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PSYCHOLOGICAL MATTERS IN THE SYMPOSIUM CYBERNETICS IN THE SERVICE OF COMMUNISM*

The symposium Kibernetiku — na sluzhbu kommunizmu [Cybernetics in the Service of Communism] contains articles by Soviet experts on matters of application of modern cybernetics to the major fields of science and technology. The articles in this symposium are arranged in the following sections, a listing of which indicates the breadth of the problems covered: 1) The Gathering, Processing and Transmission of Information; 2) Cybernetics and Living Nature; 3) Cybernetics and the Humanities; 4) Cybernetics in Science and Technology. The symposium has a lengthy introduction by A. I. Berg titled "Cybernetics in the Service of Communism," which is programmatic in nature and contains an analysis of all the principal problems of cybernetics.

Characteristic of the collection is the major attention given to problems of the interrelation between psychology and cybernetics, study of the mechanisms of thought with the object of developing automatic means of performing functions of thought, more rational performance of the psychological activity involved in work, and a number of other psychological problems. In this respect the symposium differs significantly from many of our publications and symposiums on cybernetics published in the recent past.

The literature on cybernetics published in our country usually poses questions as to the relationship between cybernetics and various sciences — physiology, genetics, linguistics, etc. In this list of sciences coterminous with cybernetics, psychol-

*Kibernetiku — na sluzhbu kommunizmu, symposium edited by Academician A. I. Berg, Moscow, Gosenergoizdat, 1961.

ogy has usually been lacking, despite the fact that modeling of psychological activity, which is one of the major problems of cybernetics, is impossible without consideration and study of the laws of this activity, constituting the subject matter of the science of psychology. The symposium under review will help to overcome the underestimation of psychological subject matter on the part of some of our specialists; this will, beyond all doubt, prove to be highly fruitful for both sciences.

In this respect a major service is performed by the editor of the symposium, A. I. Berg, who, as early as his introductory article, advances the need for psychological studies in solving problems of automation of the production process.

Berg expresses the view that "automation of the control of complex processes and systems will not free man completely of this work, but will place him in new conditions" (p. 17). Man is found to be one of the links in a system; machine – automatic controls – man. The fact that man plays this role in the system of automated production poses new problems to science. In a complex system of automatic devices, including numerous machines, flow-of-production lines, departments and plants, there is always a certain probability that one of the links in the chain will go out of order because no such thing as faultless mechanisms and machines exist. The role of man under such conditions is to get the system back in operation in the briefest possible time and to carry out the necessary control processes. "Failure, even temporary, in the functioning of any link (and in this type of system there are no 'important' and 'unimportant' links)," writes Berg, "requires immediate intervention and the performance of a number of control operations. Moreover, frequently the period of time available is so brief as to exceed the physiological and psychological capacities of man" (p. 17).

Thus, problems of psychological activity in the work involved in a system consisting of man and automatic equipment is primarily the problem of the dependability of man as one of the links in this system. Solution of this problem is one of the pathways to solution of the problem of the reliability of the automated system as a whole.

Berg sharply criticizes those designers and technologists who build automated devices without consideration of the psychological and physiological capacities of man. He writes: "There are cases in which the design organizations, designers and technologists forget about man, holding, with no foundation whatever, that in the age of automation the role of man becomes subsidiary and that his work is eased 'automatically.' In a system comprising machines, automated equipment, and man, each individual link, and the system as a whole, must function under optimal conditions. This pertains particularly to the physical and psychophysiological burden borne by man. In the last few years this proposition has begun to gain recognition."

Further, Berg emphasizes the inadequacy of the literature written in our country on labor psychology and calls for a broad expansion of work in this field which has a job to do in labor rationalization under conditions of automation: "Soviet literature on engineering psychology thus far consists only of a few articles. It must be hoped that this is only a beginning. To ignore this field will have a direct influence upon labor conditions in industry. It is highly desirable that persons who have hitherto failed to show an understanding of all the foregoing visit some of our automated plants. They would see with their own eyes how important it is to study the conditions of human labor in the age of automation" (p. 19).

The symposium contains a special article devoted to psychological questions of automation. Written by D. Iu. Panov and D. A. Oshanin, it is titled "Chelovek v avtomaticheskikh sistemakh upravleniia" [Man in Automatic Control Systems] and poses the problems previously raised in an article published in Voprosy psikhologii, 1961, No. 1. An interesting aspect of this article is that it was written jointly by an engineer and a psychologist. In this sense it enjoys a particular symbolic value and demonstrates the need and fruitfulness of creative collaboration between representatives of psychology and automation specialists in solving the most important practical problems of cybernetics.

Having demonstrated the significance of automation of processes of human mental activity in the rationalization of labor and in increasing its productivity, the authors further emphasize that it is impossible to transfer all such processes to the machine and point to the inevitable role of man even when systems of the highest degree of automation are present.

As demonstrated in the article, the role of men in modern control systems is by no means exhausted by his intervention in unforeseen and emergency situations. "Being himself the most dependable link in such systems, man performs in them a number of the most responsible functions, including those which cannot to this day be modeled in engineering" (p. 175). The fact that man's natural information channels function less rapidly than the corresponding channels of machines is compensated for by the highly efficient methods of receiving and processing information thus far possessed only by man.

The specific features of human intellectual activity to which attention is directed in this article are of major significance to cybernetics in two respects. To begin with, they advance the necessity of detailed analysis of modes of processing information by man so as to make possible subsequent transference of some of these methods to machines. They pose the problem of the need to take man's psychological properties into consideration as the most important link in the control system.

The authors give their major attention to the second problem. The article poses the problem of optimal matching of the technical and human factors in control systems. This coordination presumes precise allowance both for the relative weaknesses and for the relative advantages of each of these factors. Further, the article adduces data from engineering psychology that can be employed by designers in developing instruments and other control means.

Of particular interest from the point of view of labor psychology is the posing in this work of the problem of investigating the individual capabilities of the working individual. This problem is posed in the context of the meaning of the "human" or "subjective" factor in various types of events. We know that the "human" factor is responsible for 40 to 66% of aviation accidents. Moreover, 70 to 80% of these are due to inborn anatomic-physiological characteristics, while no more than 8 to 14% are caused by factors due to the flyer's personal experience.

The article provides a classification of individual characteristics influencing an operator's work. All these individual characteristics are divided into three groups: 1) anatomic and psychophysiological factors; 2) factors in the psychomotor and intellectual sphere; and 3) characterological and purely personal qualities.

We cannot but emphasize the timeliness and importance of these problems. It must be observed that in our literature on labor psychology the problem of choice of people for jobs is posed in an exceedingly obscure manner, and therefore the fact that this article appeals for a broader study of this important problem is most satisfying. "It must be stated with great firmness that the inadequacy of certain techniques once employed in our country and still popular abroad must not be taken as an excuse for a contemptuous attitude toward the problem of selection for jobs in general. Such an attitude is particularly intolerable in cases involving operators of control systems, people whose work often involves great risk and even danger to life, both for themselves and others" (p. 183).

An attempt to approach the solution of another problem common to psychology and cybernetics, the problem of modeling psychological (and, in particular, intellectual) functions in automatic machines, is found in a number of papers in the symposium which, although not directed to psychology in purpose or content, are nonetheless of considerable interest to psychologists.

We direct attention, in the first place, to the article by A. V. Napalkov, "Izuchenie printsipov pererabotki informatsii golovnym mozgom" [A Study of the Principles of Information Processing by the Brain]. A considerable portion of this article consists of a survey of writings on the modeling of functions of thought by learning machines. This survey is of great interest to the psychologies of labor and of thought. Inasmuch as the Russian-language literature on the problem of the modeling of thought is extremely small, it is appropriate to present here certain information from this article.

Particularly interesting is the presentation of the findings of a group of American researchers (Newell, Shaw, Simon, Reitman, Feingenbaum). It is striking that this team includes psychologists, physiologists, mathematicians, and engineers. Representatives of these various fields engage in joint studies of the mechanisms on which the solution of complex problems are based. To learn about these mechanisms, experiments are performed with human subjects (students at a polytechnical institute). The forms of intellectual activity discovered are then described by algorithms which, in turn, are employed to develop a program for an electronic computer. There is every reason to describe the experiments on which these algorithms are based as psychological.

These studies were employed to develop a theory of human problem-solving, and a program titled "the universal problem-solvers" was developed. This program, fed into a computer, enables the given machine to solve various problems. The program combines two systems reflecting the real course of the solution of these problems by man: 1) analysis of the means for achieving the goal, and 2) planning.

On the basis of analysis of means for attaining a goal, the machine selects paths for searches leading to the solution of a given problem. The planning technique involves ignoring details of the objects under analysis not significant for solution of the problem. As the survey points out, the problem is initially constructed and solved in abstract form. This solution is then transferred to the initial form. On this basis it proves possible to construct an optimal plan for solution of the task.

The article emphasizes the fact that the program of the "universal problem-solver" makes it possible

to take a (wholly appropriate) decision even if algorithms for solution of the given concrete problems are lacking and the complete information required is absent. Solution of the problem proves possible in this case on the basis of a system of rules assuring the most rational search for a solution to the problem (search algorithms). It also proves possible to determine the most promising direction for search, and the sequence in which it is most advisable to consider the various possible directions toward a solution. It also proves possible to exclude a number of variants in the search incapable of leading to successful results. It is interesting to observe that these methods of solution are termed heuristic. This emphasizes the closeness with which they approximate actual creative processes.

The automatic devices developed on the basis of these investigations are in large-scale practical use. For example, they are proving to be suitable for solution of problems involved in varying the conditions of operation of an enterprise converting to the production of a new model of a machine. In such a case, the automatic equipment resolves the question of optimal utilization of the old equipment combined with the new, the most efficient system of operation of a conveyor, raw material supply, etc.

The material adduced by A. V. Napalkov is of major theoretical significance both for the psychology of thought and for that of work, and opens broad prospects for research in both these branches of psychology. It demonstrates particularly the fruitfulness of that line of investigation in the psychology of thought that consists of study of the concrete dynamics of analysis, synthesis, abstraction, and generalization in any particular form of intellectual activity. Also clearly evidenced here is the proposition to the effect that the results of experiments in the study of the mechanisms of thought may be applied in practice and can serve as a powerful factor in technical progress.

Engineers are increasingly recognizing the fact that it is impossible to solve problems involving the modeling of thought in technical devices without analysis of the laws of human intellectual activity. In this connection the need for the most intimate contact between psychologists and engineers in the corresponding fields becomes increasingly clear. At the present time this connection is limited in our country merely to problems of optimal design of signal systems, scales, control panels, etc., i.e., chiefly to matters of visual perception. These questions are very important and their solution is a major step in the treatment of the problem of the man-and-automated-equipment system. However, as the data adduced demonstrate, contact between engineers and psychologists cannot be limited to problems of perception. The modeling of complex problems of thought, including those of a productive nature, is a no less important and pressing task. Psychologists specializing in the fields of thought and labor must be involved in the solution of these problems important to technological progress.

Large-scale treatment of this problem by psychologists is most necessary since at the present time physiologists in the field of higher nervous activity have begun to concern themselves with the study of thinking activity from the viewpoint of modeling and automating it, and this sometimes results in a certain degree of confusion in the elaboration of this important problem.

Examples of such efforts made with means inadequate to the purpose may be found in this same article by Napalkov. The writer suggests a new name for the field he is investigating -- "information physiology" -- which he advances in contraposition to the "information psychology" of K. H. Frank. Unfortunately we are left unclear as to where any fundamental distinction exists between "information physiology" and "information psychology." The author offers us no more than the assertion that "the subject area and theoretical substrate of 'information physiology' differs considerably from the problems dealt with by physiologists and psychologists" (p. 158). The meaning of this assertion is not entirely clear in the light of the author's own experimental studies.

The technique employed in Napalkov's experiments was the following. The subject was faced with a special instrument consisting of a panel with 16 buttons and two switches, as well as a panel bearing stimuli (electric light bulbs, a bell, and so forth). The instructions read: "Your object is to light the white electric bulb." The subject could solve this problem by manipulating the buttons and switches on the panel. This caused various signals, whose significance was not known to him, to appear and disappear. The switching on and off of the signals was governed by a program also unknown to the subject. The author described the results of the experiments as follows:

"Under these conditions the subjects, having carried out various probing operations and analyzed the external information appearing as a consequence, finally found a means of achieving the goal (for example, lighting the bulb). Usually the goal was attained in very complex fashion at the first try. Subsequently, with the repetition of the experiments, the subjects found more rational means of quickly securing the required results" (p. 165).

It is not difficult to see that this experiment is,

both in technique and results, one of a purely psychological nature. It is merely a modification of the classical psychological techniques of the problem box and the maze, which are more than half a century old. Under these conditions the subject performed as was to be expected. His initial acts were probing, then numerous and chaotic, "complex," subsequent to which the motor structure became stable, and the time required to carry out an assignment diminished.

It is obvious that such a modification of the old psychological experiment had meaning, and the results of the experiment are of interest particularly because modern mathematical techniques were employed in the processing. But one can hardly speak of this study as something fundamentally new, differing both from psychology and physiology. And we are wholly unable to understand the author's statement in which he presents the results of his experiment: "Thus, a precise study of the laws of the processing of information by the brain proved possible" (p. 165).

Here, in attempting to provide a physiological interpretation of a psychological experiment and, as a matter of fact, elsewhere in his article Napalkov makes a serious mistake in identifying the algorithm for solution of the problem with one for the functioning of the brain. At the present level of physiology, any such identification of man's intellectual activity and the neurodynamic processes of the brain are, to say the least, premature.

It must be emphasized that it is not only psychologists studying human thought, but engineers — whose problem it is to model intellectual functions — who have to deal with human behavior in complex situations. The method suggested by A. V. Napalkov can hardly satisfy them.

From this point of view, the article of A. D. Voskresenskii and A. I. Prokhorov, "Problemy kibernetiki v meditsine" [Problems of Cybernetics in Medicine], is of great interest, particularly the portion devoted to the prospective employment of electronic computers for the processing of diagnostic information.

The authors of the article pose squarely the most important problem in this field: "What is the relationship between the thinking of a physician and the content in mathematical logic of the algorithm (modeling the physician's process of arriving at a diagnosis)?" (p. 133). This problem is part of the more general problem in cybernetics pertaining to the correlation between the thinking activity of man and the work of a piece of automatic equipment modeling this activity. Analyzing this question further, the authors write: "Doesn't the physician's role thus reduce to that of a collector of data for a machine? In other words, won't diagnosis be completely entrusted to the machine? This question derives from the specific nature of the thinking of a physician in the process of making a diagnosis" (p. 133). And the authors provide an analysis of the intellectual activity of the physician which is of major psychological (professiographical) interest.

The complexity of a physician's thinking in his work is that at the patient's bedside he encounters human individuality: anatomic, physiological, and psychological features that are wholly unique. "The physician's knowledge and experience face thousands of fleeting subtleties, trifles, which cannot be studied in manuals and which are encountered each time in new and unexpected combinations" (p. 133).

The authors describe the course of a diagnosis as follows. The physician obtains data about the patient from conversation with him, physical examination, and laboratory analysis. He then evaluates the relative importance of various symptoms and, having arrived at a general picture, consciously considers and analyzes each of the diseases the patient may possibly be suffering from. On the basis of this activity, both analytic and synthetic, the physician comes to a definite diagnostic conclusion which he is then able to validate with a greater or lesser degree of confidence.

On the basis of analysis of the physician's thought activity, the authors conclude: an effort to formalize this model of diagnosis "to a degree that would make it possible to follow in detail the entire course of the physician's thinking, is anything but simple. A machine acting on the model of a simple matching of the given patient's disease symptoms and those in manuals on diagnostics is as poor a diagnostician as a man ignorant of medicine but capable of reading rapidly a reference volume on therapy" (p. 134).

The authors justly note, further, that even if the machine is equipped with all the special knowledge available in the entire medical literature, complete identity between the intellectual activity of the physician and the "thinking" of the machine will not occur. The difference here is that the physician seeks symptoms, evaluates their diagnostic significance, and chooses a method of treatment on the basis of his personal abilities and experience. The subjective personality factor in the physician's thinking is his "general intuition," which develops as he familiarizes himself with the given case, and which arises on the basis of analysis of this given case. These ideas of intuitive origin are regarded by the authors as the art of the physician, constituting a distinctively human ability.

"There can also be no question that intuition (or the art of the physician) is an unavoidable factor in the process of diagnosis, inasmuch as at the present level of knowledge we are incapable of including in precise analysis all the infinite variety of individual shadings in the manifestations of a disease and cannot reduce many of the symptoms encountered to single significances" (p. 134). The authors justly pose the question of automation of those components of diagnostic thought that are susceptible to formalization. Such precise formulation must be based upon a study of the thinking activity of the physician. They see the essence of the problem in "separating the diagnostic factors susceptible to exact analysis from judgments of an intuitive character" (p. 134).

One sees readily how interesting for the psychologies of work and thought is the analysis (fundamentally psychological) provided in this article of the thinking of a physician in the process of making a diagnosis.

The results of investigation of such a complex form of work-thought as the activity of a physician also suggest the direction to be followed in experimental study of thought, the results of which may facilitate solution of a number of the problems of cybernetics. The experiment should model thinking activity in work in its fundamentally significant characteristics, reflecting with adequate completeness the variety and richness of its real course. Only such an experiment can promote the discovery of the psychological laws of thought necessary to the design of cybernetic devices.

The approach to the study of thought suggested by certain physiologists, and consisting of the development of a simplified model for experiment, cannot be regarded as offering good prospects in this respect. The theoretical concept underlying this approach and characterized by a direct comparison of psychological mechanisms for the solution of problems and the physiological mechanisms of brain function also cannot be regarded as satisfactory.

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The basic content of the symposium, as we have already indicated, is devoted to elaboration of problems of cybernetics and the employment of its methods in various fields of science and technology. The more gratifying, therefore, is the considerable attention given to problems of psychology in the pages of this symposium. This fact demonstrates that even today psychology may constitute a serious factor in scientific and technological progress. It presents psychologists with serious problems.

One of these problems is research into the mechanisms of thought woven into man's activity at work. Discovery of the laws of thought activity and the objective study of intellectual processes will yield material for the design of computers that will model this activity and increase the role of psychology in technical progress.