PART I

Functional neuroscience of language organization in the brain

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The brain in functional perspective

1.1 The functional triangle of language, mind and brain

In a classical perspective a language consists of the set of its words and sentences determined by its lexicon and grammar. Words and sentences are realized as sound patterns and are mentally registered when we *hear them as sound patterns* or when we *identify them as letter figures on paper*. Today they can also be realized and identified as *letter configurations on the computer screen*.

But there is more. When *recalling* something said to us, the *memorized* words and sentences *appear as sound images in our minds* together with our mental understanding of the *words' and sentences' meanings*. We may also learn that, while our mind thinks, understands, or speaks, some of the grey cells in our brain are active. In a naïve understanding it may appear to us that pieces of uttered words and meanings are realized and kept in the brain like being printed on a physiological *tabula rasa* or in a storage space.

Many linguists disagree with the assumption that our mind images *everything* that is relevant for speaking or understanding. They emphasize that when we speak correct language we have no conscious image of all aspects of meaning and the rules that determine grammatical correctness. Indeed for speaking and understanding normal words and sentences the system of grammatical regularities is *somehow* operative, but we almost never have conscious mental images of them. Thus we must assume that the *rules of grammar* and *the rules of lexical word relations* can at best be represented structurally in the manner of an *abstract system description*. The mental system seems to be similar to other systems of rules such as the well learned intuitive competence of the rules of chess. When we are fluent players of chess we play without consciously concentrating at any moment on the rules. We rather master them spontaneously. Consequently grammarians conclude that in the linguistic system sense also is best understood as a spontaneously functioning formal system structure,

a specific kind of mental entity that is different from the concrete images our conscious mind remarks. Let us call such an abstract system a *formally mental* entity. The theoretical linguists insist that the essential core characteristics of a language form are sufficiently conceptualized in terms of such formal systems. Consequently theoretically precise results of linguistic studies should be represented by functionally mental entities. In the theoretician's view the ideas that language is in the air, on paper, on the computer screen, in a computer internal data space, in images of our conscious thoughts or occur as activities of our brain cells may well be neglected.

I think that the formalist representations denoting formalized concepts have some advantage, for instance in presenting structure constructions in clear transparency. In this perspective formally structured language is recommendable. Acknowledging this does not, however, exclude developing and applying further mental perspectives of analysis that may appear to be more revealing for more comprehensive aspects and phenomena. There are for instance good reasons to carefully study the characteristics of *psychological and phenomenological phenomena* of situation-supported language use as well as the *complex organization that our brain contributes* to our knowledge and use of language. We thus should consider all three perspectives: (a) *Language* in the *formalist linguistic sense*, for instance in terms of formalized mental systems; (b) language in *verbal imaging and conscious phenomenological reflection* in our phenomenological mind organizing speech acts; and (c) language in the biological sense determined by *complex brain architecture* as a *complex brain activity*, as well as by biological development.

In fact, it can be shown that all of the three disciplines produce their precise analyses, each completely justified in its own methodological framework. On the other hand I am certain that mutual comparison of thoughts and models as well as combinations of perspectives can open new insights and direction in each domain. I thus recommend that precise analyses in these three domains should not be kept separate and isolated. Mere collections of methodologically separate studies will not lead automatically to comprehensive understanding of the perspectives of language organization. Instead the phenomena of each perspective must have their counterpart in each of the two other perspectives. We must even assume that understanding the phenomena in one perspective is improved when the characteristics are also *functionally* distinguished by specifying their role in the perspectives of the other frameworks. The following chapters will provide many indications of how brain architectures and processes distinguish potentially the organizational functions of grammar, meaning and pragmatic usage of languages. I insist that studying functional interdependency of interdisciplinary perspectives of language is very important and improves

understanding of the general principles of language. Neither formalist linguistics nor phenomenological analyses of communicative intentionality and thought nor neurophysiological brain measurements are sufficient.

Figure 1.1 represents a triangle of disciplines whose functional interdependencies we should study and try to integrate. For each discipline we should also learn to differentiate phenomena relative to the roles they would play in the neighbour discipline. This openness would be possible after taking off the discipline's own blinkers. Clearly structured correlation of the three disciplines would generate *functional* disciplines, namely *functional neurobiology* (with respect to language structure and to phenomenology), *functional linguistics* (with respect to neurobiological brain organizations and to phenomenology) and *functional phenomenology* of intentional speech acts and thought analyses (with respect to linguistics and neurobiology of language organization). Their combination would create a *new understanding of functional cognition*.

I do not believe that this aim is utopian, but I am sure that reaching it is very difficult and the progress will require decades and centuries. Above all it is clear that a disciplined open mind and careful engagement of functional interdisciplinary analysis will be required because widely shared sceptical attitudes must be overcome. It is the aim of the present book to contribute pieces of understanding and supporting information leading to interdisciplinary studies about language structures in the mind and brain, about the brain's organizing language and mind and about the phenomenological analyses of speech acts and intentional thought.

Let me add an answer to a critical remark that might be advanced against my interdisciplinary triangle. Some linguists and philologists would think that

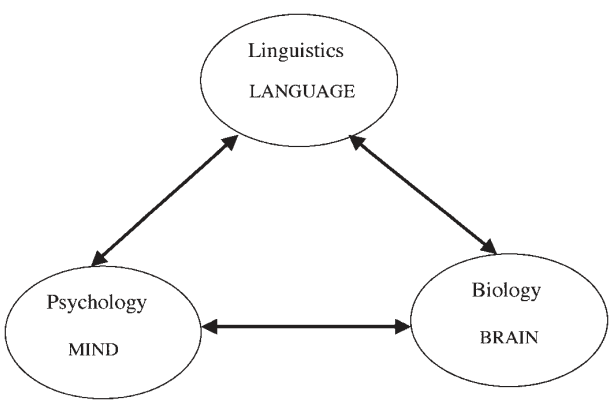

Figure 1.1. Triangle of functional interdependency of language-specifying disciplines.

the mind/brain analysis refers only to individuals' language knowledge in mind or brain and would consider such a view as inappropriate. They are persuaded that natural languages, such as English, German, French etc., must be understood as a kind of social institution; the individual merely participates and lives *in* this institution. In a sense I do not disagree. But in my view being a member of a social group is primarily the competence of applying implicit knowledge and assumptions about other people of the group one belongs to. A child acquires this knowledge during the first two decades of life. The adult person is able to put herself in the position of somebody else and only secondarily because she is formally obeying the rules or regularities of an institution. Each individual *has other mind knowledge and suppositions* that constitute the other person's social status. This other mind knowledge comprises indeed language competence of other speakers. Thus the collection of all speakers' varied individual competence of language and of its implicit communicative presuppositions about *other people and their common language usage* is a *sufficient base* for the institutional state of language.

Whoever agrees with this understanding based on the *other-self accounting perspective* might now be interested in learning the *principled characteristics and the details of the triangle of interdependent functionalism*. The following chapters and sections will present clarifications and explanations. I hope that they help to promote interdisciplinary research of functional linguistics and functional neuroscience by potentially supporting the other discipline's knowledge. But note: In the present research situation it is still impossible to present strictly established truths or established theories. *Baars' principle* is correct that science always makes inferences and assumptions that go beyond raw observations, using abstract concepts and descriptions that "make a believable story." Like any other start, ours also could encounter surprises. If so, we should be ready for changes wherever they are necessary or would lead to more plausible or more fruitful "stories."

With this insight we should conclude that universal claims of a discipline that tends to *substitute the triangle of functional studies by rigorous "unification of everything" in its own field* should be avoided, whether the unification base is formalist, phenomenological[1] or physically biologist. Though people

[1] The notion of phenomenology should be taken in the wide sense of *mentally critical psychology*. J.L. Austin introduced this perspective under the term of linguistic phenomenology in his article "A Plea for Excuses" p. 130 (in his Philosophical Papers 1961). In our context the most fruitful developments were presented and based on the notions of intentional acts by J. Searle's analyses (1969) (1983) (1992) and (1998), and on other levels Merleau-Ponty (2002) and certain aspects of Gestalt psychology. We will see below that the latter plays a certain role in the functional neuroscience of J. Fuster. These remarks were slightly extended to at least hint which aspects of psychology play a role in our context, though being less explicit in the details.

may have their own philosophy, as I have mine, all of them should acknowledge that the time has not come to rigorously argue for monistic positions against dualistic ones or vice versa or even bringing other philosophical positions into play. Philosophical discussions of this kind do not help methodologically and theoretically careful studies. Should we be able to attain a clear understanding of functional interdependencies as indicated by the triangle, it would very much help in the ultimate clarification of philosophical positions. Insisting on a strictly materialist understanding of brain processes does not really help. Why should we insist on eliminative materialism?

Instead the methodological and theoretical distinctions of the three disciplines and the openness for finding correspondences should be carefully heeded. Otherwise we run into misunderstandings. A typical case is the controversy of Chomsky and Mountcastle. Chomsky (2000) quotes statements of Mountcastle (1998): "Things mental, indeed minds, are emergent properties of the brains." Speaking of emergence does not help our appropriate perspectives about our selves. Successful clarification of perspectives prevents eliminative monism, whether materialist or formally mentalist. But Mountcastle insists. On the next page he claims: "All mental states are brain states." This is obviously misleading. A mathematician's or a linguist's concrete act of understanding in a framework of complex knowledge content is *a phenomenological analysable* act *of complex thought*, which in turn *corresponds to* a more or less extended *process of brain states*. In my view a correspondence exists indeed even when logicians and theoretical linguists follow Frege in believing that a thought's *content* itself is sufficiently understood a*s an abstract structure entity*. But I insist that a *complete understanding implies the correspondence of several types of levels*: abstract structures, phenomenological knowledge processes and brain dynamics. All three contribute to cognition that will one day be completed by unification of correspondence understanding.

In our normal understanding each of the different perspectives provides a strictly different status of *cognition*. I think that my revision of Mountcastle's forced unification could lead to more careful phrasing. I fully agree with Chomsky's conclusive statement: "A primary goal is to bring the bodies of doctrine concerning language into closer relation with those 'emerging' from the brain sciences and other perspectives. We may anticipate that richer bodies of doctrine will interact, setting significant conditions from one level of analysis for another, perhaps ultimately converging in true unification. But we should not mistake truism for substantive theses, and there is no place for dogmatism as to how the issues might move toward resolution. We know far too little for that, and the history of modern science teaches us lessons that I think should not be ignored" (Chomsky 2000, 27).

On the other hand Baars' principle should not be forgotten: In the present research situation it is still impossible to present strictly established truths. I agree with the principle that science always makes inferences and assumptions that go beyond raw observations, using abstract concepts and descriptions that "make a believable story". Like any other simplified story, ours could also encounter surprises. If so, we will have to change it accordingly.

A last remark about my book's structure: It aims to support perspectives of research in the functional triangle unit. The chapters' arrangements are determined by didactic considerations. The reader should be able to learn about the brain and the language. The first part of the book is intended to inform linguists and students of the humanities and of philosophy about the brain. In the second part, discussing the relation of language structure, meaning, and development as a component of mind will introduce the neuroscientists to some core characteristics of present linguistics. The last chapter of the book will be more "technical" and present constructions of some of my working models. Formalist structure representations of language are translated into possible counterparts in neural network representations. Given the more formal aspects of this part it is unavoidable that some passages of this chapter will be a challenge for readers who are not familiar with formalist descriptions.

1.2 Introduction to the brain: the cortical network elements

Since Galen, antiquity believed that nerves are ducts conveying fluids that are secreted by the brain and the spinal cord and transmitted to the peripheral locations of the body. But it was completely unknown how the central brain tissue operates. Was it a continuous reticulum, a tangle of netlike biological tissue? The invention of the compound microscope in the eighteenth century showed that the cortex was indeed a tissue, though like a structure of mixed stalks; somehow similar to Figure 1.2.

By the end of the nineteenth century the neurologists Wernicke, Sherrington and Ramón y Cajal introduced a new and empirically based theory according to which the brain's function found its base in a cellular system of *connectionism*. According to this view, individual neurons are the signalling units of the brain. They are generally arranged in functional groups and connect to one another in a precise fashion. This view became basically influential until recently. Fortunately the first half of the last century brought much empirical and conceptual progress. It led Hebb (1949) to propose a model whose simplest components were presented as in our Figure 1.3.

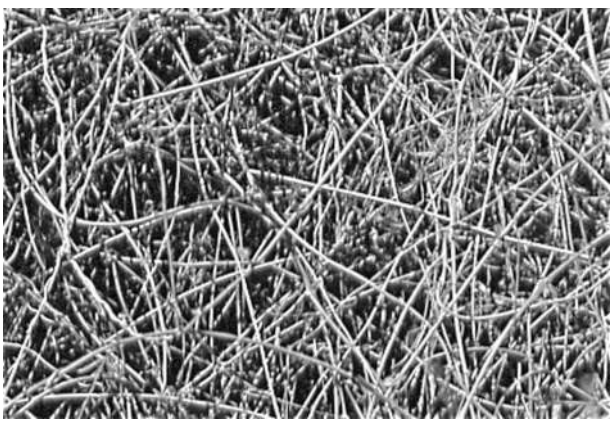

Figure 1.2. Is the forebrain a confusing tangle?

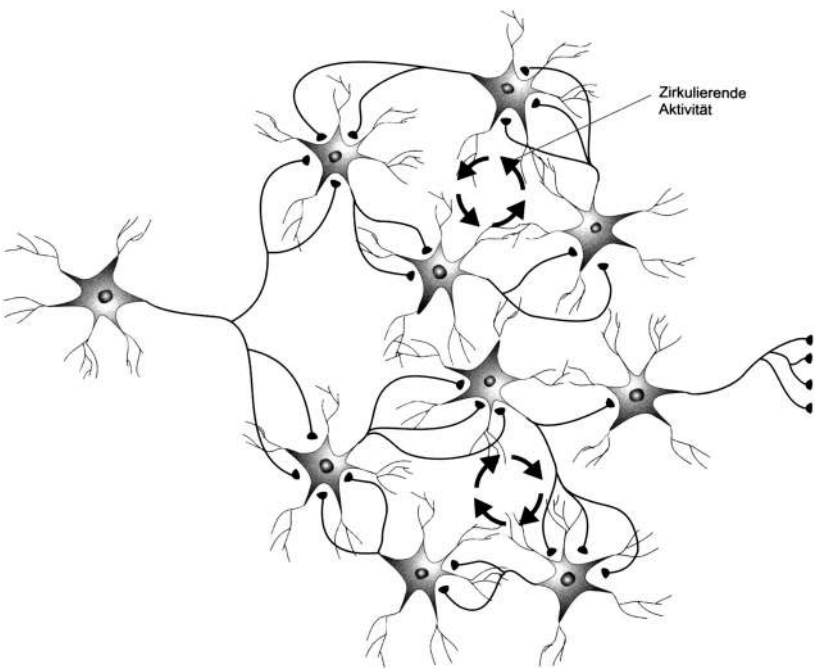

Figure 1.3. Neural sub-structure schema according to Hebb.

The cellular connections operate in very different areas of the cortex. The neuroscientist Kandel (1995, 8) wrote that the brain functions in the cerebral hemispheres are like the *bark on a tree*. In each of the brain's hemispheres the overlying cortex is divided into four anatomically *distinct lobes*: frontal,

parietal, occipital and temporal. They contribute to different sub-aspects of more globally organized specific functions such as the planning for future action, the execution and control of movement, tactile sensation, body image, hearing, seeing, learning, memory and emotion. Thus different brain components organize a single behaviour and cooperate in different regions of the brain.

However, towards the middle of the last century there was growing scepticism concerning this model. Particularly influential was Lashley (1950), who claimed that the organization of specific functions resulted from non-localized mass operation of cellular connectionism, a position that influenced fundamentally Chomsky's linguistic view. Lashley argued, and Chomsky agreed, that learning and other mental functions, such as advanced linguistic competence of language form, have no special locus in the brain and consequently cannot be related to linguistically relevant networks of neurons (Kandel 1995, p. 15).

But subsequent discoveries of neurocognitive science, based on mainly microelectrode measurements and techniques of brain imaging, provided sufficient evidence against Lashley and Chomsky's radical scepticism. They again justified the Sherrington and Ramón y Cajal idea of cellular connectionism, now, however, in a new form. Instead of single neuron connectionism, *complex groups of hundreds of neurons are the functionally operative units* each performing rather elementary specific operations over the network of mutual connections. In any case it is clear that these considerations made the step from *global interaction of cortical areas* to *microscopic analyses*. They provided a first understanding of the complexity of dynamic units. Their systematic analysis and other studies by Mountcastle and Hubel and Wiesel led Szentagothai and Arbib relatively early (1975) to the stereographic view of the neuron cluster represented in Figure 1.4. It conveys the state of knowledge at the end of the 1970s. The problem with the figure is that it looks like a single cluster being arranged around an arborization of a single cortico-cortical *afferent*. The careful reader would also remark about the efferent axons. The afferent and efferent connections characterize the cluster as being an element from a widely distributed network. But the reader should conceive a neural arrangement that is more in accord with a more modern understanding. The proper arrangement contains many intra-level excitatory and inhibitory neural activity connections to neighbouring clusters. They determine a neighbour connection system that shows that there is no conflict whatever between cluster continuity or discontinuity.[2]

The interaction network of such modules contributes specifically to efficient cooperation, which realizes complex experience and behaviour and elementary perceptions of sound feature arrangements.

[2] About more detailed explanations, see these systems in M. Arbib et al. (1998).

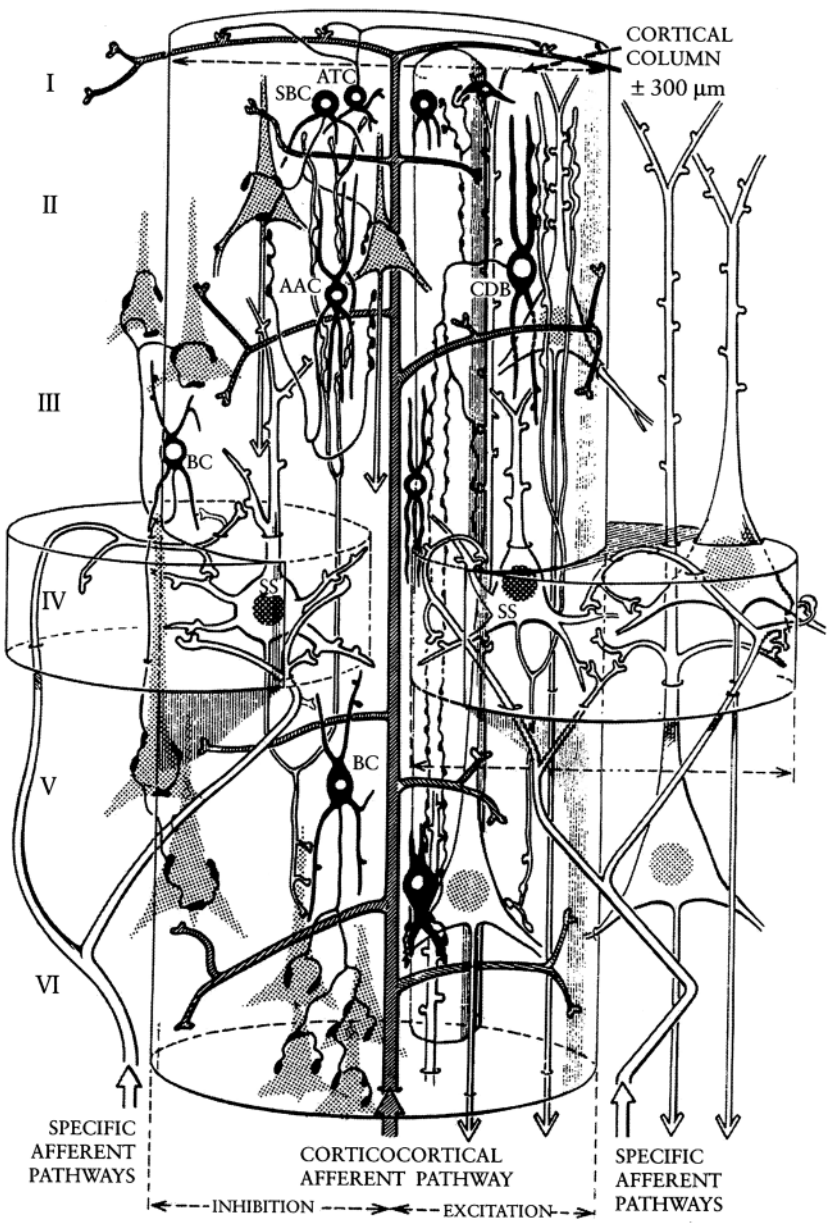

Figure 1.4. A schematic neural network contained in a local cluster module.