Language, Brain and Verbal Behavior

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This book presents some of the results of the meeting which, under the title of «International Workshop on Language, Brain and Verbal Behaviour: Neurobiological Aspects of Linguistic Capacities and Language Processing», brought together at the Institut d'Estudis Catalans (Barcelona, 28 and 29 November 1996) some of the scientists who best represent the research on the problems, foundations and methods of Neurolinguistics, or the systematic study of the relationships between brain and language. The meeting attracted a varied audience of linguists, neurologists, psycholinguists, speech therapists and other professionals, as well as students of these disciplines, who followed the presentations with interest and attention and joined in with debates not reproduced here.[1]

The meeting formed part of —opened, in fact— one of the many new initiatives recently undertaken by the IEC: the «Jornades Científiques de l'IEC», the purpose of which is to deal with questions currently of special interest for a particular field of research or ones that have an acknowledged social impact.

In my view, this Workshop more than accomplished both goals: in the first place, human language is a sufficiently central phenomenon of human nature for its study to awaken an intrinsic intellectual interest, and at the same time, linguistics is one of the most dynamic spheres of research within the human sciences. Moreover, the brain is similarly an immensely exciting world, still imperfectly understood, but one in which every small advance in knowledge generates a host of questions and opens up a host of perspectives. The study of the relationships between language and brain is of dual interest, and has consequences of incalculable human and even social value at a time when increased life expectancy is prompting a growing need to guarantee

1. In the present edition we reproduce the comments to the lectures by the assigned speakers. The texts of the discussions have been delivered to us by the authors, except for the comments on Prof. Pulvermüller's paper by Prof. M. L. Kean, which have been transcribed from the session's recorded tape.

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life's most prized quality: the integrity of the cognitive abilities or the maintenance of the individual's powers of reasoning.

Thinking about language, understood as a global phenomenon, is a privileged field in which the humanities and social disciplines converge with those traditionally regarded as prototypically scientific. Amongst the former, *primus inter pares*, is linguistics, although it is not the only one. In fact, linguistics is a discipline which cannot be said to have failed to absorb fruitful ideas from other fields or to sow its seeds in other areas of knowledge. From the interaction between linguistics and other specific disciplines there emerge overlapping areas different in nature and with different results, and areas of research that are clearly differentiated from one another and linked in diverse ways. This interdisciplinary phenomenon is good not only because it makes us consider our usual paradigms in a more relative way, but also because it opens up fields of research which otherwise could never have emerged.

During this century we have witnessed the development of a double perspective in the scientific approach to the problems that concern us. At the beginning of the century, partly under the impetus of the phenomenological revolution, psychology, logic and linguistics showed us that mental processes or brain functions such as perception, reasoning and language could be studied and described on the basis of structural regularities and formal patterns, independently of their notional content. The cognitive revolution that took place in mid century made it clear that these functions can also be studied independently of their respective physical and biological bases. The metaphor of the brain as hardware and the mind as software has been fruitful in heuristic terms and also because it has helped to narrow the gap between the humanities and the computational sciences. This paradigm has favoured the development of a «top-down» methodology, that is to say, from software to hardware, the methodology proper to the so-called cognitive sciences. However, the development of a methodology in the other direction, from «bottom-up», or from the human hardware to its software, is not unthinkable, while paying attention to questions about the neurobiological bases of language and the problems arising therefrom. This is the methodology proper to the so-called neurosciences, and the one mainly applied in the papers collected here.

The cognitive revolution of the mid century significantly affected linguistics: on the one hand, language was conceived as a system of knowledge of the human mind which underlay verbal behaviour and, ultimately, made it possible, and the subject of study was understood to be this very specific linguistic knowledge: that is to say, intuitive not reflective knowledge. On the other hand, very powerful elements of formal description were introduced: the theory of recursive functions. The system of representation of this knowledge, which was called grammar, had to be, then, a finite system capable of enumerating recursively or generating an infinite number of linguistic objects (the sentences of a language). The distinction between the internal language, as a finite cognitive system, and the external language, as a set of empirical or uttered objects (Chomsky, 1986), was based on and was a formalisation of intuitive ideas already expounded by W. von Humboldt more than a century before.

What do we understand by the intuitive linguistic knowledge of an individual? A way of explaining it would be to focus on a specific example from the Catalan language and attempt to make explicit what a Catalan speaker knows in relation to the specific case.

Now consider this Catalan sentence:

En el programa d'avui, el doctor Corbella tractarà de les relacions sexuals prematrimonials amb la Mari Pau

«In today's programme, Dr Corbella will discuss premarital sexual relations with Mari Pau.»

It is precisely thanks to their linguistic knowledge that when hearing this sentence uttered, any Catalan speaker would be able to identify a continuum of sound as a significant sentence in Catalan. Any Catalan can segment this sentence into sequences of significant and well-formed sounds which we usually call words. Any Catalan is able to assign, systematically rather than randomly, constant meanings to these words and to the sentence as a whole. They are able to group the words in the right way so as to deduce particular meanings, without in fact there always being phonic markers to indicate the appropriate groupings.

To be specific: Our anonymous Catalan speaker knows that *programa* is a polysemic word, but can guess from the context that what it means here is a radiophonic or televisual space; he or she knows that the word *corbella* designates a sickle but is also able to exclude this interpretation, since all Catalans know that *doctor*, here, is a title, and, therefore, that what follows is a surname and not a common noun or first name, and that surnames do not designate classes of objects; they know that *tractarà* is a verb and that its particular form projects the whole sentence towards the future, that *relacions* is a noun, that its particular form designates more than one relationship, and that *sexuals* is an adjective; they know that both the plural of the word *sexuals* and the plural of the word *relacions* are marked by the final *-s* and that, although *sexual* is a word in Catalan, *relacion* is not;[2] they know, however, that both words are regular formations; they know that the word *prematrimonials* is a derivative of *matrimoni*, that the suffix *-al* makes it into an adjective and that the prefix *pre-* gives it the meaning of before marriage; they know that the word *avui* denotes the day on which the sentence is uttered, that this coincides with the day on which the programme will be, regardless of whether it is Thursday or Friday or odd or even; they know that *Mari Pau* is the proper name of a person and denotes a single individual. Catalan speakers also know that the word *tractarà* and the words *de*, *el* or *la* —these latter often known as functional or grammatical words— are of a different linguistic nature. The anonymous Catalan knows all this, and more. For example, to be brief, they know that the utterance is ambiguous, since —according to how the prepositional phrase *amb la Mari Pau* is grouped— the utterance will have to be interpreted as meaning that Dr Corbella will discuss with Mari Pau the subject of

2. The singular of the Catalan word *relacions* is *relació*, but the plural is regular in so far as it is formed by applying the general rule to the underlying form which we may represent as ending with the suffix /ion/.

premarital sexual relations or will discuss the premarital sexual relations with Mari Pau he may have, or has had, or that people in general may have had with Mari Pau.

The anonymous Catalan would know all this even though in fact he or she did not know explicitly what a prefix or a verb or a proper name is, and all this would form part of the knowledge that that sound sequence activates in his or her mind.

Determining the identity of the individuals named would not form part of their linguistic knowledge —the sentence may be understood by someone who does not watch the Catalan TV channel— nor would precise determination of the day of the week or month to which *avui* refers, nor the interpretation most appropriate to the context (because in fact we have an utterance with no contextual specification), nor their moral stance with regard to premarital sexual relations.

Linguistics must specify what the substance is and, if possible, the form that this linguistic knowledge takes in our minds —and, in a word, in our brain— at a relatively abstract level of representation. So, to the extent that linguistics concerns itself with a system of specific knowledge rather than with forms of behaviour, it may be seen as part of cognitive psychology and this as part of human biology (Chomsky, 1980). The result is that the unified theory of language that linguists are endeavouring to build up, starting from a particular level of abstraction and on the basis of strictly grammatical data, will have to be compatible with an eventual theory of language elaborated from neurobiology, on the basis of data of a different type. This includes data from various forms of anomalous verbal behaviour in which the speaker appears to have lost or suspended significant aspects of the different types of linguistic knowledge just mentioned.

For neurologists, the study of the relations between brain and language starts at in the 19th century, with the works of Paul Broca (1861, 1865) and Carl Wernicke (1874) on aphasics, and their localizationist hypothesis, that is to say, the hypothesis that correlates particular forms of anomalous verbal behaviour with particular impairments on specific areas of the cerebral cortex. Aphasia is a specific verbal pathology consisting of an individual's loss of certain aspects of speech due to a cerebral lesion in the hemisphere that is dominant in verbal activity. The clinical description of the aphasias known by the name of those authors —Broca's aphasia and Wernicke's aphasia— is the foundation stone of the neurological approach to language understood as a function of the brain. Motor aphasia, characterised by serious disorders in speech production, is associated with Broca's area, a specific neuroanatomical structure located in the frontal region of the left hemisphere (in right-handed individuals) and receptive sensorial aphasia, characterised by serious disorders in understanding, with Wernicke's area, a different neuroanatomical structure, located in the temporal lobe also in the left hemisphere. The strict localizationist hypothesis, however, was replaced by Wernicke with the idea that the representation of language in the brain implied a flux of information between the two distant areas mentioned, and so was conditioned by activation of particular neuronal connections. This point of view was called the connectionist hypothesis, and in our century has been staunchly defended by Norman Geschwind (cf. 1974). This model has made it possible to explain several types of aphasia including the so-called conduction aphasia, in which the lesion actually affects the connection between the two areas.

Counter to these notions, a holistic approach has sometimes been put forward, in which verbal behaviour is understood as the result of an undifferentiated cognitive capacity and, therefore, difficult to locate in specific areas of the brain (Freud, 1891).

Roman Jakobson (1941; Jakobson & Halle, 1956) was the linguist who carried out a linguistic analysis of the pathological utterances of aphasics in the forties and fifties and produced an interpretation of the findings of Broca and Wernicke in terms of structural linguistics according to the descriptive paradigm of the period. For Jakobson, the data of the so-called anomalous or extraordinary forms of verbal behaviour —such as aphasias, children's language and poetry— illuminated, threw into relief, as it were, essential aspects of the linguistic structure of so-called normal speech. And what is more, they are an empirical validation of the minimal theoretical conception of structuralism (in itself, this was a set of analytical methods rather than a unified theory of language).

For Jakobson (cf. Jakobson & Halle, 1956), the functioning of language was based on two operations: the choice of linguistic units and their combination in the sentence. Language was structured around two axes: the axis of selection or paradigmatic axis, and the axis of combination or syntagmatic axis. Parallel to this, language disorders might affect the selection but not the combination axis -in which case semantically anomalous but well-structured utterances would be produced. Or it might affect the combination but not the selection axis -in which case the sufferer would choose semantically appropriate words but would lose the ability to construct grammatical sentences, combining them wrongly or omitting category markers or the obligatory grammatical relations, and displaying agrammatism, a kind of telegraphic speech, in so far as words and functional markers, inflections, etc. are missing. These pathological features coincide, more or less, with those described by Broca and Wernicke almost a century before.

Jakobson also formulated a theory according to which both the process of language acquisition in children and the process of loss and grammatical destructuring in aphasics obeys a hierarchical structure, that is to say the elements of grammatical structure are acquired and lost in a certain order: in one case this hierarchy is the reverse of the other. In other words, the process followed by aphasics in their disorder is the mirror image of the process followed by children in learning.

This hierarchy is independently motivated by typological reasons. Thus, in the sphere of the sound patterns of languages, which Jakobson studied in particular, the phonological features regarded as most central, such as the consonant/non-consonant or vowel/non-vowel distinction, is universal (in an empirical sense) while the rounded-unrounded distinction does not appear in all languages.

Although Jakobson's theory of regression has recently been questioned (e.g. Gleason, 1993, among others), in fact since Jakobson, the relationships between the contributions of neurology and linguistics have been far more closely scrutinised by specialists in each of these disciplines.

Some observations are relevant here. On the one hand, general features of linguistic structure in normal speakers and the functional characteristics of the non-impaired brain were deduced

from abnormal and impaired structures. In fact, we now know that in its immature state the brain is considerably plastic, and that the usual process of lateralisation or specialisation of the two hemispheres for specific functions (language and the rational component in the left hemisphere, the emotional in the right) admits certain alterations, especially in cases of early traumatism (Lenneberg, 1973). It has therefore been said that aphasia in children is qualitatively different from aphasia in adults (Gleason, 1993).

It is obvious that the study of aphasia must deal with the aphasic brain, but even though such study lies at the origins of Neurolinguistics, this discipline should be asked to produce a model of how language functions in the healthy adult brain unaffected by any pathology. In this respect, the development of molecular biology and the impact of the new technologies on medical sciences have substantially changed the outlook. The various techniques of functional neuroimaging (from electroencephalography to positron emission tomography or PET, amongst others) have made our brains more transparent than ever, permitting an approach to the phenomena based on observation of the brain's metabolism and electrical activity rather than on abnormal behaviour. An interesting problem that now arises is a methodological one: if the traditional and present-day methods of observation were to lead to contradictory results —which sometimes happens— it would still have to be ascertained whether they are actually giving us information about different realities; for example, the organisation of the brain's representation of language, on one hand, and language processing, on the other, as someone has ventured to suggest (Obler, 1993).

Secondly, the theory of the functioning of language on which Jakobson based himself has been superseded by new concepts, precisely ones more closely linked to the cognitive revolution.

Since the sixties, authors like the neurobiologist Eric Lenneberg (1966) have tried to find neurobiological justification for the formal theories of grammar elaborated by Noam Chomsky. Harry Whitaker (1970) formulated a neurological model of language functioning compatible with Chomsky's so-called standard theory (Chomsky, 1965). However it should be said that in some cases the interpretations of the facts were forced in order to fit them into theoretical models which, moreover, were rapidly evolving. In any case, it was entirely pertinent to ask questions such as whether aphasias actually affected linguistic abilities (the underlying cognitive system) or only the linguistic performance that stems from them.

This does not mean that the linguistic foundations upon which pathological verbal behaviours were interpretated should not be fine-tuned. In the explanation of agrammatism, the existence of semantically full words and of functional words had been assumed uncritically. In fact, it is not at all obvious that this distinction defines two natural classes of linguistic objects. So, contrary to the opinion current among neurologists and linguists, a reinterpretation of agrammatism as a phonological rather than syntactic deficiency was proposed, in view of the crucial role that was played by the notion of the phonological word. According to this interpretation, agrammatism is characterised by utterances which simplify a phrase into the minimum chain of phonological words (Kean, 1977, 1978).

In fact, today both linguistics and neurolinguistics understand language not as a single cognitive ability, but as a set of modular capacities that are relatively differentiated but in close interaction amongst each another as well as with other non-linguistic cognitive capacities (Chomsky, 1981, Fodor, 1982, Jackendoff, 1992).

While it is difficult to believe today that the linguistic explanation of the facts may be reduced to strictly neurological terms, the advances of neurolinguistics can been seen as an external justification for linguistic theories, on the clear understanding that, as Jakobson recommended, linguists and neurologists should avoid mixing up the terms of abstract linguistic description with those of neurological description. At another level, it is obvious, for example, that the neurologist does not seek to justify linguistic theories, but first and foremost pursues a therapeutic goal.

The fact that I have confined myself here to the problem of aphasias is because these are central linguistic pathologies, in the sense that they specifically affect verbal behaviour and leave the other abilities intact.

Other verbal disorders have also claimed the attention of neurologists and linguists, and in recent times the various senile dementias, such as Alzheimer's disease, are closely studied. In these cases, beyond the fact that we are witnessing processes of generalised regression of the cognitive capacities, we also see phenomena of linguistic destructuring, but unlike the aphasias, these are not sudden traumatic processes but gradual ones, which allow the loss of language to be described stage by stage in association with the state of general cognitive regression of the patient and which also imply factors of a pragmatic order (Hyltenstam & Stroud, 1993, Obler, in this volume).

Of particular interest to us is the case of language disorders in bilingual or multilingual contexts. To what extent, if any, are the cases of monolinguals and of bilinguals a question of differentiated situations with regard to the brain's representation of language? (Weinreich, 1970, Albert and Obler, 1978, Paradis, 1977, and also in this volume).

The studies that follow should have a bearing on our knowledge of these and other questions. As I have already said, they are the work of eminent, highly qualified international specialists in this area of interdisciplinary research, which is still so little pursued, in strictly quantitative terms, in the Catalan institutions. I invite you to read them in depth.

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