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BOOK REVIEWS

TOWARDS A NEW AGENDA FOR NEUROLINGUISTICS


Philip Lieberman is a member of a generation of linguists that grew up with the doctrines of Noam Chomsky and Eric Lenneberg. Lenneberg assembled a massive amount of neuropsychological evidence on language disorders in adults and children, and concluded that Chomsky was right: there was indeed a “language organ” in the human brain, with a distinct course of development, pattern of breakdown, and neural localisation. Norman Geschwind reinforced this argument with new clinical evidence, and rehabilitated Wernicke’s discredited model of the language brain, which placed the receptive expressive control of language in two areas of the left cerebral hemisphere, Broca’s and Wernicke’s regions. The resulting theory of aphasia was widely accepted for the next two decades.

There was at least one early exception: Philip Lieberman rejected the Chomsky-Lenneberg-Geschwind model less than a decade after it had been formulated, at a time when it encountered very little opposition. In 1975 he took a stance that was very brave for a linguist of that time, and proposed a non-Chomskyan theory of language evolution arguing that language could be accounted for without postulating a special brain organ. Moreover, he held that language must have evolved in a Darwinian manner; that it continuously within the framework of existing primate capabilities, without any qualitatively breaks or evolutionary saltations. Even worse, (orthodox Chomskyans), he held that the rules of language have much in common with those governing other kinds of skilled motor behaviour. He therefore placed the origins of language in a motor adaptation, specifically in a refinement of the high-end motor control systems of the primate brain. His best-known exposition of this idea was his 1984 book, The biology and evolution of language (Harvard University Press).

Lieberman has done most of his specialised research in the field of human phonology; but his theories about language extend to all its aspects, including its highest cognitive functions. He realised long ago that language was a thought skill, and could only have evolved to improve hominid problem-solving. The evolving language system must have incorporated within itself the existing neural resources dedicated to problem-solving; integrating them into a more powerful representational apparatus. He emphasised that the phonological, morphological, grammatical, and semantic aspects of language never exist in isolation of one another, but are always unified in their effects on adaptive behaviour. He insisted that the language system be regarded as a functional unit, and that this unity should be considered one of its central features.

Lieberman also emphasised that language is learned, not prewired like an instinct. His views have been well known in this field for a long time, and he attempted to reach a wide audience with two books, one in 1991 (Lieberman, 1991) and another in 1998 (Lieberman, 1998). One might then be tempted to ask, can he really have anything new to say in this book, given that he published his last tract less than three years ago? He does. This book is quite different from any of his previous work, and in many ways it is one of his best because it is so concise and clear. This is due to its tight focus on one topic, the subcortical underpinnings of language.

Like most other neurolinguistic theorists, in his early work Lieberman focused on the language areas of the cerebral cortex. But during the past decade he has rediscovered the subcortical speech system, which had been largely overlooked by researchers in his field. In this volume, he reviews a number of recent neuropsychological studies (including some on which he is co-author), in which aphasic symptoms are apparently caused by subcortical injuries. These symptoms occur even when the so-called language cortex is left completely intact. Lieberman believes that most of the classic aphasic syndromes associated with Broca’s region can be demonstrated without any damage to the frontal cortex per se.
Moreover, damage to the cortex alone does not always affect language. Superficial lesions to Wernicke’s region may produce no aphasic symptoms at all, if the underlying white matter is completely spared. He concludes that the cognitive and articulatory symptoms of aphasia are mostly due to damaged subcortical pathways, not injured cortex.

This finding implies a role for subcortical structures in the functional language system (FLS) of the brain. In fact, Lieberman claims that subcortical structures, especially the basal ganglia, are important even at the highest levels of linguistic integration, including grammar. He finds this to be consistent with the evolutionary history of the basal ganglia, which are known to control the serial movement patterns, or “grammars,” that define complex instinctual behaviours, such as grooming in rats. The basal ganglia play essentially the same functional role in human grammar, by controlling the sequencing of motor commands in speech. Their direct relevance to human grammar can be seen in recent clinical demonstrations of agrammatism in Parkinson’s disease, which causes deterioration in the basal ganglia while sparing the cortex. Lieberman concludes that “deterioration of speech motor control, sentence comprehension, and cognition can result from impairment to basal ganglia structures. Intact basal ganglia circuits clearly are necessary elements of the FLS” (his italics). This does not deny the cortex a role in the FLS, but it is a broader role, linked to its supervisory functions, such as working memory and attention.

Lieberman believes in the evolution of a specialised apparatus of language, but it is a very different apparatus from Chomsky’s hypothetical preprogrammed module. The FLS is not a new or distinctive anatomical entity, but a modification of some of the primate brain’s most ancient sensorimotor systems, linked together by a superordinate cortical system. The various subsystems of the FLS still perform their traditional functions, even as they engage in their new roles. Lieberman’s evolutionary theory amounts to an application of the principle of reentrance to phylogenesis (which I find quite feasible) whereby phylogenetically ancient neuroanatomical systems can evolve new connectivities by becoming absorbed into a phylogenetically newer, and widely distributed cortical integrator. The cortical component of the FLS effectively “overlays” and ties together the activities of a number of pre-existing subcortical structures, of which the basal ganglia are the most important. Hence the title of this book.

The FLS is thus a distributed neural network that resists easy localisation. To quote Lieberman, “The FLS rapidly integrates sensory information with stored knowledge.” To understand how this might be achieved, we will have to understand more about the laws governing the interrelationships between sensation and memory. This will necessarily move the focus of language research away from the traditional Broca-Wernicke cortical axis, and toward a number of subcortical structures. Future research will also have to respect the integrative nature of language, which by its very nature links together many brain resources, bringing them into focus when solving problems. Language is thus a logical extension of primate adaptive behavioural systems. It is probably not an exaggeration to say that Lieberman places language closer to problem-solving behaviour in its line of descent, than to animal communication systems.

The major message of this book is that language laboratories should be directed back to the “reptilian brain” of the book’s title. Cognition in a reptilian nervous system is governed by the limbic system, thalamus, and basal ganglia. These are its highest regulatory structures, and they form the basis of coping behaviour. They control the organism’s adaptation to its environment. By dint of this heritage, the basal ganglia and other subcortical systems have the vestigial connectivity needed to integrate the sensory, memory, and motor functions that unify language. Our obsession with cerebral cortex has led us to neglect these structures, and we need to re-examine their contribution to language.

If I had to choose somewhere to be picky and disagree with Lieberman, it would not be on any of his major themes. I agree completely with his larger agenda. However, in his enthusiasm for his subcortical proteges, he may have stacked the deck just a little. For example, he has reinforced his evolutionary argument by claiming that the selective evolutionary expansion of the human cortex has been exaggerated. Past studies of hominid encephalization have universally agreed on one thing: that the human brain expanded selectively, with very little change in most subcortical and primary cortical structures, while the greatest expansion can be seen in the hippocampus, cerebral cortex, and neo-cerebellum.
Lieberman dismisses this idea on the basis of one recent imaging study that apparently contradicts this notion. He claims that a homogeneous expansion of the whole hominid brain is more consistent with the newest evidence. But how good is this new evidence, when pitted against dozens of postmortem studies? At the very least, imaging evidence is internally inconsistent. There are some imaging studies that counter his examples. For instance, Preis et al. (1999) used magnetic resonance morphometry to estimate the relative size of the temporal plane in human subjects, and reported volumetric comparisons with established postmortem estimates of the same structure in the chimpanzee. Their numbers suggest that the human planum temporale is seven or eight times larger than the chimpanzee’s, in both hemispheres. This contradicts Lieberman’s generalization that the human cortex did not expand any more than the subcortical regions; it is equally possible that some areas of cortex may have expanded more than we have thought. Further research will be needed before we can state with precision the degree to which various Brodmann areas have expanded during human evolution.

The other area where I disagree with Lieberman is in his apparent downgrading of the cerebellum’s role in higher cognition. He briefly acknowledges the existence of the cerebellum, but in view of his emphasis on motor sequencing, I find it strange that he did not assign it a more important role in the subcortical FLS. Recent research suggests that the neo-cerebellum plays a crucial role in all acquired skills, including language. Moreover, human evolution seems to have singled out the cerebellum more than the basal ganglia, if one judges by the comparative change in their cortical interconnectivity. The human frontocerebellar pathways contain more than five times as many axons as their primate homologue (Leiner et al., 1993). This suggests that Lieberman might be underestimating the importance of the cerebellum in language evolution.

But this is a minor quibble. If Lieberman is right, his proposal should change how we do research on the neural basis of language. I agree with him that the search for isolable sub-organs of language should be abandoned. Instead of looking for local brain regions that regulate specific linguistic functions, our energies should be redirected to the study of distributed neural systems, and the nature of the large-scale neural integration imposed by the cerebral cortex on existing subcortical motor control systems. This could lead to a very different conceptual approach to language from the one afforded by our present paradigms. This kind of work is in its infancy, as Lieberman admits. Neurolinguistic theory has a long way to go, and this book might be a good rallying point for taking it in radically new direction.


REALLY NO DISPUTE


Merlin Donald correctly notes that I paid less attention to cortex than to the subcortical basal ganglia in discussing the cortical-striatal-cortical neural circuits that support human language and thought. However, the point that I tried to make in “Human language and our reptilian brain: The subcortical bases of speech, syntax, and thought,” was that the neural bases of language are a distributed system, a “Functional Language System,” (FLS) that crucially involves the basal ganglia which traditionally were associated with motor control. As Charles Darwin noted, old structures take on new roles. This seems to be the case for the basal ganglia. However, the cortical components structures of the FLS also appear to have been adapted from homologous structures in ancestral species. The “mirror neurons” present in the monkey homolog of Broca’s area may well, as Rizzolatti and Arbib (1998) suggest, signify a transition from manual language to human speech, as Doreen Kimura proposed in 1979 (Kimura, 1979).

Although I argue for continuity in the evolution of language, there clearly must be functional differences between the brains of humans and apes. Some chimpanzees, bonobos, and one orangutan, demonstrably can use manual systems to signify words and simple syntax. However, they cannot talk or acquire tens of thousands of words and complex syntax. This suggests both some degree of continuity and a possible link between the neural bases of speech motor control and other aspects of language. But the question that remains is what allows our brains to acquire full human capabilities? It’s possible that some qualitative difference in subcortical circuitry may be at the heart of the matter, but we lack relevant tracer or electrophysiologic data for ape and human brains. The enlargement of most cortical and subcortical structures in human beings might account for the functional differences. The computer that I am using at this moment is no different conceptually from the museum pieces that I used 30 years ago; increases in memory and processor speeds have allowed the development of software that regulates qualitatively different computer “behaviors,” but does the human-ape distinction derive solely from mass effects?

The debate over whether ape-human behavioral capacities derive from certain parts of the human brain being disproportionately larger is difficult to resolve. Different studies report conflicting results. The postmortem studies reported by Stephan and his colleagues (1981), for example, generally do not show dramatic isolated differences in volume for particular parts of ape and human brains. The anatomical studies reported by Gannon et al. (1998) again show similarities between the Planum Temporale in human and chimpanzee brains. There also seems to be some uncertainty concerning the degree of correspondence between the specific areas of cortex that have the same Brodmann labels in human and other primate brains. I quite agree with Merlin Donald – further research is necessary.

Another area that also calls for further research concerns the cognitive role of the cerebellum. Pickett’s (1998) study of patients having cerebellar lesions failed to show cognitive or linguistic deficits when lesions were restricted to the neo-cerebellum. In contrast, damage extending to other regions of the cerebellum resulted in a constellation of speech motor sequencing, syntax, and cognitive set shifting deficits similar in nature to those occurring in Parkinson’s disease and Broca’s syndrome. As I noted in my book, we seem to know even less about the cerebellum than the basal ganglia – hence my hesitation in discussing this topic.

What seems to be clear is that the Broca-Wernicke model is incorrect. We cannot claim that the brain bases of language and thought are “modules,” independent of neural processes that play a part in regulating motor control and other aspects of human and animal behavior. Indeed, converging evidence from many studies suggests that the FLS derives from mechanisms that yield timely motor responses to environmental challenges and opportunities. In short, motor activity that increases biological fitness, the survival of an individual’s progeny. In this light, the subcortical basal ganglia structures usually associated with motor control that are key elements of the FLS, reflect its evolutionary history –natural
selection operated on neural mechanisms that yield adaptive, that is to say, "cognitive" motor responses in other species.


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