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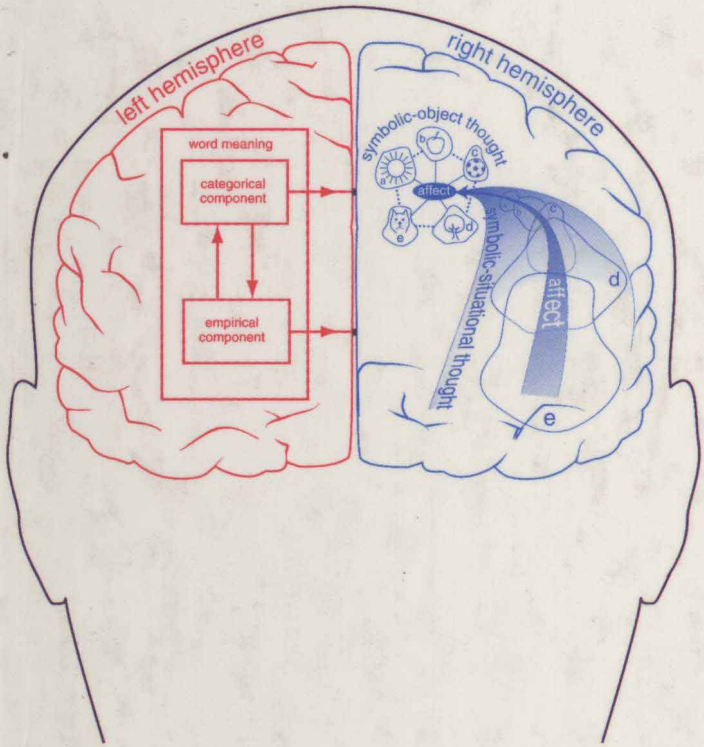
LANGUAGE, THOUGHT, AND THE BRAIN



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Language, Thought, and the Brain

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To our families

Preface

The purpose of this book is to present a novel, comprehensive hypothesis about the relationship of human language and thought to specialization of the brain. Drawing on data from a wide variety of modern and classical sources and multiple—sometimes disparate—disciplines, we offer an original attempt to relate these segments of information in a framework tracing the historical connections and common origins of language codes and aspects of thinking with their phylogenetic roots.

In this time of unparalleled technological capabilities and the resulting enormous accumulation of separate and generally uncoordinated facts, such attempts at synthesis and cohesive theorizing are essential if we are to make sense of what we already know, as well as to construct a model which we can, in turn, explore in a more directed fashion. We have revisited and integrated insights from the past and new findings from multiple disciplines, as well as our own clinical studies, as a base from which to speculate. Our model of cerebral organization of language provides a framework for greater understanding and future investigation not only of our stated areas of interest but also in a much broader context, with important ramifications for research and conceptualization in allied fields examining localization and organization of higher functions in the brain. This has tremendously exciting implications for the emerging appreciation of brain mechanisms in psychiatric disorders. The model has immediate practical applications as well, offering a theoretical basis for a new approach to the rehabilitation of various language disorders, such as aphasia and developmental language disorders.

Thus, although the purpose of this book is to present a model of the connections between language, thought, and the brain, its scope is much broader. It outlines an approach to the study of the cerebral basis and cerebral organization of

self and of symbolic thinking, whose disturbances are at the core of psychiatric disorders.

In the book we review in detail aphasia—language disorder due to local brain damage. Even in this "simple" model, with one focus on the brain, the clinical picture does not just represent loss of function of the damaged area but results from interaction between damaged and intact areas as an attempt at spontaneous compensation. These interactions are predetermined by evolutionarily fixed patterns of cortical connectivity, functional systems underlying language behavior in humans. Evolutionarily determined patterns of connections in the brain underlie a broad repertoire of human behavior. Psychiatric disorders and schizophrenia in particular elude definitive localization in the brain because there is a change in the brain connectivity pattern itself (developmental disorder), rather than damage to one area. We propose a correlation between psychopathological patterns and brain connectivity patterns.

Finally, we do not intend to give an exhaustive description of points of view and underlying facts in modern neuropsychology, neurolinguistics, and neuropsychiatry. Rather, by touching on a vast number of topics from aphasia and thought disorder due to focal brain damage to psychiatric thought disorder (delusions), our overall goal is to present a gestalt—the whole picture, but not by any means the full picture.

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I

Introduction to the Problem and Approach

1

Basic Factors in the Human Brain's Differentiation Underlying Cerebral Organization of Language Ability

1.1. Background

The history of intrahemispheric "localizing" of language functions dates back more than a century. Basic data on this subject were obtained from patients with focal brain damage by correlating language deficits (aphasia) with locations of the lesions within the cerebral hemisphere found on autopsy. Numerous studies have shown that different and specific language disorders accompany damage to the particular cortical areas in the left hemisphere: frontal, temporal, and parietal. These areas have been called "speech zones" of the brain.

The localization of higher cortical functions in classical neurology was considered in terms of independent "brain centers," although some theorists warned against too narrow a localization of cortical functions. These concepts eventually gave way to the contemporary concept of functional systems (Luria, 1966/1980), which suggests that any complex function such as language is realized by the interaction of several cortical areas, each of them making specific contributions to the whole. In the norm, functional systems are highly integrated, and thus it is difficult to "extract" the contribution of discrete cortical areas.

It is pathology—in particular, aphasia—that is the natural experiment in which focal cortical lesions result in a "falling out" of that discrete component of language subserved by this area in the norm (Luria, 1947/1970; Luria, 1966/1980). Using his concept of functional systems, Luria attempted to connect specific language disorders with dysfunction of the corresponding cortical area (Luria, 1966/1980).

Modern progress in our understanding of cerebral organization of language is a result of new neuroimaging techniques that allow immediate correlation of observations *in vivo* with the location of brain damage (Damasio, 1992; Damasio & Damasio, 1989). The findings to date have been consistent with classical descriptions, but in addition, they showed a much higher degree of cortical differentiation for language, or "linguistic specificity" of certain cytoarchitectural fields, than was previously thought (Damasio & Damasio, 1992).

All these studies, both classical and modern, focused primarily on the localization of language functions within the left hemisphere. Thus, they considered brain mechanisms of language in the framework of intrahemispheric cortical differentiation. Another aspect of cortical differentiation is interhemispheric specialization. Since Broca's finding in 1861 of a left frontal lobe lesion in a patient with expressive speech impairment, language has been connected with the left, dominant, hemisphere. However, functions of the right, nondominant, hemisphere have remained unknown for a long period of time. Research in the field of interhemispheric specialization was stimulated by the famous experiments in "split-brain" patients in the 1960s (Springer & Deutsch, 1989). At present, there is a vast amount of data suggesting the importance for normal speech activity of not only the traditional, dominant left hemisphere, but also the right hemisphere. However, these data are not systematized in the context of cerebral organization of language ability as a whole. What remains unexplored are the specific contributions of discrete cortical regions within each hemisphere and the interactions between intra- and interhemispheric dimensions.

Another concept regarding organization of cerebral functions was introduced in the period of classical neurology. It was the idea that cerebral, and in particular, cortical functions are hierarchically organized. Applying this principle to language, such seminal figures as Jackson and Head made a distinction between the symbolic aspects of speech activity (language) and its sensory and motor components (Jackson, 1958; Head, 1926/1963). However, these ideas were not considered in the context of cortical cytoarchitectonics and localization of linguistic functions.

The Russian physiologist Nicolai Bernstein (1947, 1967) developed a theory and an elegant system of function levels based on the morphological vertical hierarchy in brain differentiation. He also was the only author to combine "horizontal" (intrahemispheric) and "vertical" (hierarchical) principles of brain differentiation. His model has nearly been forgotten. It was called to our attention by Russian linguist Vjacheslav Ivanov (1978) and American linguist Roman Jakobson (1970), who recognized the potential of Bernstein's ideas and named him a leading biologist of our time.

The model of cerebral organization of language ability proposed in this book is inspired by the insights of Bernstein (1947). In this connection, we will outline Bernstein's system of brain function vertical organization. Although we begin with

Bernstein, our chief concern is with contemporary issues regarding cerebral organization of language. We thus extended Bernstein's system to include a symbolic function level, which was not described by Bernstein; we considered structure–function vertical hierarchy together with intrahemispheric and interhemispheric specialization and applied it to language.

1.2. Bernstein's Model of Hierarchical Cerebral Organization of Movements

Bernstein studied the cerebral organization of motions, and using this as a model, developed a comprehensive theory in which he explained the connections between the vertical hierarchy of brain structures and the order of the function levels. According to Bernstein, cerebral organization of motions can be represented as a multistory building composed of hierarchically overlaid stories of different phylogenetic ages that correspond to certain function levels.

Bernstein's highly insightful work not only examined the vertical principle in movement's cerebral organization but also considered each level as a relatively autonomous functional system comprising two parts operating concurrently: posterior brain regions, associated with afferentation, and anterior brain regions, associated with efferent systems. Here Bernstein followed the chief principle of the brain's horizontal differentiation, the Bell and Magendie rule, which was first applied to higher cerebral functions by Jackson. The rule states that at all levels of CNS evolution and in all CNS parts (spinal cord, brain stem, subcortical areas, cortex), the afferent systems occupy the posterior side and the efferent systems the anterior. Another general rule of basic horizontal differentiation states that the mode of operation of the posterior brain is simultaneous or spatial synthesis, whereas the mode of operation of the anterior brain is successive synthesis of constituents in time—successive or temporal synthesis. Bernstein interpreted this rule regarding each function level separately, i.e., each level is characterized by its specific simultaneous (posterior brain) and successive synthesis (anterior brain). In Bernstein's terms, each function level operates in the frame of its own "synthetic space" and "synthetic time." Regarding movement formation in the brain, Bernstein postulated the presence of a "movement image" or engram: "It is clear that each of the variations of a movement (for example, drawing a circle large or small, directly in front of oneself or to one side, on a horizontal piece of paper or on a vertical blackboard, and so on) demands a quite different muscular formula; and even more than this, involves a completely different set of muscles in the action. The almost equal facility and accuracy with which all these variations can be performed is evidence for the fact that they are ultimately determined by one and the same higher directional engram.... [It is] structurally extremely far removed (and because of this also probably localizationally very distant) from any resem-