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Current Comments

In Tribute to V.V. Nalimov: Renaissance Scholar and Scientometrician Par Excellence

Number 8 February 22, 1982

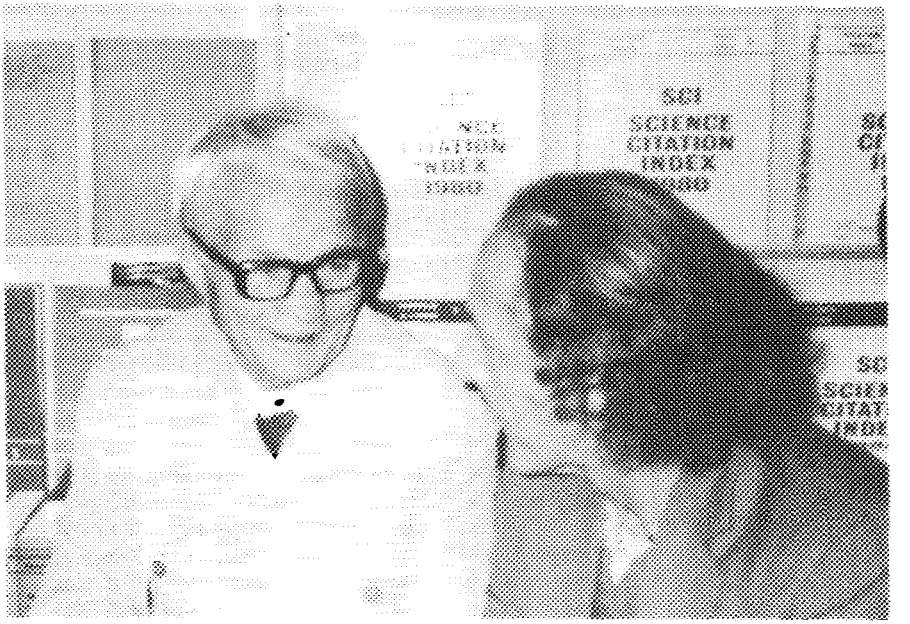
Several years ago at the first Moscow Book Fair, I met Vasilii Vasil'evich Nalimov, the highly respected Soviet statistician and information scientist. I knew that he had published important works in the fields of applied statistics and scientometrics. But he asked me to consider some of his newest work in the philosophy of science for publication by ISI Press®. Of course I was immediately captivated by Nalimov's personal charm and charisma. Later, as I read the manuscripts, I realized that his work was scholarship of the highest order. I felt that the worldwide scientific community needed exposure to Nalimov's novel way of viewing science and the exchange of scientific information. Since the primary mission of ISI Press has been to publish materials dealing with the process of scholarly communication, the Nalimov manuscripts were well suited to our goals. So we decided to introduce to English-speaking readers two of Nalimov's most original works: *In the Labyrinths of Language: A Mathematician's Journey*[1] and *Faces of Science*.[2]

These books celebrate the marriage of Nalimov's lifelong interest in experimental science and philosophy. At the same time, they represent the culmination of Nalimov's 50 years of work in chemistry, physics, statistics, and other scientific fields.

Nalimov was born in 1910, and in his childhood witnessed the upheavals and uncertainties of World War I, the Russian Revolution, and civil war. Both of Nalimov's parents were strong figures in his early life. His father, a professor of anthropology at Moscow State University, maintained a wide range of interests in the sciences and the humanities. Nalimov's mother was a dedicated surgeon. She worked vigorously throughout World War I, and died while treating the ill during the postwar epidemics.

Nalimov's interest in science and philosophy first surfaced during his high school years. The school he attended specialized in chemistry, and his teachers were scientists who also taught at the university level. Under their guidance, Nalimov became fascinated by the elegance of chemical structures. At the same time, he studied the novels of Fyodor Dostoyevsky and grew curious about the philosophical aspects of Dostoyevsky's work. These early interests in philosophy and science were to become the two main threads in Nalimov's intellectual life, but they would not become intertwined until the 1970s.

Nalimov continued his formal training in the sciences at Moscow State University, while meeting informally with friends to discuss philosophy. He did not graduate from the university, however, but instead during his senior year in 1931 began working at the All-Union Electro-Technical Institute in Moscow. There he performed studies in high vacuum physics, the photoelectric effect, and quantum electrodynamics. In



Professor V. V. Nalimov and Dr. Eugene Garfield at the Moscow Book Fair

those years, researchers were just beginning to investigate quantum mechanics, and working on the cutting edge of scientific research had a strong romantic appeal for Nalimov. During this period, he began publishing in scientific journals.

While performing experiments at the institute, Nalimov noticed that science was shifting from a world in which experimental findings could be described in terms of clear, antecedent causes, to a world in which experimental events often occurred at random, with uncertain results. Seeing conventional scientific explanations overturned, Nalimov began to pose fundamental questions about scientific terminology and methodology.

In 1943, Nalimov was appointed director of a chemical laboratory in a metallurgy plant, overseeing the quality control of all aspects of production, including various spectral analyses. Required to make crucial decisions in constantly changing situations, Nalimov made ample use of his broad background in physics.

After World War II, Nalimov participated in the geological survey of the USSR, bringing his knowledge of physical and mathematical methods to the study of geology. This experience piqued his interest in the application of mathematical statistics to research methodology—a subject of several of his later publications.

In the mid-1950s, Nalimov returned to Moscow to join VINITI, the All-Union Institute for Scientific and Technical Information of the Academy of Sciences. There he worked as a branch editor of an abstract journal in physics, and wrote his first book, *The Application of Mathematical Statistics to Chemical Analysis*.[3] Published in Russian in 1960, this textbook was so well received that it was translated into English, and appeared both in England and the US in 1963.

While working at VINITI, Nalimov defended his doctoral thesis at the Insti-

tute of Metrology in Leningrad. In 1957, he earned his Candidacy for a Doctorate in Technical Sciences, a degree prerequisite to earning a doctorate in the USSR.

During these years, Nalimov also became familiar with the work of Derek J. de Solla Price in the sociology of science, and began doing research in information science. In 1958, Nalimov published his first article in this field, with coauthors N.I. Styazhkin and George Vladutz,[4] who is now manager of basic research in ISI®'s research and development department.

The prestige Nalimov gained from the success of his textbook on statistical methods earned him an appointment at the Research Institute of Rare Metals. There he continued his investigations into mathematical statistics and the theory of experimental design, while working as a consultant to the metallurgical industry. Despite his research obligations, Nalimov continued to work on his doctoral thesis, and in 1964 he received his Doctorate in Technical Sciences. His publication record was so impressive that his professors allowed him to defend his thesis without ever having obtained an undergraduate degree.

One year later, Nalimov returned to Moscow State University to join the interfaculty Laboratory of Statistical Methods, headed by the famous Soviet mathematician, Andrey Nikolaevich Kolmogorov. Awarded the title of professor, Nalimov held the Chair of Probability Theory and Mathematical Statistics. As Kolmogorov's deputy, Nalimov devoted himself full-time to studying experimental design and the philosophical implications of his own work in statistical methods.

For ten years Nalimov worked with Kolmogorov, one of the founders of the modern theory of probability.[5] During this time, Nalimov helped launch the Soviet field of scientometrics with the publication of *Naukometriya* (*Scientometrics*) in 1969.[6] This proved to be the theoretical foundation for the work of many other Soviet and East European scholars studying the structure of scientific research. Indeed, the term he invented has been adopted by the journal *Scientometrics*, for which he serves as consulting editor.

In 1975, the Laboratory of Statistical Methods was reorganized and Nalimov was selected to head the new laboratory, now associated with the department of biology, and called the Laboratory of Mathematical Theory of Experiment. Nalimov has continued to investigate the theory of experimental design, the logical and philosophical foundations of science, and the larger philosophical relationships between science and culture. Over the past 15 years, these interests have intensified and he has produced a number of scholarly articles as well as the two books published by ISI Press. In all of these publications, Nalimov has shown a unique capacity to synthesize large amounts of literature from highly varied sources. He is thoroughly familiar with Western scholarship in the philosophy of science, for example, and fuses this information with his intimate knowledge of Soviet science in the twentieth century.

Nalimov has published so many books and papers that we could only include a selected bibliography in Table 1. Since 1933, he has published 12 books and 113 papers. There is no doubt that Nalimov's work has had a strong impact on other scientific research. According to *Science Citation Index®* (*SCI®*), Nalimov was cited 1,912 times from 1961 to 1980. His books have been especially influential. *The Application of Mathematical Statistics to Chemical Analysis*, for example, received 670 citations during these years.

As you can see from this brief biography, Nalimov's scientific career has been varied and prolific. He is in many ways a Renaissance man, bridging the

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"two cultures" of science and the humanities. Because of this, Nalimov brings an unusual perspective to philosophy and to science in the 1980s. His books sound a call to reexamine our assumptions about many of the most important aspects of modern culture—whether in the East or the West.

In *Faces of Science*, published by ISI Press in September 1981, Nalimov presents his view of science as a means of understanding man. Maintaining that "man is revealed through his vision of the world,"[2] Nalimov believes science is a mirror of human nature—not merely a tool for describing the world around us. He therefore believes that "the study of the nature of science is primarily a way of understanding man."[2] (p. xii)

Faces of Science is a series of thematically related papers, originally published in Russian. As shown in the table of contents (see Table 2), each chapter deals with a different aspect of science. What ties these papers together is Nalimov's cybernetic approach to science. Simply stated, cybernetics is the study of self-organized systems. Each system functions as a specific organism—formed from smaller parts, and unified by a system of control. Nalimov views science as a large, self-organized information system. He believes that studying the rules by which this information system operates can lead to profound insights into the nature of man.

Nalimov begins *Faces of Science* by analyzing these "rules" of science. He

Table 2: Table of contents from *Faces of Science*.

challenges the logical relationship between hypotheses and their verification by suggesting that the philosophical basis of science is not as stable as many believe. In this methodological critique, science appears not as a means of securing the truth, but as a tool for mastering nature.

Nalimov believes that the heart of science is its "creative constituent"—the ability of the scientist to pose profound questions, and to formulate novel hypotheses. In chapter two, he shows how the scientist is both indebted to, and yet burdened by, the prevailing wisdom of the day. In Nalimov's view, a scientist must rebel against the established ways of thinking to come up with productive, new ideas.

One of Nalimov's ideas which I find most interesting is his biological metaphor for science. Starting with the assumption that science is a self-governing system, Nalimov maintains that it is structurally quite similar to the biosphere. According to Nalimov, the biosphere came into existence only after the emergence of the cell. Cells develop and evolve according to certain sets of rules. Understanding these rules is the main endeavor of the biologist. Similarly, science emerged with the appearance of the modern system of scientific communication. Its "cells" are scholarly articles. The information scientist studies the rules which govern the behavior of these articles. Nalimov extends his metaphor to include citations. Like the genetic code, which transfers information between cells, citations contain much information in a compressed form, and help transfer this information from one scientific article to another.

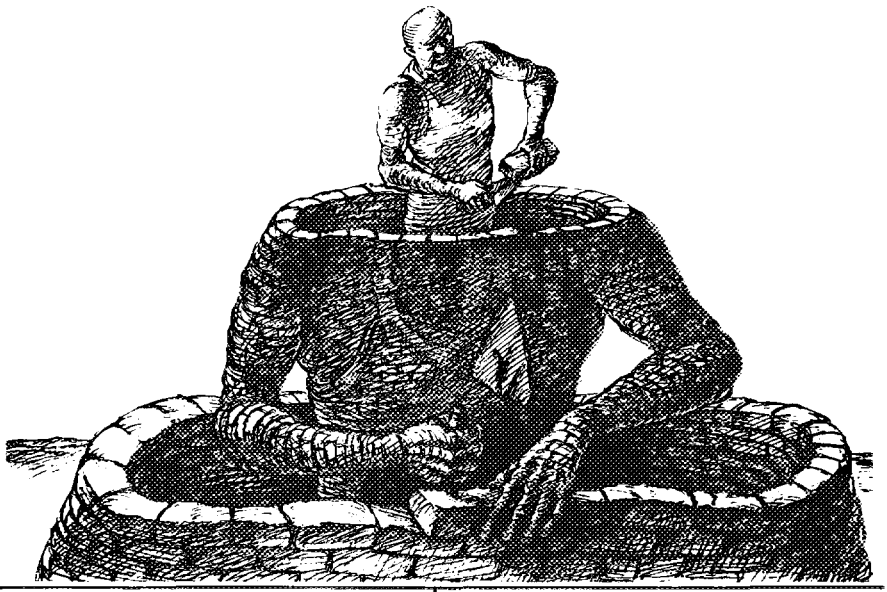
Later in the book, Nalimov applies this cybernetic thinking to some specific problems in information science. For example, during the 1960s, foreign scientific journals were concentrated in only a few research centers in the USSR. He points out that, as late as 1971, the USSR purchased only three subscriptions to *SCI*. The same is true for other major publications. While this situation has improved somewhat, he feels that the absence of such an important tool for monitoring international scientific activity has detrimental effects on the scientific "biosphere" of the USSR.

Having long been a teacher, Nalimov also examines educational aspects of science. In chapter nine, for example, he elegantly defends the humanistic education of the scientist. Studying the humanities, Nalimov believes, can help students find new approaches to problems in science.

All in all, *Faces of Science* presents a truly unique series of insights into the nature of modern science. But Nalimov does not champion a general theory of science. In his final chapter, he notes that in science "humanity has created a system whose complexity and versatility do not yield to any all-embracing description." He concludes, "All we can afford is a nibbling away at the problem."[2] (p. 274) Even so, "nibbling away" at the essays in this book provides a rich and satisfying meal.

I must say a few words about the 24 fascinating illustrations that are contained in *Faces of Science*. These drawings by Mikhail Zlatkovsky are sometimes humorous, sometimes frightening, but always thought provoking. They illustrate Nalimov's view that man's struggle to understand the universe holds the threat of intellectual confinement as well as the promise of new, liberating discoveries. One drawing, shown in Figure 1, provides a concise image of how science reflects the nature of man. The scientist appears as a bricklayer, building a model of a bricklayer, which itself is building a third model, perhaps of a bricklayer also. In Figure 2, you see

Figure 1: *Science models are rather a simulation of human consciousness than the reality of the universe.*



Zlatkovsky's visualization of the alogical nature of scientific creativity—a man leaps away from his shadow.

In *Faces of Science*, Nalimov views mathematics and other scientific methods of communication as human languages. In fact, these ideas grew out of Nalimov's earlier work, *In the Labyrinths of Language: A Mathematician's Journey*, published by ISI Press in March 1981. As you can see from the table of contents in Table 3, this book contains a series of forays into what a language is, and how a language works.

In Nalimov's cybernetic analysis, language, like science, is a self-governing system, a metaphorical organism. In chapter one of *Labyrinths*, Nalimov presents a detailed analysis of language. The small parts in the system are words, or word segments. These parts combine in different ways to form a hierarchical structure. The rules of grammar are the control system of a language, and make communication possible. For Nalimov, the primary function of a language is to transfer information, but a language must also reduce, store, and retrieve information.

As mentioned earlier, Nalimov uses cybernetic analysis to support an opinion I've often expressed—that science can be perceived through the language of citations. To illustrate the hierarchical arrangement of the scientific "language," Nalimov borrows a citation map from an article I wrote in 1970.[7] (See Figure 3.) Nalimov calls the map a "paradigm of references," and defines the term in the following way:

> Paradigm is a very polysemantic scientific term. The literal translation of the word from Greek is "example," "model." When considering an example, we usually expect that some associations are generated. For this reason, in its most general sense the term "paradigm" means an explanation of elements on the basis of association, and it is in this meaning that I shall use the term. It is also common to

Figure 2: *Scientific Creativity*

> speak of a proof from paradigm, which is based only on comparison with a well-known example. Paradigm as a grammatical term is a pattern of speech formation.[1] (p. 32)

Like the genes in Nalimov's biological model of science, and like word parts in his description of a language, citations are the building blocks in Nalimov's scientific language of references. Citations to individual articles can be grouped into larger units, and these citation groups can be used to identify patterns of scientific research. In Nalimov's view, the entire hierarchy of scientific references is stored in *SCI*. Of course, I have explained in greater detail how we form still other units, such as co-citation clusters and cluster maps from our *SCI* data base, in my book

Table 3: Table of contents from *In the Labyrinths of Language: A Mathematician's Journey.*

Foreword

Introduction to English Edition

Introduction to Russian Edition

1. What Language Is (Describing the hierarchical structure of language)
2. Probabilistic Semantics (A probabilistic model of language; computing the likelihood of successful communication; the semantic scale of languages)
3. The Language of Science (Problems in scientific terminology; the connection of terms with theory)
4. Mathematics as a Language (Mathematics as a descriptive tool for various branches of knowledge)
5. Soft Languages (Ambiguous meanings in languages—abstract painting and ancient Indian philosophy)
6. A Hard Language of Biological Codes (The precise language of genetic codes—building messages with nucleic acids)
7. The Theory of Names (Difficulty in understanding names; explanation of why names have no place on the semantic scale; philosophical and religious explanations of names)
8. Language and Thinking: Continuity vs. Discontinuity (Infinite divisibility of word meanings as an indicator of continuity of thinking; unusual or altered states of consciousness as a direct manifestation of continuity of thinking)
9. Epilogue (Summary; questioning the new dialects of science)

Appendix 1. Collection of Statements About the Term "Statistics"

Appendix 2. List of Pictures Used in the Experiment (An experiment in which an alphabet of abstract painting was created, and mathematical models were used to study the judgments of experts in painting)

Citation Indexing—Its Theory and Application in Science, Technology, and Humanities.[8] We use these clusters in our *ISI/CompuMath*™ and *ISI/BIOMED*™ systems to define highly specialized areas of research.

In *Labyrinths*, Nalimov shows how human culture is revealed through its systems of language. Each language system contains a special set of symbols, and communicates a special kind of information. Nalimov shows, for example, how the genetic code is a language in which messages are built out of nucleic acids and proteins. Nalimov draws these different languages together, and arranges them on a scale, ranging from "hard" systems with precise meanings to "soft" ones with ambiguous meanings. "Hard" languages include mathematics, computer programs, and the genetic code. "Soft" languages are such systems as abstract painting, poetry, and ancient Indian philosophy. In his holistic view, even the arts have their own self-governing language systems for communicating in the emotional arena. This language scale allows Nalimov to survey the entire landscape of human culture.

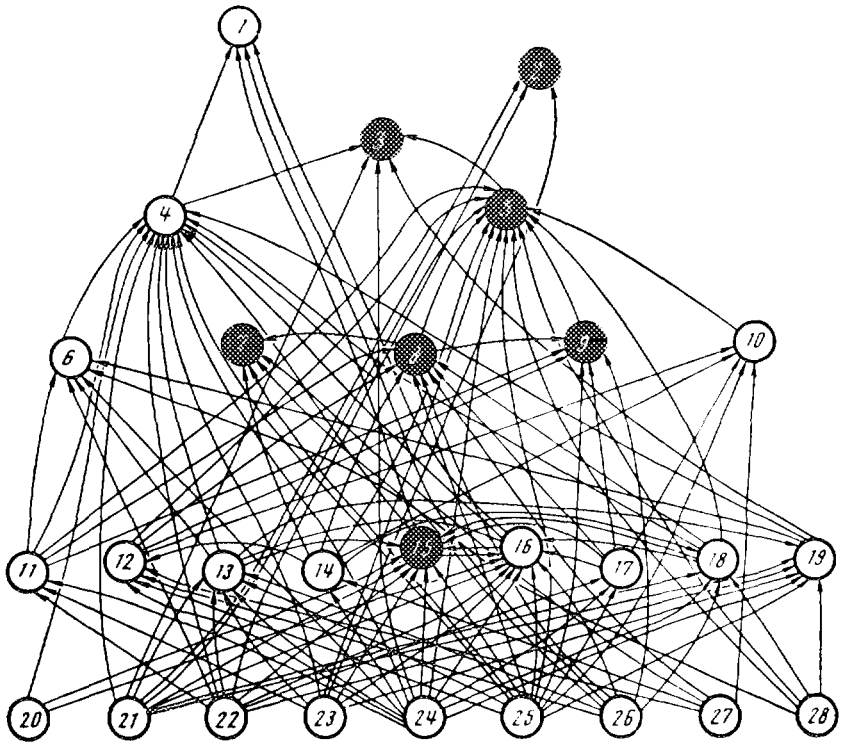
Toward the end of *Labyrinths*, Nalimov explores the relationship between language and thought, and shows how an understanding of this relationship may reveal new, creative approaches to scientific problems.

In the epilogue to *Labyrinths*, Nalimov reaffirms his conviction that "science can be regarded as the development of a certain language adapted so as to receive and mirror our knowledge of the world."[1] (p. 202) But he also shows a certain uneasiness with many of the new "dialects" science has brought forth. In our desire to invent new, ever more precise languages, such as computer programs, Nalimov believes we often lose sight of the need for varied and flexible responses to different kinds of problems.

Labyrinths presents a novel series of viewpoints on language and on science. It challenges many of our assumptions about the ways in which we communicate, and the ways in which we use languages to order the world about us.

Evidently, I am not alone in my enthusiasm for Nalimov's work. Reviews of Nalimov's books are just beginning to

Figure 3: Paradigm, formed by the net of bibliographic citations. To construct this paradigm only those publications have been used which are cited in a wide range of papers on DNA not less than five times. Blackened circles indicate publications most frequently cited. Numbers in circles allow identifications of the particulars as to place and date of publication. Paradigms of this kind can be used for practical purposes: beginning studies in the new field of knowledge, the researcher worker can fix his attention on the nucleus formed by associatively connected publications.



appear in print. For instance, Edith A. Moravcsik, University of Wisconsin, comments that *Labyrinths* "abounds in insightful analyses," and "will provide useful reading for communication scientists, linguists, philosophers, semioticians, mathematicians, and for anyone who has an interest in studying language, arts, and sciences as human activities."[9]

When I went to Moscow in September 1981 to participate in the Moscow Book Fair, and to deliver a series of lectures on scientometrics, I had the pleasure of meeting Nalimov again. We discussed yet another manuscript, entitled "A probabilistic model of the unconscious." In this remarkable work, which again demonstrates his ability to absorb and synthesize information from incredibly diverse sources, he probes an area of scientific investigation that is both an untapped mine and a potential source of controversy.

In this manuscript, Nalimov states that the study of the unconscious signifies the study of the imagination, that which distinguishes man from the computer. He argues that no sufficiently meaningful theory of the imagination has been created, since no language has been found to describe this phenome-

non whose very nature opposes formal logic. Using the language of probability, Nalimov explores this uncharted territory in the hope of discovering new paths to scientific creativity. Nalimov believes that this new work forms the natural completion of the two books I have discussed here. I am happy to report that, after having received enthusiastic responses from reviewers, ISI Press will publish this third part of the Nalimov "trilogy" later this year.

Even more than its predecessors, "A probabilistic model of the unconscious" reveals patterns in human knowledge that cross the traditional boundaries between the arts and sciences. For this reason, it deserves to be read by people outside the world of science, as well as by scientists themselves.

All three works are bonded together by Nalimov's concern that human knowledge is fragmenting into a multitude of technological specialties, and that science may therefore have difficulty finding creative solutions to global problems like pollution. This is why Nalimov takes such daring steps in probing the creative heart of human discovery. By uncovering the purely human problems which he believes underlie all other problems, Nalimov seeks to restore to knowledge its lost unity. This is a quest we cannot afford to ignore.

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My thanks to Joe Pickett for his help in the preparation of this essay.

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*Reprinted in: **Garfield E.** *Essays of an information scientist.* Philadelphia: ISI Press, 1981. 4 vols.