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The death of Cajal and the end of scientific romanticism and individualism

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This year marks the 80th anniversary of the death of the father of modern neuroscience, Santiago Ramón y Cajal. His studies into the microorganization of the nervous system, his masterful interpretation of his histological preparations – including his vivid discussions in support of the Neuron Doctrine – and his ideas on degeneration, regeneration, and plasticity, have provided us with the intellectual skeleton for our present day research into the structure and function of the healthy and diseased brain [1]. Since the anniversary of his death coincides with the 'birth' of one of the biggest scientific projects in the history of neuroscience – the Human Brain Project (https://www.humanbrainproject.eu/), it is an appropriate time to reflect on some of the radical changes that have occurred in neuroscience over the intervening years, specifically, the way we work and write.

There are numerous papers dealing with the impressive technological changes that have occurred in the past 80 years. These decades have seen the appearance of numerous new techniques that no one even dared to dream about in Cajal's day. However, there are two other radical changes that have occurred in neuroscience in the time since Cajal's death that merit attention. First, is the individual approach of the early neuroscientists versus the collective approach practiced today. The second is the artistic and romantic 'flavor' of the writings in those early days, which has now practically disappeared.

Intuitively, it seems obvious that our present knowledge of the organization of the brain is based on the dissemination and widespread application of the powerful new methods for interrogating brain structure and function developed within the past few decades. However, this matter is not as straightforward as it appears, since human vanity and individualism can impede full exploitation of new techniques. This problem was beautifully summarized by Cajal [2], when referring to the discovery and use of the staining method of Camillo Golgi, the 'black reaction', which for a long time after its discovery in 1873, passed virtually unnoticed:

> I have already expressed above the surprise I felt when I saw with my own eyes the wonderful revelatory power of the chrome-silver reaction (Golgi method) and the indifference of the scientific community regarding this discovery. How could this disinterest be explained? Today, as I better understand the psychology of scholars, I find it very natural. In France, as in Germany, and more in the latter than in the former, a severe school discipline reigns. Out of respect for their master, it is common that disciples do not use research methods that have not been passed on by him. As for the great investigators, they would consider themselves dishonored if they worked with the methods of others.

It is our view that the insight provided by Cajal in the statement above remains relevant today. Neuroscience has advanced spectacularly in recent decades: we are now able to study the brain from many angles – that is, from genetic, molecular, morphological, and physiological perspectives. However, we have only just begun to unravel some of the mysteries that this remarkable organ holds, as the gaps between conventional disciplines are huge and have barely been explored. This is where big international projects come into play. Namely, in order to unravel the complex neuronal forest that constitutes the human brain, it is necessary to pool the efforts of multiple laboratories with different areas of expertise – coordinated through big worldwide projects like the Human Brain Project based in the European Union and the Brain Activity Map based in the United States. Thanks to these and other initiatives that promote interdisciplinary collaboration, the pace of the development of new technologies and new strategies to study the brain can be increased. One of the most obvious benefits for society will be the application of these technologies and the knowledge generated to better fight the multiple brain diseases that affect millions of people.

Turning to the matter of artistic influence, the difference between scientific communication in Cajal's time and our own is particularly evident in neuroanatomy. In this field, Cajal represents a good example of the bridge between science and artistic inspiration that existed in an earlier age (Figure 1). During the time of Cajal, drawing was the most common method of describing microscopic images, because investigators lacked the highly developed

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Figure 1. Photographs taken by Cajal of himself and his daughter, Paula. In these, we can see two interesting photographs taken by Cajal himself. On the left of the figure, Cajal is looking through a microscope, while on the right, his daughter Paula is posing in a colorful dress with a basket of flowers. It is as if Cajal is intentionally trying to convey that science and art can coexist. From the private collection of Silvia Cañadas, daughter of Paula Ramón y Cajal. Reproduced from [6].

micro-photography and other imaging techniques commonly available in laboratories today. Therefore, most scientific figures presented by the early neuroanatomists were their own drawings. This provided a 'pretext' for these scientists to express and develop their artistic talent, and in turn demonstrate a profound appreciation for the beauty found in nature when interpreting the microscopic world. This coming together of the fields of art and science was beautifully explained by Cajal in an interview given to a journalist in 1900 [3]:

> Undoubtedly, only artists devote themselves to science . . .. I realized that if I wanted to make a name for myself as a painter, my hands needed to become precision instruments. I owe what I am today to my boyhood artistic hobbies, which my father opposed fiercely. To date, I must have done over 12,000 drawings. To the layman, they look like strange drawings, with details that measure thousandths of a millimeter, but they reveal the mysterious worlds of the architecture of the brain.. Look (Cajal said to the journalist, showing one of his drawings) here I am pursuing a goal of great interest to painters: appreciating line and color in the brain.

The love of Cajal for the beauty of nature and his passion for painting, drawing, and photographing nature's sceneries demonstrated his exquisite sensitivity and the depth of his perceptive feelings for all things aesthetic. This aspect of his personality was fundamental to his acquisition of scientific knowledge, because Cajal observed and admired nature through an artist's eye. That is, he was captivated by the beautiful shapes of the cells sheltered in the tiny and dense neuronal forest that constitutes the brain. The essence of this sage was embodied by the enticing architecture of nature, where he satisfied his profound aesthetic feelings and modeled his artistic soul, thus giving birth to his scientific creativity: '. . . the garden of neurology offers the investigator captivating spectacles and incomparable artistic emotions. In it, my aesthetic instincts were at last fully satisfied' [2]. Cajal's deep romantic essence was probably the trigger that allowed the first step in modern neuroscience to be taken. The similarities between the neuronal forest and an actual forest in nature were so obvious to him that he applied the vocabulary of nature to his histological findings, e.g.: 'ivy', 'creeper', 'mossy', 'tuft', 'nest', 'glade', 'vegetation', 'bud', 'pyriform', 'elegant and leafy tree', 'spines', 'garden plants', 'series of hyacinths', 'field spikes', 'climbing vines', 'pinkish efflorescences' to name but a few [4,5]. It is interesting that these words that are now commonly used in the scientific literature have their roots in this romantic approach to studying the brain, but at present the style of writing is purely technical, with virtually no license for romantic prose.

Concluding remarks

In sum, it is clear that much has changed in neuroscience over the past 80 years, not only in the tools that we use to study the brain, but also in how we go about these investigations and communicate our findings. Romanticism is in retreat as pragmatism advances. There is an increasing realization that the brain will not yield its secrets to one person alone, that massive collaboration will become the norm, and that we will need cold, calculating machines to help us digest, integrate, and understand the knowledge gained in the past, present and future.

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