

MOTOR and SENSORY
PROCESSES
of LANGUAGE

Edited by

Eric Keller
Myrna Gopnik



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MOTOR and SENSORY
PROCESSES
of LANGUAGE

NEUROPSYCHOLOGY AND NEUROLINGUISTICS

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PROCESSES
of LANGUAGE

Edited by

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Introduction: The Neuropsychology of Motor and Sensory Processes of Language

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Until about 1970, neuropsychological and neurolinguistic research remained largely rooted in its medical origins and pursued a tradition of taxonomic distinction of language behaviors.

This approach to language had evolved from the diagnosis of neurological dysfunctions, and it defined classes of behaviors primarily by their degree of impairment through insults to various parts of the brain. For example, articulation behaviors were systematically distinguished from comprehension behaviors in this tradition, because one type of patient (the Broca's aphasic) regularly showed disturbed articulation in the presence of essentially intact auditory comprehension, whereas another type of patient (the Wernicke's aphasic) had a relatively greater comprehension disturbance, accompanied by a lesser articulation impairment. During a century and a half, this approach proved to be invaluable for patient classification and for distinguishing those cognitive and linguistic functions that can be selectively impaired through a neurological lesion.

However, as neuropsychological and neurolinguistic concerns expanded into a search for larger models of real-time language functions in the brain, the taxonomic tradition began to give way to the information-processing approach. In this perspective, various subsystems of human functioning are proposed on the basis of both, normal and neurally impaired behavior, and an attempt is made to understand the effects of a neurological lesion as the interaction of normal, pathological, and compensatory processes. A disorder

such as Broca's aphasia might thus be seen as a partially compensated impairment of the articulatory programming process, a language function that can be defined on the independent basis of slips of the tongue of normal speakers and experiments in articulatory phonetics.

MOTOR AND SENSORY PROCESSES OF LANGUAGE

In the forefront of this change in research emphasis has been the study of motor and sensory language processes. These processes are easier to represent symbolically than are most other higher functions, and thus admit more readily of experimental verification, statistical analysis, and theoretical manipulation. Further, the study of these processes often provides insights into the functioning of associated, more central processes, and because they show considerable complexity, they are excellent representatives of higher mental processes in general.

A variety of empirical approaches and theoretical presuppositions are typically brought to bear on these questions. Empirically, error frequencies on specific tasks in normal and neurologically impaired populations, reaction times, kinematic and perceptual measures, as well as neurophysiological and neuroanatomical evidence, forms the rich source of data considered in connection with these issues. Theoretically, the research has been guided by notions originating in linguistics, psycholinguistics, cognitive psychology, phonetics, neurology, and neurophysiology. Yet despite the sometimes bewildering variety of empirical and theoretical arguments, some lines of general agreement are beginning to emerge concerning how neuropsychological phenomena should be understood.

First of all, real-time language processes are clearly modular in nature. This has been demonstrated not only through differential neural impairment, but also by means of detailed analyses of normal speech and perception errors. This is not surprising, because physiological and anatomical evidence bearing on linguistic as well as non-linguistic functions in humans and animals leads us to fully expect modular functioning in language. Today, the question is no longer whether language processes are modular, but which components are to be distinguished, how sharply the components are demarcated from each other, how they operate internally, and how they communicate among themselves.

Secondly, and even more fundamentally, there is general agreement concerning the desirability of understanding language processes in terms of their real-time, or "on-line," functioning. Researchers in this domain specifically address questions of how real-time language processes should be conceived when constrained by time and when interacting with learning and memory

processes. This work is a natural complement to the work being done in theoretical linguistics, where the aim is to discover the universal properties that underlie all grammars of natural languages, irrespective of time and memory constraints.

Finally, there is wide agreement in this field that theories of language processing must ultimately link up with theories of brain function. Although points of view differ as to the degree of correspondence that can presently be documented for a given language process, there is little dispute about the desirability of this conceptual link, about the pertinence of information from lesions to circumscribed portions of the brain, and about the relevance of neurophysiological and behavioral experiments on motor and sensory processes similar to those used in language. Gone are the days, one may hope, where noted psychologists publicly insisted that it did not matter whether language was processed by the brain or by the big toe.

THE HISTORICAL CONTEXT

Present-day concerns in this domain can thus be seen to be coalescing around a perspective of real-time, modular language processes mediated by the brain. It is useful to consider the development of this view in the context of the large-scale conceptual changes that have permeated the behavioral sciences during the past 20 years.

Prior to 1960, all human and animal behavior, no matter whether motoric, sensory, or cognitive, tended to be interpreted in terms of real-time processes of very great generality. In this, the so-called behaviorist or associative chain view, stimulus A was seen as giving rise to a learned response B, which in turn could evoke learned response C. For A to occur, it did not matter whether B or C was meaningfully or physiologically related to A, just that it had been learned as a regular contingency of A; further, any action was thought to be motivated by the animal's immediate "need" to reduce a fundamental drive, such as hunger, thirst, or sexual desire.

It was in their application to language that these notions were most clearly shown to be inadequate. One of the first major critiques came from the noted physiological psychologist Lashley (1951), who pointed out that an associative chain notion of motor action could not explain spoonerisms (because associative chain theories make no provision for speech planning), and that associative chain control would be too slow to account for measured delay times in limb movements. In another celebrated critique, Chomsky (1957) took exception to a number of aspects of behaviorist theory, such as the notion that language learning should be contingent on the need to reduce a given drive. He reflected a growing sentiment in the behavioral sciences; in

1953, Harlow had summarized a large number of observations showing that contrary to behaviorist expectations, simians do worse at learning various cognitive tasks when in physiological need than when not obviously affected by a primary drive. Other authors, such as the European ethologists, pointed out that responses differed from species to species and depended on the existence of predispositions toward such behaviors. Although not directly concerned with language, they prepared the terrain for Lenneberg (1967) and Chomsky (1968), who argued convincingly that language, too, depends on a special predisposition for its development.

From the profound reevaluation of the understanding of human and animal behavior that ensued, two divergent, yet ultimately compatible lines of research have emerged. One of these research endeavors is to identify the extent, the internal structure and the content of these predispositions toward the development of given behaviors in various specific domains. In the domain of language, this approach has been pursued within the Chomskyan framework, which examines in detail the species-specific innate constraints on constructing grammars, constraints that are claimed to be autonomous and not derivable from general cognitive functions. In the domain of social behavior, there has been a similar attempt by sociobiologists to account for specific behavior patterns toward which organisms might be predisposed. Although the existence of predisposition in one domain does not necessarily argue for the existence of predispositions in another, these two research endeavors are inspired by the same fundamental question.

The other major research trend is to examine the real-time processes of behavioral functioning. As exemplified primarily by research in physiological psychology, perception and motor control, this trend is concerned with establishing the real-time functional and neurophysiological events associated with a given process. In language, this means attempting to pursue the path of perceived linguistic events through its functional sequence of sensation, perception, and comprehension (mediated by cranial nerve, brain stem, thalamic, and cortical structures), and to chart out the path of produced linguistic events from intention through planning to motor processing (involving the cortex, the central gray structures, the cerebellum, and the brain stem).

Although the two research traditions presently tend to involve separate practitioners, different research tools and heterogeneous conceptual presuppositions, it is inevitable that the two manners of understanding language will ultimately have to converge. This is because language can only be manifested through the interaction between predisposition and real-time processing: language develops spontaneously through predisposition, and the predisposition only becomes evident through real-time language use. A full understanding of language can thus only emerge from an appreciation of research results of both approaches to this question.

THE PRESENT VOLUME

The chapters in this volume were contributed by a group of dynamic and resourceful representatives of the neuropsychological process approach to language research. The purpose of this volume is to collect chapters that represent the state of the art in this domain both theoretically and empirically, and that bring together researchers who, despite their different backgrounds, present a coherent and contemporary view of the motor and sensory processes of language.

Two major concerns characterize these chapters. Some authors, particularly those focusing on motor processes, are concerned with how to describe the details of language processing. Novel conceptions of processing mechanics are presented in chapters by Shattuck-Hufnagel, Bub, Keller, and Kelso and Tuller, and established processing hypotheses are examined by Nespoulous, Joannette, Ska, Caplan and Lecours, Caplan, Gracco and Abbs, and Ostry and Cooke. Some other contributors, especially those working in the domain of sensory processes, have focused on the issue of modularity: chapters by Bub, Marshall, Blumstein, and Paradis provide further details on the functional independence (as well as the interdependence) of various subcategories of the motor and sensory processes of language.

The book opens with a report by Lecours, Nespoulous, and Pioger on Jacques Lordat (chapter 1), a hitherto practically unknown early aphasiologist. Lordat was an insightful observer of neuropsychological phenomena (the authors call him "the first cognitive neuropsychologist"), who lived in southern France in the middle of the 19th century and probably published his first aphasiological treatise some 40 years before Broca's celebrated report of 1865. All but ignored by the Parisian neurological establishment, it appears that Lordat was instrumental in launching the modern aphasiological tradition.

The section on motor processes begins with chapter 2 by Stefanie Shattuck-Hufnagel; she summarizes her previous theoretical contributions to a speech production model, derived from spontaneous speech errors in normal speech (spoonerisms, etc.). In her present contribution, she argues that errors that exchange a single phoneme provide powerful evidence in favor of word-onset consonants forming a separate processing class. Shattuck-Hufnagel integrates these results into a "slot-and-filler" model of speech production, whereby word-onset consonants form one type of slot in the motoric matrix into which words are copied as they are transferred from planning to motor processes during speech production.

The study by Nespoulous, Joannette, Ska, Caplan, and Lecours (chapter 3) examines phonological errors on repetition and oral reading tasks for conduction and Broca's aphasics. This comparison is of importance to our understanding of speech production because it confirms previous analyses that

suggested that errors of conduction aphasics probably occur at the interface between planning and motor processes, whereas errors of Broca's aphasics are more indicative of motoric impairments. In a detailed statistical analysis, the authors show that the errors of conduction aphasics are essentially unpatterned, whereas those of Broca's aphasics show systematic tendencies likely to be related to motoric difficulties (devoicing and changes in place of articulation). These results lend credence to what seemed at the time to be a somewhat risky hypothesis that suggested that vowel errors of Broca's aphasics (which show a lowering tendency) are primarily indicative of motoric execution difficulties (Keller, 1975, 1978).

Chapter 4 by Bub, Black, Howell, and Kertesz investigates the question of the relative independence of language modules with respect to two specific processes, a central process specifying lexical information to be used in speaking and writing, and a more peripheral planning process charged with cumulating, or buffering, this information prior to motor outputting. By comparing meaningful and nonsense word production by three neurologically impaired patients, and by eliminating alternative hypotheses, the authors arrive at a very specific hypothesis of the impairment. They show on the one hand, that the patients' difficulties are best explained by assuming a decaying output trace in the planning buffer, and on the other hand, that these impairments are partially compensated (or even overcompensated) by information furnished to the planning buffer by the lexical process.

Caplan's contribution (chapter 5) is concerned with developing a model for word production that accounts for the data and is consistent with current linguistic theory. In order to test several proposed models, he uses data from a conduction aphasic. Caplan shows that this data is inconsistent with several of the proposed models. However, it is consistent with a model that includes a level of representation of the underlying phonological form of the word. Such a representation is necessary for the construction of adequate phonological theories of normal language. The patient's disturbance can therefore best be accounted for within the framework of a linguistically rich model. Caplan claims that this model has further implications, for example in accounting for dyslexia. The existence of an abstract, underlying phonological representation is justified both at the theoretical and the empirical level.

Keller's chapter (6) provides a transition between the immediately preceding contributions, which are primarily of relevance to neurological speech impairments, and the directly succeeding chapters that treat normal speech production. An integrated hypothesis for speech motor control is outlined on the basis of a review of the main currents of recent research on normal speech processes, as well as by considering some relevant neurophysiological data; neurological speech impairments are then related to the proposed speech processes. In this manner, the chapter attempts to relate information from a large variety of sources to the question of what specific operations are pre-

formed by the various planning and motor processes in real-time speech production, and tries to characterize neurological impairments in the light of the proposed operations.

Gracco and Abbs (chapter 7) contribute a chapter that takes this approach yet one step further. By concentrating on processes concerned with the integration of sensory and motor information in speech, the authors painstakingly review literature indicating likely neuroanatomical pathways mediating these processes. The combined effect of the reviewed information is overwhelming; with respect to strongly motoric or strongly sensory language functions, progress is clearly being made in charting out the likely neuronal structures subserving those functions.

Kelso and Tuller's chapter (8) takes us into another major current of contemporary thinking in speech motor control, a conception of speech in terms of the kinetic interactions of the participating neuromuscular structures. In previous papers (Kelso & Tuller, 1981; Kelso, Tuller, & Harris, 1983), these authors presented arguments and experimental evidence in favor of a strong interaction between central and peripheral components of speech. In contradistinction to the common assumption that the speech event is fully specified at central processing levels, these authors have argued that several aspects of speech production, such as control over speech rate and over the coordination between various articulatory organs, are in fact achieved by biasing a set of fairly peripheral neuromuscular programs. In the present chapter, they expand on these concepts by arguing that the timing of all articulatory events (not merely the general speech rate) can be explained in terms of processes intrinsic to the articulatory system's kinetic behavior.

A similar theoretical position emerges from chapter 9 by Ostry and Cooke. Although more central events may be usefully characterized in terms of phonemic or syllabic events, the specification of articulatory events will bring into play such kinematic variables as duration, displacement, and velocity. Because the interaction between these variables is likely to be specified in manners that are not unique to speech, but that can be observed for all motor actions, it is of interest to examine whether speech and limb movements share systematic properties of motor control. Indeed, the contribution by Ostry and Cooke is most revealing in this respect; the authors show that the tongue and arm movements of the same subject can be described by a single function relating velocity, duration, and extent of displacement ("movement amplitude") to all speech or arm movement variables, such as variations of rate, stress, and phonemes in speech, or variations in the duration of arm movements. The existence of such "grand" functions poses a provocative challenge to the researcher seeking to relate planning events at the phonemic level to motor events at the kinematic level.

The last three chapters in this volume are most directly concerned with the question of modularity. Marshall (chapter 10) addresses the question of the

modularity of various motorsensory language processes with respect to reading and writing. He shows that the acquired (adult) dyslexias and dysgraphias can impair distinctive processing routes in writing from written text, and that phonological and graphemic processes in speech and writing are probably largely independent from each other.

Blumstein (chapter 11) is also concerned with sensory processes and she addresses similar questions, though from a different perspective. With respect to her own extensive studies in phonemic perception and its breakdown, she demonstrates that linguistic auditory perception is clearly different from general auditory performance. Aphasics, for instance, have no problem distinguishing non-speech sounds, whereas patients with auditory agnosia do, and performance on speech stimuli is not necessarily correlated with performance on similar non-speech, or synthesized stimuli. Yet just as in speech production processing, auditory processing for language is subject to interaction with more central processes; whereas aphasic reaction times on a lexical decision task were shorter for meaningful than for nonsense words (as in normal performance), it showed additional traits reflective of the phonetic impairment typical of these patients.

Finally, chapter 12 by Paradis summarizes some of the most surprising aspects of the modularity of language processes. In Japanese patients with neurological impairments of language, the disorder can affect *kanji* (ideographic) reading and writing independently from *kana* (syllabic) reading and writing. Also, aphasia can impair one language nearly independently of another language, sometimes in alternating fashion. As Paradis maintains, this is indicative of fairly independent processing for different language systems in at least some polyglots. Moreover, relatively independent processing may exist for each orthographic system within each language system.

THE FUTURE

In view of the considerable progress that has been made over the last 15 years in the domain of the neuropsychology of language, it may be of interest to consider some potential future developments in this field.

Just as some of the most important recent gains have been due to the advent of novel techniques of relating mental processes to brain function (dichotic listening, CT-scans, event-related EEG potential, etc.), certain of the future developments in this domain will no doubt be related to further technical improvements in observational techniques. PET scans, nuclear magnetic radiation (NMR), blood flow measurements, intracranial neural recordings and magnetoencephalography (and likely others as well), will be certain to extend and deepen our understanding of the relation between brain function and language processing and its impairments. To take just one of

these techniques in some more detail, consider the measurement of magneto-encephalographic potentials, which is of particular interest to students of the relationship between brain and language functioning. In contrast to EEG event-related potentials, which represent the summation of electric activity over large portions of the cranium, magnetic currents result from the electric activity of relatively small neuronal pools; as a result, it becomes possible to localize more precisely the activity of neuron pools involved in specific language processes than it has been through EEG. It is evident already that this technique is capable of identifying fairly specific and localizable neuron pools related to various aspects of language processing (see Beatty, Richer, & Barth, *in press*).

Another probable development is the emergence of a coherent theoretical statement, which will characterize the functions of motor and sensory language processes in considerable detail. Skeletal hypotheses of speech production first emerged a few years ago from the analysis of spontaneous speech errors; more recently, we have witnessed the integration of findings from neurologically impaired populations. If this volume is any indication, we will soon witness an even grander integration of observations, coalescing notions bearing upon central and peripheral processing into a single hypothesis, and predictive of events observed in normal, aphasic, dysarthric and acquisitional language behaviors. One important area of present imprecision that such a hypothesis will have to deal with is the relative distribution of "intelligence" in the system. What processing is possible in the more peripheral modules of speech production and perception, and what aspects must be reserved for more central processes? How, and to what degree are these responsibilities shared? And how much information is conveyed from one module to another?

Also, there is no doubt that more work will be devoted to an exploration of the relation between language processing, memory, and learning. As psychology has broken away from the shackles of the rat learning model, and has begun to examine more systematically memory loss through neurological impairment, avenues of commonality have developed that permit a productive interplay of hypotheses concerning memory functions and language processes. To which degree, for instance, is the difference between procedural and declarative memory reflected in differential impairments of function and content words (agrammatism vs. anomia)? To which extent is the difference between procedural and declarative memory types conditioned by their strong or weak association with motor processes, and ultimately, temporal constraints acting upon processing speed? It seems evident that questions of this nature can be usefully addressed with existing observational techniques, and that they provide a promising avenue of further exploration.

And finally, computer modeling of language processes will be certain to come into its own right. Hampered by the difficulties of representing a large

set of complex, parallel language processing functions on machines that are still largely built around single, serial processors, computer modelling of natural language production processes has to date been of little theoretical impact in psycho- and neurolinguistics. But toward the end of the decade, when large-scale parallel processors (100 or more) are likely to become available, it will be possible to experiment with the simulation of real-time interactions between several language processing modules. In a relatively short time, in fact, there may not be much choice in the matter. Theories will attain such complexity that the only way of predicting a pattern of interaction between processing functions, or their impairment, may be by means of an astute simulation of language production or language reception processes.

To sum up, it is evident that the study of real-time language processes has now attained vigorous maturity. Kuhn (1970) argued that a given scientific domain comes into its own when it develops a set of reliable demonstrations of empirical fact, what can be called its own "paradigmatic demonstrations." Just such demonstrations are beginning to emerge in this domain, such as the distinction of planning and motor processes on the basis of spontaneous speech errors, or the demonstration of continuous articulatory feedback by means of the perturbation paradigm.

But perhaps even more significantly, it appears that a group of researchers are presently developing various aspects of what is very much beginning to look like a coherent framework of language processing notions. Upon careful reading of the contributions to this volume, it will be found that whether authors state their theoretical presuppositions explicitly or not, they tend to work within a set of overlapping hypotheses. No longer concerned with testing hypotheses derived from a sister science, these researchers are pursuing a theoretical and empirical purpose of their own.

The solid achievements that are reflected in these pages, and the excellent promise of further developments, bode well for the future of the neuropsychology of language.

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1 Jacques Lordat or the Birth of Cognitive Neuropsychology

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ABSTRACT

A few aspects of Jacques Lordat's life, personal experience of aphasia, interactions with his contemporaries, teachings, and scientific influence are outlined. Lordat is presented as a (if not the) founder of aphasiology. It is underlined that his approach to aphasia was very much akin to that of modern cognitive neuropsychology.

Jacques Lordat (Fig. 1.1) was born in Tournay, near Tarbes, in the Hautes-Pyrénées, on February 11th, 1773. In 1793 he became a military hospital student in surgery ("admis dans les hôpitaux militaires comme élève en chirurgie") (Larousse, 1878); thus, part or all of the training which led to his title of military surgeon ("chirurgien militaire") took place in Plaisance, Gers, where, according to Bayle (1939), Lordat was the disciple of a Doctor Broca.

Now, Schiller (1979) points out that "Broca" is not a common name and that the Broca family (which included a number of soldiers and doctors) was a tightly knit group. However, one only has to glance at a map of France (Fig. 1.2) to see that Plaisance is less than 150 kilometers south of Sainte-Foy-la-Grande, Gironde, where Pierre Paul Broca was born in 1824 and where his family had in all likelihood dwelt since the second half of the 16th century (Schiller, 1979). One wonders if young Lordat's first mentor, Doctor Broca of Plaisance, lived long enough to keep an eye on the earlier phases of



FIG. 1.1 Jacques Lordat teaching at the Faculty of Montpellier (circa 1860).

his disciple's medical career. One also wonders when, and in what circumstances, Pierre Paul Broca—whose father, Jean-Pierre dit Benjamin, was also a medical doctor—first heard about speech disorders resulting from brain lesions.

Lordat soon left Plaisance to study medicine at the famous Faculty of Montpellier, which in those days was considered by many scholars to outrank the faculty of Paris. Lordat's link to the Montpellier School of Medicine was a long lasting one. In 1797, at the age of 24, he received his diploma of Doctor in Medicine. Two years later, after having served as a prosector, he was teaching at the Faculty as a "Professeur libre." Tenure came in 1811 when, then aged 38, Lordat was appointed "Professeur agrégé de médecine opératoire." In 1813, when Dumas died, Lordat succeeded him as "Professeur titulaire de la chaire de physiologie," an appointment that he retained for half a century (including the period when he served as Dean of the Faculty; Bayle, 1939), that is, until a little before his 90th birthday. It was Lordat's overt opinion that, just like the cardinals of the Roman church, the professors of great medical schools should never retire (Lhermitte, personal communication, 1984).

Lordat died in Montpellier, on April 25th, 1870, at the age of 97 (Bayle, 1939). By then, Paul Broca had lost his interest in aphasia, or rather

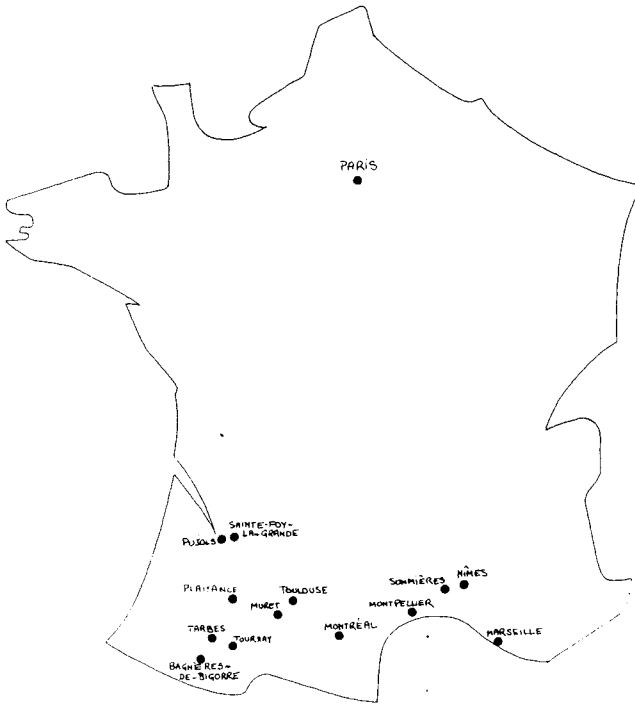


FIG. 1.2 The Hexagon.

aphemia, and, before becoming a Republican senator (Schiller, 1979), he had turned his attention and energy to worthier causes such as demonstrating that, although German big-brainedness became an obvious artifact once one's data were cleaned with great scientific care, women did indeed have smaller brains than men, and that Negroes did indeed have smaller brains than white men, and therefore that "inferior" groups are interchangeable in the general theory of biological determinism," and therefore that "social rank reflects inner worth," and so forth (Gould, 1981).

Schiller (1979) wrote that "the subject of loss of speech is in several ways tied to Montpellier, where Lallemand had been interested in it and where Lordat had given in 1820 (sic) a classical account of the mechanism and psychology of speech and its clinical disorders" (p. 193). Schiller's bibliography indicates that he found this information on Lordat's 1820 contribution in Ombredane's "L'aphasie et l'élaboration de la pensée explicite" (1951). Now, if one goes to pages 47 and 48 of Ombredane's most remarkable monograph, one can read interesting comments on Lordat's teachings as published in 1843, not 1820.

Before Schiller, Moutier, a few weeks before he was dismissed by Pierre Marie in 1908 (Lecours & Caplan, 1984; Lecours & Joannette, 1984), published his inaugural dissertation entitled "L'aphasie de Broca." The first section of this monumental book deals with the evolution of ideas concerning the mutual relationships of brain and language. Moutier (1908, p. 16) mentions three publications by Lordat: a paper printed in 1820, a book entitled *analyse de la parole* and published in 1823, and the well known Montpellier lessons of the 1804s, published in two consecutive issues of the *Journal de la Société de médecine pratique de Montpellier* (1843). Moutier raises several points in relation to the 1823 book, and he claims that this publication and the earlier one are much clearer and far more enlightening than the lessons published in 1843.¹ But then, when one consults the astonishingly exhaustive bibliographical index of Moutier's dissertation, in which are listed nearly 1,500 references on aphasia and related topics, one finds (p. 689) an 1820 reference to a paper written by Lordat in a journal identified by Moutier as *Revue périodique de la Société de médecine de Paris*, and also (p. 690) an 1843 reference to the Lordat lessons published in Montpellier. No reference is provided in relation to the 1823 "enlightening" monograph.

Likewise, before François Moutier (1908), Armand Trousseau (1877) had alluded to Lordat's early publications on aphasia (cf. *infra*), and before Trousseau the Daxes, father and son, Marc and Gustave, both of whom were of strict Montpellieran obedience. In brief, this latter story is the following:

Act I

In July, 1836, Marc Dax, who was then practicing medicine in Sommières, a small town in the vicinity of Nîmes (Fig. 1.2), submits and probably reads a paper at the "Congrès méridional de Montpellier" (Hécaen & Dubois, 1969). In this paper, Dax, the father tells about his own clinical and anatomical observations as well as those of others, and he concludes that acquired disorders of "verbal memory" are the result of lesions of the left but not of the right cerebral hemisphere. This communication is not published in Montpellier, as it might have been—although it seems to be a recognized fact that, contrary to the Faculty of Paris, the Faculty of Montpellier traditionally gave credit to oral transmission of knowledge at least as much as, and conceivably more than, to written documents (Bayle, 1939; Guedje, personal communication, 1984). The original manuscript is lost but Dax has a copy. Marc Dax dies in 1837 and his son inherits the copy as well as

¹ Of course, Moutier knew, in 1908, that Lordat had himself been struck by aphasia in 1825, but little did he know that the same would happen to him 53 years later.

his father's practice and, apparently, his preoccupation concerning the lateralization of the brain lesions responsible for acquired disorders of "verbal memory".

Act II

According to Quercy (1943), whom we believe to be a particularly reliable historian of early French aphasiology, the sequence of events is thereafter the following: **Scene I:** On March 24th, 1863, Gustave Dax officially deposits his copy of the paternal manuscript at the "Académie de médecine," in Paris, together with a paper of his own on the same topic; Joynt and Benton (1964) might be right when they suggest that Marc Dax was not ready to claim priority in 1836, but it is quite clear that Gustave was in 1863. An editorial committee is then appointed by the Academy, which decides not to publish the Meridional manuscripts for the time being (Hécaen & Dubois, 1969). Bouillaud is a member of this committee (Bayle, 1939). **Scene II:** Hardly a month later, in April of 1863, Broca publishes an updated version of his *Exposé de titres et travaux*, in which he raises the possibility of left hemisphere specialization for language. When the *Exposé* comes out in printed form, it is dated 1862 rather than 1863 (Quercy, 1943). As Bogen and Bogen (1976) wrote about Wernicke's 1874 representation of the speech area at the surface of a right hemisphere, this was probably "more in the nature of a printer's error than anything else". **Scene III:** Broca (1863) strikes again in May, this time through a note entitled "Siège du langage articulé" and published in the *Bulletin de la Société d'anthropologie* (Bayle, 1939). This is not yet the 1865 paper but Broca is explicit enough and, according to Quercy (1943), this note is the document that led Bouillaud, and Paris after him, to attribute priority to Broca rather than Dax: "Broca avait précisé en 63 et Bouillaud lui accorda l'honneur de la découverte." Interestingly enough, in his May note to the "Société d'anthropologie" (of which he was the most influential founding member), Broca refers to a January note to the "Société de biologie" that preceded the Gustave Dax move at the Academy. Of this January note, Quercy (1943) devastatingly writes, as it were *en passant*: "Je ne l'ai pas trouvée (I did not find it)".

Act III

The Dax papers are finally exhumed and published in 1865, Marc's first and Gustave's immediately following, in the April

25 issue of the *Gazette hebdomadaire de médecine et de chirurgie*. Broca's best and most famous aphasia paper (the one everyone has heard of and the one one quotes, whether or not one has read it, whenever the question of priority is raised) is published a little less than 2 months later, in the June 15 issue of the *Bulletin de la Société d'anthropologie*.

Act IV

In 1879, a Doctor R. Caizergues, of Montpellier, reports in the *Montpellier médical* that he has found the original manuscript of Marc Dax while classifying the papers of his grandfather, Professor F.C. Caizergues, who was the Dean of the Faculty of Montpellier in 1836, at the time of the "Congrès méridional." This fact is mentioned by Bayle, in 1939, by Joynt and Benton in 1964, and by Hécaen and Dubois, in 1969.

Now, this was a longish digression, although not without interest nor without purpose. What we were in fact driving at, on the one hand, is that the post-mortem 1865 paper by Marc Dax includes references to four researchers: The first is Gall, of course, and the second, Bouillaud, of course. The third is a German physician, whose magnificent name is Atheus although he wrote in Latin: "Observatum a me est plurimos, post apoplexiam, aut lethargum, aut similes magnos capitis morbos, etiam non praesente linguae paralyisi, loqui non posse quod memoriae facultate extincta verba proferanda non succurant." Marc Dax writes that he has excerpted this passage from a book edited (?) by Schenkus in 1585, that is, 280 years before the nearly joint publication of his own and Broca's manuscripts. The fourth researcher quoted by Marc Dax in 1865, or rather in 1836 if Gustave did not alter his father's manuscript, is Jacques Lordat. Marc Dax writes that Lordat's ideas on *verbal amnesia* are more in line with his own than are Bouillaud's (Dax senior could not know that Bouillaud would be there to chair the 1863 committee), and he quotes two early papers by Lordat: one in the September 1820 issue of the *Recueil périodique de la Société de médecine de Paris*, probably the same that Moutier quoted in 1908 as published in the *Revue périodique de médecine de Paris* (cf. supra), and the other in the September 1821 issue of the *Revue médicale* (p. 25).

And what we were driving at, on the other hand, is that there exists a problem with Lordat's early publications (1820, 1821, 1823): We tried to find them, but without success. Bayle (1939), who was much closer to the sources than we are in Montréal, tried before us, also without success. Nonetheless, Bayle (1939) found a paper by Bousquet in which he sees proof that Lordat's teachings were known in Paris before Bouillaud's initial paper on aphasia:

As you know, Gentlemen, the muscular movements of speech production succeed to one another as a result of habit, so that one movement calls the next without the intervention of will power. These chains of movements correspond, and I borrow this expression from Monsieur Lordat, to a form of bodily memory (“*mémoire corporelle*”), which is sometimes mistaken for a mental memory although these two forms of memory represent phenomena that are quite different. (Bousquet, 1820)

Be this as it may, Bayle’s (1939) conclusion concerning Lordat’s “early publications” is that they never existed, a point of view that we find difficult to share if only because it is somehow disquieting to ignore bibliographies that were constituted by Marc Dax (1865), Adolf Kussmaul (1876), Armand Trousseau (1877), François Moutier (1908), and Francis Schiller (1979). And the whole affair is of some interest because, if Bayle (1939) is right, it follows that the Marc Dax publication of 1865 was at least in part a fraud: Given that he died in 1837, how could he have quoted papers by Lordat if Lordat did not write on aphasia before 1843? But if Bayle (1939) is wrong, Lordat (1820, 1821, 1823) rather than Bouillaud (1825) deserves the credit of having been the founder of French aphasiology.

For the time being, given our subject matter, we will have to rely exclusively on Lordat’s 1843 Montpellier publication. The first thing one might say about it is that, although Lordat’s and only Lordat’s in all likelihood, and signed by Lordat alone, it was not actually “written” by Lordat but by one of the students who attended his lessons in the course of the academical year 1842–1843. The name of the student was Kuhnholz (Quercy & Bayle, 1940) and he was probably not the first and certainly not the last student in medicine to write for a French professor of medicine.

Now, if one chooses to consider Lordat as the founder of French aphasiology, as we would be inclined to do after pondering available documents, it should then be said that French aphasiology was founded by one who believed that students in medicine should first learn about normal language production and, from there, learn, as it were by deduction, to recognize the nature of the various types of communication disorders that can result of various types of diseases.

Lordat (1843) teaches his students that “from one’s decision to communicate one’s thought, to the embodiment of this thought into conventional sounds, one has to accomplish a succession of various acts, (some of them exclusively mental), each of which should be studied separately” (p. 130). We found it reasonably easy to translate Lordat’s formulation of his ideas into contemporary terms and to represent them following the requirements of contemporary boxology (Fig. 1.3).

The first act, isolating the “topic” or “thought” to be transmitted, is purely intellectual according to Lordat—or perhaps one might say “purely

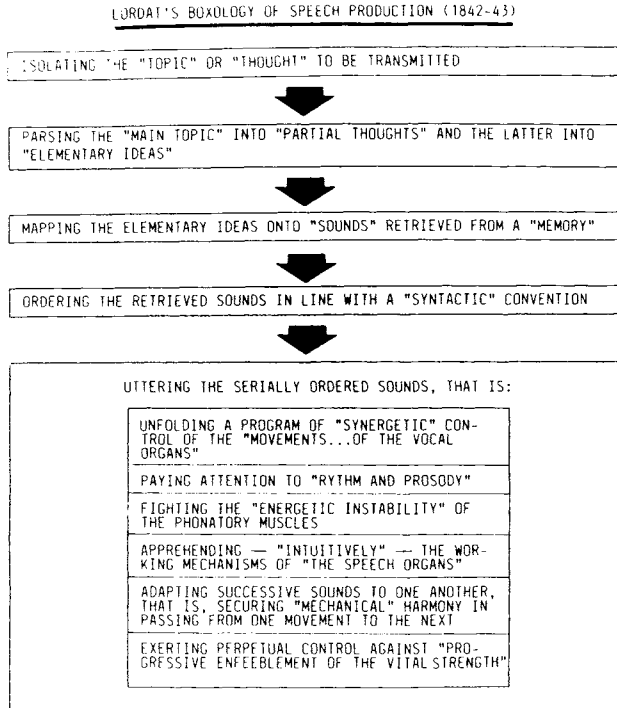


FIG. 1.3 Lordat's boxology of speech production (1842-1843).

cognitive." At all events, it is prelinguistic: It occurs without language and can persist when language is no longer possible or is grossly impaired. Nonetheless, a dysfunction of this initial act will have manifestations in language behavior: *Incoherence* is then the characteristic feature. Alcoholic intoxication, typhus, and somnoliquia are the main clinical entities that Lordat presents as typical in this respect: The subject's mental state, in any of these conditions, is such that thoughts can no longer be properly circumscribed; they are disordered, hence the incoherence in discourse, and this incoherence, discreet or gross, is proportional to the intensity of the intellectual (prelinguistic) impairment. This conception, as developed by Lordat, is perhaps at the origin of the notion of "alogia" as it was 50 years later redefined by Jules Ernest Ségla (1892), one of the early mentors of Théophile Alajouanine (Lecours, Lhermitte, & Signoret, 1981).

Lordat's second act, parsing the "main topic" into "partial thoughts" and the latter into "elementary ideas", is also purely intellectual and prelinguistic. Disorders of this particular act, according to Lordat, do not occur in organic pathology but, rather, as an effect of strong emotions such as surprise, wrath

and indignation. It is because the parsing mechanism is momentarily disturbed by such emotions that the individual in whom they are suddenly aroused cannot talk or, more typically, will attempt uttering “five or six sentences in a row without being capable of finishing a single one.”

After having told his students about these two prelinguistic steps, Lordat turns to the “admirable mental operation;” that constitutes the psychological foundation of human language. His third and fourth acts deal with internal language, and the subsequent ones with overt articulated speech.

The third act is defined as mapping the elementary ideas onto “sounds” retrieved from a memory. Here, the key words are “sounds” and “memory”; Lordat clearly thinks in terms of mental representations of sounds that must be accessed from a specialized memory. What this particular memory has in stock, specifically, has been acquired through associative learning. Sounds have been matched to sharable meanings (sharable insofar as one belongs to a given linguistic community): What others will soon designate as *images*, he labels as *correlative modes* (“les modes corrélatifs du souvenir”), and he apparently conceives of them as plurimodal nets rather than modality specific entities. In order to speak, or else to understand what the interlocutor says, one has to retrieve sets of correlative modes from a specific memory. What would happen, asks Lordat of his students, if one could no longer access this particular memory, or could access it only in a fragmentary or intermittent manner? Well, one would find oneself facing the double drama of impossible or imperfect speech production and impossible or imperfect speech comprehension; although one’s intellectual ability (one’s “sens intime”) would not be impaired, one would be cut from intellectual links with one’s kins. Does such a condition occur in nature? Yes, teaches Lordat; certain diseases, such as apoplexy, can interfere with the retrieving-mapping act, which will perforce interfere with certain aspects of the accomplishment of further acts but not with that of the two preceding ones, the exclusively mental ones (Lordat does not like at all the teachings of Condillac and disciples, especially since 1825: thought is not language nor vice versa, Lordat assures his students). This condition, continues the Professor, is known as “*alalia*”. This term is not precise enough for him, however, and he says that he has coined another to qualify this particular form of *alalia*: “*verbal amnesia*” (Lordat, 1843) or “*alalia by verbal amnesia*” (Quercy & Bayle, 1940). Here, Lordat takes time to tell about observations that he has made or read about, some of them well before 1820. For instance, he bears in mind this rainy day, many years before the disease that has led him to experience *alalia* in his own flesh, when he saddled his horse and went to visit the parish priest of Saint-Guillen-le-Désert (Fig. 1.4), the very first *alalic* patient that he has observed. The priest had been struck by apoplexia, which had resulted in complete verbal amnesia. His actions were appropriate to the situation, notes Lordat; for instance, he made it clear through gestures that his host should,

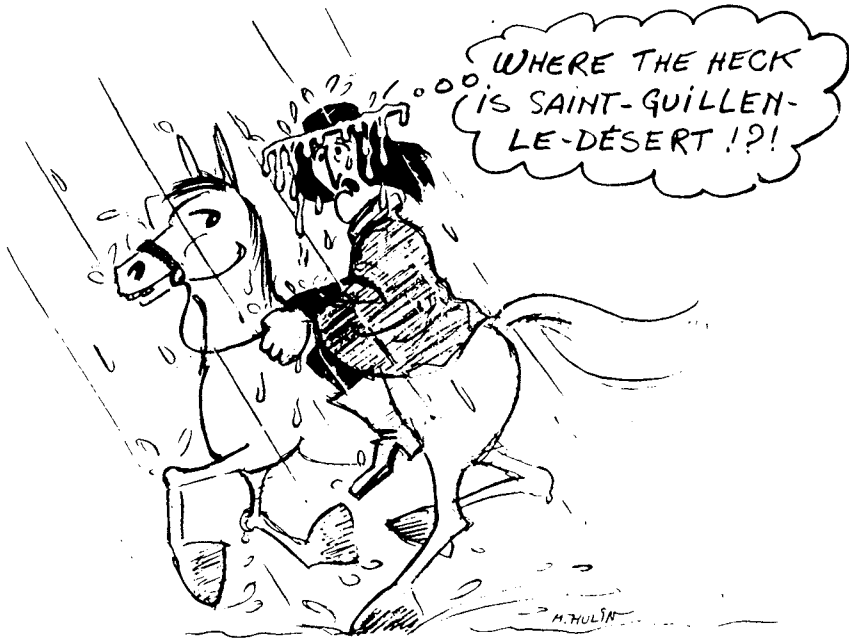


FIG. 1.4 Lordat on his way to Saint-Guillen-le-Désert. It rains.

before any medical issues were raised, sit near the fireplace, dry himself and have something to drink and eat; but all he could then utter were “two vigorous words,” one of which was “i” and the other “the most forcible oath of our tongue, which beings with an ‘f’ and which our Dictionaries have never dared to print.” The Professor also takes time to tell about his own agonizing experience with verbal amnesia, in 1825. He insists that impairment of the retrieving-mapping act will lead to disorders in both production and comprehension. He says that this impairment need not be absolute. When it is not, as was his case, familiar words are more available than less familiar ones, and very infrequent words are not available at all. Moreover, retrieval is sometimes achieved but faulty; Lordat the word coiner enters into action anew. This phenomenon he calls *paramnesia* for its mental part (and he retains *paralalia* to designate the faulty production if it occurs); he very explicitly recognizes two forms of paramnesia. In the first, the idea is mapped onto an existing word but not the target one, and the resulting paralalia is a word substitution. In the second, the target is retrieved but, in production, “the letters and syllables are interverted” (from his auto-observation, Lordat provides his students with examples that would today be labeled as verbal and phonemic paraphasias: for instance, he wished to be handed a book and asked for a “handkerchief”, he uttered “sairin” and

“Sumulman” when his targets were “raisin” and “Musulman”). There are also cases in which faulty retrieval dominates the clinical picture. Thus, Monsieur Auguste Broussonnet, another patient whom the Professor has observed when he was a young practitioner, presented “incorrigible and unconscious paralalia” (an obvious equivalent of our anosognosic jargonaphasia). Regarding comprehension, Lordat insists that the speed of elocution of the interlocutor is primordial; shorter messages, uttered a bit slower, are better understood.

Then, again and again, Lordat says that intelligence remains intact if brain disease is such that it causes only verbal amnesia, as was the fact in his own case:

Car, ne croyez pas qu'il y ait le moindre changement dans les fonctions du sens intime. Je me sentais toujours le même intérieurement. L'isolement mental dont je parle, la tristesse, l'embarras, l'air stupide qui en provenait, faisaient croire à plusieurs qu'il existait en moi un affaiblissement des facultés intellectuelles. Cette erreur, qui causa du chagrin à quelques-uns, de la satisfaction à quelques autres, ne fut partagée ni par M. Caizergues, ni par M. Anglada.

Guardia (1870), quoted by Bayle (1939), reports in this respect an interesting anecdote: In 1825, during the worst period of his aphasia, Lordat was visited by Lallemand and Dubreuil, two of his colleagues at the Faculty. At one point, Lallemand, who had himself observed a number of aphasics (Schiller, 1979) and was very much aware of Lordat's comprehension difficulties, turned to Dubreuil and told him: “Pour le coup, le principe vital est bien foutu!” which, not taking into account the cruel play on Lordat's most sacred words, would now translate as “Well, this time, he has become a real vegetable!”. Now, university professors will be university professors and Lordat kept his “air stupide,” for the time being. But months later, after Lordat came back to his work at the Faculty, he one day had and did not miss the occasion to return Lallemand's energetic prognosis to the offender, word for word, and no doubt to add a few comments. (Perhaps Lallemand had talked just at the right speed and, after all, Lordat's verbal amnesia was not complete.)

Lordat's fourth act is “ordering the retrieved sounds in line with a ‘syntactic’ convention”. From the point of view of normal (mental and overt) exercise of linguistic abilities, Lordat establishes a strict distinction between this act and the preceding one: each depends on a special memory, that is, both are founded on having learned an arbitrary convention. But these acts and subserving conventions are clearly of a different order: matching ideas to sounds in the former case, ordering these sounds in the latter. Things are not as clearly separated from the pathological point of view and Lordat teaches that verbal amnesia, as a clinical entity, usually interferes with both the third and the fourth acts. As a matter of fact, in the context of his 1842-1843 les-

sons of “physiology”, his clinical comments concerning verbal amnesia come only after he has told his students about the serial ordering act. Lordat does not quote patients showing the conversational behavior that would now be referred to as agrammatism. Maybe he had not observed any such patient. But that need be no obstacle and the Professor will invent a case for his students: there comes a point in his exposé when he teaches that an individual with an isolated disorder of the fourth act might, for instance, say: “Moi aimer vous, désirer beaucoup vous être utile.” And Lordat adds that the interlocutor would understand a faulty sentence of this sort and, of course, would recognize that the speaker’s “sens intime” is intact.

As we have indicated in our boxes-and-arrows representation of Lordat’s teachings (see Fig. 1.3), our reading of his psycholinguistic model, unlike the reading of Bayle (1939) and of Quercy and Bayle (1940), has led us to conclude that the Montpellieran conceived of his last six acts as being concomitant although he numbered them from five to ten in the introductory part of his lessons. At all events, he actually stops at five in the available published version (Lordat, 1843): somewhat abruptly, it is true (Quercy & Bayle, 1940).

Lordat’s discussion of articulated speech begins with an astounding lecture on elementary phonetics: to him, this is basic “physiology” and it is consequently a form of knowledge that students in medicine should master. He therefore teaches about the participation of respiratory and laryngeal muscles in phonation. He goes on to tell his students that vowel sounds are determined by various configurations of the oral cavity. He shows how the *velum palati* moves in a manner such that it will either direct laryngeal air to both nose and mouth, or to mouth only, and he then explains the difference between buccal sounds and nasal sounds (“Le voile du palais est une écluse qui dirige le vent du larynx à volonté, soit pour le faire sortir entièrement par la bouche, soit pour le diviser en partie par la bouche et en partie par le nez: d’où des sons buccaux et des sons nasaux dont tous les bruits vocaux sont susceptibles.”). He tells about the various muscles and movements of the tongue, and of the interactions between tongue, teeth, palate, and lips, and he goes on explaining the differences between “lingual, dental, palatal and labial letters”. He then tackles the description of the liquids (he has doubts about the status of ‘L’ as a liquid: “il est douteux que l’L soit réellement liquide”); of the sibilants as opposed to the “éruptives”; of the aspirated ‘H’; and what not. All of this, says Lordat, is “matière d’examen” at the Faculty of Montpellier and, in order to acquire proper knowledge in this respect, students should read, by their fireside (“sans vous éloigner de votre feu”), “physiology” textbooks such as those of Muller, of Amman, of Haller (Lordat, 1843).

Then Lordat turns back to pathology. Now he is no longer teaching about diseases of language as a system of sounds, but about diseases of speech as a