IN THE LABYRINTHS OF LANGUAGE: A Mathematician's Journey

by V. V. NALIMOV

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Dedication
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To the memory
of A. A. Solonovich, Russian mathematician
and philosopher.

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Foreword

It is a pleasure to express my sincere gratitude to V. I. Agol, A. G. Volkov, V. I. Dubrovskii, E. M. Dumanis, V. V. Fedorov, S. M. Raiskyi, S. K. Shaumyan, and O. V. Shimelfenik for a stimulating discussion of the manuscript during its preparation. My hope is that their criticism has eliminated some grosser imperfections of the book. None but the author is responsible for the errors which still remain.

This version slightly differs from the book *Probabilistic Model of Language* published in Russian.

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Introduction to English Edition

> . . . Without a hoard of culturally accumulated knowledge, the frontal cortex, which only evolved as a memory bank for cultural tradition, would remain empty. The same applies to its most important parts, the language area, without which there would be no logical or abstract thought, but which on the other hand could not function unless the cultural tradition provided it with a vocabulary developed over thousands of years of history.
>
> KONRAD LORENZ
> *Behind the Mirror,* p. 190

Looking back on his marvelously creative years, Albert Einstein exclaimed ". . . the eternal mystery of the world is its *comprehensibility*." One might add to this the observation that the eternal mystery of the history of human culture is the capacity of human beings to capture so many aspects of the world by means of man-made symbols, including that extraordinary artifact—language!

The self-consciousness of man as a thinking and creative creature is, in all ages, reflected in the uninterrupted effort to probe the mystery of creativity and cognition by a deeper understanding of the structure and nature of language. From the time of the early Sumerian cuneiform tablets to the epoch of computer languages, this quest has continued.

Philosophy as we have it now would be a shriveled and useless husk if we could imagine its corpus stripped of all of the debates concerning the use and interpretation of language. It might even be said that the vitality of the culture of any epoch is indexed by the concern given to the problem of communication in all its modes and forms.

When the semitic Akkadians overran ancient Sumer in the third mil-

lenium B.C., the problem of compiling multilingual dictionaries first appeared and was solved. And when within the first multi-faceted scientific culture—the Babylonian—thinkers became aware of the problem of equivalence of words and things, these ancient scribes attempted to solve the problem by seeking the clue to ontological classification by grouping together the denotative words according to their intrinsic written patterns. Thus were born the first encyclopedias, and the first *tractatus* on language.

One of the features of modern investigation of the language problem is the recognition that ordinary language—be it written or spoken—is only one member of a class of coherent symbolic communication systems. In his 1674 treatise, *On the Method of Universality*, Leibniz, the greatest of polymaths, wrote:

> That is the aim of that great science which I am used to calling Characteristic, of which what we call Algebra, or Analysis, is only a very small branch, since it is that Characteristic which gives words to languages, letters to words, numbers to Arithmetic, notes to Music. It teaches us how to fix our reasoning, and to require it to leave, as it were, visible traces on the paper of a notebook for inspection at leisure. Finally, it enables us to reason with economy, by substituting characters in the place of things in order to relieve the imagination. . . .

It seems reasonable to believe that only when our great contemporaries unravelled some of the mysteries of the brain and its links with the external world were insights into the nature of language able to advance very far beyond speculations and genial intuitions. In 1935, Anton Pavlov, the Russian physiologist, stated what was to become a major *leit motif* on the linkage of standard linguistics to emerging neurophysiology.

> The developing animal world on reaching the phase of man acquired an exceptional supplement to the mechanism of nervous activity. To an animal, reality is signaled almost exclusively merely by the stimulations—and the traces they leave in the cerebral hemispheres—conveyed directly to the special cells of the visual, auditory, and other receptors of the organism. This is what we likewise possess in the form of impressions, sensations, and conceptions of the environment, both of the general natural environment and of our social environment, with the exception of words—visible and audible. This *first system of signalling reality* is the same in our case as in the case of animals. But words have built up a *second system of signalling reality*, which is only peculiar to us, being a signal of the primary signals. The numerous stimulations by word have, on the one hand, removed us from reality, a fact we should constantly remember so as not to misinterpret our attitude toward reality. On the other hand, *it was nothing other than words which has made us human*, but this, of

> course, cannot be discussed here in greater detail. However, it is beyond doubt that the essential laws governing the work of the first system of signalling necessarily regulate the second system as well, because it is work done by the same nervous tissue.[1]

It is clear that there is now a division of labor between those who concentrate on the biological basis of the language capacity or potential and those who are primarily concerned with those aspects of language which can be analyzed at the logical-philosophical level.

Yet for those who are concerned with the unity of the world as object of cognition and who postulate that the searching mind is embedded in nature, these divisions are for analytical convenience only.

V. V. Nalimov, whose work is now to be introduced to the English-speaking world, is such a scholar. His childhood was spent against the background of war, revolution, and civil war. As a young man, trained in the sciences, he worked in high-vacuum physics during the early Five Year Plans. His work at that time also involved studies of the photoelectric effect and quantum electrodynamics. During the tragic years of the Second World War, he was attached to the laboratories of a large metallurgical plant and was a member of the board that directed the geological surveys of the USSR. In 1957, he returned to Moscow to participate in the All Union Institute of Scientific Information of the Academy of Science. For more than a decade, he has been chief of the Laboratory of Mathematical Experiment of Moscow State University. Long a professor of statistics, Nalimov was led to examine in depth the philosophical implications of the penetration of the probabilistic mode into the foundations of the exact sciences. These investigations led him to the foundational problems of science and the languages in which experimental results and inferences were expressed. The corollary was the relation between hypotheses and verification, particularly when the data supporting a theory were of a statistical nature. He knows thoroughly the texts of Popper, Gödel, Black, inter alia. In more recent years, his interest and work have expanded to include the more general relations of science, culture, and society, and to look closely at the diversity of human cultures of past and present.

In the pages that follow, a vast range of informational systems and modes of human communication are examined. The core problem is the intelligibility of communication under conditions of uncertainty. Here, analogy with the general problem of statistical inference has a great heuristic value.

[1] This paragraph was brought to my attention by Morris Coleman's extraordinary paper, "On Consciousness, Language and Cognition, Three Studies in Materialism" (American Institute for Marxist Studies, 1978).

Nalimov constructs a semantic scale of languages. Mathematics stands at one extreme of the "hard" languages, and abstract painting and Hindu metaphysics are at the extreme of "soft" languages. In between is a rather amorphous zone where is found the language of ordinary human discourse. Physics, poetry, philosophy, painting are assigned their relative places on this scale, and this procedure permits Nalimov to present a synoptic vision of human culture, a vision that illuminates significant chapters in cultural evolution. Not the least of these includes the evolving meanings of the crucial words: language and statistics.

As a mathematician, Nalimov has a professional's insight of the extraordinary role of mathematics in human culture, and his trenchant critiques of the precise limitations of the use of mathematics will be of permanent value.

He is not afraid to stand at the frontier of our knowledge (or our ignorance), particularly where the problems of language, cognition, and consciousness meet. Here, no doctrinaire answers are given, but a set of fascinating possibilities are sketched out.

It has long been recognized that the first step in advancing human knowledge is to pose challenging questions. In this sense Nalimov's work will be of permanent interest to Western scholars.

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University of Pittsburgh

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Introduction to Russian Edition

Recently, our notion of language has become much broader. Nowadays language is being studied not only by traditionally minded linguists but also by representatives of other fields of knowledge which seem to be quite independent from one another: philosophers, logicians, mathematicians, biologists, representatives of cybernetics, and art critics. At the latest Congress of Philosophy (the XIV Congress in Vienna in 1968), 41 reports were devoted to the problem of language, which is 12.4% of the total number of the reports presented at the Congress. [A brief critical account of these reports may be found in the paper by Kopnin (1971).] One of the well-known Western philosophical trends, the British school of linguistic philosophy, considers the study of language to be the principal task of philosophy.

The great interest of philosophers in language problems can be easily explained: the study of language is a way of studying thinking. It seems reasonable to believe that epistemology may be turned from a theoretical–speculative subject into a natural science if language is made an object of study. Then it will become possible in epistemology to discuss hypotheses in comparison with actually observed phenomena, as is the case in other natural sciences. When an experiment is performed, it will be possible to express the results of some observations regarding language in quantitative terms, and hypotheses will be verifiable.

True, all this must be paid for: in such an approach the profoundness in problem formulation which is characteristic of classical epistemology is lost. The same, however, happened in physics: classical physics was to a significant degree purely metrological (i.e., based on measurements and their interpretation) and remained far from philosophical analysis.

Modern physics, with such sections as quantum mechanics and the theory of relativity, looks quite different. Here, philosophical problems are already touched upon, but, again, they are no longer so profound as they used to be in traditional philosophy. Reading even very serious basic papers of modern physics, we still do not learn anything about the general philosophical state of mind of their authors. The same happens when we read papers of philosophers about language.

If one accepts an altogether naïve, from our standpoint, thesis that human languages adequately reflect the outer world, it will follow immediately that, if we succeed in constructing a *universal grammar*, we shall have a real opportunity to answer the eternal ontological questions —to understand the way the world around us is built. Such a universal grammar should, of course, embrace both the sense classification of meaningful words ("morphology") and the rules of correct ordering of words into phrases ("syntax"); in addition, it should be built so as to make it possible to abstract from the unique qualities of separate languages. Such a grammar, if at all possible to construct, could be called *philosophical grammar* (Black, 1962).

The study of scientific language has acquired quite a specific significance for the philosophers who began to study the analysis of scientific thinking. Science has become an object of investigation, and a new trend of thought has matured: *philosophy of science*. Here again, it was necessary to begin by studying the language of science. This approach has opened the possibility of tracing the logic of constructing judgments in science, the rules of inference and verification of scientific statements. One of the most popular recent schools of thought on the philosophy of science in the West, *logical positivism*, has even declared that the principal task of philosophy is a logical analysis of scientific languages.

The profound interest of logicians and mathematicians in language can be easily explained. In verbal behavior, logical constructions are broadly used; hence, naturally, the idea occurs of the possibility of creating abstract linguistic models given by a calculus. True, here another problem emerges, that of relationships between logic and mathematics. While according to the thesis of Frege-Russell mathematics is part of logic, according to the notions of mathematicians-intuitionists, on the contrary, logic is part of mathematics. I do not, at present, consider it necessary to dwell upon this opposition. Another problem is important for us: to emphasize the deep inner links between logic and mathematics which allow the comparison of the logical structure of language with mathematical models.

Mathematicians have also come across purely applied problems of a linguistic character: first among these is the construction of algorithms

for machine translation of a text from one natural language into another and the construction of artificial languages to permit a dialogue between a human being and a computer. Finally, the broadly expanding process of the mathematization of science, which has penetrated even in the fields of knowledge which had traditionally been developing outside the sphere of mathematical structure, has shown that mathematics itself can play the role of language. In any case, the interest of mathematicians in the study of language is not limited to the range of problems encompassed by *mathematical linguistics*. The subject being already too broad, it can be divided, after Bar-Hillel (1962), into *statistical linguistics*, which considers the frequency analysis of sign systems, and *structural linguistics*, which is engaged in constructing abstract models of language.

The study of language is also one of the main tasks for specialists in cybernetics. The objects of study in cybernetics are self-organized systems, specific organisms formed from a set of things unified by a system of control. Control is effectuated by means of transmitting and processing signals. Control structure is a structure of the system language. Cybernetics may study both live systems (biological organisms and their combinations, such as communities of people and their separate groups) and inanimate objects: automata artificially created by people and naturally evolved systems. Finally, mixed systems are studied, such as the biosphere, where an informational interaction takes place between live and inanimate objects. From the standpoint of cybernetics, science can also be regarded as a self-organized system which behaves as a living organism: in the process of its development, essentially new and previously unpredictable ideas arise which further undergo a complex evolution. These ideas are created and developed as a result of an informational interaction of scientists which is carried out in a special scientific language that differs from everyday language. For this reason the study of scientific language is of special interest to those who deal with the methodology and history of science, even if they are not under the influence of the ideas of logical positivism. And if we wish to speak of information science, a new field of knowledge that attempts to comprehend and improve the system of scientific communications, the development of theoretical concepts is possible only if we thoroughly understand the mode of functioning of the language of scientific interrelations.

I believe that biology, too, deals to a great extent with a problem of language. The problems of a biochemical code or, more broadly, the problems of molecular interactions in a living cell, the problems of genetics and eugenics, of evolution, and the quite old problems of classification and systematization, a concept of the biosphere as a large

organism and connected with this a problem of large-scale ecology, all this can be formulated in terms of the science of language if biology is viewed from a broad cybernetic position.

The study of art can be regarded as the teaching of a language for communication in the emotional sphere of life. We may speak of the language of abstract painting, of the language of music, and of that of rhythm in poetry, and we can carry on quite serious investigations in these directions.

Again, we owe such a broad view of language to cybernetics. Its profound philosophical significance lies in the fact that it probably for the first time in European science has proposed an altogether unique approach: studying systems as "organisms" instead of the traditional studying of separate phenomena occurring in the systems. I have already mentioned that a system is composed of things that are united in a certain control structure; then another object of study, the language, appears. But in such a broad approach to language, a notion of language proper is gradually being lost. In any case, the definitions of language which linguists of the traditional school have been attempting to formulate seem very naïve nowadays. However, in certain cases the peculiarity of the problem formulation requires the narrowing of the concept of language. This happened, for example, in a quite new approach to linguistics connected with the name of Chomsky. Here, the concept of language is again narrowed since this approach deals with the study of the universal grammar of a natural language as an inborn human structure.

The purpose of this book is to attempt to find out what language is. In an effort to formulate the criteria determining those sign systems which I would like to regard as a language, I analyze language functions, describe hierarchical structures of language and its dimensions, and consider various approaches to the classification of languages. Classification is one of the steps in a logical analysis of complex systems. Arranging phenomena according to a definite but arbitrarily chosen scheme gives a view of the system in a special way, allowing us to see clearly what has earlier remained shaded. Thus, for example, in constructing a semantic scale of languages, I try to view the whole variety of language systems with the eyes of those who ascribe a particular significance to the probabilistic structure of language. In order to perform all these tasks, I consider a wide range of languages: abstract languages of mathematics, everyday and scientific languages, the language of ancient Indian philosophy, the language of molecular interactions, and, finally, the language of abstract painting. The Danish linguist Hjelmslev seems to have been the first to suggest conducting a comparative study of those language structures which are not languages in the traditional meaning of

the word; he believed that this would make it possible to single out an elementary language structure without all the complications characteristic of highly developed languages.

From the standpoint of cybernetics, I regard language as an organism in the belief that, having once emerged under the effect of some perhaps incomprehensible forces, it continues to develop, following its own specific line of evolution and sometimes crucially influencing the hierarchically higher systems such as human thinking. The consideration of language as an independent system may be found in the work of many linguists in the pre-cybernetic period, e.g., the German linguists Humboldt and Schleicher and much later the Swiss linguists de Saussure and Bally.

If language is regarded as a living system open to direct observation, I shall have to agree with Shreider (1971), who stated that ". . . mathematical linguistics has a certain chance of becoming a field of knowledge wherein new schemes for the mathematical description of living systems will be conceived."

This book should not be regarded by the reader as a definitive monograph but rather as an attempt to formulate separate judgments of cybernetic linguistics. In presenting my views, I am broadly basing my work upon numerous and versatile publications on the problems of language, but I am not attempting to give a review of all the various scientific conceptions of language. Moreover, I am not trying to subject these conceptions to a critical analysis. The separate statements to which I have taken a fancy are used simply to illustrate my judgments, to strengthen them, and to maintain historical continuity. I believe that even extreme and eccentric statements are of great interest and value. This is just a glance at a complex system from a very special angle. Such an angle allows us to perceive the peculiarities of a given system which remain unnoticed when the system is considered from a broader, more general philosophical point of view. And it seems to me that here we should try to comprehend the way in which various extreme judgments have come to be rather than criticize them. However, sometimes the material is presented in the form of a dialogue with those who thought and wrote much about language. And since it is language which is discussed, it is important not only *what* has been said but also *in what way* it has been said. Hence, the abundance of quotations in the book.

V. V. NALIMOV