

## From Reading to Neurons

**Albert Galaburda (ed.)**

The MIT Press, 1989

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In June of 1987 a conference on developmental dyslexia took place in Florence, Italy. It was organized by Albert Galaburda, Associate Professor of Neurology at Harvard Medical School and Director of the Dyslexia Neuroanatomical Laboratory at the Beth Israel Hospital in Boston. *From Reading to Neurons*, edited by Galaburda and the latest in John Marshall's series *Issues in the Biology of Language and Cognition* (MIT Press), is a collection of most of the papers presented at the Florence conference.

An extraordinary diversity of topics and perspectives is represented in these 20 chapters, ranging from developmental cognitive science and linguistics to experimental neuropathology and molecular neurobiology. Underlying these various and not usually associated discussions is a grand theme that through a better understanding of recent advances in these assorted disciplines, a broader and more unified understanding of developmental dyslexia may be gained. To the behavioral studies of language acquisition is brought the anatomist's finding of structure, and to the molecular biologist's data on cell-and substrate-adhesion molecules is brought an unusual but intriguing context. Although focused on developmental dyslexia, the volume orients itself firmly in the broader inquiry into mind and brain, with particular emphasis on their development.

In the general organization of this collection, the earliest chapters most directly discuss studies and interpretations of developmental dyslexia. Paul Bertelson and Béatrice De Gelder, in "Learning about Reading from Illiterates," review the hypothesis of "phonological awareness"—that explicit knowledge of the phonological structure of language required for the acquisition of reading and writing but not for speech; André Lecours ("Literacy and Acquired Aphasia") presents his group's findings concerning the effects of unilateral strokes on the language of illiterates. In the first of companion

pieces, John Morton distinguishes between acquired and developmental dyslexia and summarizes the work of Uta Frith, elaborating on a model with three sequential strategies for reading ("logographic," "alphabetic," and "orthographic"). John Marshall counters strongly, citing the indistinguishable reading responses elicited from the developmental dyslexic and the adult with acquired dyslexia. He goes on to outline three primary routes—phonetic, direct, and lexicosemantic—mediating reading in a normal "universal functional architecture." Surface and deep dyslexia find modeling representations in both Morton's and Marshall's schemes. The latter closes with one of the more unusual notes: "Acknowledgment: I would like to thank John Morton and Andy Ellis for their provocation."

A third of the way into the book, Jacques Mehler, writing on "Language at the Initial State," introduces his findings on infants with an orientation that parallels the structure of the book: "paying attention to the biological foundations of this faculty provides theoretical constraints that insure that our endeavors will be fruitful in the end." After strong pieces on computational modeling by Patricia Churchland and Terrence Sejnowski and by Mark Seidenberg and James McClelland, things become distinctly clinical; "biological foundations" are strengthened. Hanna Damasio and colleagues discuss "Aphasia in Men and Women"; Galaburda and associates lay down a keystone chapter, "The Neural Origin of Developmental Dyslexia: Implications for Medicine, Neurology, and Cognition."

The last part of the volume follows the editor's lead and focuses on specific hard-science topics, such as abnormal cortical development, hormonal effects on the developing brain, and those adhesion molecules and their role in neural histogenesis. It is particularly these latter chapters that fulfill Galaburda's goal to bring to the

discussion of developmental dyslexia new research ideas. Not specifically directed at dyslexia, they nevertheless flesh out some of the hypotheses alluded to earlier. Having thus traveled through an unusual spectrum of disciplines, the reader appropriately finishes with Yadin Dudai's balanced but positive justification of reductionist analysis.

There are two strengths in *From Reading to Neurons*. The first is simply the quality of the majority of its constituent contributions, and the second is a superior editorial performance on the part of Galaburda. With regard to the first, an all-star cast of contributors—Antonio Damasio, John Marshall, Pasko Rakic—guarantees a certain level of expertise and credibility. It is the material itself, of course, that must enlighten and entertain the reader, and it does this repeatedly. In “Dyslexia: Perspectives from Sign and Script,” for example, Ursula Bellugi and co-workers share with the reader the world of linguistic systems that are primarily visuospatial rather than auditory. Studying deaf children of deaf parents, they illustrate in subjects whose primary language is visual and non-phonologic that their language shares all the linguistic complexity of other languages. With a layered rather than linear organization, their language uses spatial loci for referential indexing, verb agreement, and other grammatical relations (plentiful illustrations serve well here). Most interestingly, the language is acquired at the same pace in these subjects as other languages are in other children: at two years of age, they start using uninflected signs, and at three, they have learned fundamental principles of verb grammar such as inflections for person and number, and overgeneralize with normally uninflected verbs. Complementary studies exploring the effects of unilateral hemispheric damage, a visuospatial script (Chinese) and even Chinese sign language are similarly engaging in themselves and lead comfortably through a coordinated argument for certain central linguistic principles.

A similarly intriguing contribution is that of Thomas Bever and co-workers, which challenges the notions that all normal people process language in basically the same way and share a common or “normal” neurologic substrate for language. Geschwind and Galaburda's theory of cerebral lateralization in which an association between left-handedness and dyslexia, certain nonlinguistic talents, and autoimmune disorders is recognized, suggests among many other things, that even among right-handers different cortical representations for language ability and different language-processing styles may be present and that familial left-handedness may serve as a phenotypic marker for this. Looking at two groups of right-handed individuals differing only by the presence or absence of a left-handed family member, Bever cites multiple studies showing that the two groups differ in their relative dependence on structural (syntactic, semantic, phonological) versus conceptual information in language processing. Right-handers with familial left-handedness

seem to rely consistently less on the former. Given the classical wisdom that even the majority of left-handed individuals are left-hemisphere dominant, the somewhat inverse revelation that a significant proportion of right-handers process language differently is hardly a trivial observation.

An equal strength of this volume derives from Galaburda's editorial role. In addition to his other responsibilities, Galaburda has set himself the task of providing a commentary following each contribution. Ostensibly to aid readers through disciplines out of their field, the format runs the risk of pretension and excess; Galaburda is well above both. After reading only a few of the commentaries, one genuinely looks forward to the insights provided. A primary role of these short pieces is to unify the assortment of often disparate contributions. If the book's thematic thread is ever not apparent to the reader, Galaburda ensures its visibility. Lecours may speak of acquired language disorders in Brazilian illiterates, but the Editor's Comments point out the issue relevant to developmental dyslexia of abnormal initial state and the role of illiteracy per se. In another, Galaburda writes, “it is not immediately obvious what the contribution of developmental molecular neurobiology to the study of reading problems might be,” and then justifyingly goes on, “Yet only molecular neurobiology offers the possibility of specifying the actual mechanisms of gene expression and their epigenetic regulation.” In addition to bringing ideas together, the Comments augment the discussion. Implications and new ideas abound. When Churchland and Sejnowski discuss neural networks, Galaburda ties in conclusions from chapters by Kathryn Crossin and Gerald Edelman and by Dudai to speak to a phylogenetic selection of “relatively hardwired weightings of neuronal assemblies” (possibly translating “at higher levels into sentential or logical thinking”) that might obviate ontogenetic learning. In response to a piece on “Abnormal Neuronal Patterns and Disorders of Neocortical Development” by Verne Caviness, Jr., and colleagues, Galaburda muses on the implications of “exceedingly robust” innate functional dispositions and great variation in structure: “We must conclude, therefore, that the architecture of brain structures from genes to hemispheres may be capable of great structural variation without changing the functional dispositions of the final product. This is a very disturbing conclusion if we are interested in finding out how functional dispositions are represented at the level of material substance.” The editor's Comments are thoughtful and terse, leaving one always wanting more.

Criticism of *From Reading to Neurons* will take aim not at individual contributor's statements (such as Mehler's claim that newborns truly distinguish between French and Russian or the omission of rigorous statistical analysis supporting Bever's remarkable data) but at the great challenge of pulling together such an assortment of pieces. Does it work or is the theme too grand? Chap-

ters attempting to draw inferences relevant to developmental dyslexia are replete with precautions, caveats, and speculation; to an even greater extent this is true of more tangential contributions. The density of hypotheses must be unsurpassed.

The conclusion of this reader is that it succeeds convincingly. Wherever speculative, the authors are conscientiously upfront. Wherever hypothetical, they are true to the volume's purpose of furthering future understanding and investigation. The work succeeds in part because

of the talent assembled and equally because of Galaburda's vision. When the legitimacy of a later chapter's inclusion may be questioned, one is willing to give the editor the earned benefit of the doubt. Rather than a liability, the variety of topics assembled here is the collection's appeal, and it is to a far wider audience than any one particular discipline. The only thing better than reading Galaburda's *From Reading to Neurons* would to have been in Florence.