

Doing the Biology of Language

Eric Keller and Myrna Gopnik (Eds.)
Motor and Sensory Processes of
Language

Hillsdale, NJ: Erlbaum, 1987. 306 pp.
ISBN 0-89859-631-9. \$39.95

Review by
Michael Studdert-Kennedy

Eric Keller, professor of linguistics at the University of Quebec (Canada), is author of Introduction aux Systemes Psycholinguistiques. ■ Myrna Gopnik, professor of linguistics at McGill University (Montreal, Canada), is coeditor, with I. Gopnik, of From Models to Modules. ■ Michael Studdert-Kennedy is professor of psychology at the University of Connecticut, president and director of research at Haskins Laboratories in New Haven, Connecticut, and professor of linguistics at Yale University. He is editor of Psychobiology of Language.

If we are to understand language as a biological system, we need more than a purely formal description of its structure. We must also have an account of the behavioral and neurophysiological processes from which that structure derives. For many years, understanding of these processes rested almost entirely on inference from abnormal behavior in language breakdown. But over the past 30 years we have gained experimental access to normal language processes. The generative revolution in linguistics has precipitated empirically based, information-processing models of normal language function, and advances in neurophysiology have enlarged our grasp on underlying sensorimotor processes. The result is what amounts to a new subfield of language study, the neuropsychology of on-line language processing. This is the topic of the book under review.

The book consists of an introduction by the editors, setting what follows into historical, scientific context, and a dozen

chapters by active researchers in psychology, neurophysiology, and aphasia. Most of the contributors (15 of 22) and most of the chapters (7 of 12) come from Canadian research centers, heirs to the French tradition of aphasiology. The general bias of the book is toward motor rather than sensory processes, and these will be the focus of most of what I have to say.

The book opens with a drolly written piece of bibliographic delving that proves surprisingly apt. The authors (Lecours, Nespoulos, and Pioger) outline the virtually unknown work of Jacques Lordat (1773-1870), Doctor of Medicine, professor of physiology at the University of Montpellier in southern France, and "a (if not the) founder of aphasiology" (p. 1). Lordat developed, perhaps as early as 1820, an introspective account of the normal course of speaking, from word retrieval and serial ordering of the retrieved words according to syntactic conventions, through an unfolding program of "syn-

ergetic" control with attention to prosody and rhythm, to the activation of "bodily memory" and the mechanical coordination of speech movements. Lordat then deduced from the posited course of normal function what forms of dysfunction might occur. Finally, he looked among his patients for examples of the hypothesized dysfunctions. He found and named various patterns, including "verbal amnesia," roughly corresponding, it would seem, to Wernicke's aphasia, and "asyn-ergetic alalia," corresponding either to pure anarthria or to Broca's aphasia. Lordat (who himself suffered a severe aphasic episode in middle age) emphasized that the patient's intellectual capacity ("sens intime") remained intact. He thus anticipated a view of language as an autonomous "module," independent of general cognition.

I have dwelt on Lordat because, ironically, his work serves as an epitome of the new approach to language processing (from the normal to the abnormal rather than the reverse), and because many of the following chapters lend behavioral and neuropsychological substance to his insights. Thus, Shattuck-Hufnagel (SH) exploits the preponderance of word-onset consonants as targets of speech error, to "unpack" the early stages of Lordat's introspective account. She expands her "slots-and-fillers" model of speech production planning (e.g., Shattuck-Hufnagel, 1983) into a five-step process that not only explains the error bias but also embodies a mechanism by which patterns of lexical stress may mesh with hierarchical, phrasal syntax to form the metrical structure of an utterance.

Implicit in the SH model is the possibility that syntactic form has evolved under constraints from the natural rhythm of action, the source of metrical structure. The common kinematic regularities of both speech and limb movements (Ostry and Cooke), and the possible origin of those regularities in the intrinsic dynamics of the motor system (Kelso and Tuller), thus emerge as a potentially crucial link between cognitive planning and more peripheral motor processes. Of course, behavioral function is grounded in neural anatomy and physiology, and functional models must, in the end, conform to their modes of physical realization. This is the theme of a chapter by Gracco and Abbs, charting in authoritative detail the cortical and subcortical structures and pathways by which speech motor programs are executed. The chapter includes an excellent discussion of experimental results from perturbation studies, assessing

the role of feedback from muscle receptors and cutaneous mechanoreceptors in speech motor control.

Much of this work comes together in an ambitious synthesis by Keller. He draws an important distinction between the more-or-less time independent processes of cognitive planning (open-class, content word selection, and syntactic organization) and the "automatized," time-constrained processes of motor programming and execution that operate on recurrent, predictable elements (phonemes, syllables, and closed-class function words). Given the rapid rate of speech (some 10 to 15 phonemes per second), and the large number of speech muscle groups to be controlled (around 60), some degree of automaticity is essential. Presumably this is achieved by at least partially stereotyped movement synergies (cf. Kelso, Tuller, & Harris 1983). The role of feedback then comes again into question. Keller suggests that the contribution of feedback varies with conditions, and is greater for the language learner than for the skilled speaker. On the basis of both human and simian cortical stimulation studies, he assigns time-constrained programming and execution of motor synergies to primary motor cortex, time-independent planning and movement organization to secondary motor cortex.

To test the adequacy of this broad model of speech output, we can, in the spirit of Lordat, look for evidence of breakdown at the several posited stages. Thus, from a detailed comparison of the performances of Broca's aphasics and conduction aphasics in oral reading and repetition, Nespoulos and his colleagues (Ska, Caplan, and Lecours) conclude that conduction aphasics are impaired at the interface between planning and motor processes, and Broca's aphasics are impaired in programming and execution. Keller concurs, adding that Wernicke's aphasics appear to be impaired at the level of planning. What is new here is that the impairments are diagnosed (much as, say, a heart ailment might be diagnosed) on the basis of an independently motivated account of normal function.

I have no space to discuss all the remaining chapters that follow the more familiar course of inferring normal from abnormal function. These chapters give more attention than the others to perceptual processes and therefore, not surprisingly, to language modularity. Marshall has a beautifully argued chapter on acquired forms of dyslexia and dysgraphia, which includes a brief but lucid discus-

sion of the vices and virtues of the "new diagram-makers" (p. 242), addicts of boxes (processing stages), and arrows (information flow between boxes), among whom he counts himself. Striking too is a chapter by Paradis on double dissociations between aspects of reading and writing in Japanese dyslexic and dysgraphic patients, and between the various languages of polyglot aphasics. He concludes, following Marshall (1982), that the language faculty fractionates into a collection of "functional modules [that] map fairly directly onto discrete, punctate, but large anatomical modules" (p. 286). Lordat might have been surprised by the anatomical claim, since he was not a localizer. But he would surely have recognized and applauded the general modularity thesis, no less than the elaborated output model we have discussed.

In conclusion, this is a difficult book, packed with experimental detail and intricate argument. But it will repay the persevering reader with a lode of fact, insight, and provocative theory.

References

- Kelso, J. A., Tuller, B., & Harris, K. (1983). A "dynamic pattern" perspective on the control and coordination of movement. In P. F. MacNeilage (Ed.), *The production of speech* (pp. 137-173). New York: Springer-Verlag New York.
- Marshall, J. C. (1982). What is a symptom complex? In M. A. Arbib, D. Caplan, & J. C. Marshall (Eds.), *Neural models of language processes* (pp. 389-409). New York: Academic Press.
- Shattuck-Hufnagel, S. (1983). Sublexical units and suprasegmental structure in speech production planning. In P. F. MacNeilage (Ed.), *The production of speech* (pp. 109-136). New York: Springer-Verlag New York.