BOOKS: NEUROSCIENCE

How the Brain Made Language

Michael T. Ullman

Your three-year-old daughter Clementina says, "I want Adrian's green snake." Apart from the fact that she's your daughter, there's really nothing so special in what she just said. Right? Wrong. In fact, once you think about it, you realize that that little utterance of hers reflects an amazing capacity. This capacity, which is language, allows us to communicate an infinite number of concepts to each other. And while children master language without much effort at all, to our knowledge no other living species comes anywhere close to being able to convey the complexity of Clementina's remark, even with a large amount of instruction (*1*).

Lingua ex Machina
Reconciling Darwin and Chomsky with the Human Brain
by William H. Calvin and Derek Bickerton

MIT Press, Cambridge, MA, 2000. 306 pp. $26.95, £17.95. ISBN 0-262-03273-2.

Lingua ex Machina brings together three big questions about this uniquely human capacity. What is language? How does the brain support it? And why do we have it in the first place? These questions have been difficult to answer. Certainly we understand much less about language than about vision or memory, let alone domains such as chemistry. Nonetheless, in recent decades a number of parallel revolutions have shed light on many aspects of the what, how, and why of language. Now William Calvin, a jack of many scientific trades including neurophysiology and evolutionary theory, and Derek Bickerton, a linguist with expertise on the emergence of new languages, have gathered numerous strands of these largely independent enterprises. They have woven them together to create a complex tapestry that reflects the actual interdependence of the different levels of language study. But before discussing their handiwork, it may be useful to examine the recent history of each of the three main strands.

Over the last 50 or so years, Noam Chomsky and other linguists have brought about a major shift in our understanding of the what of language. According to this perspective, language is a mental construct—a system of representations and computations in the mind that underlie sound and meaning, and link the two together. Particular advances have been achieved in our understanding of grammar, the mental capacity that generates structured representations of sound and meaning. It has become clear that those silly trees you drew in grade school to represent nouns and verbs really weren't so silly after all. The trees represent the hierarchical structure of language; they show the relations between verbs like "want" and nouns like "snake." Such structural relations form the backbone of syntax, the grammar of phrases and sentences. Because one phrase can contain another (for example, Clementina wants the snake that wants the mouse that wants the cheese), syntax allows us to produce and comprehend an infinite number of combinations of words, giving us the remarkable communicative richness of language.

We also know that language is not computed in the liver or the heart, but in the brain. Unfortunately, it has been difficult to ascertain exactly how the brain supports language. The vast majority of our knowledge of brain function has been gleaned from animal studies. But, unlike vision or memory, language is found only in humans. And the invasive methods used to study the brains of sea slugs, mice, and even monkeys (such as inserting single-neuron recording devices or damaging specific brain structures to see what functions are impaired) cannot be performed on humans. Thus, most of our understanding of how the brain works is not directly relevant to language. Nevertheless, a number of general principles of neuronal organization and computation have emerged from investigations of animals, and these seem likely to hold for humans as well. Moreover, the advent of noninvasive brain imaging techniques such as functional magnetic resonance imaging and electroencephalography, methods that allow one to "film" the activity of the brain in action, are proving useful in identifying the where and when of brain function—that is, which specific brain structures underlie what linguistic functions, and exactly when these structures are active while we perform those functions.

Perhaps we know least about the why of language. Not surprisingly, this is also the most contentious area of study. Nativists argue that language (or aspects thereof) is dependent on dedicated cognitive capacities that are innately specified (*2*). Generalists claim that language learning and use involve only general-purpose cognitive processes (*3*). Researchers from both camps have largely ignored evolutionary principles. The nativists often assume that language came into being ex machina, simply wheeled onto the stage like the deus ex machina used to resolve difficult plot conflicts in Greek and Roman plays. The generalists frequently ignore Darwin for a different reason: they do not believe that any language-specific structures have evolved.

In *Lingua ex Machina*, Calvin and Bickerton set themselves the important goal of integrating the what, how, and why of language into a single theoretical edifice. Most significantly, they propose a marriage of Chomsky and Darwin. The authors begin by arguing that syntax separates humans from all other living animals. On their view, before syntax our ancestors had only "protolanguage," which consisted of short unstructured lists of words that had minimal communicative power. The authors also adhere to the nativist position of innately specified underpinnings for syntax. But what brought us from there to here? In evolutionary theory, something can only evolve from an earlier something. For example, Darwin proposed that the fish's swim bladder served as the evolutionary precursor of lungs. Calvin and Bickerton suggest that syntax emerged from complex brain systems that originally arose because they offered clear evolutionary advantages for nonlinguistic functions, including certain social interactions and motor skills such as throwing at targets.

Lingua ex Machina is an ambitious book. The integration of the different strands of language study is a difficult but

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necessary enterprise, and the authors are to be congratulated for tackling it. By strengthening each side of their theoretical edifice with support from other areas of study, they succeed in building an intriguing and largely coherent story. Their account is also fun and interesting to read. The dialogue between the authors—structured as a correspondence at an Italian villa cum conference center where they spent an engaging month of bocce ball, walks in the countryside, scrumptious dinners, and conversations with literati—enlivens the subject matter. Calvin and Bickerton offer a plethora of engaging anecdotes, quotes, and informational tidbits from many different disciplines. They provide an appendix to explain linguistic theory, a clear glossary, and (in keeping with the times) even a web address for additional information. Both authors are original thinkers, and they present many provocative ideas in addition to their main hypotheses.

Nevertheless, the book suffers from several substantial weaknesses. There is perhaps too much speculation. This leaves the reader with the feeling that although many of the claims might be right, there is no good reason to believe them. Despite the difficulties in obtaining hard evidence in some of the scientific domains discussed (especially in the evolution of language), much greater attention could have been paid to existing empirical findings. In addition, by ignoring a number of alternative theoretical perspectives the authors only reduce the strength of their own arguments. Finally, even though the integration of the various scientific strands is impressive given the difficulty of the task, it falls short in places.

The book's strengths and weaknesses are both reflected in the authors' claim of a link between motor skills and grammar. I believe this view to be important and likely to be largely accurate (*4, 5*). But the omission of supporting evidence and the neglect of other explanations weaken their case. In particular, because some of this evidence suggests a common neural basis for motor skills and grammar, these omissions preclude an opportunity to better integrate the neural theory into the broader perspective.

In sum, Calvin and Bickerton have given us an ambitious, intellectually exciting, and deeply stimulating discourse that brings together the what, how, and why of language. Despite its weaknesses, most readers will learn a lot from *Lingua ex Machina* and enjoy themselves while doing so.

References

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BOOKS: MUSEUMS

Hallowed Halls for Nature

Mary P. Winsor

This book by a young historian of architecture at Rutgers University will be welcomed by anyone interested in natural history museums. Carla Yanni has searched through British libraries and archives to uncover the stories behind three great cathedrals of Victorian science: the Oxford University Museum and the Royal Museum of Scotland (both designed in the 1850s) and London's Natural History Museum in South Kensington (designed in the 1860s). She reviews some of their predecessors, including the popular exhibits of Bullock and Peale, abortive plans for a Cambridge University Library, and two versions of the Hunterian Museum of the Royal College of Surgeons. She goes behind the scenes at Oxford, Edinburgh, and London to describe the competing tastes that shaped the design of their great museums. Her account is accompanied by over 100 illustrations, beautifully printed. Yanni supports her discussion with selections from contemporary news reports, entries in architectural competitions (losers along with winners), and her own photographs. She asks how, in the decades before the radical "new museum idea" of the 1880s finally separated the public displays from the storage of research material, Victorians thought their great collections should be housed.

Well-lit nave. The specimen-free central hall of Waterhouse's Natural History Museum has a church-like quality.

The answer is that there was no single answer. The glass roofs that provided illumination in Oxford and Edinburgh were excluded from consideration for the British Museum, perhaps because their resemblance to contemporary shopping arcades made this solution seem undignified. At Oxford, a committee of professors debated the merits of classical, Renaissance, and Gothic styles, but they also kept a sharp eye on costs and worried about rainwater. Yanni shows that the building, the site of T. H. Huxley's 1860 exchange with Bishop Wilberforce about apes and grandmothers, was conceived by men confident that biology could never conflict with truths about God's creation. Meanwhile, government bureaucrats were assigning an engineer to draw plans for the Edinburgh Museum of Science and Art. Francis Fowke's adaptation of the famous Crystal Palace (a giant greenhouse) of the 1851 Great Exhibition suited the Board of Trade, which wanted to encourage the Scottish people to see their natural resources as money. Yet in London, Fowke's temporary 1862 Exposition Building in London was scorned. The jury for the new British Museum (Natural History) did not know whose drawings they were judging when they selected the plans he submitted. It was only Fowke's premature death that brought Alfred Waterhouse into the project and shifted the style to the Romanesque.

Nature's Museums
Victorian Science and the Architecture of Display
by Carla Yanni

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To me, statements like "there is no nature outside culture" are unhelpful, but in museum studies these days such language is de rigeur. I do know that making sense of the history of natural history museums is extraordinarily difficult, and I applaud the courage, insight, and hard work that went into this well-conceived study. I judge Yanni's book a success because it leaves me wanting others like it, ones packed with pictures of European, American, and colonial museums. Thanks to her, I would pore over such books asking, Did this one have galleries like Charles Barry's Hunterian Museum, where Richard Owen worked? Did it have "glazed haunches" (skylights on the sides of a vaulted roof) like the Museum of Practical Geology, where Huxley lectured? *Nature's Museums* will convince the reader that however stolid and self-assured an old museum may seem, its past conceals a local story of vision, conflict, and compromise.

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