it is one of these pieces of information that leads them to the diagnosis. But intuition is still in the realm of the "conscious."

In reality, most of the time, discovery is made unconsciously. Scientists commonly agree that the solution rarely comes immediately and fully formed into consciousness. Thus, mathematicians, who have reflected extensively on the question of the psychological mechanisms leading to discovery, believe that discovery usually occurs after a long period of unconscious incubation, a phase of the mental process that occurs between the moment when one poses the question and the moment when one finds the solution. The process entails setting aside the question for a more or less extended period, and when an answer is found, it implies that the brain resolves the question without being aware of it.

In this way, the process is like a "Brownian motion phase," a combination of thoughts and images that appear and disappear, associating seemingly at random. These thoughts and images remain nonconscious for a variable period, from a few minutes to several years. Henri Poincaré spoke of an "automatic, spontaneous, intuitive, and unconscious activity." It is as if conscious intellectual activity is on the lookout, in contact with an "anteroom" full of associated ideas located just below the threshold of consciousness.

If this is the process of discovery, what makes a discoverer? There are many gifted individuals who never make discoveries. They "tick all the boxes," they are brilliant, but not effective. On the other hand, there are seemingly uninspiring researchers who make discoveries. Some compensate through hard work, while others suddenly catch the "discovery bug." They embark on the hunt for what no one had thought, for the seductive pleasure of identifying the unexpected, the subtle satisfaction of imagining a new concept, and the pride of being the best. Finding is a reward, like scoring a goal for a player or football team that wins.

There are also those who hardly experience this kind of satisfaction, who do not seek competition, and who, deep down, lack this ambition. They simply do their work properly. Their unsuspected qualities will insidiously reveal themselves over time.

Finally, there are those who enjoy making discoveries so much that they become dependent on it. What was once a simple joy becomes an addiction, with that particular habituation that requires more and more to achieve the same degree of pleasure. In these cases, anything can be seen, from juvenile boasting to overwhelming megalomania, including the questionable pursuit of honors.

Not everyone has the gift of creativity. Just because one can solve a geometry problem does not mean they are a great mathematician. You can possess all the qualities (curiosity, rigor, knowledge, imagination, intelligence, sensitivity, independence, audacity, etc.), but still not have the talent to make discoveries. So, what makes a discoverer? It may be simpler than we think.

In this spirit, if we were to define the primary qualities of a "discoverer" compared to a "good scientist," we would say: the ability to invent. The discoverer is an inventor, an artist, a pioneer who can think differently and thus change the game! If so much of the work of discovery is done silently, imperceptibly, in our unconscious, it means that instead of persisting unnecessarily, one must learn to "decant," that is, interrupt the process of reflection to resume it later after allowing the brain to rest.

It must also be taken into account that modern science is no longer performed by a single genius isolated in the laboratory. Nowadays, apart from the personality of the investigator, high-level science implies the cooperation of laboratories at the international level all over the world. This accounts for the ability of modern science to exponentially increase the number of discoveries, thereby contributing to expanding social benefit for humanity.

Acknowledgments. This text would not have been produced without the help of Thomasine Kushner "ma voix" whom I deeply thank.

Competing interest. The author declares none.

Notes

1. Dehaene S. *Le Code de la conscience*. Paris: Odile Jacob; 2014.
2. Agid Y. *Le Cerveau, Machine à Inventer*. Paris: Albin-Michel; 2023.

Cite this article: Agid Y (2024). Consciousness and Scientific Discovery: The Iceberg Effect. *Cambridge Quarterly of Healthcare Ethics*: 1–3, doi:10.1017/S0963180124000252