New Ideas on the Structure of the Nervous System in Man and Vertebrates

S. Ramón y Cajal,
Translated by Neely Swanson and Larry W. Swanson
MIT Press, 1990, xi + 201 pp., $29.95

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Cajal has a unique position in the history of neuroanatomy. He contributed more than any single person to our understanding of the structure of nerve cells and their interconnections in the brain and spinal cord. He pioneered in the study of how the brain develops in the embryo and neonates, and he explored the conditions under which neuronal regeneration does and does not take place. He had a remarkable combination of a highly creative mind with great persistance and skill. His most fundamental contribution was to establish the validity of the neuron doctrine. Before Cajal the dominant view among anatomists was that the brain is a reticulum in which elements of the nervous system are fused in an extended network. Cajal affirmed the idea that the brain and the spinal cord are made up of individual cells. Axons and dendrites are parts of the nerve cell. These neuronal processes touch one another but they do not fuse.

Cajal's earliest work was ignored at first by the senior scientists of his day. For one thing, he had no history. He was not a student of a famous master. He came from Spain, a country that had not been a source of major contributions to medical science in the nineteenth century. But the profound importance of his contributions soon led to his recognition by the rest of the world. This book was one of the means by which Cajal announced his discoveries to a broader audience beyond the borders of Spain.

This book was first published in 1893 in Spanish as *Nuevo concepto de la histología de los centros nerviosos.* In the same year a German translation appeared, and by the next year there were two successive editions in French, translated by Azoulay, who later translated Cajal's great textbook (1899; 1904) *Textura del sistema nervioso del hombre y de las vertebrados.*

The present English version is based on Azoulay's 1894 French volume. It is succinct, being about 200 pages long in a relatively small sized text. There are 12 chapters, 10 of which are each centered on a major focus of Cajal's work. The final two chapters are devoted to general conclusions and to a discussion of the Golgi method for neurological staining. There are chapters describing the structure of the spinal cord, the cerebellum, the cerebral cortex, Ammon's horn, the olfactory bulb, the retina, the nerve endings of the inner ear, neuronal ganglia, neuroglia, and the development of nerve cells.

Why are neuroanatomists so uniformly enthusiastic about the contributions of Cajal? The reasons may not always be obvious since so much of his work has become a part of textbook neuroanatomy. This book helps us to appreciate how much of our understanding is in fact due to Cajal. In each chapter he reviews what was known when he started his work and he then tells you about his own discoveries. For example, there is a thoroughly muddled diagram that summarizes earlier views about the structure of the spinal cord. Afferent fibers are shown ending in a tangled syncytial net within the gray matter of the cord. Efferent fibers leave willy-nilly from the ventral root on the same or the opposite side. Cajal illustrated his own views on spinal cord organization, in a figure that might be used in a modern text.

Cajal's anatomical descriptions formed the basis for many of the physiological advances that came much later. Two of Cajal's greatest contributions, for example, were his description of the structure of the retina and of the cerebellum. Later analyses of the role of individual cell types in the construction of visual receptive fields in the retina or the control of firing of the Purkinje cells in the cerebellum are ultimately based on Cajal's superb anatomical description of the kinds of cells that are found in these structures and how they are interconnected.

There are a few problems in reading the book without a guide, and even some areas in which its conclusions might actually mislead. For example, much of Cajal's work was based on study of neonatal and embryological material. In his day, it had not yet been discovered that many more cells are formed in the developing brain than survive in the adult. Accordingly, Cajal's descriptions, based as they are on neonatal or embryological material, may in some cases not be directly applicable to the adult nervous system.

This is a handy and useful introduction to Cajal's contributions, but it is not immediately apparent who its most appropriate audience would be. For specialists there is Azoulay's translation of Cajal's textbook the *Histologie du Système Nerveux* and the translations of Cajal's original reports on the cerebral cortex recently published by DeFelipe and Jones. For the new students interested in the origins of neuroscience and Cajal's contribution to it, there is Cajal's autobiography, *Recuerdos de mi vida* (Recollections of My Life) which has now been reprinted from an earlier English translation. The autobiography gives a popular and easy to read outline of Cajal's work in relation to the events of his life. But anything Cajal wrote is worth reading. The book is an introduction to the great breadth of Cajal's studies and it has some of his beautiful drawings of the structure of the brain and spinal cord, along with his clear and succinct descriptions of the cell types and their interconnections. The translation is most useful to our appreciation of Cajal's great contribution to modern neural science.

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Unified Theories of Cognition

Allen Newell
Harvard University Press, 1991, 549 pp., $39.95

Review by Richard Granger
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The past three decades has witnessed the development of interdisciplinary research encompassing cognitive psychology and artificial intelligence (AI), with the goal of identifying formal computational hypotheses of mind. Allen Newell has been one of the leaders of this research from its inception, and publication of his new book *Unified Theories of Cognition*, based on the author's William James lectures at Harvard University, represents the amassed results of a major research effort in this field. It will be reviewed for its content and clarity in many forums; here instead a brief attempt will be made to address the book, and the line of research it represents, from the perspective of cognitive neuroscience. To this end, the main question that will be raised is how can we identify what functional psychological operations are primary or fundamental, i.e., those that combine to produce complex cognitive phenomena? This is a shared quest of cognitive psychology, artificial intelligence, and cognitive neuroscience; Newell's book offers an opportunity for evaluation of successes and prospects in these fields.

Newell dedicates his book to a specific task: "to urge on psychology unified theories of cognition . . . theories that gain their power by positing a single system of mechanisms that operate together to produce the full range of human cognition" (p. 1). Newell indeed assumes both the existence of a single set of mechanisms and the ability in principle to identify that set. Most of the book is devoted to the presentation of a proposed example of such a theory, consisting of a rich set of coherent hypotheses that purports to explain a wide range of sometimes disparate psychological phenomena, together with a computer system implementing these hypotheses. This computer system, called SOAR, is an artificial intelligence computer program, based on a "production system" architecture, i.e., a set of "If-Then" rules for behavior. This fact raises some immediate controversy: the very architecture of the system contends that all of memory is uniformly composed of these productions or rules. Moreover, it is proposed that this uniform architecture accounts for psychological phenomena ranging from the power law of speedup with practice, to solving "crypt-arithmetic" problems: finding appropriate numbers to solve an algebraic addition. Newell is quick to admit that this proposal of unification via a production system is disconcerting in light of the many findings of neuropsychological dissociations and other evidence for multiple forms of memory, but he offers little in the way of amelioration, and does not consider modifying the unified theory to account for such dichotomies. Rather, Newell intends the very unification of his theories to amend what he sees as excessive dichotomizing in psychology: serial versus parallel processing, massed versus distributed practice, procedural versus declarative memory. For Newell, the demonstration of apparent modularities in cognition (being able to point to a thing but not to name it, being able to remember what happened four minutes ago but not ten, being able to learn to read in a mirror but be entirely unaware that any such learning has occurred) does not remove the necessity of "a theory that . . . explains the role of the [modules] and why they exist" (p. 18).

When the object of study is an artifact, understanding it can be aided by prior "top-down" information about its intended operation; thus the performance of David Marr's cash register (*Vision*, 1982) can be addressed with respect to its intended operation: adherence to the Peano axioms of arithmetic [adding something and then taking it away should result in zero (law of inverses), adding two things individually or as a group gives the same result (associativity), and so on]. Cognitive psychology attempts to apply such means to the behavior of natural systems; the complex meanders of Herbert Simon's hypothetical ant on the beach (*The Sciences of the Artificial*, 1969) can be greatly simplified by reference to the interactions of two factors: the ant's intended (internal) target and the (external) obstacles in its path. Attribution to the ant of a specified set of intentions enables a computational-level analysis of its activity. In the absence of knowing the "intentions" of the object, we can know only measured behaviors (as in the standard "behaviorist" argument), including, of course, measured neural re-