Language in the Brain

Linguistics, neurocognition and phenomenological psychology are fundamentally different fields of research. Helmut Schnelle's aim is to promote an interdisciplinary understanding of a new integrated field in which linguists will be competent in neurocognition and neuroscientists in structure linguistics. Consequently the first part of the book is a systematic introduction to the functional constitution of form and meaning organizing brain components. The essential core elements are perceptions, actions, attention, emotion and feeling. Their descriptions provide foundations for experience-based semantics and pragmatics. The second part is addressed to non-linguists and presents the structure foundations and formal presentations of currently established linguistic frameworks. This book should be serious reading for anyone interested in a comprehensive understanding of language, in which evolution, functional organization and hierarchies are explained by reference to brain architecture and dynamics.

HELMUT SCHNELLE graduated in 1957 with a degree in Physics. His Postgraduate studies between 1958 and 1962 included cybernetics, linguistics and philosophy, leading to the first doctorate in philosophy on Leibniz' *de Arte Combinatoria*. In 1967 he achieved his second doctorate (Dr. phil. habil.) based on the book manuscript *Prolegomena for formalization of levels of linguistics* and became Full Professor of linguistics in Berlin. He is a member of Academia Europea (London), Honorary Member of the Cercle Linguistique de Prague and in 2000 became an Honorary Doctor of the University of Bielefeld, Germany. He was Editor of the journal *Theoretical Linguistics* between 1974 and 2000. Helmut Schnelle also organized the first conference about language and the brain, on the occasion of awarding an honorary doctorate to Roman Jakobson and has since organized a "MIND/BRAIN" Conference in Paris. He is now continuing work with the Ruhr Universität Bochum, focusing on studying language in the brain and its organization of neural networks.

Language in the Brain

HELMUT SCHNELLE

CAMBRIDGE
UNIVERSITY PRESS

Shaftesbury Road, Cambridge CB2 8EA, United Kingdom

One Liberty Plaza, 20th Floor, New York, NY 10006, USA

477 Williamstown Road, Port Melbourne, VIC 3207, Australia

314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India

103 Penang Road, #05–06/07, Visioncrest Commercial, Singapore 238467

Cambridge University Press is part of Cambridge University Press & Assessment,
a department of the University of Cambridge.

We share the University's mission to contribute to society through the pursuit of
education, learning and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9780521515498

First published 2010

A catalogue record for this publication is available from the British Library

Library of Congress Cataloging-in-Publication data
Schnelle, Helmut.
Language in the brain / Helmut Schnelle.
p. cm.
Includes bibliographical references and index.
ISBN 978-0-521-51549-8 (hardback) – ISBN 978-0-521-73971-9 (pbk.)
1. Neurolinguistics. 2. Cognitive neuroscience. I. Title.

QP399.S36 2010
612.8´233–dc22 2009052596

ISBN 978-0-521-51549-8 Hardback
ISBN 978-0-521-73971-9 Paperback

To Marlene

Contents

Preface

My ways to the studies of language were rather indirect. After having graduated in physics (1957) I read John von Neumann and Morgenstern's *Theory of Games* and was fascinated by their exemplification of the modern axiomatic method. I asked myself the burning question how far mathematical theories and formalization could lead in disciplines that develop beyond the natural sciences. The question led me to studies of the humanities. I first concentrated on the philosophy of Leibniz' *de Arte Combinatoria* and his *Characteristica universalis* and wrote my first dissertation thesis about *Symbolic Representations used in modern science* exemplifying, among other systems, networks of automata systems and the notations in Frege's *Conceptual Notation for Logic*. Subsequently I studied Neo-Humboldtian linguistics and wrote my second thesis about its possible formalization in terms of information flow networks.

An interesting research position about theoretical and computational linguistics and their possible applications to machine translation led me to many cooperation visits to research institutes in Europe, the United States and Israel, and participation at the 1964 International Colloquium for Algebraic Linguistics and Automata Theory about linguistic models in Jerusalem. During my years in Berlin I formally compared the theoretical varieties of Generative Grammar with the more mathematical models of Montague Grammar. Changing from Berlin to the new University in Bochum initiated a new start, caused by organizing a colloquium in honour of the famous linguist R. Jakobson at the occasion of his honorary doctorate. Since Jakobson knew that our group had already studied the clear introduction and detailed descriptions to functional brain architecture in Popper-Eccles' book *The Self and its Brain* he proposed the colloquium title: *Language and Brain*, hoping that we thus joined the new orientation he had described in a well-known New York University lecture. His words were "Progress in neurolinguistic research demands an even closer linguistic, or to put it more exhaustively, semiotic approach. The joint

efforts of linguists and neurologists are summoned to suggest and open even deeper insights both into the structure of language with reference to the brain and into the structure of the brain with the help of language."

In the following years I constructed dynamic information flow models and dynamic organizing language structures thus competing with early connectionism. Here also I agreed with von Neumann's challenge that we need explanations of perception, action and thought based on *architecture and neural compositions of organisms*. Purely formal mechanisms or constructs like those of Turing or Chomsky are explicitly *limited to proving feasibility in principle* and thus not sufficient for understanding the complexity of human perception, thought and language. Turing did not contradict. In his self-criticism he even acknowledged that the precise notion of computation mechanisms *implies principled constraints*, which are relevant in various types of practical applications. He characterized one of them in an ironic mood: "Machines can't do certain things such as enjoying strawberries with cream. But the reason is not that computers and brains differ in operative architecture. Possibly a machine might be made to enjoy this delicious dish, but any attempt to make one do so would be idiotic." I believe with von Neumann that normally the architecture of our nervous system is made to enjoy strawberries with cream. Our difficulties in constructing corresponding machines should not prevent us from studying empirical neural organization that is relevant for generating this joy. I must say that the brain's organization of joyful self-experience is indeed interesting, and sections in my book will study present knowledge about these phenomena.

Parallel to these studies of Turing's self-critique my interest in complex phenomena was further encouraged by learning from my wife basic characteristics of creative invention and interpretation of visual art based on phenomenology and the neurocognitive details of visual thinking. Part of what I learned from the discussions or reading her books (1990 and 2002) is presented in particular sections of this book. Fortunately our common interests in neurocognition of vision and art arose at a time in which excellent new books were published and caused common studies over many years.

Let me now turn to the construction of the book. The discussion of language in the brain is confronted with three disciplines, studying language, studying the brain, both participating in phenomenological studies of mind. It is clear that for a comprehensive understanding of the same fact each discipline can contribute aspects that are appropriate in its own methodology, terminology and theoretical framework. In my view it is unfortunate that generally the disciplines remain separated. They shouldn't! On the contrary, comparison of interdisciplinary characteristics would lead to mutually fruitful conceptualization.

I think that the most appropriate ways to become acquainted with interdisciplinary correspondences is to present the book's content in two parts. The first introduces to linguists phenomenologically or mentally structured neurocognition; thus *functionally marking* brain architecture and processes. The second part concentrates on certain conceptually defined structures of grammar, lexicology, meaning and pragmatic usage of expressions or utterances. Here also many components are functional linguistics in the sense that phenomenological analysis is brought into correspondence with structure description.

Here is a brief survey of the four chapters of the *first part*. The first chapter explains the functional roles of neural networks in the brain. The neurons form internally organized clusters. Many narrow or distant clusters are mutually connected clusters that may exhibit mutually simultaneous activity patterns. In the case of *functionally characterized* smaller or larger cluster networks – for instance when they represent word or phrasal structures – one may say that their synchronized activation patterns represent momentarily active pieces of knowledge. Vice versa we may say that different pieces of linguistic competence knowledge exist in the brain as different distributed neural cluster activities. The related *pieces of knowledge* and functionally coherent clusters are functional units called *cognits*. This cluster network is mainly located in the cerebral cortex. It is moreover related to other parts of the body such as sensory perception or the muscles or the visceral system that organizes the internal body organs. The cortical clusters and the two other components are interdependent and interactive. The peripheral and internal connections exist already at birth, whereas the completion of cortical structure patterns takes many years through infancy, childhood and adolescence.

While the first chapter concentrated on principles of cluster networks in the cortical architecture the second chapter concentrates on their role in perception and action organization characteristics in the mammalian cortex. The chapter also introduces a radical extension of the perception–action hierarchy existing already in all mammals—somehow forming a concrete semantic organization. The *Homo sapiens* brain combines this system with language form that is *grammatically organized speech sound perception and action* located in *Broca's and Wernicke's areas*.

Both semantic and grammatically organized systems offer two kinds of operation: lower level *automatic self-organization* of normal and standard grammatical form and operations in which structure components can be *selected* and *composed in more complex ways*.

The third chapter will discuss a number of brain functions organized by perception–action systems whose measurements and detailed analyses marked breakthroughs for our understanding of neurocognition. There was

the discovery of the *mirror neuron system* explaining the existence of functionally important interdependencies of perception and executive organization of actions. Measurements of *developmental characteristics contributed to the understanding of perception–action complexity*. Of particular importance were *studies of vision.* It turned out that the organization of *vision is much more complicated than is commonly assumed*. *Saccadic eye-movements* already play fundamental roles in simple identifications of objects and situations.

Whereas the facts studied in Chapter 3 are automatic in the sense that their execution does not involve consciousness Chapter 4 concentrates on combination and integration of intelligent thought and feeling. In order to introduce the essentials of their character the chapter begins with characterizing the *phenomenology of acts of creativity*, in art as well as in science. The neurocognitive analyses show that the *organizations in the prefrontal cortex* play a dominant role. They are for instance involved in operations of selection, attention, intentionality, thought integration, selective operations and evaluations of constructive thoughts and imaginations. These characteristics indeed play an important role in all *actions of creativity, whether in science or art* and also in constitutions of self-experience and the interpretation of and empathy with other self's experiences.

As a summary of the linguistic aspects of the book's first part we may emphasize that not only Broca's and Wernicke's areas of the brain contribute to language organization. They are rather involved in organizations of language form. Language meanings involving perception and action of concrete situations as well as feelings connected with them are organized in almost all components of the nervous system. This means that semantics and pragmatics have a completely different neurocognitive status than language form organization. Language studies that are reduced to formal language structure of syntax and formal semantics are too limited and inappropriate for practical usage of language. As in the case of Turing machines and formal rule-based syntax they may contribute to defining "structure feasibility" in principle. But what is needed is the understanding of concrete semantics and pragmatics or a neurocognitively interpreted semiotic approach, as Jakobson said. The explanations of the second part will show that language studies tend to develop in this direction.

The *second part* introduces linguistic approaches. It begins in the fifth chapter with explaining descriptive aspects, which strongly determined the second half of the last century. Carnap's earlier idea that syntax is the core of formal logic was accepted by the linguist N. Chomsky though in a radical adaptation to the conceptualization of the traditional grammar and inventions of linguistically transparent representations. Since this transparency is still

valid, in particular for learners, the chapter begins with their exposition. But in the last decades many linguists followed the tendency to extend explanations to more integrated combinations of syntax and semantics. Chapter 5 continues by discussing essential stages of extensions proposed by the influential linguist R. Jackendoff. But when considering the range of neurocognitive knowledge presented in the first part of the book we are led to the conclusion that important parts of concrete semantics, in particular those characterizing attitudes and self-experiences of persons, remain inappropriately represented and characterized in terms of logically based conceptualizations. The end of the chapter criticizes this approach.

The approaches discussed in the sixth chapter follow a typical and influential variety of cognitive- and usage-based linguistics as it is presented in Langacker's cognitive grammar. Grammar is not understood formally or schematically but as a "grammar in life". The chapter discusses a selection of Langacker's proposals. They are partially based on phenomenologico-grammatical analyses. Specifications are provided by frames of distinct archetypes of understanding and by variations of flexibility of expression. They often contrast with Jackendoff's analyses that are represented in the fifth chapter in terms of formation rule generated structures.

Grammatical organization in Langacker's system can be understood as being based on different *examples of phenomenological and philosophical archetypes*. In addition to the archetypes there are considerations of the linguistic relevance of philosophical distinctions like *objectivity* and *subjectivity*. The different discussions lead to very interesting explanations of how the words are selected and grammatically arranged when a speaker intends to utter knowledge and grounds the structure by word and particle arrangements in the sentences. It should be obvious that our brief survey of semantic and pragmatic interplay can only name few of the elementary perspectives. The last two chapters invite the non-linguists to learn in which ways the different linguistic approaches distinguish linguists and their schools.

The last two chapters, Chapters 7 and 8, return to a central aspect of Jackendoff's *new perspectives for linguistic descriptions*, namely his idea to *push "the world" into the mind/brain/body* of a person. The idea per se is fruitful but requires the development of an *improved stage of analysis* leading to a *more radical reorganization* of the mind/brain/body analysis in its linguistic perspective. My way to the required schema will be prepared by fundamental critiques, revised explanations as well as new evaluations of selective powers of usage archetypes ending with final proposals for translations of formalist syntax into dynamic structure schemata that solve Jackendoff's critiques of connectionist proposals of cognitive neuroscience.

My essential critique concerns the constituent elements of sentence semantics, more specifically the fact that they are still used in the format that derived from logical abstraction schemata. They present sentence semantics in terms of the main verb that denotes *relations of objects*, an approach that leads to *argument structure models,* which are only secondarily sub-categorized. I still prefer approaches in which the persons, animals or dynamic objects denoted by noun-phrases have priority. On this base the semantic interpretations of body-based feeling, social attitudes and social group feelings and empathy can be accounted for. A particular exemplification will be presented in connection with the list of verbs that can be used in "each-other sentences".

The eighth chapter concentrates on further aspects of dynamic language organization. The first sections discuss the dynamic role of phenomenological interpretations of archetypical prototypes and background-based interpretations as well as very different types of efficient communicative function-based structures of sentences. The second part is rather technical in its studies demonstrating how formalist syntax structures are possibly translated into neural cluster systems. Using relatively simple syntax the translated result shows how configurations of syntactic trees like those that were introduced in Chapter 5 are translated in networks generating momentarily synchronized activity patterns corresponding to linguistically static descriptive configurations. It is shown how classic representation problems like token plurality and other difficulties can be solved. It is also demonstrated how cluster networks can organize context and background influences on syntactic alternatives.

Let me finally summarize the content. We are looking for new interpretations. Language in the brain should be described as a dynamic competence organization of form, meaning and usage. Neural networks are mentally activated in the intentional energy of speech acts and also historically changed by social *energeia*, as Humboldt said. These dynamic views should in principle be better substantiated by the analysis of *language in the brain* rather than *language in symbolic formalisms.*

Which are the essential elements of neurocognitive understanding? We should definitely not forget the fundamental integration of our brain organizations in the automatically self-organizing sub-systems, the perception–action organization system and the body's internal autonomous and somatic nerve systems and their integration organization in the prefrontal cortex and the nervous system centres of the hypothalamus and thalamus.

Though language form organization is only a section of the perception—action system it is closely connected with practically all other sub-systems that contribute in many ways to our understanding and self-understanding, conceptually focused in selective ways.

Combining our competence of language and thought in the brain the following is the most important point: Given the complexity of our bodies and minds and given our selectivity in consciously focusing and literally or ritually fixing what we consider as basic, we normally do not acknowledge that what we know consciously is necessarily only a skeletal system of what seems to exist 'here and there' but is supported by a much more detailed infinity of elements constituting the flow of 'now and then'.

Acknowledgements

As explained in the preface many years of my interdisciplinary research concentrated on perspectives, dimensions and facts that would contribute to an ultimately unified understanding of language, mind and brain. Thanks go to the authors of many books and articles mentioned and discussed in the various chapters of my book. I also owe debts of gratitude to many colleagues and friends who were ready to discuss my ideas in their details and their interdisciplinary perspective, in particular M. Arbib, M. Bierwisch, W. Brauer, P. Eisenberg, G. Fanselow, J.A. Feldman, A. Friederici, M. Gross, E. Hajicova, B. Johansson, M. Kay, S. Kanngießer, T. Kohonen, M. Krifka, W.J.M. Levelt, U. Maas, U. Mönnich, C.F. Küppers, R. Posner, G. Rickheit, G. Rizzolatti, P. Sgall, J. Sinclair, I. Wachsmuth, Chr. Von der Mahlsburg, W. Wahlster, and D. Wunderlich. I owe particular gratitude to the many discussions with my friend and teacher Y. Bar-Hillel, and the fruitful talks with V. Braitenberg and F. Pulvermüller, which led me to functional and concrete neuroscience. But much more influential for my interdisciplinary thought were the almost daily discussions with my wife, the historian of art and photographer, about the relations of neurocognition, phenomenology and gestalt psychology, in particular in their application to acts of production and perception of art and the possible in which our brains might organize creativity in art and science. There is no better way to express my gratitude to her involvement than to acknowledge that she was my worst critic, my best critic, and day to day source of inspiration and reason.