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USSR Report

LIFE SCIENCES

BIOMEDICAL AND BEHAVIORAL SCIENCES

(FOUO 1/82)

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CONTENTS

BIOCHEMISTRY

HANDBOOK DESCRIBES RAPID MICROBIAL IDENTIFICATION METHODS

Kishinev USKORENNYYE METODY ENZIMOINDIKATSII MIKROBOV in Russian 1979 (signed to press 9 Jan 79) pp 2-4, 170-171

[Annotation, table of contents, and foreword from book "Rapid Enzymatic Methods of Microbial Identification", by Valentin Mikhaylovich Nikitin and Stepan Vasil'yevich Plugaru, Kishinev State Medical Institute, Moldavian SSR Ministry of Health, Izdatel'stvo "Shtiintsa", 1,525 copies, 172 pages]

[Text] This monograph presents rapid methods of enzymatic identification and biochemical differentiation of microorganisms. For the first time, a microbiological classification, developed by the authors, of rapid methods for studying the biochemical activity of microbes is presented. The book illuminates the theoretical, methodological, and technical problems associated with rapid enzymatic methods of microbial identification, and it examines the influence of various factors on the rate of bacterial enzymatic reactions.

The monograph is intended for a broad range of specialists--microbiologists, biologists, biochemists, epidemiclogists, specialists in infectious diseases, and laboratory technicians.

Contents Page

Foreword

The biochemical activity of microorganisms can be studied by determining their capability for breaking down various chemical compounds (organic, inorganic, and synthetic) by means of specific exo- and endoenzymes released by them. Such determinations play an important role in identification of such microorganisms in the laboratory, and they are broadly employed as a means for describing the pathogenic properties of microorganisms. Moreover industrial microbiology uses methods to determine the spectrum of enzymes and their activity in its search for microorganisms that actively produce specific enzymes which are used in directed catalysis with the purpose of obtaining useful biological products and various bacterial cultures, which are in turn used to break down various wastes and toxic chemicals.

Medical microbiologists interested in identifying pathogenic microorganisms and determining the properties of different populations of bacteria study their biochemical activity, inasmuch as this activity is the basis of bacterial classifications, and it is always used to establish the generic membership of disease agents, and as a means for their specific and typological differentiation.

The longest and most laborious stage of microbiological analysis performed in the course of laboratory diagnosis of a given infectious disease is that of studying the biochemical properties of pathogenic microbes (especially when 8-10 and more specific enzymes produced by the disease agent must be revealed).

It takes 24-48 hours and longer to analyze 5-7 enzymes by the commonly accepted, universal serial differentiation technique, used to study the biochemical properties of microbes. This length of time for determining the biochemical traits of microbes fails to satisfy the demands of microbiological practice and the epidemiological service today.

New methods of rapid determination of the biochemical properties and enzymatic activity of microorganisms have been developed, and existing methods have been improved in the last 20-30 years in the Soviet Union (Adamov, 1964-1972; Andreyeva, 1960; Andreyeva, et al., 1976; Blinkin, 1963; Blokhina, 1977; Kalina, 1973-1976; Kiktenko, 1953-1966; Kichenko, 1948; Nikitin, 1964-1978; Plugaru, 1970-1977; Ravich-Birger, 1955-1970, and others) and abroad (Closs, 1971; Matsen, 1970; Schwartz, 1968; Thiry, 1974). Owing to their quickness, and the negligible outlay of labor and materials, rapid enzymatic methods for determining the presence of microbes and identifying them has significant advantages over Hiss's commonly accepted classical serial differentiation technique, and chemical methods. They are distinguished by high specificity, simplicity of execution, and high information content; moreover they may be used to study fermentation of substances with chemical nature that is unknown or insufficiently revealed.

A large number of diverse rapid micro- and macromethods of determining the enzymatic activity of microbes have been developed and proposed. But most of them have not enjoyed broad application in bacteriological laboratories. This can be explained by a number of reasons: imperfections in many rapid methods that seriously limit their use; lack or extreme scarcity of a number of chemicals and preparations necessary for quick enzymatic identification of microorganisms, and absence of a scientific classification of these methods, and of the required scientific references and manuals.

A real necessity has arisen for testing a number of the most promising rapid and economical methods of fast enzymatic identification of microbes; information obtained from experiments with these methods would permit us to select one (and possibly two), and recommend it for introduction into microbiological practice.

This monograph will promote broader and fuller use of the possibilities of rapid enzymatic methods of bacterial identification, and further development of the theory and improvement of the microbiological methods of rapid detection of the biochemical properties of microorganisms.

11004
CSO: 1840/191

BIONICS

UDC: 153.001.57+621.391

ALGORITHMS OF INTELLECTUAL ACTIVITY

Tashkent ALGORITMY INTELLEKTUAL'NOY DEYATEL'NOSTI in Russian 1979 (signed to press 20 Dec 79) pp 2-6, 132

[Annotation, foreword, introduction and table of contents from book "Algorithms of Intellectual Activity", by Adyldzhan Akhmedovich Usmanov and Anatoliy Viktorovich Napalkov, Uzbek Scientific-Production "Cybernetics" Association, Uzbek Academy of Sciences, Izdatel'stvo "Fan", 100 copies, 132 pages]

[Text] This monograph is the result of joint research of specialists in the area of algorithmic analysis of brain function and theoretical cybernetics. It describes the methods for the study of higher nervous activity in man and some models related to analysis of thinking while playing chess. Analysis is made of the learning process; an algorithmic description is given of man's orienting and exploring [research] abilities under difficult environmental conditions. Analysis is made of the process of decision making in new situations that are not known to man. There is discussion of the means of using algorithmic descriptions of intellectual activity to solve practical problems.

This book is intended for a wide circle of scientists, students, school children and all those concerned with problems of development of cybernetics and creation of artificial intelligence. Illustrations 7; bibliography lists 185 items.

Foreword

Development of cybernetics opened up vast new opportunities to study brain function. The period that has elapsed since the publication of the works of N. Wiener revealed that most efforts to analyze the mechanisms of intellectual activity on the basis of existing methods of formal description did not lead to perceptible results. Until recently, there has been a rift between neurophysiological studies related mainly to accumulation of facts and development of theory in the field of cybernetics. The rich opportunities for demonstration of the mechanisms of brain function, which were created on the basis of development of cybernetics and computer technology, have remained unused. For this reason, the ideas of V. K. Kabulov concerning the algorithmic direction in cybernetics are considered to be extremely relevant.

The problem of applying theory of information processes to the study of brain function is of special importance. Thinking is an example of the most complex and refined information processing. Many studies are presently being pursued in this direction. Many questions are the subject of serious discussion.

This book reflects one of the directions whose goal is to provide an integral description of the mechanisms of higher nervous activity on the basis of the method of algorithmic analysis. The material is arranged in accordance with the principle of advancing from simple processes and means of their formal description to more complicated ones. This mode of presentation also conforms with the history of formation of theory of information processes. First, there is discussion of the general conception of information-related activity as a phenomenon of construction, transformation and transmission of images, then there is analysis of different mechanisms of brain function. The methods, which are based on use of cybernetic theory, are compared to the results of psychological and neurophysiological studies.

Introduction

The main function of the brain is to process information. There are amazing properties in information and its processing. While they do not exist by themselves, in a "pure form," they are always expressed by some physical or chemical systems, they move from one system to another, retaining their main "content" (remaining unchanging). Thus, it is well-known that messages can be transmitted over radio waves, expressed in the form of sonic oscillations, written on paper, etc. The essence of information cannot be reduced to any of its physical "carriers." The same properties were found in a study of information processing, in particular, in development and use of computers. The program as a description of information activity cannot be reduced to the physical arrangement of a computer. The same computer, as a physical system, can be used for different information-related activity, for example, the capacity to play chess or control melting of steel.

These properties create great difficulties in the study of information processes, if they are expressed in living organisms. They have the capacity to emerge in the form of various physical and chemical manifestations, altering their "external image."

Information processes are organized in the form of social structures and constructions, which do not have an unequivocal conformity to the structure that expresses their basis. For this reason, isolation of physicochemical elements playing an informative role does not make it possible to analyze integral information activity as such. When a researcher tries to study information activity on the basis of isolation of physical or chemical elements that express it, for example, he determines the structural formula for insulin, effect of renin on blood pressure, or examines bioelectrical phenomena in neurons of the brain, he inevitably overlooks integral information processes. Only physicochemical phenomena are the object of his observation.

In the past, the above-mentioned difficulties were underestimated. For this reason, as has been recently shown, a substantial gap developed in the system of man's knowledge about phenomena in nature. Assurance that science has sufficient information about information processes in living organisms turned out to be a great and dangerous illusion. The extent of the miscalculations made in science is determined by the great significance of information processes in different areas of man's life.

In our times, it became apparent that, while science had a powerful armamentarium of resources in the area of investigation of chemical and physical phenomena

in nature, including the feasibility of formal description of processes (for example, in the form of structural formulas and systems of chemical equations), it has far from modern resources for the study of information activity of living systems and, in particular, the study of brain function. There, studies are essentially on a primitive level, and they do not rise above the simple collection of facts. On the one hand, it has become apparent that the previous attempts at studying information activity on the basis of analysis of physicochemical processes were doomed to failure. On the other hand, efforts made to artificially construct information systems within the framework of "artificial intelligence" were in the nature of an intuitive search, similar to some extent to the search for the means of synthesizing complex chemicals during the alchemy period. Of course, they could not lead to results that would become the foundation for investigation and comprehension of mechanisms of brain function. For this reason, in our times a new and pressing problem emerged, that of organizing research of information processes as such, on the basis of isolating them from the obscuring physicochemical systems.

First of all, the question arose of the possibility of isolating and "cultivating" information activity outside living systems. We know that until chemical processes were studied in "test tubes" and microorganisms were cultivated on nutrient media it was not possible to study the complex phenomena occurring in living organisms under normal conditions and in the presence of pathological deviations. This problem became even more acute in the study of information processes since, in addition to the task of isolating the essential main process from complex systems, the problem emerged of separating them from the effecting physicochemical basis. Then it was necessary to express the isolated information processes in dynamic systems, where they could be "preserved" for a long time and studied. In this connection, a need arose for special symbols and rules of construction of information structures and their elements.

Just as it was necessary to start with the reproduction in test tubes of the most elementary reactions in the field of chemistry, in the study of information processes one had to artificially reproduce, at the first stages, the most elementary information structures and their correlations. Then it became possible to reproduce in models and to study the properties of complex information systems. After the foundation of abstract theory of information processes was laid in this manner, it was possible to analyze on its basis the complex, complicated information systems existing in nature, for example, the thinking of a designer, investigator, information processes at the basis of control of development of an organism and biocenoses, pathogenic information systems responsible for development of diseases.

The correlation between theory of information processes and mathematics is very important. Apparently, the formal means of describing information processes cannot be reduced to any of its existing parts. They resemble most the means of abstract description (systems of formulas) that are used in chemistry. At the same time, since mathematics is part of information activity, there is the prospect of constructing a single, integral system of modern mathematical means of formal description.

Contents

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BIONIC MODELING OF FISH ELECTRIC COMMUNICATION AND LOCATION SYSTEMS

Moscow VESTNIK AKADEMII NAUK SSSR in Russian No 1, Jan 81 pp 99-110

[Article by V. M. Ol'shanskiy, A. A. Orlov, and Dr Biol Sci V. R. Protasov]

[Text] The methods of creating bionic models differ from methods usually employed in biological research to model any processes or phenomena. Every biological object is typified, on one hand, by universality in relation to the functions it performs and, on the other hand, unique features inherent only to a living organism. Using technical devices to directly copy biological structures performing certain functions fails to produce optimum solutions. Therefore when building a bionic model, it would be best to use only the general phenomenological characteristics typifying a particular aspect of the activity or function of a living organism, applying in this case the sum total of presently available knowledge and technical devices.

Information on Electric Fish

About 300 of the 20,000 presently existing fish species possess special electricity generating tissues and are capable of generating electric fields. Among these, only the electric eels, electric catfish, electric skates, and American stargazers have distinctly pronounced electric organs with which they create intense electric fields about themselves, used in attack or defense. The electric organs of the skate, for example, generate discharges having an amplitude of up to 50 w and a current intensity of up to 50 amp in sea water. The energy of such a discharge may be estimated as 1 mj per gram of electric organs. The frequency of discharges in response to stimulation attains 150 Hz, each discharge lasting 3-5 msec.

The rest of the species make up a second group of so-called weakly electric fish, which generate relatively weak electric fields with amplitudes on the order of 5-10 w in water.

Weakly electric fish are divided in terms of the sort of discharges generated into wave and pulsating species. Pulsating species include all Mormyriformes (except for gymnarchids) and the bulk of the gymnotids. The duration of discharges produced by pulsating species is much shorter than the time interval between discharges; in this case the fish may vary the discharge frequency within broad limits. For most pulsating species, this range is 1-60 pulses/sec. Wave species generate

quasisinusoidal discharges of practically constant frequency. These frequencies are species-specific , and they fall within the 50-2,000 Hz range.

Fields generated around fish differ from electric fields around dipole sources (Figure 1) mainly due to nonuniform distribution of a fish's electric skin resistance.

The electric organs of fish consist of specialized cells (electric plates) transformed, as a rule, out of muscle fibers and, in some species, out of nerve fibers. A typical feature of these cells is functional differentiation of cell membranes, taking the form of innervation of just one side. At the moment of stimulation, the potential difference across an electric plate attains 40-120 mv. Electric plates in electric organs are stacked into columns, which are in turn connected in parallel. Owing to this the emf and current produced by the whole electric organ significantly exceed the corresponding outputs of a single electric plate. The orientation of these columns in electric organs located in the fish body predetermines the polarity of the discharge and the current direction.

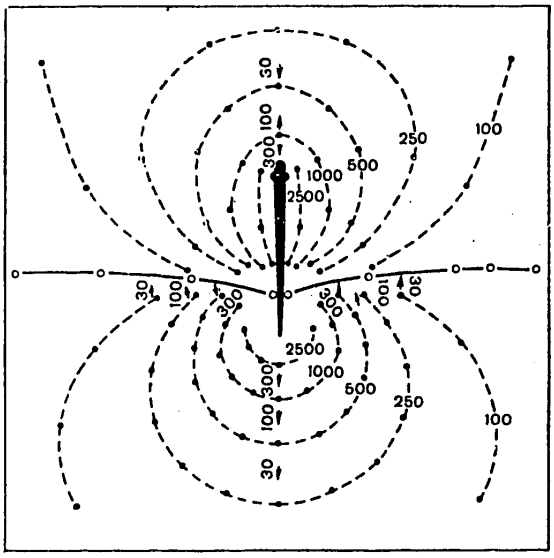


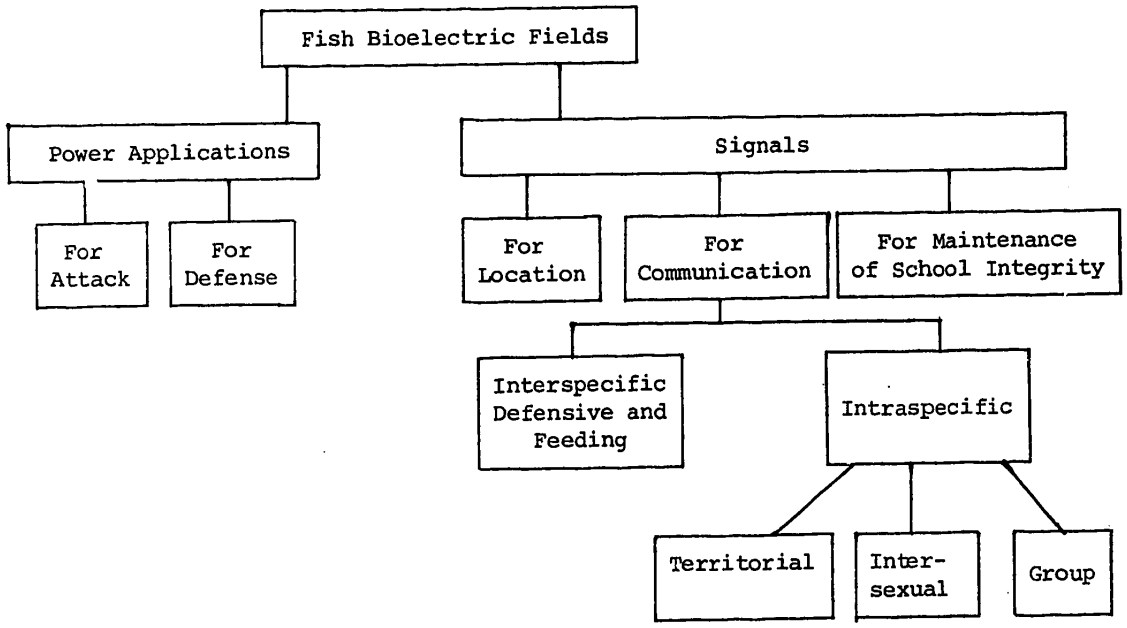
Figure 1. Electric Field of a 22 cm Long *Apteronotus* in Water With Specific Resistance Equal to 3.2 kohm·cm (From Knudsen, E. I., "Spatial Aspects of the Electric Fields Generated by Weakly Electric Fish," JOURN. COMP. PHYSIOL., Vol 99, 1975, pp 103-118): Field potentials are indicated horizontally in μv on the equipotential lines corresponding to them. Field intensities are indicated vertically in μw/cm near the vectors associated with them.

All weakly electric and many strongly electric species have electroreceptors exhibiting high electric sensitivity. They evolved from fish lateral line organs, and they are situated in the skin, communicating to the body surface through pores.

Their density is usually greatest in the anterior parts of the body and the head. In terms of their physiological properties, electroreceptors are divided into two basic types--tonic and phasal. Tonic electroreceptors adapt slowly, and they are sensitive to low frequency electric fields in the 0.5-20 Hz range. Receptors of this type have also been found among both freshwater and marine electric fish, as well as among some nonelectric species. Phasal electroreceptors have been found only in freshwater weakly electric species and in the electric eel. These quickly adapting high frequency receptors exhibit their greatest sensitivity in the 60-2,000 Hz range--that is, in the frequency range of electric organ discharges.

The joint operation of electric organs and electroreceptors of weakly electric fish supports electrolocation and electrocommunication functions. Because tonic electroreceptors are insensitive to the discharges of electric organs, their basic purpose is apparently associated with so-called passive location and orientation--that is, with registration of external electric fields of biotic and abiotic origin. The ways fish use their bioelectric fields in their vital activities are diagramed below (Diagram 1).

Diagram 1



Modeling Electrocommunication Systems

The principal carrier frequencies of the discharges of the electric organs of weakly electric fish are species-specific as a rule, and therefore we can hypothesize that electric fields are used by fish mainly for intraspecific communication. Experiments have demonstrated the existence of electrocommunication in a large number of weakly electric fish, and that such communication has dominant significance in sexual and territorial mutual relationships. The range of electrocommunication detected by R. Bauer in experiments with a 15 cm long *Gnathonemus petersii* is

30 cm, which agrees with the theoretical estimate of this value for most weakly electric species.

Investigation of fish electrocommunication requires thorough physicotechnical analysis of close electromagnetic low frequency communication in conducting media. Without clear physicotechnical premises, we cannot perform competent experiments, theoretically predict the possibilities of fish electrocommunication systems, reveal the mechanisms of their operation, adequately describe the parameters of electrocommunication systems, and assess their optimum parameters from different points of view. Moreover it would doubtlessly be interesting to develop electroconductive communication devices of direct practical significance. From a historical standpoint, most pioneering efforts in this direction were started under the influence of ideas suggested in the biological literature.

Examining the problems associated with short-range underwater electrocommunication, we should distinguish the following physicotechnical aspects:

propagation of electromagnetic fields in conducting media; effectiveness of transmitting and receiving antennas, and matching antennas to the apparatus; factors restricting transmission and reception possibilities; design of the system as a whole--selection of the operating frequency and type of modulation, estimation of the range and dependability of communication in relation to given overall dimensions of the apparatus and its power supply possibilities, and so on.

Let us examine these problems briefly.

Propagation

In most technical situations, the required ranges of communication significantly exceed the necessary depths of communication. It would be advantageous in this case to select the working frequency of communication such that the electromagnetic signals would propagate as a so-called "surface wave", which may be arbitrarily imagined as a signal propagating upward from its source to the water surface, then through air along the surface and, finally, downward through water to the receiver. The nature of propagation is basically defined as the product of two terms:

$$\frac{1}{r^3} \quad \text{and} \quad e^{\frac{-z+h}{\delta}},$$

where r--range of communication, $z+h$--total depth of communication, δ--magnitude of skin layer in water. Approximations describing propagation of an electromagnetic field in practically all real communication situations have been published.*

* Bannister, P. R., "Quasi-Static Fields of Dipole Antennas at the Earth's Surface," RADIO SCI., Vol 1, No 11, 1966, pp 1321-1330; Kraichman, M. B., "Handbook of Electromagnetic Propagation in Conducting Media," NAVMAT, 1970.

In biological and some technical applications, meanwhile, the surface wave assumption (the assumption that the total depth of the source and receiver is much less than the range of communication) is unacceptable. In these cases the simplest approximation is used in the estimates as a rule--equations for the field of a dipole source in a boundless, uniform conducting medium.

In a conducting medium (in distinction from dielectric media), the polar diagrams of a dipole source may be plotted only on the condition that the orientation of the receiving antenna is determined. The receiver's polar diagram may also be plotted only on the condition that the coordinates of the reception point relative to the source and the magnitude of the skin layer at the operating frequencies in water are given. At ranges from the source commensurate with the magnitude of the skin layer in water, elliptical polarization of the electric field's intensity vector is significant, and the polar diagram does not possess a zero point, no matter what the orientation of the receiving dipole antenna in the polarization plane.

Assessment of Antenna Effectiveness

An electric dipole source can be fully described by the dipole moment Il. If we represent Il as

$$Il = \sqrt{\frac{P}{|z_e|}} \cdot l = \sqrt{\alpha_e P},$$

where P--power, z--total impedance, and l--effective antenna length, coefficient $\alpha_e = l^2/(|z_e|)$ may be used as a measure of the effectiveness of an electric dipole antenna: Of two identically situated and identically oriented antennas of equal power, that having the greater α_e will emit the greater signal at any distant point.

If the class of antennas is given, we can optimize them--that is, we can find the antenna with the greatest α_e. For example in the class of dipole antennas with a fixed total length L, those antennas having electrodes with longitudinal dimensions on the order of $1/3L$ are optimum.

α_e may be increased by placing an insert made from insulating or fully conducting material between the electrodes. This raises the effective length of the antenna.

α_e may be used to assess the effectiveness of dipole antennas in terms of not only emission but also reception: The greater α_e is, the greater is the signal to noise ratio. However, this is valid only if two conditions are observed:

the length of the receiving antenna is much less than the range of communication;

The sensitivity of the receiver depends on the antenna's thermal noise, and not some other factors (for example the level of atmospheric disturbances).

There are many practical situations in which these conditions are not satisfied. Such situations require development of ways to suppress outside interference; therefore it would be suitable to use multi-electrode antennas, which would require subsequent correlation processing of the recorded potentials (recall that the number of electroreceptors in fish is very large). Multi-electrode antennas require a fundamentally new approach to assessment of the effectiveness of receiving antennas. Developing such an approach is a pressing problem of engineering and bionics.

The Electromagnetic Background

The electromagnetic background in water is the product of sources of different origins (Diagram 2). Each component in the diagram may dominate under certain conditions. However, at the frequencies used for underwater electrocommunication, fields produced by thunderstorms (atmospheric disturbances) are dominant as a rule. A large number of papers devoted to them not only cite experimental data but also thoroughly analyze the origin and propagation of atmospheric disturbances.* A knowledge of the theory of atmospheric disturbances permits us to approximate experimentally measured levels and spectrums at other depths, explain the temporal and spatial features of the background, and predict the unique features of the given region. It is important to study the electromagnetic background both from the standpoint of practical engineering problems and from the standpoint of biological problems (electro-ecological in particular). Investigation of fields of biological origin is an important part of the study of electromagnetic fields in water.

The Design of Concrete Electrocommunication Systems

In contrast to the situation with most known communication systems (radio, acoustic, optical), the design and parameters of underwater electrocommunication devices depend to a significant extent on the concrete application, and as a rule, if communication is to be maintained with a different object, a new device of a different sort would have to be developed. Designing such devices entails determining the communication frequency (f), signal intensity (E_c) at the reception point required for communication, and transmitter power (P); the most suitable types and designs of antennas are revealed, and their α_e are computed. If the particular communication problem is fundamentally soluble, the dependability of communication may be assessed with a consideration for the possible mutual orientations of the transmitting and receiving antennas. The computations are usually made in several stages, in each of which the values of the parameters and the designs are narrowed down more specifically.

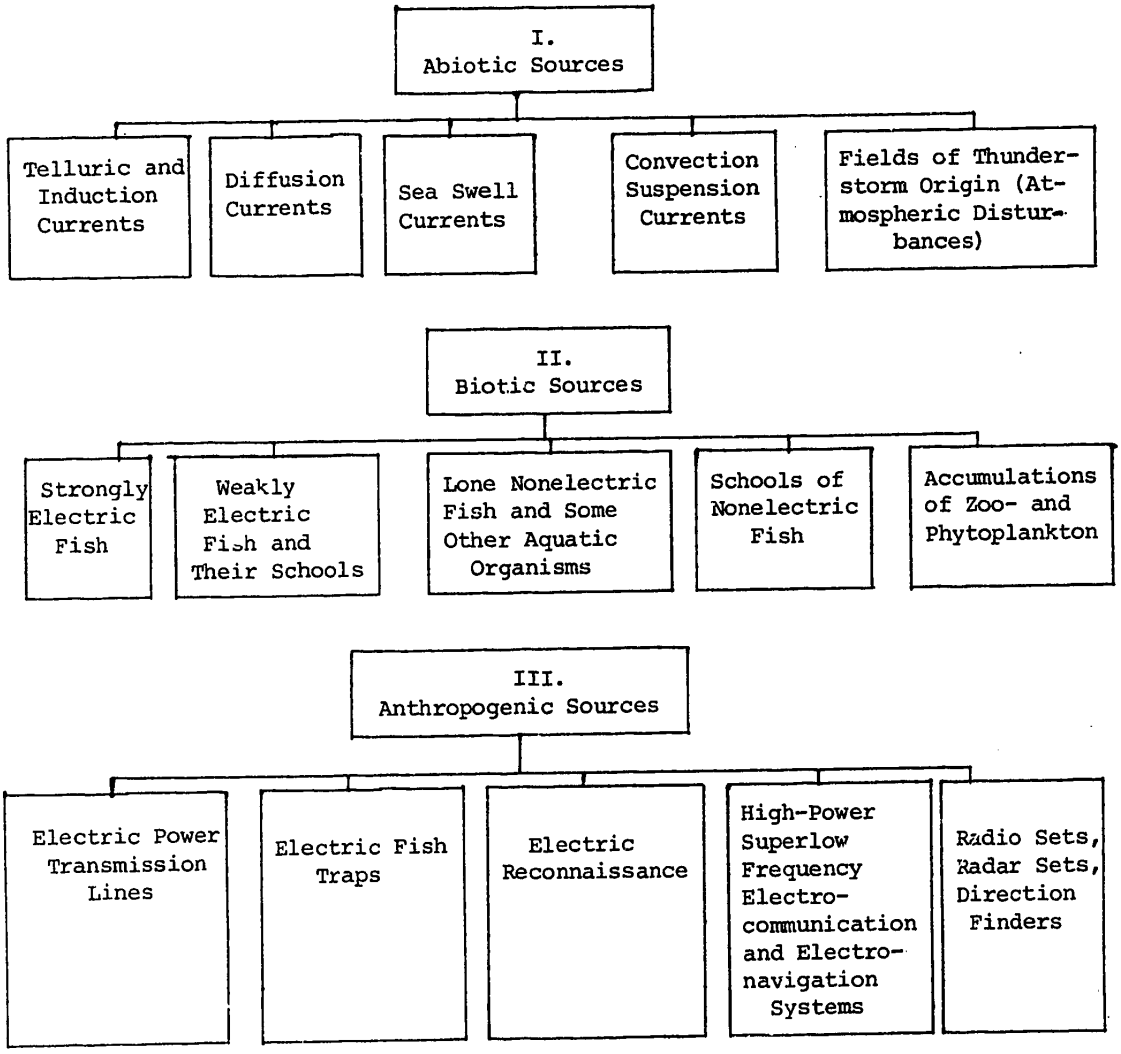
We will go through the motions of making a tentative assessment of the operating frequency of communication as an illustration of the whole computation process.

Because there is an exponential term in the equations for propagation in a conducting medium, electromagnetic communication is impossible at frequencies at which

* Maxwell, E. L., "Atmospheric Noise From 20 Hz to 30 kHz," JOURN. RES. NBS, Vol 2, No 6, 1967.

Diagram 2

Sources of Electric Fields in an Aquatic Environment



the depth of the skin layer in the medium is significantly lower than the range of communication (or, in the case of a surface wave, lower than the total depth of the source and receiver).

On the other hand the low information content typical of communication at low frequencies and the usually observed decrease in the level of the electromagnetic

background in water in response to growth in frequency indicate to us that it would be unsuitable to use frequencies so low that the depth of the skin layer in the medium would significantly exceed the range of communication (or, correspondingly, the total depth of the source and receiver).

Consequently it would be suitable to select the operating frequency such that the maximum communication range would be equivalent to several (three to five for example) skin layers in water. Correspondingly, in the case of a surface wave the operating frequency must be such that the total depth of the receiving and transmitting apparatus would be equivalent to two or three skin layers. Thus if commands must be transmitted from a vessel to fishing gear located up to 400 meters below the surface in ocean water, the specific electroconductivity of which is 4 ohm^{-1} m^{-1}, then, considering that a skin layer of 100 meters corresponds here to a frequency of 18 Hz, we can recommend this frequency as the one to be used.

In addition to these considerations, when selecting the operating frequency of communication we also account for the nature of the signal (for example, speech), the need for suppressing the industrial frequency (50 or 60 Hz) and its harmonics, and the possibilities and convenience of practical realization of the device. Thus if we are dealing with weakly electric fish communicating in fresh water (the specific electroconductivity of which is about 10^{-1} ohm^{-1} m^{-1}) at ranges on the order of several meters, frequencies on the order of hundreds of MHz would be the most advantageous. But the known frequency range used by weakly electric fish does not exceed units of kHz, which is apparently associated with the difficulties of achieving high frequencies in biological structures.

We computed the parameters for several concrete systems on the basis of these considerations.

They included a shipboard device to control apparatus mounted on a trawl (Figure 2), a system permitting communication among SCUBA divers (Figure 3), and "shore-to-water" and "water-to-air" communication systems. The computation results were checked out by natural experiments conducted in the Sea of Japan. The parameters of the systems are presented below.

For the shipboard device controlling apparatus mounted on a trawl: communication range--1 km, depth--up to 400 meters, operating frequencies--10-16 Hz, dipole moment--10,000 amp•m.

For electrocommunication between SCUBA divers: communication range--70 meters, depth--up to 50 meters, operating frequencies--300 Hz to 2 kHz, dipole moment--2 amp•m.

For "water-to-air" communication: communication range--200 meters, transmitter depth--50 meters, altitude of reception point--70 meters, communication frequency--300 Hz, dipole moment--7.5 amp•m.

For "shore-to-water" communication: communication range--2 km, communication depth--50 meters, working frequencies--16 Hz to 2 kHz, dipole moment--1,000 amp•m.

These devices are now being introduced for practical use.

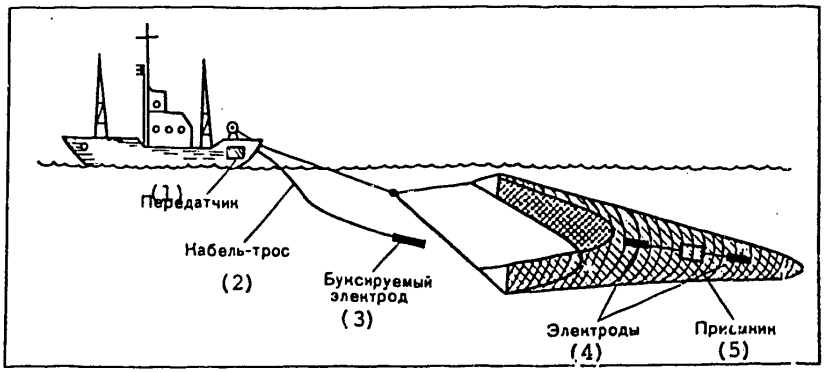


Figure 2. Shipboard Device Controlling Apparatus Mounted on a Trawl

Key:

1. Transmitter
2. Cable
3. Towed electrode
4. Electrodes
5. Receiver

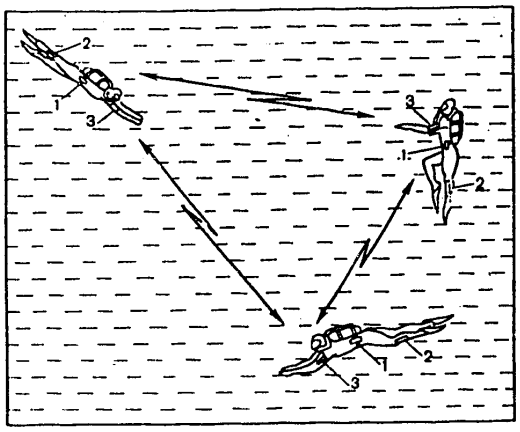


Figure 3. Electrocommunication Between SCUBA Divers: *1*--apparatus, *2*--leg-mounted electrode, *3*--shoulder-mounted electrode

Discussing the prospects and limitations of bionic modeling of fish electrocommunication systems, we should point out the following basic differences between these systems and the underwater electrocommunication devices known today.

Biological electrocommunication involves distances commensurate with the dimensions of the object involved. At the location of a receiving partner, the electric field is significantly nonuniform, and it is picked up by a large quantity of electroreceptors located all over the body of the fish. In a technical application, meanwhile, communication entails distances significantly exceeding the dimensions of the object involved, the field near the receiving partner is quasiuniform, and the signal is picked up by dipole antennas. Fuller utilization of the spatial structure of a signal and interference, and transition to dipole antennas from multi-electrode receivers would be promising from the standpoint of solving the most important problems of underwater electrocommunication, such as raising the information content of communication, raising the signal to noise ratio, improving electromagnetic compatibility, and improving interaction with other systems (electric location and orientation systems).

On the other hand, in distinction from the situation in the biological world, technical applications permit the use of components with specific electroconductivity significantly exceeding the specific electroconductivity of water--components made of superconducting metals. Such components make it possible to employ concepts that are inapplicable to living nature--that is, ones outside the scope of bionic modeling.

Modeling Electrolocation Systems

Active electrolocation is defined as registering changes in the electric field produced by weakly electric fish due to distortion of this field by objects characterized by conductivity different from the conductivity of the surrounding medium. Almost all known weakly electric fish of both wave and pulsating species have an electrolocation capability. It should be noted in this case that the two basic taxonomic groups of weakly electric fish--African Mormyriformes and South American gymnotids--reside in the turbid waters of rivers and streams. The capability for detecting and discriminating between objects by means of an electric field is a remarkable adaptation of a living organism to an environment in which conventional visual orientation is difficult and often impossible. This is precisely why a fish's electrolocation system, which to some extent substitutes for the animal's vision, represents a new sensory system--"electrovision".

The electrolocation function was first discovered in 1958 by G. Lissmann and K. Meychin in a representative of the African Mormyriformes, *Gymnarhus piloticus*. Using a conditioned reflex technique, the scientists revealed that the fish are capable of distinguishing between metallic and dielectric objects enclosed in porous cases, and distinguishing between fresh and salt water contained in these cases. It was also demonstrated that the distribution of the potential of the electric field on the surface of the fish's skin, created by electric organ discharges, becomes distorted when objects having electroconductivity different from that of water come near the fish body. It was hypothesized that channel-like structures located in the skin--mormyromasts--are responsible for picking up

these distortions, and thus that they are electroreceptors--a new class of sensory units discovered among representatives of the animal world. Numerous studies subsequently performed* in this direction were devoted to the physiology and morphology of electroreceptors and electric organs, as well as to the principles and mechanisms of their joint work.

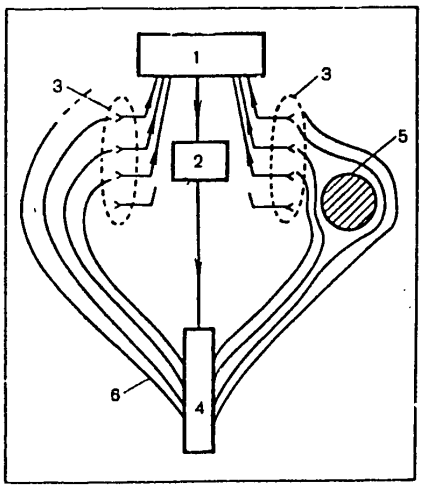


Figure 4. Active Electrolocation: *1*--central nervous system, *2*--electric organ command (triggering) center, *3*--electroreceptors, *4*--electric organ, *5*--object of detection, *6*--electric field flux lines

Figure 4 provides a general diagramatic approximation of active electrolocation. The field generated by the electric organ and distortions within it are picked up by phasal electroreceptors located in the fish's skin (the density of electroreceptors in some species attains 80 per square millimeter). Then information is successively transmitted by a system of nerve tracts to different divisions of the central nervous system. In addition to processing signals structurally associated with the lateral lobes of the medulla oblongata, the central nervous system monitors the work of the command center controlling the electric organ. There are intracentral associations directly associated with the electrolocation function . One of them manifests itself as avoidance of jamming signals by changing the fundamental carrier frequency of the electric organ's discharges.

Electroreceptor systems participating in active location must react in the best way possible not to the electric field itself but to changes within it, thus manifesting a capability for so-called relative sensitivity. The general functional characteristics of any electroreceptor are:

passive conduction of electric current through the tissues of the electroreceptor to the surface of the receptor cell;

*Bennett, M. V. L., "Electric Organs. Electroreception," in Hoar, W. S., and Randall, D. J. (Editors), "Fish Physiology," New York, 1971; Protasov, V. R., "Bioelektricheskiye polya v zhizni ryb " [Bioelectric Fields in the Life of Fish], Moscow, 1972; Heiligenberg, W., "Principles of Electrolocation and Jamming Avoidance in Electric Fish," Berlin-Heidelberg-New York, Springer-Verlag, 1977.

the activity of the receptor cell itself, expressing itself as generation of a reception potential and synaptic transmission of a stimulus to nerve endings;

the capability for encoding signals in a form convenient for subsequent transmission by an afferent fiber.

An adequate stimulus acting upon a receptor would consist of a potential difference between the opening of the receptor pore on the skin surface and the basal membrane of the receptor cell. The mechanism of action of the receptor is as follows: Current generated either by an outside source or by the electric organ itself first passes through the highly conductive tissues of the channel, and then through the apical nonconductive membrane of the receptor cell, which acts as a high frequency filter, and through the basal membrane. If the voltage drop across it reaches the absolute threshold, the cell generates a regenerative receptor potential, which is responsible for activation of the nerve fiber innervating the cell. This activity carries information on gradual changes in the electric current passing through the receptor, and it is responsible for one of the types of codes carried by the fiber.

Mention should be made of the great diversity of information encoding methods (four or five basic types are conditionally distinguished) correlating approximately with this type of electroreceptor. The advantages of a particular type of encoding used by fish are to a great extent hypothetical, though they are discussed in detail in many papers. Incidentally, the large number of functional types of electroreceptor units is obviously associated with the need for differentiating their properties so as to permit their use in electrolocation and electrocommunication. In this case even receptor units intended solely for location are characterized by different adaptation times in relation to a varying stimulus, which indicates that they are predisposed for detecting either motionless or moving objects. Some phasal electroreceptors (the *T*-units of gymnotids) exhibit so-called phasal sensitivity--that is, they respond differently to stimuli, producing either an ohmic or a capacitive load of the same impedance. This is believed to be associated with the capability fish have for identifying plant and animal objects which, as we know, have significant capacitive properties.

Electrosensory information undergoes primary processing in the lateral lobes of the medulla oblongata, when signals from a tremendous number of receptors covering the entire surface of the animal's body experience temporal and spatial integration. Just at the level of the lateral lobes, a fish's sensitivity to objects rises by about one order of magnitude in comparison with the sensitivity of a single electroreceptor, which agrees with data from conditioned reflex experiments performed to determine the threshold sensitivity of fish.

We can conditionally distinguish two directions in contemporary research on fish electrolocation systems. The first concerns itself with the spatial aspects of electrolocation and deals with the following problems:

investigation and numerical modeling of the geometry of fields generated by electric organs, and fields associated with introduced objects;

study of the spatial orientation of the electroreceptors with the purpose of revealing how important it is to assessment of the dimensions of an object and the range to it, and to precise determination of the object's conductive properties.

The second direction is associated with the temporal aspects of electrolocation. It deals with the following problems:

clarification of the way the rate or frequency of electric organ discharge affects whether or not the electrolocation system is optimum;

investigation of the ways and means of functional differentiation of electroreceptor units permitting their simultaneous participation in electrolocation, using a single processing center in this case;

study of the electrolocation capability of fish in the presence of noise.

The advances that have been made in both directions provide a sufficiently full impression of the general peripheral phenomenology of fish electrolocation systems, and thus allow us to construct its bionic model. It is also obvious that further study of the mechanisms and principles of information processing in the central nervous system will make it possible to significantly update this model.

In its physical interpretation, the problem of modeling fish electrolocation systems boils down to building an electrolocation system which can detect an object on the basis of the amount of distortion it creates in the primary electric field, and to seeking optimum circuits for the emitting and receiving devices. For practical purposes this problem should be divided into two. The first concerns close-range electrolocation, or "electrovision", which permits detailed identification of the object, to include its structure, shape, and dimensions. Certain advances have already been made in this direction in our country by A. I. Bondarchuk (Minsk Radiotechnical Institute), but the resolution of his system is satisfactory only when the array of measuring electrodes is located right next to the object. The second problem, which will be examined below, consists of building a model capable of detecting objects at greater range. The first step in this problem is to try to formalize the basic principle of electrolocation, so as to permit sensitive assessment of the object size which the model could detect and the ranges within which it can function.

Simple mathematical expressions may be obtained, for example, for the case of a metal ball located within the field of a dipole emitter (Figure 5). If the distance d from the emitter to the object is much greater than the length l of the dipole and the diameter $2a$ of the ball being detected, a dipole approximation may be used to describe the field of the emitter, and near the object the field itself may be assumed to be uniform. If, moreover, the object is located on the axis of the emitting dipole, then the intensity of the distorting field at the location of the emitting antenna is

$$E_1 = \frac{Il}{2\pi\sigma_1} \cdot \frac{a^3}{d^6} \cdot$$

In order to register the maximum difference of potentials, the measuring electrodes must obviously be located as far apart as possible. But because the entire

electrolocation model must obviously be contained within the same carrier and occupy a limited volume, the maximum spread between the measuring electrodes would have to be limited to the length l of the emitting dipole. In this case the maximum potential difference bearing information about the object is

$$U_1 = I \frac{a^3 l^3}{2\pi\sigma_1 d^6}.$$

Thus if prior to introduction of the object the potential difference at the emitting electrodes was U (assuming no change in current), then after the object is introduced, we observe an increment in the potential difference across the electrodes, U_1, which depends on the dimensions of the object and the distance to it. It is easy to see that the term

$$\frac{a^3 l^3}{2\pi\sigma_1 d^6}$$

has electric resistance as its unit, and the inclusion of an object in the circuit of the emitting electrode changes the external load R, defined by the value of interelectrode resistance, by the amount

$$dR = \frac{a^3 l^3}{2\pi\sigma_1} \cdot \frac{1}{d^6}.$$

Similar expressions may be obtained for any solid having a shape different from spherical.

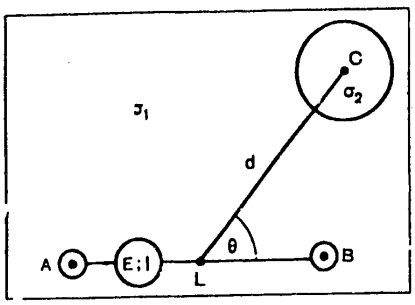


Figure 5. Emitting Electrodes A and B, Separated by Distance L, are Contained in the Circuit of a Generator With an emf of E: I--current in the emitting circuit; a spherical object of detection with radius a and its center at point C is separated from the emitting dipole by distance d; θ--angle between dipole axis and a radius-vector extended from the center of the dipole to point C; σ_1, σ_2--specific electroconductivity of the medium and the object

In addition to a useful component bearing information on the object, dR would also include all sorts of noise-producing fluctuations in electric resistance. They include:

Fluctuations in interelectrode resistance occurring due to temperature changes in the medium, changes in salinity, and so on;

noise-caused changes in electrode resistance associated with instability of the double electric layer and fluctuations of electric potential;

noise produced by the motion of water masses, particularly by waves on the water surface.

The expression for U may thus be rewritten as:

$$U_1 = I\left(\frac{a'l^2}{2\pi\sigma_1 d^6} + dR'\right),$$

where dR' represents the total noise-caused fluctuations of impedance. In this case the maximum possible electrolocation range would be defined by the ratio dR/dR', and it would not be affected by an increase in the power of the system, as is the case in electrocommunication. In order to plan and tentatively assess the possibilities of an electrolocation system, we would need to know the values of all known noise parameters, and account for them.

One of the first systems based on this principle is a highly simple electrolocation system* intended for installation aboard small vessels and yachts. Such a system is capable of detecting underwater obstacles within a range equivalent to 1.5-3 vessel lengths, and determining the direction of their movement.

Research aimed at improving this electrolocation system involves theoretical and experimental determination of all noise components. From the design aspect, this means seeking optimum electrode systems characterized by minimum impedance fluctuations.

As far as the prospects of bionic modeling of fish electric systems in general are concerned, electrocommunication models are now the nearest to immediate practical use in this vast area, and the most enticing direction is that of creating "electrovision", which would have great significance not only to engineering but also to biology, cybernetics, and medicine.

* See Swain, W. H., "An Electric Field Aid to Underwater Navigation" in "IEEE Int. Conf. on Engineering in Ocean Environment. Panama, Florida," Vol 1, 1970, pp 122-124.

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CYBERNETIC APPROACH TO MAN-MACHINE INTERACTION ANALYZED

Moscow MYSHLENIYE CHELOVEKA I PERERABOTKA INFORMATSII EVM in Russian 1980 (signed to press 20 Jun 80) pp 2-16, 288

[Annotation, table of contents, and introductory article by Academician A. I. Berg, Doctor of Philosophical Sciences B. V. Bivyukov, and Doctor of Psychological Sciences N. I. Zhinkin from book "Human Thinking and Computer Information Processing", by Samuil Iosifovich Shapiro, Izdatel'stvo "Sovetskoye radio", 8,000 copies, 288 pages]

[Text] This monograph is devoted to human thinking and its relationship to computer programming, and to joint work with a computer in mutually advantageous dialogue. Another aspect of the book has to do with computer simulation of individual fragments of the thinking process with the purpose of identifying its laws.

This book is intended for psychologists, educators, mathematicians, cyberneticists, and specialists in artificial intelligence.

Contents Page

Man and Computer: Simulation of Thinking and Man-Machine Dialogue

As we know, the main objective of cybernetics is to study the mechanisms by which intricate dynamic systems are controlled--information-logical mechanisms primarily. In two ways, this objective is inseparably associated with the "human factor". First, man's participation is a distinguishing trait of a broad spectrum of such systems (in engineering and technology, in economics, in communications, in military affairs, and so on) (sometimes referred to as "humanistic" systems); this trait of intricate systems is closely associated with the modern scientific-revolution, typified by growth in the importance of intellectual labor in all spheres of culture, in the broad interpretation of this word. Second, control of intricate dynamic systems, optimization of which is the principal aim of cybernetics, has the goal of raising the effectiveness of human activity. Considering that the scale and rate of processes and systems that must be controlled are ranging ever-further beyond the "natural" possibilities of human intelligence, automation of a number of intellectual procedures on the basis of the ideas and resources of cybernetics (as well as mathematics and logic) is becoming an acute necessity.

The problem of broadening the possibilities for cognitive and practical control activity by creating "cybernetic amplifiers" of the human brain requires that we conduct intense integrated research at the interface of cybernetics, psychology, and logic. This is a grandiose problem, apparently much more so in its complexity than that of describing physics in mathematical terms--a problem which has been addressed since the times of Kepler and Newton. The reason for this lies in the fact that solution of this problem depends on progress in cybernetic simulation of perception and thinking, and on advances in psychological analysis of those phenomena which characterize man's internal world. This is so because we would first need to understand the nature of these processes and phenomena, their course, and their properties before we can reproduce certain manifestations of these processes and phenomena with modern computers.

At the dawn of cybernetics, it seemed to some scientists that simple application of mathematical methods and the resources of cybernetics to the area of intelligence would insure success in discovering the "secrets of thinking". The work of the brain began to be interpreted as operation of a giant computer, and it seemed that this notion, which was theoretically grounded by the concepts of information and algorithms, model and feedback, and so on, was in and of itself a guarantee of success. But one of the founders of cybernetics, Claude Shannon, himself warned in 1956, in connection with the "information fad", that the premises of information theory would not be intrinsically productive in psychology.[1] They might turn out to be productive, but if this is to be so, then we would need to meticulously study the appropriate factual material, interpreting it from a new point of view.

It is now fully recognized that a knowledge of mathematics and logic and use of the hardware of cybernetics cannot compensate for insufficient knowledge of the essence of the processes to which the new theoretical and technical resources are applied. Moreover these resources are still a long way from taking full account of the "human factor": The "cybernetic paradox" of our times is that while man has invested the computer with that which is not inherent to his own "information processing" apparatus--high speed in successive performance of elementary operations leading to solution of computation problems, a speed beyond the reach of the "natural" human computer, he has not imparted that which is specifically "human" to the computer--wisdom, intelligence, thinking, and recognition. Human thought, which has created so many things in the world of science--from a model of the gene to pictures of the boundless universe, itself remains dramatically incomprehensible: Our scientific knowledge of the intimate mechanisms of the mind, of the laws of human behavior, and of the essence of the processes by which man solves complex problems and learns, is still extremely incomplete, and in many instances fragmentary, and most importantly, in terms of its determinacy, the language of this knowledge is far from that of that ideal scientific rigorousness which has evolved in mathematics and logic and which expresses itself practically in computer programs used in the processing of digital and symbolic information. Thus it is no surprise that the notion, which came into being back in the 1950's, of making computer operations and complexes of operations analogous to corresponding acts of human behavior, continues to be an unreachable goal--even despite the fact that the intensity of efforts in this area is growing. As Bongard validly noted in his time, the reason for this lies in the shortcomings of the idea "of the means for devising programs with which to simulate complex human behavior".[2] The reason for this is that modern experiments in computer simulation of intellectual processes and solution of complex "noncomputational" problems are compelled to borrow from man's "experience" of perception and

thinking, and reproduce, in computer programs, only some elementary methods of human actions.

The fact remains, however, that cybernetics has graphically demonstrated that it is possible to describe a number of aspects of intellectual and cognitive activity in formal terms. Although there is still much that is unclear and debatable in the prospects and limits of such formal description, one thing cannot be doubted: The bounds of "human" attributes that can be invested into a computer, though they may not embrace the latter in their "entirety", will continue to expand more and more.

Researchers attempting to envision the boundaries of cybernetic simulation of intellectual procedures sometimes cite the limitations of logical formal description, as follows from Godel's well known theorems suggesting that our rather substantial scientific theories, beginning with the arithmetic of natural numbers, are incomplete, and that it is impossible to prove the consistency of such formalized systems by the resources formalized by these systems themselves. Such suggestions must be approached with great caution, since describing the rules of human behavior in complex problem solving in formal terms is not the same thing as describing an arithmetic axiom in formal terms. But inasmuch as some real methods by which people reason can be expressed by the machinery of mathematical logic and formal arithmetic, Godel's results are an indirect argument in favor of the impossibility of "infinitely complete" formal description of perception and thinking--this is true even despite the fact that at the moment no one is able to indicate the "upper boundary" of the corresponding achievements of cybernetics.[3] However, sticking with the facts, we would have to assert that more and more forms of human intellectual labor are being transferred to the computer.

It would be an obvious mistake to interpret reproductions of certain manifestations of the mind in model form--as computer programs--as transgressions upon the "purity" of psychological science, upon the object of psychology, or to interpret this as "substitution", by cybernetics and mathematics, of the psychological methods of studying the phenomena of perception, thinking, memory, and learning. To reason this way would mean viewing "descriptiveness", which is in many ways still inherent to psychological research, as sometimes positive in psychology as a science. In fact, "descriptiveness" and "analytical rigorousness" are not opposites in scientific thought--they are only different stages of development typical of one science or another. Every science, even mathematics, begins with "simple descriptions" in order that it could subsequently rise to theoretical generalizations. For many sciences, this ascent turns out to be associated with the use of the machinery of analytical formulas. This is true not only for mathematics but also physics, and not only logic but also psychology. Logic rose to the mathematical level in the latter half of the past century, while psychology is experiencing this metamorphosis today. The analytical method was part and parcel of all aspects of logic: In logic, that which is theoretical is inseparable from that which is described in formal mathematical terms.

Not being a deductive science, psychology could never become similar to logic in this respect. To it, mathematics will apparently always be a modeling tool, which will consequently presuppose presence of a vast library of empirical knowledge on the behavioral and psychological side of man.

The mathematization of psychology is a difficult process, inasmuch as we are dealing with penetration of the ideas and methods of mathematics and cybernetics into areas that are far removed from the ideal of "rigorousness" and "constructiveness" which mathematics and logic have brought into being, and which cybernetics has assimilated. Bellman was right when he wrote: "Classical mathematics is based on methods requiring complete universality.... In the course of its evolution, the brain arrived at methods of operation which are 'correct' only in general terms, and which are not at all 'rigorous'."[4]

Development of "mathematical psychology" would be possible only on the basis of integrated research conducted at the interface of psychological knowledge with cybernetics on one hand and mathematics and logic on the other. This research, it would seem, must be based on a unique compromise: "relaxing" the ideal of precision with the goal of bringing it closer to the "imprecision" of human thinking, learning, and understanding.

We know that usage of loosely defined (indistinct, fuzzy) concepts and sets plays an important role in man's cognitive activity and in his practical, orientational and controlling activity. If a concept is strictly defined, and if a set is distinct, then for each object in relation to which it would make sense to raise the question as to its membership within this set, we could answer this question by an "either-or" approach: The object either belongs to the given set (it falls within the strictly defined concept), or it does not belong. But when we deal with indistinct sets, we can refer not only to (total) membership and (total) nonmembership of an element in a set, but also to different degrees of membership. Formalization of this interpretation of the relationship between particular objects and fuzzy concepts led to development of the cybernetic theory of fuzzy sets and algorithms;[5] in this case, fuzzy algorithms have found their natural place on the "scale of algorithmicity", being a "transitory form" between structures of the algorithmic type and structures of heuristic nature.[6]

Although the ideas of "fuzzy logic" had arisen in mathematics before they did so in cybernetics (an example is the description given at the beginning of our century of the so-called sieve of Bruno--a generalization of the well-known sieve of Eratosthenes--making it possible to select, from the set of natural members, those which are prime or "almost" prime) and in logic (in particular, in connection with the theories of multivalent and infinite-valent logic, developed in the 1920's), the ideas of precise handling of imprecise ideas on the basis of a special "logic of nonrigorous objects" arose mainly in response to the need for modeling complex and "humanistic" systems. This can be explained by the fact that models containing fuzzy sets and algorithms of the same sort may be used successfully to describe processes and systems, for which the application of the conventional formal terms of mathematics and logic (ones reproducing the world through spatially defined concepts and rigid constructs) would not be very effective. In this case, the properties of such systems yield to analysis by fully rigorous methods.

Development of "fuzziness" theories is one of the manifestations of the growing effort to apply formal mathematics and logic to man, which is a product of the influence of cybernetics and the need for simulating intellectual processes.[7] But of course, this is not the only manifestation. Others we can name include the obvious yearning to account for, in "precise knowledge", the contradictory phenomena of human thinking (note in this connection that fuzzy concepts indirectly contain

within themselves a "(Kucha)" paradox and reliability (the property of thinking that allows mistakes to be made in the acquisition of results).

* * *

There is an Eastern fable about three blind men who came across an elephant and tried to determine what it was. The one who grasped the elephant by its tail said that the elephant was a rope. "No, it is like the trunk of a tree," objected the one who held the elephant by its leg. "Both of you are wrong," declared the third. "An elephant is a snake." He was holding the animal by its trunk....

This fable is not a bad account of the present situation in cybernetic simulation of cognitive psychological processes. Scientists develop various "intellectual" models, but they are unable to persuasively answer the following questions: How do these models "in fact" relate to the human mind? How can we prove that these "nonpsychological" programs are adequate, in a certain sense, to that which is being modeled--the mind?

Of course, we could simplify the problem by assuming the stance of "cybernetic behaviorism"--by adopting the thesis that man is a certain finite automaton. From a "psychological" standpoint this simplifying thesis takes the form of the "maze hypothesis" of thinking, according to which thinking entails a search for the path to a goal within a maze of possibilities given in some particular form, a search directed by certain criteria; and, as we know, maze problems can be represented in the terms of an automaton without difficulty. Both approaches are similar in that the work of the brain and the function of human intelligence are interpreted as algorithmic activity.

The significantly simplifying nature of these approaches was quickly recognized by cyberneticists and psychologists. At the very first symposium on "mechanization of thinking" (Taddington, England, 1958) the American cyberneticists (M. L. Minskiy) and (D. M. Mak-Key) said that logical thinking is not exhausted by algorithms. Some Western psychologists contrasted the behaviorist-algorithmic conceptions of thinking with the point of view of Gestalt psychology: There is no such thing as a mechanism of "information processing", a processing mechanism involving discrete steps. Man "sees", "grasps" a situation integrally, and he envisions the path to solution of a problem just as integrally.

In terms of modeling cognitive processes, however, we can assume a position independent of these psychological conceptions--a position that is "psychologically neutral", one which is often associated with the "artificial intelligence" direction. The essence of this position is to create computer systems for solving complex problems without making simulation of "artificial intelligence" a mandatory prerequisite: The main thing is for the computer programs to produce results that are no worse than those obtained by man.[8] Such an approach is fully possible, since research efforts in the "artificial intelligence" direction are in fact directed not at simulating the essence of cognitive processes in and of themselves, but rather at automating complex forms of activity, at automation, for which description of the "external" behavior of the individual would be sufficient.

But this "artificial intelligence" approach does have its limits as well. Beyond a certain point, a knowledge of the properties of the process which we wish to automate becomes increasingly more desirable. But at this point, we encounter the difficulty which was metaphorically presented in the fable of the elephant and blind men presented above. The inconsistency between the enormous amount of facts accumulated in psychology and that modest fraction of these facts which are reflected in cybernetic models is obvious. Moreover the cognitive activity of an individual operating in "cooperation" with modern automatic devices has been poorly studied. In particular, not enough research has been conducted on the psychological aspects of the relationship between human thinking and computer programming. Work in this area is only just beginning. The results obtained in this area thus far make it all the more obvious that we need to answer the complex of questions pertaining to man-machine control systems.

It is in light of these conclusions that we should approach S. I. Shapiro's monograph. It analyzes a question of importance to cybernetic simulation of cognitive mental processes and human behavior--the nature of the qualitative differences existing between human thinking and information processing by a computer. The author sheds light on the dialectical unity of the process and result of thinking; he analyzes the ambiguous nature of the relationship between mental phenomena and their logical, "formal" description. The book quite rightly emphasizes the fundamental role played by the principle of hierarchical organization in the work of the human nervous system and mind; it makes mention of the significance of techniques for reducing, encoding, and recoding psychological material--all that justifies the need for analyzing human mental activity at different levels.

One of the book's main points of emphasis is the problems associated with studying thinking from the standpoint of computer programming and joint work of man and computer in dialogue mode. These problems are precisely what make it so necessary to develop formal descriptions of the individual aspects and parts of intellectual processes, and to reveal the laws of human heuristic activity, so that effective computer programs for solving complex problems of one class or another could be written. The book demonstrates how computer simulation imparts concreteness to experimental study of the individual aspects of thinking.

In his examination of all of these questions, the author rests on the traditions of domestic psychological science, which reject both the one-sidedness of the behavioristic "maze" conceptions of thinking and the extremism of the approach of Gestalt psychology to intelligence, in which mental phenomena are viewed as somehow being unyielding to analysis in strict terms.

The general aim of the author's analysis may be stated as follows: Creating computer programs for solving complex ("noncomputational") problems on the basis of intellectual procedures which, at the given stage of development of psychology, cybernetics, and logic, yield to formal description, and concurrently reproducing certain manifestations of thinking in these programs. According to the author's main idea, the "bridge" should be built from both sides: from the human side--from the logical and psychological processes relative to which we can establish that they "participate" in human problem solution, and from the computer side--creation of computer models aiding the study of thinking. In this case both approaches--but especially the first--when viewed from their applied aspect, are aimed at raising the effectiveness of the "art" of programming.

Shapiro's book is the first in domestic literature to systematically study the question of "psychological" computer software. Development of such software, the author believes, may be defined as the "zone of immediate programming development". But this "zone" may be very important to psychology: Psychologically substantiated programs can serve as limited computer models of intellectual procedures which, through "comparison" with human mental actions, could lead us step by step closer to their prototype, and predict the mental process being simulated.

"Mutually advantageous" dialogue between man and computer was chosen in the book as the principal method of analyzing the problems noted above. In this case attention is centered on the distribution of functions between the participants of the dialogue, on the basis of the principle of the unity of psychological and mathematical support to the dialogue systems.

As we know, psychological experimentation is the principal means of studying human thinking. Being himself a teacher of mathematics in high school and college, the book's author is, so to speak, at the "starting point of the development of human thought", and he makes competent use of this method, and of the data that have been accumulated with its help. Relying on an original logical-psychological conception of thinking, as described in his previous book,[9] in the present monograph the author develops his logical operator model of intelligence further, from the aspect of organizing man-machine dialogue systems. Thus he introduces the concept of logical-psychological coordinates, which are a further development of the concept of logical coordinates used in the book "Ot algoritmov--k suzhdeniyam" [From Algorithms to Conclusions]; Shapiro demonstrates the function of logical-psychological coordinates in terms of general heuristics, and he examines their role in human thinking and learning, and the possibilities for their "extension" into computer information processing programs.

Shapiro centers his research on developing programming approaches based on information on the process of logic and creativity, derived from psychological experimentation.[10] The author successfully solves the problem of "bringing to the surface" these landmarks of human activity in problematic situations. As Shapiro's work shows, logical-psychological coordinates are concurrently both a prerequisite for understanding the corresponding mental mechanisms and a means for developing the "psychological software" of computer systems.

Logical-psychological coordinates are a tool of heuristic activity; however, this tool is associated with algorithmic behavior. This is why the book undertakes the study and formal description of some psychological mechanisms of man's knowledge assimilation in terms of the algorithmic approach. Such description is necessary because if we are to process the obtained data, we would need to build logical information models which are corrected in a computer experiment on the basis of data from a psychological experiment, one revealing the appropriate logical-psychological reference point. In this case a dialogue is established between man and computer, in such a fashion as to capitalize on the strong aspects of each of the "partners". As Shapiro's results show, this approach makes it possible to study some questions associated with the relationship between conscious and unrecognized components of the strategy followed by the individual, with the way information is encoded, and with the way heuristic and algorithmic symbolic structures are used in thinking and neurodynamics.

The concept of logical-psychological coordinates may be a productive basis for further research on the mechanisms of mental activity. As we know, control of purposeful human behavior is inseparable from speech, which follows the rules of language; in this case the dynamics of speech are "automatic", while the goals of language are comprehended. This process of comprehension involves complex interaction between meaning expression and the objective ("denotative") aspect of linguistic constructs, and discrete and continuous ("analog") structures participating in mental processes. It would seem that the logical-psychological coordinate conception would be capable of making a significant contribution to the study of problems associated with all of this, on the condition that this conception is refined further, particularly from the aspect of broadening its psychological foundation.

Shapiro validly notes that the special methods for studying thinking must rely on a corresponding theoretical conception of thinking activity. And such a conception is developed by the author, in which case two hypotheses are placed at the basis of this conception--a "gnoseological"-operational model of thinking: The assumption that consciousness has a "single-channel" nature and descriptive intuition has a "multichannel" nature, and the premise that there is "reciprocity" (incompatibility) in the conscious part of the intellectual operational (associated with the fulfillment of operations) and logical-psychological (conceptual) components of the thinking process.

What the "single-channel--multichannel nature" hypothesis means is that several concurrently occurring mental processes cannot simultaneously serve as the focus of consciousness; only one of them is fully realized; the stronger it is and the more active the process of recognition is, the more significant is the complex of processes proceeding in parallel in the unconscious sphere. The hypothesis of "reciprocity" declares that concrete mental actions ("operators") and the logical-psychological reference points which control them are processes of different types, in which case (according to the premise of the "single-channel" nature of consciousness) domination of one of these processes leads to displacement of the other from the center of consciousness. It is impossible for man to clearly recognize both his own mental actions and the logical-psychological mechanism controlling them simultaneously.

As Shapiro shows, the operational-"gnoseological" model of thinking he proposes is supported by concrete psychological facts, and it is consistent with the conclusions of logic and cybernetics. Thus the "reciprocity" hypothesis places a psychological foundation beneath the logical-somatic model of human information processing,[11] while the hypothesis of the single-channel nature of consciousness sheds additional light on a number of mechanisms of perception, thinking, and learning; in particular it provides some explanation to the phenomena described by Bruner (growth in the concreteness of cognitive activity in response to extreme stimuli) and P. A. Shevarev ("displacement", from the consciousness of subjects under certain conditions, of the rules of algebraic action in order to validate the appropriate behavioral acts), and so on. Shapiro's conception leads to an interesting approach to interpreting the psychological nature of Hick's law, which establishes a dependence between the latent time of the choice reaction on the amount of information contained in a stimulus. It reveals new ways for building information models of problematic situations formally describing (to a certain extent) not only recognized but also the unconscious components of thinking.

The monograph develops and utilizes, in various classes of programming problems, an entire series of logical-psychological reference points revealed through psychological experiments; by taking this approach the author excludes repeat "moves", minimizes the distance to the goal--both final and intermediate, creates the basis for planning behavior and counterproposing "coordinates", and so on. Studying the relationship between the algorithmic and heuristic components of thinking in the way that they are represented in different variants of computer programs, the author thus investigates the actions of an individual directed by algorithms described from without: As Shapiro shows, the more fully the logical-psychological reference points borrowed from the individual's "repertoire" are employed, the more effective is the program.

The sort of interaction occurring between man and computer depends on the nature of the problems being solved. Thus in the case of the "director problem" (and its generalization--"the circular conveyor problem", which is a variant of the classical three machines problem), it would be suitable to have the computer first thin the branches of the goal tree, and for man to prune the "dry branches" on the basis of logical-psychological coordinates. In problems of another type ("visible squares", and others), it would be better for the solution to begin with the individual, who would plan the general course of the work, relegating to the computer the task of sorting through the largest set of variants, ones equally remote from the extreme--most and least probable--alternatives.

There is no single rule of object recognition in problems of the "classification of numbers" type. These are problems with ambiguous conditions, ones often encountered in life, in science, and in day-to-day experience. In each case, man does somehow solve them. Analyzing these solutions, the author distinguishes two levels of logical-psychological reference points: "universal" coordinates which remove the "upper" layer of uncertainty, and coordinates permitting closer tuning, a closer approach to the given type of problems. Shapiro demonstrates how these reference points interact with each other, how they fall into order in response to partial sorting, and how these processes could be embodied within programs promoting an effective search for solution.

We can see here that the operational-"gnoseological" conception of thinking is consistent with the logic of nonrigorous objects, discussed above. We can presume that further synthesis of both approaches will make it possible to obtain new, interesting results in the simulation of cognitive processes. But even in its present form, Shapiro's work signifies a new step in the development of the methods of cybernetics representation of complex "humanistic" systems. Many of the author's conclusions may be laid at the basis of further research on heuristic programming and on "artifical intelligence", and therefore they should be of interest to psychologists, logicians, cyberneticists, and developers of man-machine complexes.

FOOTNOTES

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2. Bongard, M. M., "Problema uznavaniya" [The Recognition Problem], Moscow, Izd-vo Nauka, 1967, p 6.

3. For more information, see Dreyfus, Kh., "Chego ne mogut vychislitel'nyye mashiny. Kritika iskusstvennogo razuma" [What Computers Cannot Do. A Criticism of Artificial Intelligence], Moscow, Izd-vo Progress, 1979, and the postscript to the Russian translation of this book, written by one of the present authors.

4. Bellman, R., "Kibernetika i meditsinskaya diagnostika" [Cybernetics and Medical Diagnosis], Moscow, Izd-vo Nauka, 1967, p 25.

5. The reference is primarily (though not exclusively) to the conception L. A. Zade developed in the mid-1960's. Of the numerous works of this scientist and his school, we cite only a few: Zade, L. A., "The Principles of a New Approach to Analyzing Complex Systems and Decision Making Processes," in "Matematika segodnya" [Mathematics Today], Moscow, Izd-vo Mir, 1974; Zade, L. A., "Ponyatiye lingvisticheskoy peremennoy i ego primeneniye k prinyatiyu priblizhennykh resheniy" [The Concept of the Linguistic Variable and Its Application to the Making of Approximate Decisions], Moscow, Izd-vo Mir, 1976.

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8. Pospelov, G. S., and Pospelov, D. A., "Artificial Intelligence Research in the USSR," in Berg, A. I., (Editor), "Kibernetiku--na sluzhbu kommunizmu" [Cybernetics in the Service of Communism], Vol 9, "Control and Information," Moscow, Izd-vo Energiya, 1978.

9. Shapiro, S. I., "Ot algoritmov--k suzhdeniyam. Eksperimenty po obucheniyu elementam matematicheskogo myshleniya" [From Algorithms to Conclusions. Experiments on the Elements of Mathematical Thinking], Moscow, Izd-vo Sov. radio, 1973.

10. See Berg, A. I., Biryukov, B. V., and Stolyar, A. A., the "Operational-Logical 'Model' of Thinking and Learning, and Cybernetic Pedagogics," in Shapiro, S. I., "Ot algoritmov--k suzhdeniyam" [From Algorithms to Conclusions], Moscow, Izd-vo Sov. radio, 1973.

11. Shreyder, Yu. A., "Semantic Aspects of Information Theory," in "Informatsiya i kibernetika" [Information and Cybernetics], Moscow, Izd-vo Sov. radio, 1967; see also Biryukov, B. V., "Kibernetika i metodologiya nauki" [Cybernetics and the Methodology of Science], Moscow, Izd-vo Nauka, 1974, Chapter 3.

11004
CSO: 1840/187

BIOTECHNOLOGY

UDC 612.2:599.5

RESPIRATION AND OXYGEN PATTERNS OF DOLPHINS

Kiev DYKHANIYE I KISLORODNYYE REZHIMY ORGANIZMA DEL'FINOV in Russian 1980 (signed to press 3 Apr 80) pp 2-5, 331

[Annotation, introduction and table of contents from book "Respiration and Oxygen Patterns of Dolphins", by Asya Zelikovna Kolchinskaya, Irina Nikitichna Man'kovskaya and Anatoliy Grigor'yevich Misyura, Izdatel'stvo "Naukova dumka", 1,000 copies, 332 pages]

[Text] The monograph presents the authors' ideas on the respiratory system, patterns of gas mass transfer, and control of these processes in the body of mammals. Experimental data and information are presented that are available in the literature on the functions of the organs of external respiration, circulation, the respiratory function of blood, the features of capillarization of cardiac and skeletal muscles, the content and distribution of myoglobin in the muscle fibers, and on tissue respiration of dolphins. Experimental and theoretical (on mathematical models) studies are described on mass transfer of gases, oxygen patterns of the body and oxygen patterns of the muscle tissue of these animals.

It is designed for physiologists, specialists in the field of mathematical modeling of biological processes, engineers, zoologists, biochemists, biologists, physiologists and veterinarians.

Contents

Introduction

A study of the dynamics of marine mammals attracts the attention of an ever greater number of domestic and foreign researchers. The increased interest in this question is explained, first of all, by the fact that the respiratory system with its complicated mechanisms that guarantee gas exchange in the lungs, gas transport by the blood, and oxidation processes in the tissues plays an exceptionally important role in the adaptation of marine animals to underwater conditions. Since the lungs, cardiovascular system and respiratory function of the blood in different species of marine mammals have undergone the deepest and most general changes during adaptation to an aquatic medium, their study is of undoubted value for basic sciences, evolutionary physiology, biochemistry, zoology and bionics.

For physiologists and specialists in the field of mathematical modeling, the respiratory system of Cetaceans, and of dolphins in particular, is not only an interesting, but also a rewarding object of research. The approach to studying the respiratory system from the position of the theory of control on this original biological subject is somewhat simplified by a number of circumstances. Under natural conditions the main links in the dolphin respiratory system are seemingly separated. During submersion to depths over 100 m the gas exchange in the lungs of these animals is practically missing and gas transport by the blood is isolated both from external respiration, and from the respiration of a large group of tissues, support, muscle, etc. The powerful and short respiratory act that is implemented on the sea surface in Cetaceans is replaced by a respiratory pause of incommensurable duration. During this pause, as during a slow-motion movie, events unfold that occur in the respiratory cycle. The ventilation-perfusion ratios, the general blood flow and the blood supply to the greater part of the body change significantly. This governs drastic alterations in the rate of gas streams through the alveolar-capillary membrane. These and other features of the functioning of the respiratory system and the process of gas mass transfer in the dolphins seem to suggest to the researcher engineering solutions for controlling this complicated physiological process. The authors of the presented monograph,therefore, did not refrain from attempting to create a mathematical model for the dolphin respiratory system. They present for the reader's judgment the results of their experimental and theoretical research on this system.

Currently the world literature on marine mammals has less than a thousand sources. A major contribution to the ecology, morphology, physiology and biochemistry of Cetaceans has been made by our domestic and foreign scientists summed up in monographs and surveys [1,2,21,23,45,61,86-88,116,117,125,126,144,184,198,206,208, 234,237,249,262,269,279,282,293,374,404,527,530,590,680,721,722,752,755,774,788].

Certain surveys and sections of monographs cite information about the respiration of marine mammals [6,45,86-88,117,126,207,269,279,282,516,527,530,533,534,539,

556,560,574,576,758,785,798, and others]. However there are as yet no special monographs on the physiology of dolphin respiration. In addition, the works that discuss external respiration, the respiratory function of blood, circulation, the adaptation mechanisms that permit marine animals to withstand oxygen deficiency, hypercapnia, high pressure and its drops are primarily based on morphological data.

The extreme lability of the oxygen patterns in dolphins (transition from hyperoxic to very pronounced hypoxic states) cannot help but stir the interest of physiologists in a study of the oxygen supply system, and investigation of the oxygen pattern of Cetaceans, and the mechanisms controlling them.

Oxygen deficiency that develops during prolonged diving is considered the main factor restricting the diving depth and the time for the animals' stay underwater. Therefore, starting with the end of the last century up to our time, determination of the oxygen reserves of diving animals and study of the adaptive mechanisms that guarantee their least expenditure underwater have been at the center of attention of many researchers. The publications on this subject present calculations of oxygen reserves in diving animals of various species. It is a significant shortcoming of these calculations that they take into account the condition of the animal that was recorded at a certain time period in a stationary pattern that does not exist in reality, i.e., the oxygen reserves are defined as if in an unchanging system. In reality, a constant redistribution of the oxygen reserves and change in the demand for them by groups of tissues that are considerable in weight occur in the Cetaceans. The complex interaction between different physiological adaptive mechanisms requires a new approach, the application of a different principle for computing the reserves and the possible expenditure of oxygen, an approach that is based on a description of the dynamics for the functioning of the entire respiratory system and the system of regulating the body's oxygen patterns. Such an approach was used in the joint work of the scientific collectives of the A. A. Bogomolets Institute of Physiology (department of hypoxic states, headed by Doctor of Medical Sciences A. Z. Kolchinskaya) and the Institute of Cybernetics of the Ukrainian SSR Academy of Sciences (department chairman--Doctor of physical-mathematical sciences B. N. Pshenichnyy). The results of the joint studies are presented in this monograph. It also surveys the published data on these questions. Individual results of experimental studies described in the monograph were obtained by the authors jointly with V. M. Alekseyev, V. V. Belenikin, P. V. Beloshitskiy, L. N. Bogdanova, M. G. Bukhman, S. A. Gulyar, K. A. Dzhincharadze, V. P. Dudarev, K. F. Zhikhareva, B. A. Zhurid, V. A. Zaboluyev, M. I. Zapopad'ko, V. F. Zelenskaya, O. G. Karandeyeva, Yu. N. Korolev, O. G. Koshev, S. K. Matisheva, T. D. Minyaylenko, V. S. Mishchenko, L. L. Levchenko, N. P. Ocheretnaya, Ye. V. Prudnikova, I. F. Sokolyanskiy, A. S. Spakhov, Yu. V. Stepanov, Yu. T. Strelkov, V. I. Fedorchenko, M. M. Filippov, V. M. Shapunov, N. V. Shtuchenko. References for these works are given in the appropriate sections. The development and realization of the mathematical model described in the book for the respiratory system on the digital computer BESM-6 and studies on the model were done by A. Z. Kolchinskaya, and A. G. Misyura jointly with B. N. Pshenichnyy, Yu. N. Onopchuk, D. I. Marchenko, D. V. Shevelo, I. S. Rappoport. The studies of P_{O_2} distribution in the dolphin muscle tissue were done by A. Z. Kolchinskaya, I. N. Man'kovskaya and Ye. G. Lyabakh [108] on the model [148].

We consider it our pleasant duty to express our sincere gratitude to all colleagues who participated in our joint research, as well as the director of the Georgian branch of the VNIIRO [expansion unknown] of the USSR Ministry of the Fish Industry, Candidate of biological sciences L. E. Tsuladze, scientific coworker K. A. Dzhincharadze, and the entire collective of this branch where a considerable portion of the experimental work was done.

9035
CSO: 1840/144

ENVIRONMENT

ANIMAL ECOLOGY ASSISTS IN BEHAVIOR CONTROL

Moscow EKOLOGICHESKIYE OSNOVY UPRAVELNIYA POVEDENIYEM ZHIVOTNIKH in Russian 1980 (signed to press 11 Jul 80) pp 2, 188-191

[Annotation and abstracts of articles from book "Ecological Principles of Animal Behavior Control", edited by Doctor of Biological Sciences D. S. Pavlov and Doctor of Biological Sciences V. D. Il'ichev, USSR Academy of Sciences Institute of Evolutional Morphology and Ecology of Animals imeni A. N. Severtsov, Izdatel'stvo "Nauka", 2,700 copies, 192 pages]

[Text] This collection is devoted to control of the behavior of animals in different taxonomic groups. Development of the biological principles of controlling animal behavior and creating, on their basis, a strategy for wise behavior control would make it possible to solve the highly complex problems of exploiting natural and artificial ecosystems. Thus the problems discussed in articles contained in this collection are very timely.

UDC 591.511

BIOLOGICAL PRINCIPLES OF ANIMAL BEHAVIOR CONTROL

[Abstract of article by B. P. Manteyfel', D. S. Pavlov, V. D. Il'ichev, and L. M. Baskin]

[Text] Development of the biological principles of animal behavior control is significant to many areas of science and economics. Three directions of work are distinguished: I--utilization of the laws of animal behavior, closely associated with behavior prediction; II--stimulation of animals to display reactions in their repertoire, III--change of behavior by genetic methods or by interference in the ontogenesis of behavior. The first direction unites the passive methods of control, while the last two deal with the active methods. Four groups of control methods are distinguished among the latter: 1--creation of a certain motivation of behavior; 2--influence by effective stimuli; 3--interference in the ontogenesis of behavior; 4--change in normal animal reactions by genetic methods.

Bibliography--55 references.

UDC 591.51:595.511

PRINCIPLES AND APPROACHES TO INSECT BEHAVIOR CONTROL

[Abstract of article by G. A. Mazokhin-Porshnyakov]

[Text] The mechanisms and informational organization of insect behavior are examined. A distinction is made between programmed behavior controlled by neuron-detectors, and modifying behavior, which is subordinated to lower and higher associative schemes of internal behavior control supported by feedbacks and individual memory. Sensory inputs are analyzed, and a scheme of signal-assisted control of insect behavior is given. Signal-assisted control of the behavior of harmful and useful species (by man) is demonstrated with various examples of successful chemical, optical, and acoustic signaling methods, and of exposure of insects to an artificial electric field.

Bibliography--73 references.

UDC 591.51:597:639.2

CONTROL OF FISH BEHAVIOR DURING FISHING

[Abstract of article by B. V. Vyskrebentsev and M. P. Aronovov]

[Text] A combination of defensive and exploratory reactions is typical of the behavior of fish in a trawl, as are orientation reactions. Fish behave differently in different zones of a trawl. Bottom-dwelling fish would best be influenced by stimuli eliciting an exploratory reaction in zone one of a trawl. Mechanical devices and acoustic and electric fields may be used as the controlling stimuli. Pelagic fish require development and use of stimuli which also elicit an exploratory reaction in zones one and two of a trawl, preventing their exit from the fishing zone into zone two. Stimuli for pelagic fish may include electric and optical fields, as well as various mechanical devices.

UDC 591.51:597.639.2

BASIC MECHANISMS AND PRINCIPLES OF CONTROLLING FISH SCHOOLING BEHAVIOR

[Abstract of article by V. V. Gerasimov, A. A. Darkov, and D. V. Radakov (deceased)]

[Text] The basic laws governing fish schooling behavior and mechanisms insuring contact and coordinated actions between individuals in a school are described on the basis of the authors' and published data. A number of ideas are suggested on the principles of controlling fish schooling behavior.

Bibliography--14 references.

UDC 591.51.597.639

SOME ASPECTS OF INDIRECT LEARNING BY FISH IN A GROUP

[Abstract of article by T. S. Leshcheva]

[Text] Experimental studies are used as the basis for describing the unique features of first- and second-order indirect learning among schooling and nonschooling species of fish. The dependence between indirect learning and the tendency for schooling is established; it manifests itself especially distinctly in second-order indirect learning.

Bibliography--34 references.

UDC 591.185:597.639

OLFACTION AND THE PROBLEMS OF FISH BEHAVIOR CONTROL

[Abstract of article by G. A. Malyukina, Ye. A. Marusov, and A. O. Kasumyan]

[Text] Intra- and interspecific communication of fish based on olfaction is complex and diverse. Its significance is also extremely great in certain periods in the life of species exhibiting a relatively low level of olfactory development--microsmatic species. It is experimentally demonstrated that the olfactory organ of fish is highly sensitive to many natural odors. More so than other substances, these stimuli are behaviorally active; their attractant or repellent action is the basis for developing methods to control fish behavior.

Bibliography--116 references.

UDC 591.51:597.639

CONTROL OF THE BEHAVIOR OF FISH IN FLOWING WATER

[Abstract of article by D. S. Pavlov]

[Text] The biological principles of controlling the behavior of fish in flowing water are analyzed with the example of freshwater, semi-migratory, and migratory fish. The rheo-reaction ("rheotaxis") is the basis for the behavioral reaction of fish living in flowing water. In the course of evolution, fish developed two basic behavioral stereotypes in flowing water--the behavioral stereotypes of pelagic and bottom-dwelling fish. Among pelagic fish, the dominant orientation mechanism is visual, and they are typified by low threshold and high critical flow rates for the rheo-reaction. Among bottom-dwelling fish, the tactile orientation mechanism has the greatest significance, and they are typified by high threshold and low critical flow rates. Two principles of control of the behavior of fish in flowing water are distinguished--active and "passive".

Bibliography--14 references.

UDC 591.51:598.599

ADAPTATION OF THE BEHAVIOR OF BIRDS AND MAMMALS TO THE ANXIETY FACTOR

[Abstract of article by A. D. Vladyshevskiy and D. V. Vladyshevskiy]

[Text] The ontogenetic sequence of formation of behavior directed at minimizing the negative consequences of anxiety and direct pursuit is analyzed. The following types of behavioral adaptations are distinguished: higher intensity of reactions, withdrawal or covert movement, and differentiation. It is concluded that adaptation of animal behavior to anxiety is directed on one hand at the most effective assurance of security possible and, on the other hand, at minimization of time and effort expended on defensive reactions.

Bibliography--14 references.

UDC 591.51:598.334

CONTROL OF THE BEHAVIOR OF FISH-EATING BIRDS AT MANMADE WATER BASINS

[Abstract of article by B. M. Zvonov]

[Text] Intensive development of pond fish culture has made it necessary to protect water basins from fish-eating birds. Direct observations at fish farms in Astrakhanskaya and Odesskaya oblasts led to development of the rules of acoustic repulsion of birds from water basins using tape recordings of the alarm and distress signals of different species of seagulls and wading birds.

UDC 591.51:598

THE ORIENTATIONAL NATURE OF REINFORCEMENT STIMULI IN THE CONTROL OF BIRD BEHAVIOR

[Abstract of article by V. D. Il'ichev]

[Text] Analysis of practical experience accumulated in the use of bird repellents, and of field experiments permits recommendation of combined repellents as a new means of behavior control. Combined repellents have been developed on the basis of an analogy with the natural reactions of birds having signaling importance, to include, besides warning cries, cues indicating a situation dangerous to birds (danger cues). Combined repellents presuppose simultaneous use of acoustic alarm or distress signals and imitations of a factor mortally dangerous to birds, creating a situation of extreme danger.

Bibliography--13 references.

UDC 591.51:598

BIRD GROUP BEHAVIOR AND THE EFFECTIVENESS OF ACOUSTIC REPELLENTS

[Abstract of article by A. V. Tikhonov]

[Text] Experimental material is used as the basis for discussing the unique features of the defensive reactions (flight, dispersal) of colonial birds and birds forming

temporary flocks. The principal attention is devoted to the adaptive features of defensive reactions in different taxonomic and ecological groups of birds (web-footed, wading, gulls, Corvidae) having important significance to further development of methods to control their behavior. Some geographic and interspecific aspects of the effectiveness of acoustic repellents are examined. Practical recommendations are given on repelling birds from agricultural materials and fish culture basins with the help of acoustic repellents.

Tables--4, bibliography--24 references.

UDC 591.51:598

CONTROL OF BIRD BEHAVIOR BY ACOUSTIC REPELLENTS AT AIRFIELDS OF THE LITHUANIAN SSR

[Abstract of article by V. S. Shevyakov]

[Text] The ornithological situation at airfields of the Lithuanian SSR was studied in joint research conducted by representatives of airfield services. The effectiveness of acoustic repellents upon different species compositions and upon nesting and migrating birds, and the action of repellents in different seasons and times of the day were determined. Recommendations are given on organizing bioacoustic measures employing acoustic repellents to frighten birds away from airfield landing strips. Concrete descriptions are given of a permanent acoustic device at a landing strip, and movable devices installed aboard motor vehicles.

Tables--1.

UDC 591.51:599.6

USE OF DEFENSIVE BEHAVIOR IN UNGULATE CONTROL

[Abstract of article by L. M. Baskin]

[Text] Ungulate defensive reactions are basically species-specific, while effective stimuli are specific to populations. Formation of defensive behavior is associated with assimilation of the experience of the mother and companions. The relationship between defenses and social behavior is significant. These principles lie at the basis of control of defensive behavior. The control methods differ in the case of a defensive dominant and the case of a combination of fear with other stimuli.

Bibliography--14 references.

UDC 591.636.599.6

CONTROL OF THE BEHAVIOR OF AGRICULTURAL ANIMALS AT INDUSTRIAL COMPLEXES

[Abstract of article by T. N. Venediktova, Ye. A. Karavayev, and V. G. Pushkarskiy]

[Text] The prospects and basic principles of controlling the behavior of agricultural animals at industrial livestock complexes are discussed. Methods for controlling the motor reactions of pigs and cattle are proposed. Ways for reducing aggressiveness and decreasing arousal of animals at times of regroupings and relocations are developed.

Tables--1, bibliography--10 references.

UDC 591.51:599

LOCAL DIALECTS, GEOGRAPHIC VARIABILITY, AND HEREDITARY TRAITS OF THE ACOUSTIC SIGNALS OF MAMMAL PROGENY

[Abstract of article by A. A. Nikol'skiy]

[Text] The traits of acoustic signals produced by mammals are subject to geographic variability. However, the local specificity of these traits may be a consequence of two processes--genetic inheritance and learning. The capability for imitation is the basis of learning. The simplest case of imitation involves monotonous execution of a group species-specific signal. The imitation capability of mammals has been studied very poorly. The signals of hybrids possess intermediate traits in relation to the traits of the signals produced by the initial species (or subspecies), which confirms the genetic inheritance of these traits. Mutual imitation of acoustic signals (merger of individual traits) may be a compromise between the genetic stability of species-specific traits and the need for creating isolation between different groups.

Bibliography--21 references.

UDC 591.34:599.323

PHEROMONES AND MAMMAL BEHAVIOR. THE ROLE OF OLFACTORY STIMULI IN THE AGGRESSIVE BEHAVIOR OF HOUSE MICE

[Abstract of article by V. Ye. Sokolov, Ye. V. Kotenkova, and E. P. Zinkevich]

[Text] The results of many authors, including those of this article, on the effect of volatile components liberated by house mice upon the aggressive behavior of individuals (mainly males) of the same species are generalized. The following problems are examined: The influence of experimental anosmia in house mice on aggressive behavior; hormonal control of excretion of the pheromone causing aggressive behavior, and of its sources; "repellent" pheromone and its relationship to the pheromone of aggressive behavior; effect of prior exposure to olfactory signals on aggressive behavior; the complexity of the structure of the aggressive behavior pheromone, data on its chemical composition, and the role of olfactory signals in the aggressive behavior of other rodent species.

Tables--4, bibliography--72 references.

11004
CSO: 1840/175

MEDICAL DEMOGRAPHY

LIFE EXPECTANCY: ANALYSIS AND MODELING

Moscow PRODOLZHITEL'NOST' ZHIZNI: ANALIZ I MODELIROVANIYE in Russian 1979 (signed to press 8 Jun 79) pp 2, 156-157

[Annotation and table of contents from book "Life Expectancy: Analysis and Modeling", edited by Ye. M. Andreyev and A. G. Vishnevskiy, Department of Demographics, Scientific Research Institute of Planning Computer Centers and Systems of Economic Information, Central Statistical Administration of the USSR, Izdatel'stvo "Statistika", 11,000 copies, 157 pages, illustrated]

[Text] As a result of lowering of the mortality rate, there has been a significant increase in mean life expectancy in most countries of the world. However, the lowering of mortality differed in different countries, and even in different regions of the same country. Analysis of these differences helps demonstrate the main socioeconomic and biological factors, upon which the mortality level depends, and to define the main directions of control for further decline thereof. The authors of the articles in this collection explore the most important trends and patterns of mortality in the USSR and foreign countries; they propose new methods for analyzing it and mathematical modeling.

This book is of interest to demographers, social hygienists, sociologists and economists.

Contents

10,657
CSO: 1840/999

UDC: 312.432/437

THE ENVIRONMENT AND HEALTH

Moscow OKRUZHAYUSHCHAYA SREDA I ZDOROV'YE CHELOVEKA in Russian 1979 (signed to press 19 Oct 79) pp 4-7, 213-214

[Annotation, foreword and table of contents from book "The Environment and Human Health", edited by A. D. Lebedev, Institute of Geography, USSR Academy of Sciences, Izdatel'stvo "Nauka", 4250 copies, 215 pages]

[Text] This monograph describes, for the first time in Soviet literature, the principles and methods of geographic investigation of human ecology; several theoretical concepts were developed on this subject. The conception was introduced of territorial anthropoecological systems. It was demonstrated that various types of environments can affect human health, and analysis was made of geography approaches to optimization thereof.

Illustrations 32, tables 20; bibliography lists 459 items.

Foreword

Among problems of Soviet constructive geography, the mainstem of which is research on the scientific prerequisites for optimizing interaction between man, society and the environment in the presence of the progressive scientific and technological revolution, the problem of environment and health holds a special place. This is not simply a pressing problem; preservation and improvement of man's health is one of the important goals of a fully developed socialist society. It is related to the search of criteria of optimum interaction between society and the environment, to assure the environmental qualities needed by man.

The new Constitution of the USSR, which recognizes that the supreme goal of social production is to meet the needs of the Soviet people, directly states that a healthy environment is a guarantee of health of the citizens. Under conditions of developed socialism, there is ample room to implement this conception. The decisions of the 23d, 24th and 25th CPSU congresses are directed toward this.

In accordance with the importance of this problem, general humanization of science became evident in the early 1960's, including the system of geographic sciences. Along with traditional studies of natural resources and conditions of placing industries, there was a drastic increase in importance of studying man's environment, both natural and altered by industrial endeavors, including the markedly urbanized environment. A new direction of research in medical geography was one of the manifestations of this process; at one time it had devoted much attention

to infectious pathology of man, where the links between human diseases and the environment are the simplest and easiest to study. At present, studies of ecological geography of noninfectious diseases and pathological states of man began to gain increasing significance in that branch of geography.

Studies in medical geography started as far back as 1962 at the Institute of Geography, USSR Academy of Sciences. At first, they dealt with specific medico-geographic investigations of a regional geographic nature. Gradually, there was intensification of geographic investigation of human ecology, on the basis of methodological interpretation of the demonstrated correlations between human diseases and the environment. There was substantial expansion of the range of research. Of course, the characteristics of man's living and working conditions do not merely refer to demonstration of environment-caused diseases and pathological states. We are dealing here with the need to investigate various features of both the natural and urbanized environment, upon which depend, more or less, favorable or unfavorable living conditions, and then to relate them to social, biological, engineering or other needs of people. And it is important to do this, not only for a single individual, but for different population groups, societies and mankind as a whole.

A new scientific direction, the study of geographic aspects of human ecology, began to form in 1971 at the Institute of Geography. It was based on conceptions of integration of heterogeneous phenomena in specific parts of earth, the possibility of society having an active influence on the environment in accordance with set goals.

The constructive sets of modern geography enable us to formulate the question of tasks and means of protecting and improving man's environment, to develop problems of optimization thereof. At the same time, the question of objective criteria of quality of the environment, as well as range of human capacity to adapt to unfavorable states thereof in general and individual changes in particular, is acquiring special meaning to constructive formations.

It is apparent from the foregoing that studies of geographic aspects of human ecology, which accumulated many of the achievements of modern medical geography, developed expressly within the framework of constructive geography.

The scientific conception of this new direction, which is being developed at the Institute of Geography, USSR Academy of Sciences, was formulated in articles by A. D. Lebedev, V. S. Preobrazhenskiy and Ye. L. Raykh (Lebedev et al., 1972; Preobrazhenskiy, Raykh, 1974; Raykh, 1976). In addition, the main theses dealing with research on geographic aspects of human ecology were discussed at a large conference, which convened in 1974, of the Institute of Geography, USSR Academy of Sciences, together with the Institute of Human Morphology, USSR Academy of Medical Sciences. A collection, "Theory and Methods of Geographic Studies of Human Ecology" (1974), with the complete text of papers, was published for this conference.

In view of the fact that the questions raised at the conference inspired much interest in the community, it was decided to continue to discuss them and elaborate them further in the collection, "Geographic Aspects of Human Ecology" (1975), which was prepared at the Institute of Geography, with the participation of geographers, medical specialists, philosophers and other specialists.

Thus, the monograph offered to the reader, "The Environment and Human Health," so to speak, completes a certain stage of work on this complex and vast problem. As they began to work on the monograph, the authors' objective was not so much to answer comprehensively all questions that arose (which could not be done, not only because of the limited size of the book, but current depth of work on the problem), as to outline the main aspects of the problem. For this reason, the contents of this monograph are limited primarily to discussion of those problems of human ecology, for which the existence of geographic aspects is the most apparent. The authors also took into consideration the fact that the most general theses of the close link between human health and nature of social relations, which must serve as the foundation for analysis of this problem, have already been discussed in the book, "Society and Human Health" (1973), which was written by an international team of authors, with G. I. Tsaregorodtsev as the general editor.

The structure of the monograph reflects both conceptual theses of the new direction and specific studies. Among the latter, the sections dealing with the effects on health of various socioeconomic changes in the presence of the scientific and technological revolution, urbanization, pollution and effects on man of the technogenic environment are probably referable to more traditional aspects of recent literature, related to consideration of the state of man's environment. The authors were aware of the fact that questions of man's life and endeavor under urban conditions and development of cities in the interests of man were discussed in the monograph by Yu. V. Medvedkov, "Man and the Urban Environment" (1978), which is also in the "Problems of Constructive Geography" series.

The sections of the book dealing with adaptation to the environment, including extreme states thereof, and ecology of nutrition against the background of food resources are more unusual.

The monograph ends with sections, in which an effort was made to outline the geographic aspects of the problem of optimizing the environment in their more general form, as well as in one of the more special, but specific variants, pertaining to regions of new economic development.

Extensive use was made in working on this book of the 10 years of experience of several of its authors in research in the field of medical geography of the African continent, and this was partially reflected in the choice of specific examples to confirm general scientific theses.

Most of the work on writing and preparing this monograph was done by a team of staff members of the Institute of Geography, USSR Academy of Sciences, consisting of L. V. Maksimova, Ye. L. Raykh, L. I. Saravayskaya, M. P. Stradomskaya and P. A. Frumkin under the general guidance of Ye. L. Raykh, A. D. Lebedev and V. S. Preobrazhenskiy. In addition, some sections of the book were authored by V. P. Alekseyev (Institute of Ethnography, USSR Academy of Sciences), B. B. Prokhorov (Institute of Geography of Siberia and the Far East, Siberian Department of the USSR Academy of Sciences) and V. I. Rusanov (Tomsk State University).

Contents

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PHYSIOLOGY

AVIATION MEDICINE

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[Annotation, foreword, chapters 4 and 5, and table of contents from book "Aviation Medicine", edited by Prof. A.N. Babiychuk, doctor of medical sciences, Izdatel'stvo DOSAAF SSSR, 17,000 copies, 248 pages]

[Text] This book deals with questions of aviation medicine as they relate to the features of medical support for flights aboard aircraft of the civil aviation and DOSAAF. Measures for creating optimum working conditions for aircrew personnel are examined, the complex of measures insuring a high level of health among aircrew personnel and their psychophysiological capacities is presented, and other top priority matters of medical support to insure flight safety are examined.

Foreword

As a result of scientific and technical progress in the field of aviation technology, the inventory of aircraft available to civil aviation is being constantly enlarged with the Tu-134, Tu-154, Il-62, Il-76, Tu-144, Il-86 and other airliners that handle passengers and freight on a massive scale; and with the Mi-6, Mi-8, Mi-10 and Ka-26 helicopters that are used extensively in the various sectors of the national economy. Aviation materiel is also being improved in the civil aviation flying schools and the DOSAAF flying clubs.

Today's aircraft and helicopters are complex flying machines equipped with the latest automatic and semiautomatic devices, but, as before, man plays the leading role in the man-machine system.

The control of modern aircraft is regarded as a comprehensive task including, on the one hand, the human operator, and on the other, the technical control devices, with both elements interlinked.

Good reliability and efficient operation of this system can be insured only if the specifications of the elements of the aircraft interacting directly with the human operator conform to his physical and psychological capacities, and if flight factors do not adversely affect the operator by lowering his work capacity.

In this connection, medical backup for flight safety in the civil aviation and DOSAAF is organized in two directions.

The first direction provides for the creation of the most favorable working conditions for aircrew personnel in the broad sense of the concept.

These measures are realized directly in the design of the flight deck and its equipment in accordance with special medical engineering requirements, and they include rational layout of working places and equipment in them, devices that insure the proper cabin environment, protection of the cabin environment from pollution by noxious chemicals, protection against noise and vibration, observance of lighting standards and so forth.

The second direction in medical backup for flight safety provides for the set of measures, whose main object is the human operator, that insures a high level of health in aircrew personnel and their psychophysiological and psychological capacities, such as to guarantee high reliability in the human element of the system by which an aircraft or helicopter is controlled.

The medical measures in this direction cover candidate selection for civial aviation flying schools and DOSAAF flying clubs in respect of candidates' state of health and observation of their health during training and flight activities; evaluation of candidates' personal qualities also plays a certain role.

An important place is assigned to questions of work, rest and eating schedules, and also to observation of the physical preparedness of aircrew and flight engineer personel and other special aviation medicine matters.

One special area in insuring flight safety is medical analysis of the causes and conditions of flying accidents and aircrew errors in order to prepare medical recommendations to prevent them.

The most topical questions of medical backup for flight safety in civil aviation and DOSAAF aviation are discussed in the relevant chapters.

This book is intended for aviation doctors and other aviation specialists, and its aim is an attempt to offer a systematized presentation of questions of aviation medicine as they apply to the features of medical backup for flight safety in aircraft of the civil aviation and DOSAAF.

Contents

Chapter 4. The Role of Vision in Flight Activity.

In order to insure normal flight both by day and at night, pilots should have vision good enough to read the instruments quickly; their eyes should focus well when looking outside the aircraft cabin, particularly against a background of the unfocused field of vision; they should be able to distinguish correctly any light or colored orientation devices and light signals; they should be able to adapt quickly to bright or dim illumination; they should be able to see instrument readings in emergency and pre-emergency situations, that is, in time-deficit conditions. It has been shown that in aircrew personnel the organ of sight is under great stress when flying an aircraft in both clear and difficult weather conditions.

According to both Soviet and foreign publications, about 90 percent of all information the pilot receives comes through the visual analyzer. This has also been confirmed by the fact that in today's aircraft there is a large number of flight instruments which the pilot must constantly monitor. In individual types of aircraft there are now as many as 600 instruments and symbols carrying various kinds of visual information. In addition, the instruments combine readings for several parameters characterizing the aircraft's position in the air.

During flight, the visual analyzer is subjected to the effect of various adverse factors, as for example the speed of flight, which is frequently combined with a time deficit in observing the readings of the flight instruments and evaluating the spatial position of the aircraft. Time deficit is seen particularly in emergency situations when the pilot does not manage to perceive instrument readings correctly; this can lead to pilot error.

Considerable significance for visual work in flight attaches to the layout of instruments and control panels. It is common knowledge that many of them are located not in the center of the pilot's field of vision but way above his head, or on the side, to the left and right relative to his position in the cabin. In order to maintain constant and simultaneous visual observations on all instruments

and the various symbols within his working area, the pilot must not only turn his head to either side but also change the position of his trunk within his seat, as a result of which he is under constant stress.

In addition to his work on the flight deck the pilot must at the same time observe the situation outside the cabin. This means that he frequently flies with unfavorable light conditions in the cabin. At night, lighting conditions in the cabin are not usually optimum since if illumination is normal the pilot will be able to orient himself only poorly with respect to the situation outside. This is why during night flying, illumination of the instrument panel and control console should be minimal but at the same insure that instruments can be read. Irrational lighting at the pilot's position can lead to premature visual fatigue.

In civil aviation many aircrew personnel are aged 45-50 or more. Efficiency in their work depends not only their general physical condition but also on the status of the visual analyzer, and in particular, its functional reserves. There is good evidence that in pilots in the older age group, during the process of flying work these reserves are rapidly depleted, and during intense and prolonged stress they may be completely exhausted. In this connection, great significance attaches not only to the status of the visual analyzer at any given moment but also to its reserves for insuring further visual work at a sufficiently high level. Therefore, in evaluating the status of the visual functions in aircrew personnel, particular significance attaches to special examination methods that must be adequate for flying work and sensitive enough to detect visual fatigue. Moreover, they should assist the aviation doctors in detecting the early signs of pathologic and functional disorders in the visual analyzer during the process of flying activity. It is very important to conduct these studies in time-deficit conditions, and this is achieved by giving subjects special tests.

Among the large number of visual functions there are some on which flight procedures and ultimately flight safety depend directly. These include visual acuity and accommodation, night vision, spatial orientation, color vision and so forth.

Visual Acuity and Vision Correction in Flight Activity

Visual acuity is determined by the resolution of the retina. The central part of the retina, called the macula lutea retinae, insures the highest level of visual acuity (1.0-1.5 and more). On the periphery, retinal resolution falls off sharply. Thus, for example, at a distance of 10° from the macula lutea retinae, visual acuity is 30 percent of the maximum, and at a distance of 20°, only 15 percent. Visual stress in a pilot when monitoring instruments on the flight deck of an aircraft and other orientation devices outside it is put mainly on the central vision.

Visual acuity is a quite stable function, but under flying conditions its level, when acted upon by various adverse internal and external factors that the pilot frequently encounters during flight, can be altered. Enhanced flight stress affects visual acuity in pilots. As a result, as a rule there is fatigue of the ocular muscles that insure ocular accommodation. Accommodation disorders in pilots are observed most frequently at ages 45-50 or older. In most cases they cannot read the text of flight documents rapidly and correctly at the usual distance without

appropriate correcting glasses. At the same time, given only a small degree of age-related hyperopia (of the order of 1.0-1.5 diopter) they can distinguish the instruments and other symbols on the control panel, located at a distance of some 60-80 centimeters from their eyes, quite satisfactorily. With a large degree of presbyopia (for example, 3.0-3-5 diopter), and in maximum magnitudes of hyperopia in refraction, which are regarded as serious medical conditions, instrument readings can be seen with difficulty, while small symbols or slight deviations in needles on scales of instruments cannot be seen at all. The onset of visual fatigue is rapid in pilots aged 45-50, and in this connection they are forced more frequently to take breaks in order to rest. At a greater distance, however, that is, outside the aircraft cabin, as a rule these pilots are well oriented. The only exceptions are those pilots who are found to have a high degree of hyperopia (1.5-2.0 diopter) during medical flight examinations.

Vision acuity studies during medical flight examinations by boards are usually done with the aid of the Golovina-Sivtsev chart, which consists of 12 rows of symbols. This chart has serious shortcomings since the difference between the rows of symbols on the test chart corresponding to visual acuity of 0.1-0.2 is 100 percent, 0.2 to 0.3, 50 percent, 0.3 to 0.4, 33 percent, and so forth. This method allows error in evaluating visual acuity when doing studies on individuals with lowered visual acuity. This defect is eliminated in visual acuity studies with the aid of the Kholina chart, which consists of 33 rows of Landolt's rings. Visual acuity is determined with an accuracy down to 10 percent at all stages in loss of acuity.

Thus, in cases where it is necessary to clarify visual acuity through conclusions reached by a board, or for the purpose of prescribing prophylactic measures, the use of the Kholina chart can be fully recommended as an additional method during visual acuity studies.

Visual acuity studies can also be done with the aid of just one symbol, by using a broken Landolt's ring. By moving it toward and away from the subject the threshold distance can be determined for the correct response; which, given the appropriate recalculation, will characterize visual acuity.

The ability of pilots to make observations outside the aircraft cabin during flight, particularly during takeoff and landing, that is, when there are time constraints on tracking ground and air orientation devices, is evaluated from the status of dynamic visual acuity.

At a rate of movement for an object at up to 20°/second at an exposure time of 1.0 seconds, dynamic visual acuity is static (M.G. Kozyr'kova). Each subsequent increase in the rate at which an object moves relative to the preceding 20°/second reduces dynamic visual acuity by 0.1 to 0.2 As a rule, as exposure time is reduced, dyanmic visual acuity falls off. An individual ability to distinguish moving objects, and also age-related changes in dynamic visual acuity, have been established. The lowest indexes for it occur in individuals older than 40. In order to determine the relationship between static and dynamic visual acuity so as to clarify individual and age-related features in the perception of moving objects, it is advisable to conduct studies on dynamic visual acuity with objects moving at a rate of 80°/second at an exposure of 0.25-0.5 seconds.

Correction of Vision

The use in flight of correcting glasses by individuals with age-related weakening of accommodation is provided for by the existing regulations on medical certification for aircrew personnel in civil aviation.

Aircrew personnel with abnormal refraction are not permitted to fly when using correcting glasses.

Compared with other countries that are members of the ICAO, in the Soviet Union, standrad requirements for permitting aircrew personnel to fly are considerably more stringent in terms of the status of the main visual functions (visual acuity, refraction accommodation). Thus, for example, minimum requirements for visual acuity for pilots of classes 1 and 2 aircraft within the civil aviation system are 0.6-0.7, while abroad, these functional requirements have been lowered to 0.1-0.3, that is, by a factor of 2 or 3.

Correcting glasses designed for aircrew personnel should possess a number of advantages over regular correcting glasses made for the general public in our country. First of all, flying glasses should be unbreakable, fireproof and dustproof to a certain extent, fit closely on the pilot's face, and have reliable fastenings. They should restrict the field of vision as little as possible. The optical glass in flying glasses should have one or two, or even three focal distances if required, and the glass should be able to be replaced easily for other glass. Each crew member who uses glasses should have a spare pair made to the same prescription when he flies.

Aircrew Personnel Vision in Night Flying

In civil aviation night flying and flying at dusk now occur extensively. Modern navigational aids, improved airfield lighting and radar equipment make it possible for pilots to continue flying in even the most complex weather conditions. However, the increased stress on the visual analyzer in conditions of relatively low internal cabin illumination can negatively affect the quality of the pilot's work. It has been established that in night flying, pilot recognition of instrument readings and weak light signals in the aircraft cabin and of orientation devices outside the cabin is possible only if he has a high level not only of light sensitivity but also of acuity in night vision. In this connection, the maintenance of conditions that promote a high functional status for the visual analyzer in aircrew personnel during reduced illumination is considered a major problem in medical support for night flying.

In contrast to day vision, night vision is more labile. Factors reducing night vision include insufficient oxygen supply, fatigue resulting from incorrect organization of work by aircrews, the consumption of alcohol on the day before flying and so forth. The use of vitamins by aircrew personnel is most important for maintaining a high level of night vision. Thus, for example, if vitamins A, C and B are deficient in food, night vision can be reduced extremely rapidly. At the same time it can be rapidly restored to its initial level after vitamins have been supplied to the pilot's body (M.S. Trusov).

In our country, several instruments have been proposed and applied for light sensitivity studies for the purpose of professional selection of pilots. They have included in their time the extensive use of the Kravkov-Vishnevskiy chamber. However, during the process of operating this instrument serious defects were found that affected the quality of studies on night vision in aircrew personnel. Thus, for example, the Kravkov-Vishnevskiy chamber did not enable visual acuity to be studied in lowered illumination, as at night. As a result, the medical board's conclusions on the suitability of aircrew and trainee personnel for flying were based only on data on the rate of nighttime adaptation. At the same time, visual acuity is of great significance for pilots' visual orientation in conditions of lowered illumination. Nighttime adaptation and visual acuity are insured by different elements of the retina and are not mutually dependent. In medical flight examination certification, nighttime adaptation and visual acuity for night can be studied differentially by using the instrument of I.D. Semikopnyy.* The instrument (figure 4.1) is a portable rectangular box with lightproof covers forming a dark chamber 50 centimeters long. This length precludes the effect of accommodation on the results of the study. Red and orange aircraft silhouettes and Landolt's rings are used as the experimental test objects (figure 4.2). A facility for altering their position during the study makes it possible at the same time to monitor the indications of the subject. Inside the chamber, illumination can be varied within the limits of 0.0004 to 3 lux, which makes it possible to create the conditions of a natural night varying from dark cloud cover to moonlight, and also to simulate twilight. Studies are done in three stages (baseline adaptation, a 2-minute deadaptation, and the study proper of nighttime adaptation and acuity in night vision). The fact that the instrument is portable and the facilities for rapid studies (3 to 5 minutes) make it possible to use it (in flight) for professional selection and subsequent monitoring of the status of night vision of aircrew personnel in the periods between medical certification.

Many years of experience have shown that aircrew personnel with lowered night vision functions in regard to nighttime adaptation (more than 60 seconds) and with a visual acuity of less than 0.03 usually experience difficulties of some kind in visual orientation during night flying. According to available figures, they make up 2.2-2.6 percent of all individuals studied. During the winter and spring period the number of individuals with lowered night vision is sharply reduced (to 1 percent).

Comparative studies done on healthy subjects and individuals with impaired night vision using the Semikopnyy instrument under clinical conditions at the Military Medical Academy imeni S.M. Kirov and the Moscow Institute of Eye Diseases imeni Gel'mgolts have made it possible to establish a standard for permitting flying work

*I.D. Semikopnyy's instrument for doing night vision studies has now been adopted by the USSR Ministry of Health for supply to all medical establishments in the country. In addition, in 1961 at the International Congress of Military Ophthalmologists in Budapest it was confirmed as the standard instrument for testing night vision in pilots in the socialist countries.

in pilots who have a rate of nighttime adaptation of no more than 60 seconds and an acuity of night vision of at least 0.03. Individuals in whom the status of these functions is lower than the established level are grounded for night flying for a period of treatment. Experience in the Air Force has shown that timely administration of prophylactic vitamin therapy for pilots with a rate of nighttime adaptation of between 50 and 60 seconds and visual acuity down to 0.03 sharply reduces the number of individuals grounded from night flying because of the status of this function.

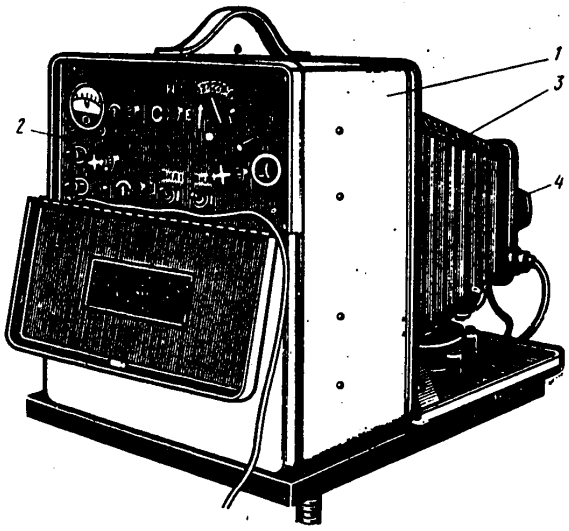

Figure 4.1 The Semikopnyy Instrument for Night Vision Studies

1. Housing 2. Panel 3. Lightproof cover 4. Obturator

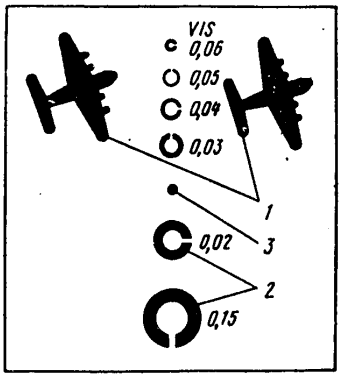

Figure 4.2 Experimental Test Objects for Night Vision Studies using the Semikopnyy Instrument

Spatial Orientation in Flight

The pilot's spatial orientation includes definition of the bearing and distance of visible orientation devices and also evaluation of their relative locations. For a pilot to judge the quality of visual evaluation of distance under flight conditions it is necessary for him to have an adequately high level of perception for the relative and absolute distance of objects.

Depending on the observation conditions, visual orientation in space is effected in binocular or monocular vision. However, in monocular vision the signs characterizing spatial vision are perceived less precisely. Binocular vision insures better quality perception of space because of the additional pulses arriving in the cerebral cortex from the eye muscles in convergence and divergence.

Observation of space is made difficult in a so-called "empty field," when there are no kinds of landmarks, as for example against the background of the sea, in a cloudless sky, or at night with lowered illumination. The pilot becomes to some extent myopic and unable to observe distant landmarks. The Howard-Dolman instrument is used for studying spatial vision in pilots. In research work, many people use various modifications of this instrument.

Some interest has been aroused in the modification made by the Polish ophthalmologist E. Zagar (1961). This instrument makes it possible simultaneously to evaluate the depth between objects and their height. Three rods (or needles), one of which moves, are used as the test objects. The subject observes the object through an aperture in a screen measuring 20 centimeters wide by 12 centimeters high while his head is restrained by a special device.

A modification of the intrument--a portable version with an indpendent power supply, named the "Neptun,"--has been developed at the State Optics Institute (Leningrad) for evaluating relative distance in flight activity conditions (directly at the pilot's working area). However, because of the extremely small dimensions of the test objects and the small distance at which they are presented to the subject (not from 5 meters as provided for by the Howard-Dolman method, but from 20 centimeters), accuracy and reliability of results are reduced. At this distance it is not so much the status of spatial vision but the status of accommodation in the subject that is determined.

In order to judge the quality of visual evaluation of distance in flight activity conditions, in 1967 V.V. Baranovskiy developed an instrument with whose aid individual sensitivity is determined to basic stimuli that have a signal value in evaluating absolute distance. The study takes no more than 3 to 5 minutes, which makes it possible to use this instrument in civil aviation and DOSAAF during medical flight examinations, and in research work. Within the instrument a set of stimuli are modeled, typical for the visual perception of changes in absolute distance. The instrument makes it possible to alter the magnitude of the object and the degree of its approach, which corresponds to real observation of an object moving within limits of 30 to 50 meters.

A dependence has been established between the quality of flying and the status of absolute distance on the instrument; this dependence is particularly noted when an aircraft is landing. In individuals making good or excellent landings, the perception threshold is 1 to 9 meters. In satisfactory and unsatisfactory landings, thresholds increase to 18 meters. Threshold magnitudes of 10 meters for absolute distance when an object is moving away from the observer have been established as standard.

When studying spatial vision and the facility to evaluate a spatial position correctly during flight, it is also necessary to know the status of other visual functions that participate directly or indirectly in spatial vision and insure that it is at an adequately high level. These functions include binocular vision, muscular balance in the eyes, the availability of fusion reserves and others.

The status of muscular balance in the eyes is insured by the correct placement of the two eyeballs in their orbits; this is known as orthophoria. In this version of muscular balance, both eyes are directed toward a fixed point without additional load. However, other innate versions of muscular balance also exist, as for example in latent strabismus, when the visual axis of one eye does not match that of the other. This condition is known as heterophoria. Fixation on a point in space by both eyes is in this case compensated by fusion forces in the oculomotor muscles.

In this connection it is generally assumed that heterophoria is an indicator of potential instability in binocular vision. However, experimental studies by V.V. Baranovskiy and Yu.P. Petrova using a measured load on the convergence-accommodation apparatus have shown that stability of binocular vision in aircrew personnel with heterophoria of 2° is greater than in orthophoria or heterophoria of 1°. It is suggested that this kind of stability in binocular vision in heterophoria is explained by the itineration of the nerve pathways in the central part of the visual analyzer resulting from continuous excitation of the retinal convergence reflex to the activity.

These data have served as a basis for lifting the restriction on flying in individuals with impairment of this function. Practical flying activity has shown that there have been no aviation accidents associated with heterophoria in pilots.

According to some authors (E. Zagar), muscular equilibrium is considered impaired only when esophoria reaches 3.0 D and exophoria 5.0 D for distance, and esophoria up to 2.0 D and exophoria up to 8.0 D for close vision.

When doing studies on the oculomotor apparatus it is very important to rule out oculomotor paralysis and paresis, which can be detected by using the double-image method (with colored glasses). This method is used when individuals complain of diplopia, and also when, during diploscope studies, the symbols on the chart are read by the subject not along one horizontal line, because the diplogram for one eye is higher than that for the other.

Fusion reserves make up that status of muscular strength in the external and internal ocular muscles in convergence and divergence. They determine the binocular stability of both eyes. To study this function, a special device called a Herschel prism is now in series production in the GDR. Two prisms are mounted in a special frame with a handle for holding it in the hand. In the zero position the prisms neutralize

each other and appear as plain glass. When one prism is turned within the frame relative to the other, refraction is either increased or decreased. During the study the prism is held in front of the left or right eye. The subject focuses both eyes on a point at a distance of 1 meter. The prism is then rotated with the base facing the nose, or the other way round. In the first case fusion reserves on the internal ocular muscles will be determined, and in the latter case, the external muscles. The instrument is scaled in diopters.

Significance of Color Vision in Flight

The ability to perceive different colors in the working area and outside it is an innate function related to day vision. At night, colors are not distinguished by their shade at illuminations less than 0.1 lux. At night, individuals with normal color vision distinguish unlit colored orientation devices or colored objects on the ground and in the air not by the color shade but by their relative brightness or color brightness. In the dark an orange-red shade is perceived as mostly dark, while a green-blue shade is mostly light.

The ability to distinguish colors normally is mandatory for aircrew personnel, since during flight it is essential to distinguish rapidly and accurately signals such as airport and navigational lights, warning signals, rockets, flags and so forth. The ability to distinguish the color of landmarks on the ground under local conditions is just as important; this is essential, in particular, in forced landings. Colored light indicators are used extensively in the aircraft cabin.

Luminous colored signals are perceived much better than signals illuminated by natural light. However, the angular dimensions of signals and their brightness characteristics are by no means unimportant in the pilot's discriminator ability. Colored signals that are small or at extremely low brightness may pass quite unnoticed or be taken as a signal of another color if the pilot is in a time-deficit situation. Color vision can be impaired in various kinds of nervous disorders or in nervous stress, as frequently occurs during flight under complicated conditions, and also subsequent to diseases of the eyes or central nervous system

Color vision studies can be done using several methods: with the aid of color charts, anomaloscopes and colored lights. The Ye.B. Rabkin polychromatic charts are usually used in medical certification for aircrew personnel. In studies of the status of color vision, when using these charts the function is considered defective when there is incorrect reading of its individual test objects, without taking into account the features of professional activity. Research conducted by A.B. Flekel' has shown that type C anomalous trichromats can correctly distinguish the colored lights used in aviation practice.

The decisive factor in studies of color vision by medical flight certification boards should be the determination of thresholds for distinguishing colors. The (Rautin) anomaloscope is the most suitable for this; it makes it possible to determine acuity in distinguishing color in each of the systems of the color-perception apparatuses of the eyes, namely those for red, green and blue. Using this method it is possible to detect early impairment of color vision.

The use of colored lights does not permit quantitative differentiation in the status of color vision but it does insure maximum approximation to conditions in flying work connected with distinguishing colored signals used in aviation. The colored-light method is used to present to the subject lights with different color characteristics (as in air navigational lights) at great distances (up to 2 to 3 kilometers) under airfield conditions.

The visual work capacity of aircrew personnel in civil aviation is evaluated on the basis of results from testing visual functions at relative rest, that is, on nonflying days. Naturally, under these conditions, the maximum level of visual functions is determined, and in the process of flying activity it can be substantially changed as the result of adverse factors in flight.

Studies of Pilot Visual Functions in an Aircraft Cabin

With respect to the working conditions of the pilot, it is first of all essential to evaluate the status of the visual functions subject to the greatest change in the process of flying activity. These functions include accommodation, stability of clear sight, visual throughput capacity, and close visual acuity. Evaluation of visual perception of instruments and signs by pilots should be done directly in the working area of the aircraft cabin. During the first stage, these studies can be done in up-to-date simulators during the training of aircrew personnel in whom impairment of visual functions was found during the course of medical flight examination boards or during hospital examinations.

Accommodation studies can be done with the aid of a portable ergograph, determination of close and distant points in clear vision separately for each eye, or by moving a special text closer to and further away from the subject's eyes. For this it is necessary to have a special ruler with a movable area on which Landolt's rings or letters from regular charts for studying close visual acuity can be affixed. For young individuals (20 to 30) text 5 or 6 from this chart can be used. For older individuals the text should be selected on an individual basis and should have considerably larger angular dimensions.

Determination of stability in clear sight consists of fixed observation of rings with gaps (the gap being equal to 1/5 of the ring diameter) for two or three minutes at a distance close to threshold for the sight of a nonfatigued eye. In isolated periods the gap in the ring is observed clearly while in others it merges with the ring. "Block" tests consisting of an image of groups of squares can be used for the same purpose. When looking at a given test the subject sees the figures and the background alternately. This corresponds to a clear sight of the gap in the ring. Exposure of the "block" test is the same. Here, account is taken of the time that the squares themselves are seen (one above and two below: position I) and the time that they are not seen, that is, the time that the background is seen (two squares above and one below: position II).

Results from this study are expressed by the relationship between the time of clear sight (position I) to total exposure time (positions I and II). When using the "block" test it is essential to present them against a white background. The subject should gaze fixedly at the center of the squares for three minutes. Using a stopwatch, the time for the shift in the process of perception is recorded for various positions.

Visual throughput capacity is studied with the aid of the Krzywoglawy chart, which is a square arrangement of 49 rings with gaps. Each ring has the gap in one of eight possible directions (above, below, on the right, on the left, upper left, lower left, upper right, lower right). The probability of the ring being in any one of these position is one in eight. The chart is placed at the level of an instrument panel. Illumination on it should correspond to conditions in appropriate cabin illumination. Aircrew personnel being tested determine the position of the gaps in the rings as rapidly as they are able. Each response equals 3 bits ($\log_2 1/8$). The information capacity of the entire chart is 147 bits (3 x 49). As required, the capacity of the chart can be doubled or trebled during testing by turning it one way or the other.

Incorrect identification of a ring means a loss of three bits of information. Taking into account the time spent on the test, throughput capacity equals

$$\frac{147 - (3n)}{T}$$

where n is the number of incorrectly recognized or missed rings, and T is the time that the chart was exposed.

Change in the throughput capacity of the visual analyzer can also be evaluated from the number of errors made before and after stress, that is, before and after flying. The physician must have a second copy of the chart to monitor and record errors. Before the test it is necessary to make four or five dummy runs with each subject.

Studies of Visual Perception of Instruments

As the result of age-related changes in ocular accommodation or other impairments of the visual analyzer, the ability for good perception of visible objects can be lost. In this connection, studies of the quality of visual discrimination of instrument readings under aircraft cabin conditions (or in simulators) should be done on individuals at various ages, wearing, if required, correcting glasses that compensate accommodation impairments or refraction anomalies. Here it is essential to take into account fatigue in aircrew personnel during the process of working under various illumination conditions for the instrument panel. In one case the level of illumination is set by the pilot himself. In the other two cases illumination should correspond to the minimum and maximum levels permitted by the standards (Sector Standard 1.00796-75).

The small symbols from the No 5 or No 6 Sivtsev chart, designed for studies of close visual acuity, are then set on the instrument panel level against one of the instruments. Evaluation of the visual function can also be done from accurate and rapid discrimination of readings of navigatonal instruments at various levels of illumination. Response time is recorded using a stopwatch. Errors made in discerning instrument readings are considered separately.

Chapter 5. Effects of Altitude Factors on the Body and the Physiological-Hygiene Features While in a Rarefied Atmosphere.

Main Altitude Factors Characterizing High-Altitude Flight, and Their Biological Significance.

The properties and condition of ground-level atmosphere largely determine the characteristics of all life-support facilities, primarily altitude and oxygen equipment, and hence, the working conditions for the crew.

The atmosphere consists of several layers, each of which has its own character in terms of changes in and properties of physical-meteorological parameters. The lowest and most dense layer of the Earth's atmosphere is called the troposphere; it extends from the Earth's surface up to various heights in different parts of the world: above the pole up to 7,000-8,000 meters, in the middle latitudes up to 10,000-11,000 meters, and above the equator up to 17,000-18,000 meters.

The troposphere is of great biological importance and a main element in the Earth's entire ecologic system in which the metabolic processes essential for maintaining life take place.

Above the troposphere is the stratosphere. In terms of its physical-meteorological characteristics it is more stable.

The absence of fog and dust in the stratosphere determines the good visibility and more favorable flying conditions. The stratosphere extends up to 50,000-60,000 meters. Air temperature in the stratosphere at altitudes of 11,000 to 32,000 meters is almost constant within the range -56°C to -57°C.

Atmospheric air is a mixture of various gases whose composition at various locations on the Earth's surface and at various altitudes remains virtually unchanged; up to 7,000 meters it also contains moisture.

At sea level, the main gases are found in air in the following proportions: nitrogen 78.08 percent, oxygen 20.95 percent, argon 0.93 percent, carbon dioxide 0.03 percent. In atmospheric air, oxygen is found in three forms, namely molecular, atomic, and in the form of ozone.

Atomic oxygen possesses toxic properties. However, considering that it is found at altitudes greater than 100,000 meters, it presents no danger to the human body.

The availability of molecular oxygen in atmospheric air is of great biological significance since it insures the conditions essential for supporting life. The redox processes in the human body take place thanks to molecular oxygen.

Ozone is found in small amounts in atmospheric air. It is formed mainly by the action of ultraviolet rays from the Sun and cosmic rays, and, in the lower atmosphere, in lightning discharges. Ozone possesses high biological activity and toxic properties and is a powerful oxidant.

While indifferent for the body, nitrogen is of great importance in forming the gaseous medium and atmospheric pressure, but it cannot be considered harmless for the body during changes in barometric pressure.

Carbon dioxide is a metabolic end product. Increasing or decreasing the amount of carbon dioxide in the body can affect the nature of functional acitivity in various systems.

Various kinds of radiation in the atmosphere are of certain biological significance. They include electromagnetic, corpuscular, ultraviolet, X-rays and others.

Barometric pressure falls with altitude, and as it falls partial pressure for oxygen also falls.

At great altitudes the human body is subjected to comprehensive effects from the following adverse factors: lowered partial pressure for oxygen, low barometric pressure, low air temperature, radiant energy, and others. Of these, the most adverse are lowered partial pressure for oxygen and the drop in barometric pressure.

Change in Barometric Pressure and its Effect on the Body

Causes of and Conditions for the Onset of Changes in Barometric Pressure

Changes in barometric pressure in terms both of rate and magnitude are not without consequence for the body. Man feels pressure gradient during climbing to or descending from altitude, and also when an aircraft cabin depressurizes. By a pressure gradient is meant an increase or decrease in barometric pressure; and also the difference between the pressure of the surrounding medium and the pressure in a pressurized aircraft cabin.

Depending on its direction, a gradient is either a decompression gradient or a compression gradient, that is, it is either falling or rising. The main characteristics of a pressure gradient are the rate, the multiplicity factor, the magnitude and the duration.

The rate of a gradient is the change in the magnitude of pressure per unit of time (mmHg per second). Gradient multiplicity factor is defined as the relationship between the pressure in a pressurized cabin (in normal flight) and the barometric pressure of the surrounding medium. Gradient magnitude is defined by the difference in barometric pressure inside the cabin before and after depressurization.

Pressure gradients that occur in less than one second are called explosive decompression. This kind of situation can occur in sudden accidental depressurization of the cabin. In explosive decompression there is a noise like an explosion which is the sound of the air rushing out of the cabin; condensation of air vapors forms fog and dust in the cabin.

The causes of cabin depressurization during flight at great altitudes, and of changes in barometric pressure in the cabin, can be damage to the walls or glazing (windows), engine failure or failure of the air-conditioning system, and inadequate pressurization of individual cabin elements because of malfunction.

Change in the barometric pressure during flight exerts a definite effect on the bodies of the pilot and passengers, and the magnitude of this effect depends on cabin pressurization and the operation of systems regulating pressure. In a drop in barometric pressure, various kinds of dysbarism processes can occur, that is, disorders in the body associated with the change in barometric pressure that depend on a number of conditions, including the time taken for the pressure change, the frequency, and the multiplicity factor of the gradient. Dysbarism processes are usually divided into three main groups:

processes associated with the expansion of gases and the occurrence of excess pressure in the hollow organs and difficulties in equalizing this pressure with ambient pressure; this is the phenomenon of altitude meteorism associated with the expansion of gases in the gastrointestinal tract, blocked ears, earache, pain in the area of the sinus maxillaris and the sinus frontalis, and so forth;

processes associated with the formation of gas bubbles in the tissue from gases previously dissolved in the tissues (altitude joint and muscular pain, altitude cough and other decompression disorders);

processes associated with the formation of vapors ("boiling") in fluid and semifluid mediums, particularly the onset of altitude subcutaneous emphysema.

Effect on the Body of Gas Expansion in the Pneumatic Cavities

Processes associated with the expansion of gases and increased pressure in the pneumatic cavities in the human body are usually considered in the following aspects:

in decreased ambient pressure--a decompression gradient;

in increased ambient pressure--a compression gradient;

in small pressure variations in a pressurized cabin during varying flight conditions.

Climbing to altitude is accompanied by an increase in the volume of gases present in the gastrointestinal tract (altitude meteorism) (see table 5.1)

Table 5.1 Characteristics of the Increase in the Circumference of the Torso at the Level of the Abdomen at Altitudes 2,000-14,000 Meters

	Altitude in meters						
Condition	2000	4000	6000	8000	10,000	12,000	14,000
Perimeter of the torso at the level of the abdomen (umbilicus), cm.	0.6-0.8	1.0-1.8	2.2-3.4	4.0-4.7	5.1-5.8	6.4-7.9	8.2-10.4

As the intestines dilate and abdominal pressure rises, the mobility of the diaphragm is restricted during inhalation and exhalation, the depth of respiration is reduced and the tidal volume of the lungs is decreased. Pressure on the diaphragm changes the position of the heart and as a result circulation is impeded. In addition to the mechanical effect on internal organs and the circulatory and respiratory systems, altitude meteorism exerts a marked reflex influence on other organs and systems. With only a slight increase in the expansion of gases in the intestine, individuals experience unpleasant sensations in the abdominal field. With a significant increase in the volume of gases in the intestines, severe autonomic vascular disorders can develop. The ingestion of food rich in fat or of carbonated beverages promotes the formation of intestinal gas.

Gradual decrease in the pressure of the surrounding medium causes virtually no unpleasant sensations in the middle ear or the frontal and maxillary sinuses. However, in sharp pressure gradients or if there are inflammatory processes present, blocking of the ears and sensations of "popping" and pain can occur as the result of swelling of the mucosa and stenosis of the canals. A drop in pressure in the surrounding medium is usually tolerated better than an increase, since air is removed from a cavity more easily than it is forced in.

If the pressure gradient moves from low to high, in most individuals the unpleasant sensations and popping and pain in the ears are usually experienced when the gradient is moving at the rate of 1.2-1.6 mmHg/second. The pressure difference formed between the cavity of the middle ear and the surrounding medium acts as a definite irritant on the nerve endings. Similar phenomena occur in the frontal and paranasal sinuses when equalization of pressure is impeded in the case of compression gradients.

Rapid (explosive) decompression, which is most often associated with rapid cabin depressurization during flight, occupies a special place in the general scheme of the effect of barometric pressure on the human body. The special feature of its effect is that the drop in pressure in the medium surrounding the body creates a large difference between the pressure in the hollow organs and in the surrounding medium. Excess air pressure (free gas) in the hollow organs (intestines, paranasal sinuses, frontal sinuses, lungs) can cause unpleasant sensations and sometimes even pain. The effect of explosive decompression on the body depends mainly on the magnitude and duration of the gradient, and also on the patency of the respiratory airways, respiratory resistance, the phase of the respiratory cycle, the design of oxygen masks, means of compensation and the method by which oxygen is being fed to the lungs.

During decompression, under the effect of excess pressure occurring at the moment of decompression pulmonary tissue is subjected to expansion and the diaphragm is displaced downward. A stream of nerve impulses passes to the central nervous system from the lungs, diaphragm and other internal organs. In the first instant of the effect there is a reflex deep exhalation followed by breath holding and, after a certain period of time, rhythm disorder. The structure of the respiratory cycle is disrupted especially significantly when the explosive decompression coincides with the inhalation phase. Respiratory muscles are usually stressed and the amplitude of the electromyogram for the respiratory intercostal muscle is increased. This change in the respiratory function is the body's protective response to prevent the danger of overdilation of the the lungs.

Small pressure variations of varying amplitude and duration occurring during various flight conditions also affect the body. In isolated cases variations in pressure can reach 18-20 mmHg at a rate of 7-8 mmHg/sec. These pressure changes can cause unpleasant sensations in the ears, headache, and the phenomenon of general malaise. Their intensity depends on the duration of the effect.

In accordance with standards for air worthiness and the requirements for aircraft cabin pressurization in civil aviation, the rate of pressure change established for the cabin at any stage of flight, including during climbing and descending from altitude, should not exceed 0.18 mmHg/sec ±15%. However, even these magnitudes of variation can cause unpleasant sensations in the ears in some individuals.

Changes in the Body During the Liberation of Gases Dissolved in the Blood and Tissues.

Above altitudes of 7,000-8,000 meters, any further drop in barometric pressure can be accompanied by decompression disorders that include a range of various changes in the body, including altitude pain in the joints and muscles, dermal itch, altitude cough, retrosternal pain and so forth. Decompression disorders are seen in different ways in different individuals. The probability of their occurrence and their duration depend on the degree of atmospheric rarefaction, the rate of climb, the length of time spent at altitude, the degree of body cooling, physical stress and so forth. Decompression disorders are very rarely seen until an altitude of 7,000-8,000 meters has been maintained for 5 minutes. The longer these altitudes are maintained the greater the percentage of cases of decompression disorders.

For example, while maintaining altitudes of 10,500-11,000 meters for 1 hour, decompression disorders are seen in 25-30 percent of individuals (averaged figure). Physical stress increases the onset of disorders to 30-45 percent. Most authors think that the cause of the main forms of decompression disorders is the formation and expulsion of bubbles of nitrogen or some other indifferent gas dissolved in body fluids and tissues. Carbon dioxide is also involved in the formation of gas bubbles. Reduced barometric pressure leads to a situation in which body tissues become saturated and oversaturated. The content of gases in the tissues is greater than the limit they can retain at a given pressure. Under these conditions the so-called process of desaturation of the body from gases takes place. Excess gas contained in the tissues passes into the blood. This process depends on the duration and multiplicity factor of the barometric pressure gradient. In a slow pressure gradient the gases are given off mainly by diffusion. In a rapid pressure gradient gas in dissolved state is given off in the form of bubbles.

In falling barometric pressure the body tissues possess the ability to retain a certain amount of excess gas. This ability of the tissue is characterized by the coefficient of saturation, which is defined as the relationship between the pressure of a gas dissolved in a fluid and the total ambient pressure.

The ability of the tissues to retain gases in a slightly oversaturated state creates conditions for maintenance of stability in the internal physicochemical medium. During a sharp barometric pressure gradient moving downward, when gas saturation in the tissues exceeds the maximum limit, gas bubbles are formed. Intensity of bubble formation depends on the difference in the partial pressure of the gas

dissolved in the tissues and the pressure of alveolar air, and also on the hydrostatic pressure in tissues, the condition of the inner surfaces of the vessels, temperature, and the surface tension of fluid mediums in the body. The bubbles that form exert pressure on the tissue surrounding them and cause pain.

Typically, gas bubbles can be washed out by venous blood and reach the capillaries through migration. When they enter the pulmonary capillaries the gas bubbles can cause a tickling in the throat and and coughing. When they reach the field of the central nervous system they can cause dizziness, vision changes, paresis, convulsions, paralysis, deterioration of the general condition and loss of work ability. Pain can result from reflex spasms in capillaries and vessels (as the result of deformation).

Prolonged pain, in which the dynamic equilibrium of basic nerve processes begins to be disrupted, is frequently accompanied by a secondary reflex response. In these cases, instead of the normal sensations of pain, secondary sensations can occur, with functional disorders in most of the body's systems, acute loss of work ability and collapse (shock).

In some cases decompression disorders are seen in the form of loss of sensation in individual parts of the body or pain along nerve roots. If there are lesions of the higher sections of the central nervous system there can be serious impairment of respiration and the activity of the cardiovascular system, accompanied by manifestations of general asthenia, dizziness, excessive perspiration, nausea, a precollapse condition and sometimes loss of consciousness.

Vapor Formation in the Fluid and Semifluid Media of the Body.

In conditions of lowered barometric pressure, below 47 mmHg (at altitudes above 19,200 meters) with a body temperature of 37°C, the process of vapor formation, so-called "boiling' of biological fluid media, takes place in the most porous tissues of the body as the result of the diffusion of water vapor and dissolved gases (oxygen, nitrogen, carbon dioxide and others). Here, the so-called "altitude" tissue emphysema develops (figure 5.1).

The formation of vapor takes place regardless of the degree of blood oxygen saturation. As altitude increases, the gas bubbles formed initially expand, separating the surrounding soft tissues. Individuals experiencing this first begin to feel pressure and then difficulty in moving the hands and fingers, and pain is sometimes felt at the site of the gas bubble.

After descending from altitude, the reverse process takes place (vapor condensation); the gas bubble first decreases in volume and then completely disappears. Tissue emphysema forms mainly on skin surfaces not protected by compensating devices, and it is also of a localized character limited to some small area; accordingly, for short periods of time (5-10 minutes) it presents no danger to the life of a human being wearing a special compensating outfit.

In order to prevent the formation of vapor on the surface of the body appropriate counterpressure is created, which should be greater than 47 mmHg when added to atmospheric pressure. The use of full-pressure suits or compensating suits and of compensating gloves and hose for the hands and feet substantially reduces the danger of vapor formation in biological fluids in the human body at high altitudes.

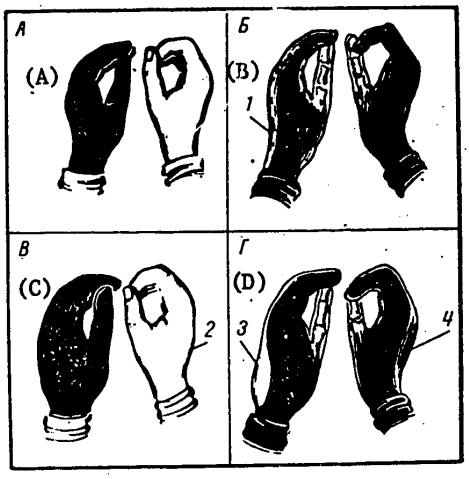

Figure 5.1 Image of Hands in Conditions of Rarefied Air at Barometric Pressure of 8.5 mmHg with the Onset of Altitude Emphysema

Key: A and B. Initial condition at barometric pressure of 760 mmHg
C and D. At barometric pressure of 8.5 mmHg after 10 minutes (the images on the left are outside the hand, the ones on the right are X-ray pictures)

The left hand is protected by a compensating glove.

1. Image of the layers of the compensating glove with air residues
2. Raising of the skin on the back of the hand because of the vapor and gas bubbles formed beneath the skin
3. Image of expanded air in the compensating glove
4. X-ray pictute of the vapor and gas bubble on the back of the hand (altitude tissue emphysema)

The Role of Partial Pressure in Supplying Oxygen to the Tissues at High Altitudes

Features of Breathing Atmospheric Air at Altitude

Under the conditions of rarefied atmosphere, the magnitude of partial pressure for oxygen is of great importance for the human body since the process of oxygen saturation in the body takes place only when oxygen partial pressure in the pulmonary alveoli is greater than in the capillary blood in the alveolar walls, and in other tissues when it is less than that of capillary blood. Magnitudes for partial pressure for oxygen and carbon dioxide in inhaled air and the human blood and tissues in sea-level conditions are shown in table 5.2.

Table 5.2

	Partial pressure mmHg	
Object	Oxygen	Carbon dioxide
Inhaled air	159	0.23
Alveolar air	100-110	40
Arterial blood	75-98	35-43
Venous blood	35-45	41-50
Body tissues	10-20	55-60

Water vapor and carbon dioxide with a partial pressure of 47 mmHg and 40 mmHg respectively are always present in alveolar air. Oxygen partial pressure is determined by using the following formulas:

in alveolar air

$$P_{O_2}\text{alv.} = (P_n - 47)\frac{O_2}{100} - 40 ;$$

in inhaled air (under mask and in the upper airways)

$$P_{O_2}\text{inhal.} = (P_n - 47)\frac{O_2}{100} ;$$

in atmospheric air

$$P_{O_2}\text{atm.} = P_n \cdot \frac{O_2}{100} ;$$

where P_{O_2} is partial pressure for oxygen, mmHg; P_n is atmospheric pressure, mmHg; O_2 is the content of oxygen in inhaled air, volumetric percent; 47 is partial pressure for water vapor in the lungs, mmHg; and 40 is the mean magnitude of partial pressure for carbon dioxide in alveolar air, mmHg.

As altitude increases total pressure of gases falls; but partial pressure for its component parts, such as carbon dioxide and water vapor, remains virtually unchanged in alveolar air. In this case a substantial change occurs in the oxygen pressure gradient in alveolar air. As a result of the drop in total pressure and particularly in partial pressure for oxygen in alveolar air, the process of diffusion is impeded, that is, the passage of oxygen through the alveolar walls into the blood, its bonding with hemoglobin, and its penetration of the tissues. The oxygen deficit in the tissues is caused by the drop in its partial pressure in alveolar air, which causes oxygen starvation (hypoxia). When oxygen is cut off from the tissues in sea-level conditions, human work capability deteriorates already in the first 2-3 minutes because oxygen reserves in the body are used up relatively quickly; after 5-6 minutes the situation is life-threatening.

In most individuals, in climbing to altitudes of 1,200-1,300 meters virtually no changes are observed in the body. The body copes satisfactorily with the oxygen deficit in the inhaled air. Starting at altitudes of 1,200-1,500 meters the level of activity in individual functional systems of the body begins to change. These changes differ in different individuals. One early sign of hypoxia in these conditions is a deterioration of visual perception of instrument readings at night (the ability to distinguish poorly illuminated figures on instruments deteriorates against the dark background and shaded light, and nightime adaptation suffers).

In some individuals, at altitudes of 1,500-2,000 meters initial changes are seen in the activity of the cardiovascular system, external respiration, and higher nervous activity. These changes are frequently insignificant and the pilot's body retains quite satisfactory work capacity. Above 2,000 meters is referred to as the reaction threshold, and the layer of air between 2,000 and 3,000 meters is called "the zone of full compensation," since the human body can cope quite satisfactorily with this kind of oxygen deficit for 3-4 hours. However, in long duration flights (6-8 hours) at altitudes of 2,000-3,000 meters (cabin pressure) the human body begins to show signs of oxygen starvation.

Marked functional changes are seen in the body at altitudes of 3,000-4,000 meters. If these altitudes are maintained for prolonged periods, pulmonary ventilation, heart rate and minute volume increase, arterial pressure is elevated and a number of other functional changes of an adaptive nature are initiated. At the same time the onset of general lassitude, somnolence, dyspnea, sensations of heaviness in the head and sometimes dizziness and other signs is seen, that is, all the signs of "altitude disease." The reserves of the body are depleted.

An altitude of 4,000 meters is known as the "impairment threshold": heart rate and pulmonary ventilation rise steadily, the capacity for correct perception of surrounding objects and incoming information falls off, and the attention and memory wander; as a result of which general work capacity drops, the onset of apathy and fatigue is seen, and sometimes the phenomenon of euphoria, a state of excitement and slight "intoxication" and so forth. In marked oxygen starvation metabolism is impaired and changes occur in the process of oxidation in protein, lipids and other substances that play key roles in the biochemical responses of the body. Fluid loss also occurs; this happens mainly as the result of increased evaporation from the skin and the mucosa of the upper airways.

In most people, in oxygen deficit the motor activity of the digestive organs is altered, food passes slowly through the gastrointestinal tract, and the functions of the salivary and gastric glands are changed. These phenomena can sometimes be accompanied by loss of appetite, changed taste sensations and nausea.

The altitudes between 4,000 and 6,000 meters are usually referred to as the zone of "incomplete compensation": in most healthy individuals the body can still cope for short periods with the oxygen deficiency in the inhaled air even though it does not fully compensate for demand. The marked increase in the activity of the cardiovascular system and respiration during the first stages of hypoxia is caused mainly by the neuroreflex response.

When altitudes of 5,500-6,000 meters are maintained for prolonged periods, the vital organs beging to suffer to a more marked degree from the oxygen deficiency. Marked changes are seen in the central nervous system and the balance of basic neural processes (excitation and inhibition) is upset. The speed of response reactions slows, there is difficulty in motor coordination, logical thinking, attention and memory deteriorate, and differentiated inhibition is affected. Despite the substantial increase in pulmonary ventilation and heart rate, the body is unable to maintain functional systems and the activity of the organs at the required level. Respiration often becomes shallow, the tidal volume decreases, periodicity is seen in the respiratory cycle; the cause in acute oxygen starvation is excessive inhibition of the cerebral cortex and subcortical centers (I.P. Petrov).

Because of the onset of marked disorders in the body, the altitude of 6,000 meters is known as the "critical threshold." As altitude increases blood oxygen saturation and oxygen partial pressure in alveolar air decrease steadily. Mean figures for change in oxygen partial pressure in alveolar air and blood oxygen saturation when breathing atmospheric air in activity simulating that involved in flying an aircraft 10-15 seconds after the oxygen supply has been cut off, as seen in an altitude chamber (altitudes 6,000 to 12,000 meters), are shown in table 5.3, while the oxyhemogram is shown in figure 5.2.

Table 5.3

	Altitude in meters			
Parameter	6000	8000	10,000	12,000
Oxygen partial pressure mmHg in alveolar air	35.7-39.8	30.1-34.2	25.3-26.7	21.6-22.4
Oxygen blood saturation from oxyhemograph %	64-69	54-57	48-50	40-43

At altitudes of 7,000-8,000 meters life-threatening signs are seen and the mental capacities begin to deteriorate relatively quickly (after several minutes). Perception and processing of incoming information is impeded and operator activity deteriorates.

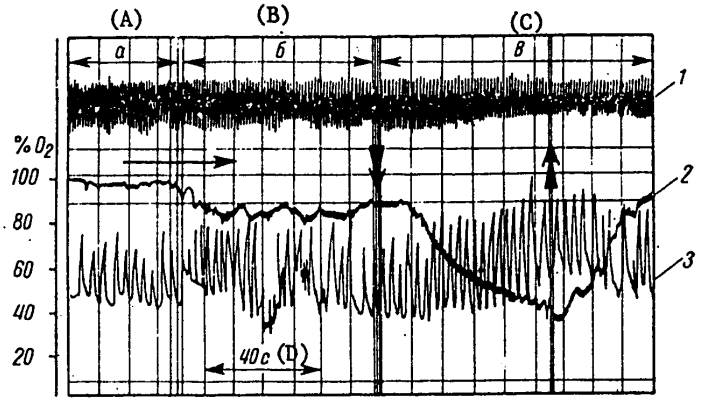

Figure 5.2 Oxyhemogram of Subject I. Recorded at an Altitude of 12,000 meters Following Oxygen Cutoff

Key:

A. Oxyhemogram in ground-level conditions
B. Oxyhemogram at 12,000 meters breathing oxygen
C. Oxyhemogram at 12,000 meters after cutoff of oxygen supply via mask (the arrow pointing downward marks the moment of oxygen cutoff, the arrow pointing upward marks the moment when oxygen was again supplied via the mask)

D. 40 seconds

1. Heart rate trace
2. Oxyhemogram
3. Respiratory movements of the thorax (marked in 10-second intervals)

Numerous erroneous actions and lack of motor coordination occur. On the EEG (figure 5.3) slow high-amplitude waves are seen, while on the EKG (figure 5.4) the waves are altered, indicating significant oxygen starvation.

Taking into account the frequent cases of critical conditions initiated in the body, the layer of air at altitudes above 6,000 meters is arbitrarily designated as the "critical zone," where without additional oxygen supply it is dangerous because of the rapid impairment of work capacity and loss of consciousness. When the so-called "reserve time" has run out when breathing rarefied air, work capacity in man is completely disrupted, autonomic disorders are seen, and the onset of a syncopal conditions follows.

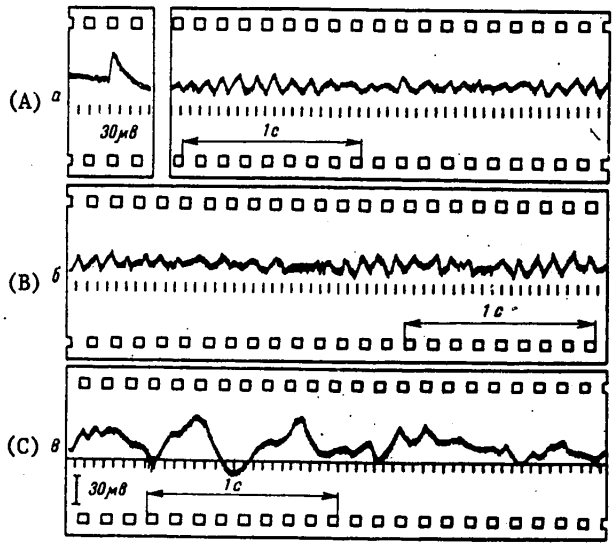

Figure 5.3 Electroencephalogram of Subject L.

Key:

A. In ground-level conditions
B. At altitude of 12,000 meters using "demand oxygen equipment"
C. At altitude of 12,000 meters 1 minute after cutoff of oxygen supply to the mask.

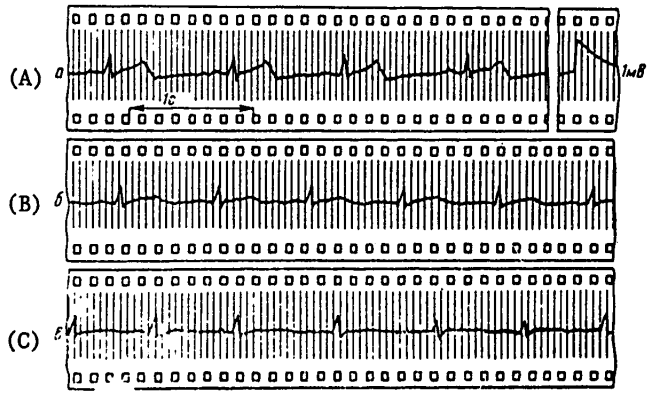

Figure 5.4 Electrocardiogram of Subject P. in Various States of Oxygen Starvation at 11,000-12,000 Meters after Cutoff of Oxygen Supply to Mask

Key: A. EKG in ground-level conditions breathing normal oxygen (lead II)
B. EKG at 11,000 meters 1 minute after cutoff of oxygen supply to mask (marked in 0.05 second intervals, 1cm=1mV)
C. EKG at 12,000 meters 1 minute after cutoff of oxygen supply to mask

Reserve time is the period in which work capacity is retained after the body receives insufficient oxygen, or the time elapsed after cabin depressurization before work capacity is lost. At altitudes above 6,000 meters, according to various figures, the time for possible retention of work capacity varies within considerable limits. This is explained by the fact that the studies were done in dissimilar conditions using different methods.

"Reserve time" as a function of altitude is shown in table 5.4. (averaged figures).

Table 5.4

Altitude, meters	8000	9000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000
Reserve time seconds	120-130	80-90	25-30	20-25	16-20	15-18	10-15	9-12	9-10	8-10

At altitudes of 13,000-18,000 meters the time that the altitude can be maintained is substantially reduced and is associated with rapid reduction of oxygen in the blood and also with the constant presence of water vapor in alveolar air at a partial pressure of 47 mmHg and carbon dioxide at 40 mmHg.

Features of Breathing an Air-and-Oxygen Mixture

At altitudes above 12,000 meters the normal supply of oxygen (without excess pressure) with facilities for the delivery of atmospheric air via a mask is ineffective in the event of cabin depressurization and does not adequately protect the pilot's body from oxygen starvation. For example, at 14,000-15,000 meters, even when pure oxygen is being breathed from "demand oxygen equipment" not at excess pressure the onset of oxygen starvation is rapid and physiological functions are altered substantially. Respiration becomes more rapid, pulmonary ventilation increases and after a relatively short period of time, periodic (forced) deep respiratory movements are seen against the background of fast respiration. When great altitudes are maintained oxygen partial pressure in alveolar air falls. Blood oxygen saturation progressively decreases. In these cases, the quality of operator activity deteriorates sharply.

Average figures on the change in oxygen partial pressure in alveolar air and blood oxygen saturation in different individuals when using demand oxygen equipment while maintaining altitudes of 10,000-14,000 meters for 2-3 minutes while engaging in simulated flying activity are shown in table 5.5.

Table 5.5 Change in Oxygen Partial Pressure in Alveolar Air and Blood Oxygen Saturation at Altitude

Altitude	10,000	11,000	12,000	13,000	14,000
Oxygen partial pressure in alveolar air, mmHg	105-108	78-84	62-66	38-44	30-33
Blood oxygen saturation from oxyhemograph, %	98.4	94-96	80-83	55-64	42-44

With respect to higher nervous activity, at altitudes of 14,000-15,000 meters a predominance of the inhibitory process is noted in the cerebral coretx. This is indicated by the increase in the latent period in response to incoming stimuli, constraints on movements, tension, the degree to which conditioned reflexes are shown with time, and also the appearance of slow, high-amplitude waves on the EEG. In addition, in these conditions, the handwriting deteriorates, task solving becomes difficult and errors are seen in the execution of various kinds of tasks. This is also explained by the development of excess inhibition in the cerebral cortex caused by the lack of oxygen in the body.

During the initial period when maintaining altitudes of 14,000-15,000 meters, when a periodic-type oxygen set is used, the EEG of a subject shows a rhythm of 7-9 waves per second. As oxygen starvation develops and the general condition deteriorates, the normal alpha-rhythm disappears from the EEG and slow, high-amplitude waves are seen, first at 6-5 per second and then at 4-3 per second. Under the same conditions, on the EKG lowered R and T waves are observed, with smaller R-R, QT and TP intervals and an increase in the systolic index. Heart rate increases 30-60 per minute and arterial (systolic) pressure is elevated 40-50 mmHg. Following a pressure gradient at these altitudes, subjects relatively rapidly begin to experience difficulty in determining colors on the instrument panels and when they attempt to carry out tasks associated with physical stress (on the control column and pedals) a deterioration is seen in their general condition and, in turn, a drop in heart rate. The time that altitudes of 13,000-15,000 meters can be maintained with retention of work capacity depends not only on the oxygen supply but also on the observance of eating and rest periods before climbing to altitude.

Averaged figures for reserve time when breathing oxygen without excess pressure are shown in table 5.6.

Table 5.6

Altitude	13,000	13,500	14,000	14,500	15,000	16,000
Reserve time	7-8 min	5-6 min	2-3 min	25-35 secs	15-18 secs	14-16 secs

Analysis of material from research conducted at altitudes of 14,000-16,000 meters using "demand oxygen equipment" which does not exclude the possibility of inhaling air via the mask, has shown that this principle of oxygen supply cannot be used as the basis for a practical supply of oxygen to pilots at these altitudes because of the rapidly developing signs of oxygen starvation.

Features of Breathing Pure Oxygen (Excluding Air Supplied Via a Mask)

When atmospheric air is prevented from entering the mask a relatively satisfactory condition with a certain degree of oxygen starvation is maintained at altitudes of 13,000-14,000 meters for longer than when a mask is used that allows air to be sucked into the airways. While, however, the increase in the time that altitudes of 13,000-14,000 meters can be maintained is more or less significant, at altitudes of 14,500-15,000 meters it is insignificant. Under these conditions, despite some improvement in the oxygen supply, human work capacity remains at a low level and can be maintained only for short periods.*

*Air being sucked in under the mask was eliminated by creating a small oxygen overpressure in the mask (35-50 millimeters of water).

At altitudes of 14,500-15,000 meters, even when air is prevented from entering the mask, physiological reactions in subjects start to change relatively quickly. Heart rate and respiration increase considerably, along with pulmonary ventilation. Heart rate in some individuals reaches 140-150 per minute and respiration 30-32. On the EKG the R and T waves are suppressed, the R-R, QT and TP intervals are shortened and the systolic index rises. (see figure 5.5.). After a short time subjects begin to make errors when solving arithmetic problems. Their handwriting deteriorates (see figure 5.6). Blood oxygen saturation drops to 55-50 percent. Systolic pressure is elevated 5-65 mmHg, and diastolic 5-50 mmHg. As the altitude is maintained, inhibitory processes are initiated. Conditioned reflexes increase with time.

With closed eyes, in cerebral bioelectrical activity (during the initial period at these altitudes) the rhythm decreases to 9-8 and then to 7-5 waves per second, with a slight drop in amplitude. As the degree of oxygen starvation increases and the general condition deteriorates, the normal alhpa-rhythm disappears from the EEG and high-amplitude slow waves appear at 3-2 per second. At this time cardiac activity begins to weaken, motor coordination is impaired and the skin becomes pallid, with subsequent transition to a precollapse and collapse condition. Oxygen partial pressure in alveolar air and blood oxygen saturation decrease progressively as altitude increases.

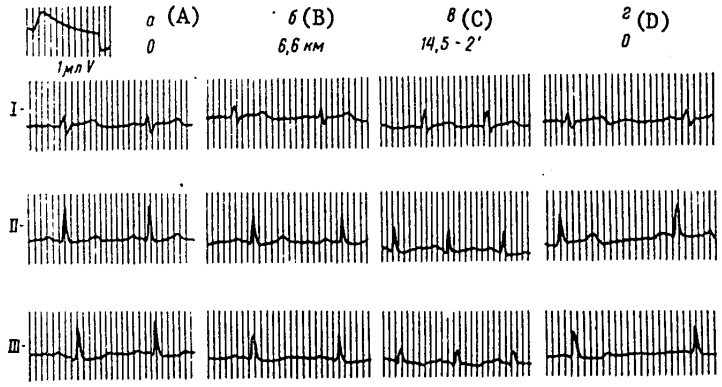

Figure 5.5 Electrocardiogram of Subject M at an Altitude of 14,500 meters Using an Oxygen Mask that Excludes Inhalationof Air: leads I, II and III

Key.
A. Baseline trace
B. At an altitude of 6,600 meters before pressure gradient
C. At an altitude of 14,500 meters after 2 minutes
D. After losing altitude

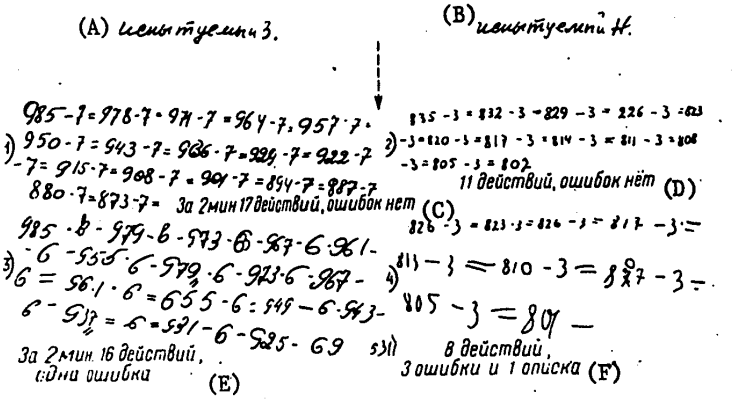

Figure 5.6 Samples of Handwriting and Solving of Arithmetic Problems by Subjects Z. and N. at an Altitude of 14,000-14,500 Meters (Inhalation of Air under Mask Excluded)

Key:

1 and 2. In ground-level conditions before the experiment
3. At an altitude of 14,000 meters
4. At an altitude of 14,500 meters

A. Subject Z.
B. Subject N.
C. After 2 minutes: 17 actions, no errors
D. 11 actions, no errors
E. After 2 minutes: 16 actions, 1 error
F. 8 actions, 3 errors, 1 slip of the pen

Average figures on the change in oxygen partial pressure in alveolar air and blood oxygen saturation in different individuals after 2-3 minutes at 10,000-14,000 meters as the aircraft pilot (with intake of air under the mask excluded) are shown in table 5.7.

From analysis of the material presented it follows that the onset of marked tachycarida (heart rate of 140-150 per minute or more) with depressed R and T waves on the EKG and simultaneous appearance of slow, high-amplitude waves on the EEG (5-3 per second) are the signs of an incipient presyncopal condition. Marked bradycardia following marked tachycardia, and a drop in arterial pressure with marked changes on the EEG indicate considerable weakening of cardiac activity and the onset of a precollapse condition resulting from marked oxygen starvation.

Table 5.7 Oxygen Partial Pressure in Alveolar Air and Blood Oxygen Saturation at Altitudes of 10,000-14,000 Meters

	Altitude				
Physiological Sign	10,000	11,000	12,000	13,000	14,000
Oxygen partial pressure in alveolar air, mmHg	107-110	82-88	68-73	46-54	34-37
Blood oxygen saturation from oxyhemogram, %	98.8-99.8	96-98	83-86	62-68	46-50

For comparison, the times that altitudes of 13,000-15,000 meters can be maintained in conditions when the intake of air under the mask is excluded are shown in table 5.8 (averaged figures)

Table 5.8 Time Spent by Subjects at Altitudes of 13,000-15,000 Meters When Intake of Air under Mask Is Excluded

Altitude, meters	Time Maintained
13,000	95 minutes
13,500	30-40 minutes
14,000	10-20 minutes
14,500	2-3 minutes
15,000	20-30 seconds

In order to improve the oxygen supply, at altitudes above 12,000 meters oxygen sets are used that deliver the oxygen for breathing under excess pressure.

Features of Breathing Hyperbaric Oxygen

Comprehensive studies conducted by large collectives jointly with industrial enterprises have made it possible to some extent to clarify the problem of providing oxygen at hyperbaric pressure at altitudes of 12,000-15,000 meters, establish a number of the laws involved in the change in basic physiological functions, work out the permissible magnitudes for delivering the oxygen, and develop special sets of oxygen equipment for flights in the stratosphere.

The use of excess pressure for breathing which automatically increases to maintain an absolute pressure of 112-115 mmHg (by absolute pressure, in this case we mean excess pressure under the mask plus atmospheric pressure at a given altitude) has made it possible considerably to increase the time that altitudes up to 15,000 meters can be maintained, even given the marked functional changes in respiration and circulation. At altitudes above 13,500 meters the excess oxygen pressure under the mask added to the barometric pressure and regulated automatically, remains

virtually constant. For example, if the pilot is at 15,000 meters, where atmospheric pressure is 90 mmHg, excess pressure under the mask will be maintained at 25 mmHg, which makes a total of 115 mmHg, with small variations on either side. When descending to 13,000 meters and then to 12,000 meters, absolute pressure increases to 145 mmHg first by reducing and then by removing the excess pressure under the mask.

Despite the relatively large magnitudes for oxygen excess pressure under the mask, partial pressure in the alveoli and blood saturation are reduced as altitude increases, although the drop in blood oxygen saturation is less than without excess pressure. The nature of these changes (averaged figures) is shown in table 5.9.

Table 5.9 Dependence of Oxygen Partial Pressure in Alveolar Air and Blood Oxygen Saturation on the Magnitude of Excess Pressure at Altitudes of 12,000 to 15,000 Meters

	Altitude, meters			
Factor	12,000	13,000	14,000	15,000
Magnitutde of excess pressure, mmHg	30-50	95-115	185-208	320-350
Oxygen partial pressure in alveolar air, mmHg	66-74	52-60	44-50	36-45
Blood oxygen saturation from oxyhemograph, %	87-90	78-83	73-77	64-68

When excess pressure of 300-400 mm water or more is created, unusual conditions are set up for respiration: resistance is created in the trachea, bronchi and lungs to the movement of the inhaled oxygen, and because of this a corresponding pressure is created on their walls. The oxygen pressure acts as a kind of irritant on the pulmonary receptor apparatus.

When acted upon by excess pressure, all parts of the pulmonary tissue are expanded, the degree to which they are filled is increased, respiration becomes slower and deeper, and the relationships between respiratory capacities in the respiratory phases are altered. The structural characteristics of the respiratory cycles are also altered, the exhalation phase is extended, particularly during the initial period, the inhalation phase is shortened, and the total respiratory cycle is more prolonged. The most clearly marked changes are observed directly after cabin depressurization at great altitudes.

When breathing oxygen under excess pressure the mobility of the diaphragm is restricted and the intercostal and abdominal muscles used in exhalation are stretched more than those used in inhalation. The excess pressure exerts a considerable effect in the intensity of the muscle bioelectric potentials. This dependence is of a directly proportional nature (see figures 5.7, 5.8 and 5.9).

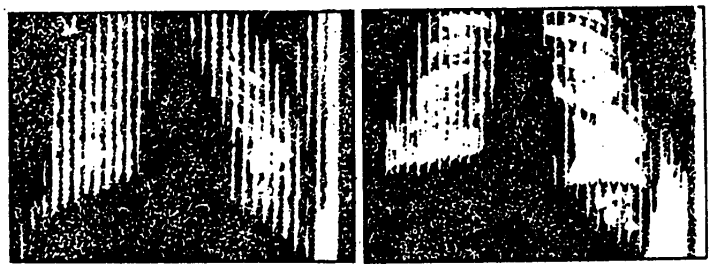

Figure 5.7 Roentgenkymogram of Respiratory Movements of the Diaphragm in Subject C. When Breathing Oxygen under Excess Pressure.

left: baseline recording
right: with pressure of 500 mm water under the mask (mobility of diaphragm is restricted)

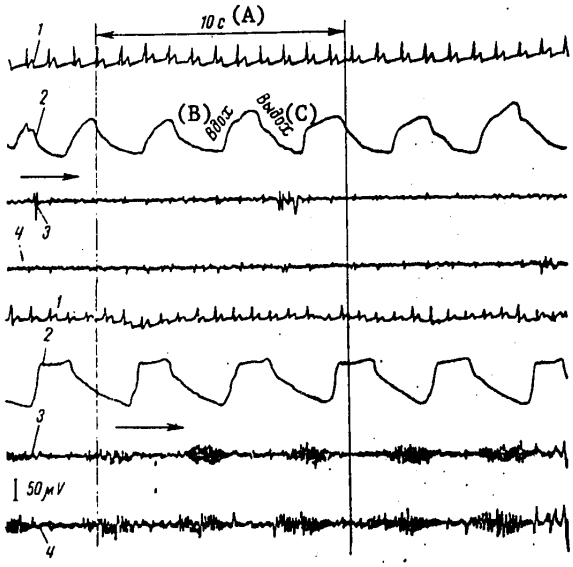

Figure 5.8 Electromyogram of Subject B.

Above: baseline recording
Below: breathing oxygen under excess pressure of 500-600 mm water

Key:
1. EKG
2. Respiratory movements of chest
3. Electromyogram of intercostal muscles
4. Electromyogram of oblique muscles of abdomen (left to right: inhalation, above; exhalation, below)

A. 10 seconds B. Inhalation C. Exhalation.

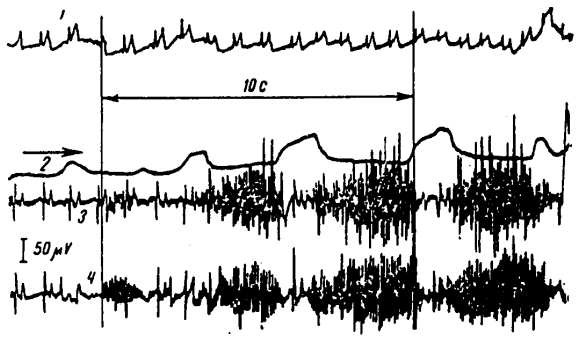

Figure 5.9 Oscillogram of Physiological Functions of Subject K. with Excess Pressure in the Lungs from Zero to 1,200 mm water

(left: start of delivery of excess pressure)

Key:
1. EKG
2. Respiratory movements of chest
3. Electromyogram of intercostal muscles
4. Electromyogram of oblique muscles of abdomen (inhalation above, exhalation below)

Speech difficulties are characteristic of breathing under excess pressure. Words can be articulated only after taking a deep breath and with great effort on the part of the entire respiratory and articulatory apparatuses. The hemodynamics of pulmonary circulation also change, resistance to blood flow in the pulmonary circulation increases, and the return of venous blood to the heart and into systemic circulation is impeded. The flow of tissue fluids and the blood is slowed.

The marked shrinking of the shadow of the heart and vascular bed under excess pressure of 400 mm water can be seen on the X-ray image (figure 5.10) Associated figures are shown in table 5.10

Table 5.10 Changes in Heart Size and Vascular Bed during Respiration under 400 mm water Excess Pressure (average figures)

Phase of respiration	Percentage decrease in basic size of heart		Percentage decrease in size of vascular bed		Remarks
	length	breadth	size at level of aortic arch	size at level of arch of pulmonary artery	Decrease in size of heart and vascular bed is shown as percentage of initial condition
Inhalation	12.0	5.1	7.2	8.1	
Exhalation	13.4	6.4	10.2	9.7	

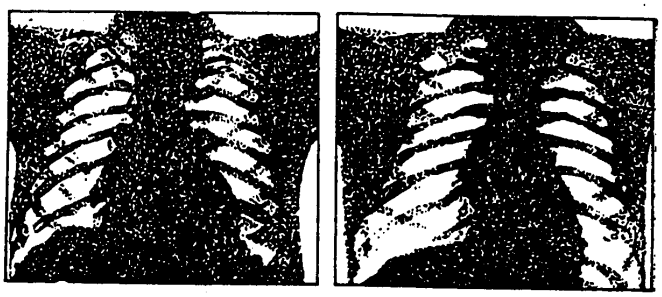

Figure 5.10 Shadow of Heart and Vascular Bed in Subject L. Breathing Oxygen under Excess Pressure

Left: Baseline recording, no excess pressure
Right: In excess pressure of 400 mm water under mask (shadow of heart and vascular bed is smaller. Pictures taken at full inhalation)

The attempt by the developers of equipment to supply oxygen in respiration under excess pressure using a pressure of 115 mmHg encountered great difficulties at altitudes of 16,000-18,000 meters. The time that man can spend at each successive altitude decreases significantly. Whereas at 16,000 meters the limit averages 6-8 minutes, at 17,000 meters it is reduced sharply to 50-60 seconds, and at 18,000 meters to 30-40 seconds, with marked functional changes in peripheral circulation and external respiration.

At altitudes of 16,000-18,000 meters, when oxygen is breathed at excess pressure some individuals become distended, with hyperemia, the palpebral fissure is narrowed, the eyes water, perception of instrument readings deteriorates and heart rate and respiration rate increase considerably. In some individuals the heart rate increases 60-80 per minute above normal rate. Blood pressure is elevated and there is considerable speech difficulty.

In the conditions encountered at 16,000-18,000 meters the general condition in man and the time that these altitudes can be maintained are influenced not only by the oxygen deficit in the body but also, and chiefly, by the changes associated with excess pressure in the lungs, and in particular by circulatory disorders. One of the causes of the deteriorating general condition is the development of functional insufficiency in the cardiovascular system. The marked increase in excess pressure in the airways and lungs creates even greater difficulties in pulmonary circulation. Afferent impulses arrive in the brain from the receptors in the upper airways and lungs. Respiration and circulation are adjusted autonomically and the blood pressure in the vessels of systemic circulation is elevated. When the load on the heart is increased, especially on the right atrium and right ventricle, conditions are created for the development of congestion in the peripheral vessels. This all adversely affects the general condition of the body. In such cases the reason for lowered work capacity is evidently not only hypoxia but also autonomic changes in cerebral circulation.

Along with hypoxia, hypocapnia also plays a definite role in the deterioration of the pilot's condition. Free carbon dioxide is "flushed out" of the blood in the excessively rapid and deep respiration, that is, in increased pulmonary ventilation. Hypocapnia reinforces the adverse effect of oxygen starvation, reducing work capacity even further.

Since respiration under excess pressure substantially alters the activity of the most important functional systems in the body, mainly the respiratory and circulatory systems, in excess pressure of more than 400 mm water, external counterpressure must be used. For example, at a magnitude of 530-550 mm water, without counterpressure, after 1-2 minutes marked shifts are seen in autonomic responses, with considerable deterioration of the general condition (collapse, loss of consciousness). This happens because of circulatory disorders, cardiac arrhythmias, extrasystole, a restricted flow of venous blood to the heart, disruption of the structure of the respiratory cycle and other symptoms typical of the stage of decompensation.

However, a healthy individual who has been trained to breathe oxygen under pressure, regardless of the difficulties encountered in emergencies, can withstand sudden excess pressure under the mask up to 800 mm water for short periods (up to 30 seconds) without using compensation devices, and up to 1,000 mm water in the mask when wearing a vent suit, without pressure in the tension devices.

Features of Breathing Hyperbaric Oxygen with the Use of Compensating (Counterpressure)

The use of compensation devices when breathing under excess pressure makes it possible to extend the range of altitudes between 16,000 and 18,000 meters that can be maintained safely and to weaken or prevent the rapid development of functional changes in the body. For this purpose use is made of special equipment in the form of a compensating jacket or vent suit that creates counterpressure on the surface of the human body. In this case, also, however, despite the large excess pressure in the lungs and the counterpressure on the thorax, oxygen partial pressure in alveolar air and blood oxygen saturation still decrease as altitude increases (see table 5.11).

Table 5.11 Change in Oxygen Partial Pressure in Alveolar Air and Blood Oxygen Saturation at Altitudes 16,000-18,000 Meters when Breathing under Excess Pressure

Indicator	Altitude 16,000	17,000	18,000
Excess pressure in mask, mm water	440-490	610-660	740-800
Pressure in chamber of vent suit mm water	440-490	610-660	740-800
Oxygen partial pressure in alveolar air, mmHg	36-40	35-38	33-36
Blood oxygen saturation, from oxyhemograph, %	70-74	68-70	62-66

Despite the creation of more favorable conditions for respiration, the use of a compensating jacket does little to limit the development of functional changes in respiration and circulation. At an altitude of 16,000 meters, and even more so at 18,000 meters, subjects are in an extremely stressed condition. Heart rate and respiration are slower than without the compensating jacket but are nevertheless substantially increased. For example, at an altitude of 16,000 meters heart rate increases 44 percent from its initial status; at 17,000 meters it increases 56.5 percent, and at 18,000 meters, 66 percent. In some subjects, at altitudes of 17,000 to 18,000 meters heart rate reaches 175 per minute.

The use of a compensating jacket with a rubber chamber coupled to the breathing system does not provide adequately effective compensation for excess pressure in the lungs at magnitudes greater than 40 mmHg, and it cannot prevent the onset of disorders in peripheral circulation that disrupt the supply of blood to vital organs. The counterpressure created with the compensating jacket is applied only to some parts of the body while the head, neck, and upper and lower extremities remain unprotected. In these areas of the body, at altitudes of 16,000-18,000 meters the return of venous blood to the right heart is hampered and reduced, and pulse pressure drops. The elevated arterial pressure and increased heart rate are obviously associated with these changes.

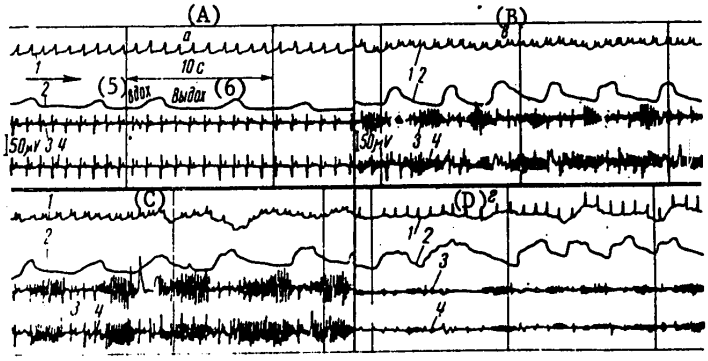

Figure 5.11 Oscillogram of Subject L. Breathing Oxygen under 1,200 mm water Excess Pressure Using Various Forms of Compensation

Key:

A. Baseline recording
B. Breathing oxygen under excess pressure without compensation
C. In a compensating jacket
D. In a vent suit

1. EKG
2. Respiratory movements of thorax
3. Electromyogram of intercostal muscles
4. Electromyogram of oblique muscles of abdomen (left to right: inhalation, above; exhalation, below)

5. Inhalation
6. Exhalation

Improvement in conditions for the supply of oxygen at altitudes of 16,000-18,000 meters can be provided either by increasing the efficiency of the compensating jacket and developing "self-breathing" devices that actively assist respiration, or--and this is more reliable--by using compensating garments that cover the entire body, including the upper and lower extremities.

The use of a vent suit in combination with an oxygen mask and the creation of excess pressure up to 75 mmHg improves the efficiency of the oxygen equipment. At altitudes of 17,000-18,000 meters further increase in excess pressure above 75 mmHg causes intense lacrimation and narrowing of the palpebral fissure, resulting in difficulties in the perception of instrument readings. The increased pressure also adversely affects the sense of hearing.

A pressure helmet provides the best conditions for breathing under elevated pressure. When a vent suit is used in combination with a pressure helmet it is possible to create more excess pressure in the lungs. Absolute pressure at altitudes above 12,000 meters can be brought up to 145 mmHg, thus significantly increasing the altitude that can been maintained safely, even during cabin depressurization.

Given the same magnitudes for excess pressure in the lungs, when vent suits are used respiratory movements are made more easily than when compensating jackets are used; this can be seen from the bioelectric potentials for the respiratory muscles on the electromyogram (figure 5.11).

Despite the relatively satisfactory conditions created by oxygen sets and altitude special garments (in the form of compensating jackets and suits, masks and pressure helmets), in cases of accidental cabin depressurization, the most favorable conditions for supplying oxygen to the body at altitudes above 15,000-16,000 meters are created inside a full-pressure suit within which elevated pressure (compared to that of the surrounding medium) essential for normal respiration in man is maintained. However, because of their cumbersomeness and certain inconveniences in operation, full-pressure suits are not used extensively in aviation.

9642
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REGULATING MECHANISMS OF MEMORY

Leningrad REGULIRUYUSHCHIYE MEKHANIZMY PAMYATI in Russian 1980 (signed to press 13 Feb 80) pp 5-6, 95-96

[Foreword and table of contents from book "The Regulating Mechanisms of Memory" (Proceedings of the International Symposium "Mechanisms of Memory Control" in Leningrad, 1976) edited by G.A. Vartanyan, Izdatel'stvo "Nauka", 2050 copies, 101 pages]

[Text] This publication is based on several papers and materials discussed at the international symposium "Mechanisms of Memory Control" held in Leningrad in November 1976. In view of the great number of studies presented at the Symposium, the organizing committee was not able to publish all of the material. In connection with this and taking into account the great scientific importance of questions raised during the Symposium, the organizing committee requested that those speakers and discussants whose material was not available for the proceedings of the Symposium expand and revise their work for publication in the form of a separate book, which a majority of authors agreed to do.

According to the basic directions of research on this problem, the book is divided into three sections: I. Memory Mechanisms and Possibilities for Their Regulation; II. Neurophysiological Studies of Memory Control Mechanisms; III. Neuropharmaceutical Methods of Memory Control.

Since these general tendencies have not been definitively solidified, the reader will find various principles and approaches to the problem of memory control: how it is studied from different points of view and how it is perceived by representatives of various disciplines from various "schools". But this, at first glance diverse, material is unified by a persistent search for ways of actively influencing memory function in the interest of mankind. In all three above-mentioned areas there is an accumulation of interesting data which apparently will soon require new explanations.

In the area of memory mechanisms the interest is again on the structural-chemical hypotheses of memory. Data has been obtained on the transfer of constant functional and pathological states of the brain from animal donors to intact recipients by neuro-humoral factors of a peptide nature obtained from the brain and cerebral-spinal liquid. These experiments question the real nature of the participation of specific neuropeptides-connectors in the formation of new adaptive connections in the central nervous system (CNS). At the same time it has been shown that a series of recently

discovered neuropeptides, fragments of hypophyseal hormones in the brain, has a general alleviating effect on memory.

Electrophysiological studies of the brain are continuing successfully and confirm the actual role of interstructural synchronization of electrical processes in the optimization of learning and memory. Studies of the pre- and post-synaptic mechanisms with the goal of increasing the effectiveness of synaptic transmissions for brain and memory flexibility have been further developed.

In the field of neurophysiological approaches to the study of the control mechanisms of the mind, it has been shown that electrostimulation of a series of non-specific brain structures plays an important role in transforming certain defense mechanisms of the higher brain functions, including memory. Studies on the mechanisms of intra- and trans-cranial micropolarizations, which aid memory processes and optimize a series of other CNS functions, are also continuing successfully. With respect to the regulation of brain function and memory processes, the recently discovered brain phenomenon of formulating artificial stable functional connections, whose activation can elicit super-activation of higher brain functions and thus overcome certain permanent pathological brain conditions, has been especially promising. In relation to this, the indicator of brain states—a constant extra-slow potential or a quasi-constant potential difference--is exceptionally informative.

In the field of neuropharmaceutical approaches to memory control, studies to determine the role of various mediatory systems in the formation and fixation of temporal relationships and long-term memory are developing. On this basis are also being developed the principles of active involvement in the process of memorization and information retrieval in the brain. The recently formulated problem of pharmaceutical non-specific connections, which as experimental data show, ensure the immediate fixation of active effective neurodynamic connections, is being intensively studied.

Interesting experimental data have appeared on the role of chromosome restructuring in the growth of several CNS functions. The reciprocal translocation of certain antosomes leads to pathological shifts of CNS activity. However, in the presence of other Robertsonian chromosome translocations, there is an optimization of several CNS functions. These studies open up new, cytogenic, approaches to the study of brain function and in part, memory.

Real physiological principles and mechanisms of the organization of memory have been successfully used in mathematical and machine modelling of learning processes in neuron nets, which can give additional evidence on the paths of active involvement in the organization and course of memory processes.

It is impossible to even mention all of the "new developments" in the problem of memory control. However, the directions of research mentioned above indicate that it is possible to hope that the time is near when the study of the brain will enable us to productively optimize the memory processes in the event of their destruction or for immediate activation in unusual circumstances or under experimental conditions.

Books devoted to the problem of memory, the most controversial and perhaps the most important problem of contemporary neurobiology and medicine, have always aroused a great interest among readers. The collective of authors and editors here hopes that this publication will be of use to specialists in the field of memory problems as

well as to a wide circle of interested readers.

Table of Contents

Section III: Neuropharmaceutical Methods of Memory Control

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OBJECTIVE METHOD FOR EVALUATING VESTIBULAR STABILITY FROM TREND OF NYSTAGMIC INDICES AFTER EXPOSURE TO CUMULATIVE CORIOLIS ACCELERATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA BIOLOGICHESKAYA in Russian No 2, Mar-Apr 81 (manuscript received 15 Feb 80) pp 276-283

[Article by I.A. Sidel'nikov]

[Text] Studies in which 172 electronystagmograms (ENG) were recorded were conducted on 30 volunteers. These investigations showed that the cumulative action of Coriolis acceleration either stimulated nystagmus or suppressed it (although there were no significant changes in nystagmic indices in some cases). The present article proposes an objective new method for individual evaluation of the functional status of the vestibular analyzer during stationary vestibulometry, based on comparative evaluation of the trend of the changes observed in nystagmic indices after continuous cumulative exposure to Coriolis acceleration [CCCA].

Subjects in which the rate of the slow nystagmic phase (RSP) after exposure to CCCA exceeds its normal value prior to exposure are considered to be vestibular-stable, while those in which the nystagmic RSP undergoes a significant reduction (or remains unchanged) after CCCA are regarded as vestibular-unstable.

The effect of Coriolis forces on the semicircular canals is due (Voyachek, 1908) to the production of a resultant between the Coriolis forces acting on opposite ends of the canal.

Stimulation of the otolithic apparatus is also undoubtedly of etiological significance in the development of autonomic disturbances under the action of Coriolis acceleration (Markaryan and Sidel'nikov, 1967). Bergstedt (1961) believes that Coriolis acceleration is registered only by the otolithic apparatus and that, if the subject moves his head, e.g., in the frontal plane, the acceleration due to gravity is doubled. However, in Guedry's opinion (Guedry et al., 1961), the Coriolis acceleration that develops when the head is moved is insignificant in comparison with the acceleration due to gravity. The reaction of the otoliths to movement of the head is therefore almost identical to the normal reaction, i.e., that observed with the chair not rotating, while the semicircular canals exhibit an intensified reaction. It is hypothesized that this unusual type of stimulation of the semicircular

canals causes a reflex interaction of the two vestibular systems, which is reflected in the corresponding reactions and is responsible for the difference in the stimuli associated with tilting and straightening of the head.

Thus, it is obvious from the studies cited above and other reports by a number of authors (Khilov, 1936, 1969; Popov, 1939; Yuganov, 1963, 1965; Yuganov et al., 1963, 1964; Bryanov, 1963; Lebedinskiy et al., 1963; Kurashvili, 1967; Sidel'nikov, 1970; Schubert, 1954; Bornschein et al., 1954, 1962, 1963; Dowd et al., 1966; Sinka, 1968; Collins, 1968, and others) that Coriolis acceleration represents a complex and unusual external stimulus to the semicircular canals and otolithic apparatus.

In view of these circumstances, we felt it expedient to utilize a test involving simulation of Coriolis acceleration, particularly continuous cumulative Coriolis acceleration (CCCA), by the Markaryan-Sidel'nikov method (Markaryan et al., 1966) as a functional load on the vestibular analyzer. What we had in mind was the fact that nystagmus is an integral reaction of this analyzer, so that the stimulation of the cupular system and otolithic apparatus during such tests should affect the degree of nystagmus. In this case, data on the nystagmic reaction recorded before and after exposure to CCCA could be used to evaluate the sensitivity and stability of the vestibular analyzer or make an objective judgement regarding tolerance to the action of Coriolis acceleration. The present investigation was conducted to determine whether this approach is feasible.

EXPERIMENTAL METHOD

Studies in which 172 electronystagmograms (ENG) were recorded were conducted with 30 volunteers 20-40 years of age. A special electronystagmographic technique (Sidel'nikov, 1970, 1978) was used to record nystagmus. Electronystagmography was carried out during two rotation tests (ω = 60 deg/sec in test I and ω = 180 deg/sec in test II) prior to exposure to CCCA and two rotation tests (ω = 180 deg/sec in test III and ω = 60 deg/sec in test IV) immediately after exposure to CCCA. The acceleration (1 deg/sec^2), angular velocities (ω = 60 and 180 deg/sec), and chair stopping time (stop stimulus = 0.15 sec) were always constant. Stopping of the chair and recording of the postrotation nystagmus were conducted after the rotation nystagmus disappeared, i.e., generally after rotation at a constant angular velocity for 40-120 sec. In making each record of postrotation nystagmus, we employed a method for biological enhancement of the information content of the nystagmic indices (Sidel'nikov, 1970a and c, 1974). The intervals between the rotation tests were 5 min.

Continuous cumulative Coriolis acceleration (CCCA) was carried out during the third rotation test, i.e., with a constant rotation speed of 180 deg/sec. During rotation, the subject made steady pendulum-like movements of the head through angles of 30° to the left and right of the vertical position. The duration of the right-left and left-right head movements was 2 sec. Continuous rotation and tilting of the head toward the shoulders was continued until nausea and pallor appeared, but for no more than 15 min. Subjects who displayed pronounced symptoms of air sickness (seven in number) were retested 1 or 2 days later but with a CCCA that was reduced by a factor of 2. We also conducted control studies (six) in which the subject rested for a time equivalent to the duration of the CCCA test. The indices obtained for the postrotation nystagmus recorded after exposure to Coriolis acceleration were compared with the nystagmic reaction recorded immediately before the CCCA test. The

ENG data were employed to determine the duration and rate of the slow phase (RSP) and the amplitude and frequency of nystagmus. The latter three indices were evaluated every 5 sec over the first 30 sec of nystagmus. We also determined the average indices for the first (1-15 sec) and second (16-30 sec) 15-sec periods of the nystagmic reaction. The indices in question were measured with the aid of specially developed nystagmometric gages and reference tables, i.e., Sidel'nikov nystagmometers (Sidel'nikov, 1970b, 1975). In order that the nystagmographic indices could be compared with the sensitivity and stability of the cupular system and otolithic apparatus, we determined the threshold of sensitivity to linear acceleration, the resistance to cumulative linear acceleration in Khilov-swing tests, the threshold of sensitivity to electric current for the vestibular analyzer, the threshold of nystagmic sensitivity to angular acceleration, the duration of nystagmus in the Barany test, and the resistance to CCCA for each subject.

The experimental data were subjected to statistical processing, establishing the mean (M), mean error (m), and reliability of the changes in the indices investigated, with the error probability (P) serving as the reliability criterion (Kamenskiy, 1964).

EXPERIMENTAL RESULTS

Proceeding from the results of 30 studies utilizing the maximum CCCA time, the 30 subjects were divided into two groups. The first group consisted of subjects (15 individuals) who withstood maximum exposure to Coriolis acceleration without manifesting vestibuloautonomic reactions. When determined by other methods, the vestibular stability of this group was rated as high and its vestibular sensitivity as low. The second group comprised subjects (15 individuals) who displayed the symptom complex of motion sickness during CCCA; when determined by other methods, their vestibular stability was rated as low. The subjects in the second group participated in experiments in which the duration of the maximum exposure to continuous cumulative Coriolis acceleration was reduced by a factor of 2. Table 1 gives the indices of vestibular sensitivity and stability for the two groups of subjects, together with the average durations of nystagmus in response to the stop stimulus for rotation speeds of 60 and 180 deg/sec before and after exposure to Coriolis acceleration.

As can be seen from Table 1, the changes in the duration of nystagmus following CCCA were slight, took different directions, and were independent of the degree of vestibular stability, i.e., exhibited no regular pattern, while the indices of the functional status of the vestibular analyzer (Table 1) showed a clear division of the subjects into vestibular-stable and vestibular-unstable with respect to the action of adequate stimuli.

The results obtained for other nystagmic indices (RSP, amplitude, and frequency) were somewhat different. The clearest and most reliable changes were observed in such indices as the rate of the nystagmic slow phase. Table 2 gives data on the changes in nystagmic indices during the first 5 sec and over the first (1-15 sec) and second (16-30 sec) 15-sec periods of the reaction.

The data in Table 2 indicate that the RSP decreased in all the subjects toward the end of the nystagmic reaction. This parameter was highest during the first 5 and 15 sec of nystagmus. The nystagmus rate was greatest for the higher angular rotation speed. Thus, the RSP found for the stop-stimulus period after rotation at

180 deg/sec was twice that obtained for the stop-stimulus period following rotation at a speed of 60 deg/sec.

After continuous exposure to Coriolis acceleration, both groups of subjects exhibited characteristic and reliable changes, especially in the RSP during the stop-stimulus period following rotation at a speed of 180 deg/sec and during the first 15 sec of the nystagmic reaction.

Thus, after maximum exposure to CCCA, the first group of subjects was characterized by a significant increase in the RSP during the stop stimulus following rotation at a speed of 180 deg/sec and no changes after the stop stimulus following rotation at 60 deg/sec.

A significant decrease in the RSP during the stop stimulus following rotation at a speed of 180 deg/sec and CCCA and a reliable decrease in this index during the stop stimulus following rotation at a speed of 60 deg/sec were typical of the second group of subjects. When the duration of the CCCA was reduced by a factor of 2, the maximum change in the RSP for the second group of subjects was similar to that for the first group, i.e., the RSP increased after CCCA. Figures 1, 2, and 3 illustrate these variation patterns for the RSP.

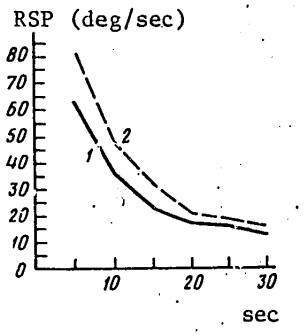

Fig. 1. Graph representing change in nystagmic RSP during stop stimulus following rotation at speed of 180 deg/sec for first group of subjects, who withstood cumulative Coriolis acceleration without vestibuloautonomic disturbances. 1) RSP before CCCA; 2) RSP after CCCA.

Analysis of all our experimental data showed that the action of stimuli during tests involving continuous cumulative Coriolis acceleration (CCCA) altered the levels of certain nystagmic-reaction indices. After the subject was brought to a stop following rotation at a speed of 180 deg/sec, the most significant changes were in the rate of the slow phase and the nystagmus amplitude. The character of the changes in these indices for the maximum CCCA duration were similar to those in the RSP when the subjects were exposed to 2-g loads (increased weight) and linear accelerations during swing tests (Sidel'nikov, 1970a, 1979). In those cases where exposure to CCCA did not produce autonomic disturbances in the subjects, the change in the RSP took the form of stimulation. Conversely, in those cases where a vestibuloautonomic motion-sickness syndrome developed, the subjects exhibited an inhibition effect, i.e., a decrease in the RSP from its original level. These changes in the nystagmic reaction were quantitatively most pronounced during the stop stimulus following rotation at a speed of 180 deg/sec.

Thus, the graphs representing the nystagmic RSP recorded before and after maximum exposure to CCCA showed two types of relative positioning for the corresponding curves. The RSP curves were located above the initial curves in the first type of reaction and below then in the second type. It must be noted that the second type of reaction was characteristic of subjects who exhibited a distinct vesti-

Table 1

Duration of Postrotation Nystagmus and Vestibular-Function Indices for Stable and Unstable Subjects Under Action of CCCA

№	(1) Характер исследований	(2) Группа обследуемых	(3) Количество обследуемых	Продолжительность нистагма при стоп-стимулах со скорости вращения (*град/сек*) (4)			(6) Показатели вестибулярной функции					
				до и после НКУК (5)	60	180	НКУК, *мин* (7)	порог по нистагму, *град/сек* (8)	проба Барани — продолжение нистагма, *сек* (9)	отолитометрия, *g* (10)	гальванометрия, *ма* (11)	качели (12)
							M±m					
1	Предельное воздействие НКУК (13)	I	15	До (16)	25,5±2,8	26,3±1,8	13,9±0,8	8,1±0,8	20,3±0,8	0,007±0,0003	1,5±0,05	>30,0
				После (17)	26,4±2,8	27,2±1,8						
		II	15	До (16)	27,8±2,1	28,3±1,5	1,3±0,1*	4,0±0,3*	25,7±1,4	0,002±0,0005*	1,2±0,1*	19,1±2,1*
				После (17)	26,7±1,8	28,4±2,0						
2	Половина предельного воздействия НКУК (14)	II	7	До (16)	22,0±3,2	27,0±2,1	0,7±0,1*	4,0±0,5*	25,0±2,9	0,002±0,0009*	1,2±0,1	18,0±3,3*
				После (17)	21,0±1,4	26,0±1,8						
3	Контрольное исследование (15)		6	До (16)	23,0±3,0	29,0±3,5	7,0±2,7	6,8±2,5	26,0±3,7	0 005±0,003	1,1±0,1	21,0±5,1
				После (17)	21,0±2,0	28,2±3,5						

(18) * Достоверные различия с данными первой группы обследуемых при вероятности ошибки $P<0,05$

Key:

1. Type of study
2. Group of subjects
3. Number of subjects
4. Duration of nystagmus during stop stimulus following rotation at speed of (deg/sec)
5. Before and after CCCA
6. Vestibular-function indices
7. CCCA, min
8. Nystagmus threshold, deg/sec
9. Barany test, duration of nystagmus, sec
10. Otolithometry, g
11. Galvanometry, mA
12. Swing
13. Maximum exposure to CCCA
14. Half of maximum exposure to CCCA
15. Control study
16. Before
17. After
18. *Reliable differences from data for first group of subjects, error probability $P < 0.05$

Table 2

Nystagmic Indices over Periods of 5 (1-5 sec) and 15 (1-15 and 16-30 sec) sec During Stop-Stimuli Following Rotation at Speeds of 60 and 180 deg/sec Before and After Exposure to CCCA

№	(1) Характер исследований	(2) Группа обследуемых	(3) Количество обследуемых	(4) Стоп-стимулы со скоростью вращения, *град/сек*	(5) До и после НКУК	(6) Интервалы расшифровки показателей нистагма, *сек*								
						(7) СМФ, *град/сек*			(8) амплитуда, МЭК			(9) частота, *уg/сек*		
						1—5	1—15	16—30	1—5	1—15	16—30	1—5	1—15	16—30
						M±m								
1	(10) Предельное время действия НКУК	I	15	180	До¹³	61,9±5,4	41,4±3,7	13,5±1,8	173,3±17,9	143,2±13,4	101,8±13,0	3,6±0,3	3,9±0,3	1,8±0,2
					После¹⁴	82,2±6,9*	54,3±4,4*	14,5±1,2	192,7±16,5	205,8±31,5	117,6±17,5	3,8±0,3	3,0±0,3	1,7±0,2
				60	До¹³	32,9±3,4	25,8±2,4	10,3±1,8	143,4±17,1	133,9±14,5	95,0±10,4	2,7±0,2	2,4±0,2	1,6±0,2
					После¹⁴	35,3±3,9	25,2±2,4	12,1±1,5	136,5±14,7	120,6±11,1	89,0±10,7	3,0±0,3	2,4±0,3	1,4±0,1
		II	15	180	До¹³	73,8±4,8	48,7±3,7	15,9±1,7	215,2±25,4	185,1±20,8	118,2±13,9	4,0±0,4	3,2±0,3	1,7±0,1
					После¹⁴	64,7±6,4	38,5±3,2*	15,8±1,0	183,0±20,8	146,2±14,9	105,2±10,2	3,1±0,4	2,9±0,3	1,7±0,2
				60	До¹³	40,5±3,2	30,4±2,2	14,4±1,5	165,2±15,0	148,5±15,0	124,2±24,1	3,1±0,3	2,5±0,3	1,5±0,2
					После¹⁴	30,3±2,2*	22,6±1,8*	12,7±1,9	117,0±16,0*	112,6±12,5	98,0±15,0	2,9±0,3	2,2±0,3	1,4±0,2
2	(11) Половина предельного действия НКУК	II	7	180	До¹³	49,0±8,2	34,0±6,0	12,0±2,6	102,0±16,8	104,0±16,0	80,0±9,0	4,0±0,4	2,5±0,3	1,4±0,3
					После¹⁴	82,0±15,0	50,0±4,0*	18,0±2,8	134,0±32,0	152,0±21,0	110,0±12,4	3,6±0,3	5,0±0,5	1,5±0,2
				60	До¹³	25,0±5,0	20,0±3,5	9,0±0,9	76,0±10,0	85,0±11,1	79,0±9,0	2,5±0,5	1,9±0,3	1,2±0,3
					После¹⁴	34,0±6,0	35,0±4,1	10,0±1,7	111,0±19,0	102,0±13,4	67,0±3,0	2,3±0,5	2,0±0,3	1,1±0,1
3	(12) Контрольное исследование		6	180	До¹³	62,0±13,0	41,0±6,6	17,0±3,2	225,0±25,5	166,4±28,0	107,2±18,0	3,3±0,4	2,9±0,3	1,6±0,3
					После¹⁴	65,0±10,0	45,0±7,1	16,0±2,3	232,0±32,0	168,0±26,0	115,0±15,0	3,4±0,3	3,1±0,3	1,7±0,4
				60	До¹³	30,4±6,8	28,6±5,5	11,5±1,4	137,0±24,3	123,0±20,0	85,0±14,2	2,4±0,5	2,8±0,4	1,5±0,2
					После¹⁴	31,6±7,0	25,8±5,4	11,7±1,2	145,0±23,7	127,0±20,0	87,0±12,5	2,4±0,3	2,2±0,4	1,3±0,3

(15) * Достоверные различия с данными контрольных исследований (До) при вероятности ошибки $P<0,05$.

Key:

1. Type of study
2. Group of subjects
3. Number of subjects
4. Stop stimulus following rotation at speed of, deg/sec
5. Before and after CCCA
6. Intervals for determination of nystagmic indices, sec
7. RSP, deg/sec
8. Amplitude, mV
9. Frequency, yg/sec
10. Maximum exposure to CCCA
11. Half of maximum exposure to CCCA
12. Control study
13. Before
14. After
15. *Reliable differences from data obtained in control studies (before), error probability P < 0.05.

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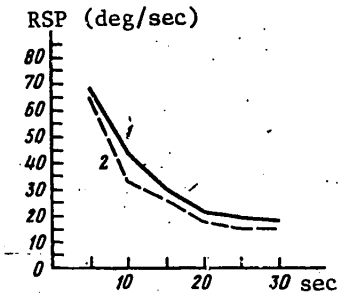

Fig. 2. The same, for subjects in second group, who displayed pronounced vestibuloautonomic reactions when exposed to continuous cumulative Coriolis acceleration. Symbols the same as for Fig. 1.

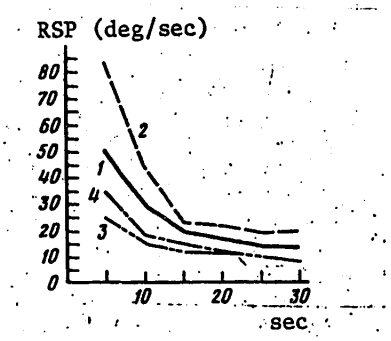

Fig. 3. Change in RSP during stop stimuli following rotation at speeds of 60 and 180 deg/sec for second group of subjects, who withstood exposure to Coriolis acceleration for a period equivalent to 50% of maximum time without vestibuloautonomic disturbances. 1) RSP before CCCA (180 deg/sec); 2) RSP after CCCA (180 deg/sec); 3) RSP before CCCA (60 deg/sec); 4) RSP after CCCA (60 deg/sec).

buloautonomic syndrome at any point during exposure to CCCA for the maximum time, while the first type of reaction was characteristic of subjects who withstood the tests without developing the autonomic symptom complex of motion sickness. The stop stimulus following rotation at a speed of 180 deg/sec made it possible to use the RSP data to obtain definite and very valuable information on the functional status of the semicircular-canal receptors and otolithic apparatus, as well as on the characteristics of their interaction. The existence of two types of changes in the rate of the nystagmic reaction was confirmed by the fact that the data obtained in other vestibular tests showed the subjects to differ in vestibular stability.

However, we also obtained the first type of change in nystagmus rate for the subjects in the second group when they participated in experiments in which the duration of exposure to CCCA was only half the maximum duration. This indicated that, in addition to the original functional status of the analyzer, the extent (or phase) of the vestibuloautonomic motion-sickness syndrome was important for the change in nystagmus rate.

Data on the nystagmic RSP level in the second-group subjects exposed to CCCA for only half the maximum time were of particular interest for elucidation of certain of the mechanisms by which the observed effects were produced.

As we saw above, stimulation of the nystagmic RSP occurred in place of inihibition in this experimental variant. Phenomena of this sort enable us to hypothesize that stimulation of the nystagmic reaction can occur only when the vestibular-analyzer otolithic apparatus receives a stimulus of definite optimum strength.

In cases where the otolithic apparatus is overstimulated (a process whose strongest manifestation can be seen in vestibuloautonomic disturbances), there are paradoxical cupular reactions. In view of the fact that these are a product of the functional interaction of the otolithic apparatus and cupular system, one can also speak of the existence of "paradoxical" forms of this interaction. We observed similar phenomena in studying nystagmic indices after cumulative exposure to linear acceleration (in swing tests).

Analysis of the RSP over shorter reaction times (5 and 15 sec) showed the changes in nystagmus rate to have the same character, especially during the first 15 sec after the stop stimulus following rotation at a speed of 180 deg/sec.

The experimental results obtained in these series of experiments can thus serve as still another confirmation of the fact that nystagmus is actually an integral reaction of the vestibular analyzer and that the character of the changes in this reaction depends on the functional state of the semicircular canals and otolithic apparatus and is governed by the characteristics of their interaction.

Recording of nystagmus in combination with imposition of a functional load by the CCCA method, like swing tests, makes it possible to determine two types of cupular reactions, making it useful in examination of flight personnel for determination of vestibular stability in cases of simulation or dissimulation, for objective evaluation of tolerance to cumulative Coriolis acceleration and particularly to the CCCA test.

Another striking feature of our investigations was the fact that, after preliminary exposure to CCCA, the second group of subjects exhibited the RSP changes characteristic of a rotation speed of 180 deg/sec when subjected to the stop stimulus following rotation at a speed of 60 deg/sec. In view of this fact and the substantial difference between the first and second groups. it would seem possible to improve the technique described above for objective determination of vestibular stability during CCCA. The data obtained in these studies will be published in a separate article.

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[Annotation, introduction and table of contents from book "Problems of Space Biology, Vol 39: Effects of Hyperbaric Environment on Man and Animals", by G. I. Kurenkov, B. O. Yakhontov, A. V. Syrovegin, A. I. Sterlikov, V. P. Nikolayev and D. B. Vandyshev, editor-in-chief: Prof A. M. Genin, Izdatel'stvo "Nauka", 900 copies, 259 pages]

[Text] This book describes research on the main problems of submarine biology and medicine. Attention is devoted specially to questions of saturation and desaturation of body tissues with inert gases when atmospheric pressure and composition of the gas environment change, as well as respiratory function in a high-density environment, toxic effects of high levels of oxygen pressure, effects of inert gases on the nervous system under hyperbaric conditions, heat exchange in man under water at high pressure. The authors' objective did not include comprehensive discussion of the problems mentioned.

This book may be of interest to a wide circle of biologists, physicians and specialists in the field of submarine and space medicine.

There are 10 tables and ... [illegible] illustrations; bibliography covers 27 pages.

Introduction

At present, a new branch of natural science is completely formed--submarine biology and medicine, which deals with the functional state of man and animals exposed to the set of deleterious factors that appear when submerging into a marine environment. The objective of these studies was to find means of protection that would enable man not only to work well at elevated pressure, but to preserve entirely his health.

Submarine biology and medicine was conceived on the basis of classical physiology in the second half of the 19th century, when a special type of human endeavor appeared, work at high pressure in caissons and under water.

In the presence of elevated atmospheric pressure, there are a number of factors that man had not encountered in the course of evolution, which affect the organism: high hydrostatic pressure, high partial pressure of oxygen and other gases in the respiratory atmosphere, high density of gases in the respiratory mixture.

The fullest information on this score was first furnished in the classical work of Paul Bert, "Atmospheric Pressure" (1878). Human physiology was enriched with new data about the toxic effects of oxygen, processes of saturation and desaturation of body tissues with inert gases when atmospheric pressure changes, and about functional disturbances during and after decompression. Subsequently, hyperbaric physiology was augmented with conceptions of the narcotic effects of inert gases (nitrogen, argon, neon, krypton), specific effects of helium, safe range of use of nitrogen and helium at elevated pressure, possibility of man's adaptation to long-term exposure to a hyperbaric environment.

The feasibility of developing the world's oceans depends on advances in submarine biomedicine. The increasing interest in hyperbaric physiology is also linked with the development of new therapeutic methods, for example, oxygen barotherapy, and the prospects of manned flights to such planets of the solar system as Venus, where atmospheric pressure near the surface constitutes about 96 kgf/cm^2.

The following are the most complex biological problems that prevent man from submerging to great depths at the present time: overcoming respiratory functional disturbances and neurological disorders that occur when air pressure rises to more than 6 kgf/cm^2, i.e., at depths in excess of 60 m. At such depths, when divers breathe with air they develop a state of so-called nitrogen anesthesia, which is characterized by diminished efficiency, drowsiness, hallucinations, loss of sense of time and space. Most researchers consider the chief cause of this state to be the specific effect of elevated partial nitrogen pressure; however, it has also been demonstrated that elevated oxygen pressure, carbon dioxide pressure and general cooling of the body have an enhancing effect on formation of nitrogen anesthesia. One of the chief factors involved in accumulation of carbon dioxide in the body and accentuation of cooling properties of gases under hyperbaric conditions is the increased density of gases, which affects diffusion of gases in the lungs and heat transfer.

The signs of nitrogen anesthesia can be ruled out when nitrogen in the respiratory mixture is replaced with a less dense gas, helium, and thus one can increase the depth of diving. However, when submerging very rapidly, at depths of 300-350 m, man develops neurological disorders, the clinical manifestations of which differ from the state of nitrogen anesthesia. These neurological disorders are characterized by a set of symptoms indicative of increased excitability of different structures of the central nervous system (tremor, hyperkinesia and others). At the present time, the state of heightened excitability under hyperbaric conditions while breathing with helium and oxygen mixtures is known under the name of the nervous high pressure syndrome (NSVD). It is believed that the causes of NSVD could be pressure per se, the effect of helium at elevated pressure, heat stress, as well as accumulation of carbon dioxide in body tissues with the use of a dense respiratory mixture. On the basis of the results of studies of NSVD, some researchers concluded that 300 m is the maximum depth to which man can submerge when using mixtures containing helium, just like a depth of 60 m is the maximum when breathing with gas mixtures containing nitrogen. However, it was learned that one can create conditions that postpone the deleterious effects of high pressure. Thus, there was substantiation of the possibility of man and animals overcoming NSVD at depths in excess of 300 m.

This book submits the results of the authors' own research on the effects of high pressure of respiratory mixtures on man and animals. Reference is made

chiefly to the data of foreign authors in their discussion of the results of their studies.

The team of authors expresses its sincere gratitude to V. N. Chernigovskiy, academician of the USSR Academy of Sciences, Ye. M. Kreps, academician of the USSR Academy of Sciences, Prof I. A. Sapov, Prof G. L. Zal'tsman, Prof A. G. Zhironkin, Prof V. B. Malkin, Prof V. S. Farfel' (deceased), I. S. Breslav, doctor of medical sciences, Z. S. Gusinskiy, candidate of medical sciences, G. A. Kuchuk, candidate of biological sciences and A. I. Selivra, candidate of medical sciences, for their useful comments and assistance in preparing this work for publication.

Contents

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BOOK EXPLORES ADVANCED THEORY OF EXTRACELLULAR BRAIN CURRENTS

Moscow BIOFIZIKA VNEKLETOCHNYKH TOKOV MOZGA in Russian 1980 (signed to press 13 Jun 80) pp 2-4, 182-184

[Annotation, foreword, and table of contents from book "Biophysics of Extracellular Brain Currents", by Aron Meyerovich Gutman, USSR Academy of Sciences, Scientific Council for Problems of Biological Physics, Institute of Biological Physics, Izdatel'stvo "Nauka", 1,700 copies, 184 pages]

[Text] This monograph presents the theory of the extracellular field and electric influence upon the cell. The theory is refined down to assessments used as the basis to analyze electrostimulation, the origin of the ECG and EEG, the methods of determining stimulation sources by EEG interpretation, the layered distribution of potentials in the cortex, and the extracellular spike. Objections are raised to the hypothesis of (efapticheskoye) interaction of neurons and some commonly accepted ideas about the genesis of a number of biopotentials of the central nervous system. The concept of the EEG quantum is introduced--an elementary impulse of biocurrents in the gray matter, or a synchronous extracellular postsynaptic potential from all synapses of one axon. Theoretically predicted registration of the EEG quantum and its use in direct investigation of a synapse are described. The concept of the EEG quantum is applied to EEG and ECG interpretation.

The book is intended for biophysicists and physiologists involved with the problems of neuro- and electrophysiology.

Forty-three figures, 601 bibliographic references.

Contents Page

Foreword

The principles of the theory of the tissue electric field were discovered back at the dawn of biophysics by Helmholtz (330). Research on this problem is being continued (404, 456) together with further development of electrophysiology. However, usually the extracellular field is now analyzed quantitatively only in relation to relatively simple situations, such as a cylindrical fiber in infinite space (487), permitting a sufficiently precise numerical solution. But in most cases researchers limit themselves to examination of the orientation of dipoles, and to determination of potential signs (118). Use of the intermediate approach of gross quantitative assessments is justified by its simplicity and by the broad range of its applications. Quantitative assessments are very popular in physics, at least in terms of the frequency of their application. They must be utilized even more broadly in biology, inasmuch as the accuracy of an experiment is often limited to the first significant figure, and precise calculations are incomparably harder to arrive at in biology than in physics. It would appear suitable to apply this approach to the highly confusing problem of brain gray matter biocurrents.

Although the principal object in this book is the extracellular field, Chapter I begins with a description of the intracellular potential fields, inasmuch as we can assume with satisfactory accuracy that an intracellular potential, which determines extracellular biocurrents, does not itself depend on the latter. This result follows from the conclusions of Chapter II on polarization of the membrane of a cable by a given extracellular field. Chapter III is devoted to the general theory of the extracellular field; moreover a method for simple quantitative assessment of a dipole and of a set of dipoles representing a source-cell is proposed. This chapter uses a simplified approach to the nonhomogeneity and nonisopropicity of the brain and its membranes. This method is used in Chapter IV to assess concrete electrophysiological phenomena occurring mainly in the cerebral cortex. Chapter V presents the most important conclusions, demonstrating that an elementary impulse of biopotentials in the gray matter elicited by a single afferent spike, which has come to be called an EEG quantum, may be recorded. This prediction was experimentally confirmed.

Inasmuch as extracellular currents are a continuation of intracellular currents, and in the gray matter the latter are associated mainly with thick nerve fibers--dendrites, the book devotes its main attention to analyzing dendrites as sources of an extracellular field.

I am grateful to many individuals, and mainly to my laboratory colleagues, for their cooperation. I extend my gratitude to N. Khusainoven for his great assistance in preparing the manuscript.

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HUMAN FACTORS

UDC: 612.172.2

PROBLEMS OF SPACE BIOLOGY, VOL 41: BIOLOGICAL RHYTHMS

Moscow PROBLEMY KOSMICHESKOY BIOLOGII, TOM 41: BIOLOGICHESKIYE RITMY in Russian 1980 (signed to press 23 Oct 80) pp 4-9, 316-319

[Annotation, introduction, conclusion and table of contents from book "Problems of Space Biology. Vol 41: Biological Rhythms", edited by Academician V. N. Chernigovskiy, Izdatel'stvo "Nauka", 2300 copies, 320 pages]

[Text] This collective monograph deals with biological rhythms on different levels of organization of living systems (cellular, organismic, population), as well as their relation to periodicity of the environment on our planet. On the basis of data in the literature and experiments conducted by the authors, there is discussion of the system of biological rhythms, correlations between them and their lability, role of rhythms in normal function of the organism, effect of exogenous conditions on rhythms and capacity of some rhythms to adjust to the periodicity of the environment.

This monograph is intended for specialists in the field of space biology and medicine, physiologists, botanists and biologists in other fields.

Tables 3, illustrations 72; bibliography listed on 39 pages.

Introduction

A brief report about one of the experiments of the famous French naturalist, J. J. de Meran, was published 250 years ago in the works of the Royal Academy of Paris. He discovered that plants retain their circadian rhythm of leaf movement in total and constant darkness. For the first time, it was demonstrated that biological rhythms are a special category of phenomena, rather than a simple reaction to changing conditions. This is how development of a new science, the science of biological rhythms, began.

One quarter of a millennium later, the problem of biological rhythms became one of the basic problems of modern biology. Numerous studies have shown that biological rhythms are the very basis of biological processes.

The start of exploration of space served as a powerful impetus for further development of the science of biological rhythms. Expressly there, many problems of biorhythmology acquired special meaning, and often very marked practical relevance as well. Impairment of biorhythms has often been observed during space flights. Yet the rhythmic structure of any organism is just as important to life and just

as complex as the spatial structure. This time structure is flexible and labile, but still it is very vulnerable. Impairment of rhythmic structure leads to diseases and even death. For this reason, one of the most important tasks of space biology is to study biological rhythms--their stability, factors affecting them and periodic changes in sensitivity of the organism. The study of biorhythms is just as important to space exploration as, for example, studies of the effects of weightlessness.

This task can be formulated on a broader basis: it is not only in space, but on our planet that we have to be concerned with preservation of the time structure of life, which is so sensitive to diverse factors.

What are biological rhythms? They are periodically recurring changes in nature and intensity of biological processes and phenomena. Each of these recurrences usually differs somewhat from the preceding and subsequent ones, both in amplitude and in duration of period. However, if one studies rhythm long enough, one usually finds that the mean values of rhythm parameters are quite stable. These mean parameters change in a consistent way when there is a change in exogenous conditions.

Rhythms are not the exclusive property of living matter. Appearance of fluctuating processes is inevitable wherever there is regulation with lagging feedback. Accordingly, the most diverse processes, very distant from one another, in both inanimate and animate nature, may be rhythmic.

However, living matter differs from nonliving in that there is more order in the rhythmic processes. The more complex the system, the more important to it is organization in time. Evidently, life in general is impossible without rhythms, without pulsations. And, although biological rhythms of a given organism, or population, must be coordinated, the mechanisms of most rhythms are profoundly different. Although it would be tempting to conceive of low-frequency rhythms arising on the basis of high-frequency ones and to find the "rhythmic unit," there is still no convincing experimental evidence of such unity of rhythmic structure. One thing is certain: some rhythms model others in the organism, there is syncrhonization and entraining (prolongation) of rhythms.

The science that deals with biological rhythms--biorhythmology--is a part of chronobiology--the science dealing with time in biology, but it actually uses all of the main contents of modern chronobiology. The impression could be gained that such a science is utterly artificial, as it deals with such profoundly different processes and uniting them according to a rather formal feature, the presence of rhythmicity. After all, there is no science, for example, such as physicorhythmology dealing with photic, sonic, mechanical and other fluctuations.

If we were to refer to the current situation in biorhythmology, we would find evidence that would appear to confirm this thought. Different rhythmic processes are studied by biologists in the most varied directions, virtually without a connection between one another. Only one category of rhythms is the primordial field of research by biorhythmologists. We refer to so-called ecological rhythms: daily, seasonal, tidal, lunar, i.e., rhythms that have distinct atronomical analogues in the environment. At the present time, the study of rhythms of the organism reminds one of the well-known parable about the blind men who tried to

determine what an elephant was like, some feeling only its leg, others only its tail, other yet only the trunk, etc.

Still, the subject of the science that is forming only now--biorhythmology--does definitely exist. The task of future biorhythmology will be not only to analyze the mechanism of a given specific rhythm (which can only be done by a specialist in the narrow field of the phenomena studied), but primarily to synthesize all of the rhythmic systems of the organism in all its interactions.

Our book is an effort to integrate in some way these scattered studies, to stress the fact that all of them pursue the same ultimate goal, that of studying the rhythmic structure of the organism.

A rhythmic structure is apparently mandatory, to some extent or other, in all living things and it is present on all levels of organization, from intracellular to population processes. Biological rhythms can be observed in virtually every cell of a multicellular organism. Some cells or groups of cells take on the role of synchronizers, controlling the rhythm of organs or even the organism as a whole. It is well-known that biological rhythms can persist for some time in organs and tissues isolated from the organism.

The rhythmic structure of an organism, like its morphology, is genetically fixed. Most rhythms appeared spontaneously in ontogenesis, but some require specific exogenous influences for their manifestation.

All organisms adapt to the environment and bear its imprint. This also applies to the rhythmic structure, which developed not only as the inevitable result of complex interactions within the organism, but as adaptation to environmental rhythms. There is a rhythmic pattern of events inherent in each plant, and everything living that exists on earth is permeated with terrestrial rhythms, which are part of its substance. When we leave our planet, we still remain terrestrial and bear its rhythms.

Under natural conditions, these ecological rhythms conform strictly with periodic changes in the environment due to astronomical causes. Apparently, the study of such rhythms is of special importance in connection with exploration of space.

Ecological rhythms serve as a biological clock for the organism, enabling it to be oriented in time and prepare in advance for expected changes in conditions.

Stability of period is typical of ecological rhythms, with regard to diverse chemical factors, different levels of temperature and illumination, i.e., they are self-sufficient with respect to metabolic processes. Because of this relative independence, the endogenous ecological rhythm controls the rhythms of the entire organism, affecting the level of motivations. But motivations apparently have no effect whatsoever on endogenous rhythm. The rhythm of animal activity observed under natural conditions is a complex combination of elements of behavior that are actuated by the endogenous rhythm and immediate reactions to exogenous conditions. This entire behavior is substantially modified by the biological state of the animal.

All other rhythms, unlike ecological ones, either have no marked and stable exogenous analogues, or else have some specific phasic relation to them. This

applies to most physiological rhythms, such as, for example, the heart beat, respiratory excursions, etc. However, all of these rhythms are modeled to some extent or other, in frequency and amplitude, by ecological rhythms.

Development of biorhythmology began with the proof of preservation of ecological circadian rhythm in continuous darkness. There are two interpretations of this phenomenon: either the rhythm is endogenous, i.e., spontaneous, and the fluctuations are determined by an endogenous mechanism, or else the organism, when isolated from alternation of light and temperature, perceives some sort of time signals from the outside, senses the regular changes in geophysical factors that penetrate through the laboratory walls.

At present, it can be considered that the spontaneity of all of the main rhythms, including ecological ones, has been completely proven. However, an actual rhythm always has both endogenous and exogenous components. The question of the role of exogenous factors in maintaining and regulating endogenous, spontaneous rhythms cannot be considered definitively answered. We cannot rule out the possibility that geophysical factors play a significant part here.

To test this hypothesis, experiments must be conducted at a considerable distance from our planet, where complete isolation from terrestrial factors can be obtained. It is quite apparent that this question has more than great theoretical significance. If "penetrating" geophysical factors are mandatory to maintain rhythms, it would be impossible to make any distant and long-term space flights without simulating the natural rhythmic environment for living organisms.

The change in period under constant laboratory conditions is another distinction of ecological rhythms. Solar daily, lunar daily, weekly, lunar semimonthly, lunar monthly, annual rhythms become "circa-" rhythms in the absence of the usual environmental changes, i.e., "near-" solar daily, "near" lunar daily, etc. The period of a rhythm under constant conditions is individual for each specimen, and it also depends on prevailing conditions.

By analogy with physical oscillations, such rhythms are called free-flowing under stable conditions. This implies that, expressly under stable conditions, the rhythm is manifested as such, without any exogenously imposed elements.

Apparently, constant conditions [sic], on the contrary, have a marked unnatural effect on the organism, deforming the parameters of rhythm. They cannot by any means be considered the neutral background against which rhythm is manifested.

Any regulation of ecological rhythm is possible because of the fact that unstable states--time of potential readiness (TPR)--appear several times within each of its periods. They correspond to the time when the organism is ready to receive an exogenous signal, a certain change in conditions. If the signal is somewhat behind or ahead of time, there is a corresponding shift in rhythm phase. The same reaction to conditions occurs when they are constant. If these conditions are close to signal values, the rhythm phase shifts ahead during TPR, and if they are far from these values, it shifts back. There is a corresponding deformation of the period of rhythm, and the magnitude of this deformation equals the algebraic sum of all phase shifts within each of the TPR's.

Thus, ecological rhythm is never a "free fluctuation." It regularly "consults" with exogenous conditions to which the organism is exposed. The complex rhythmic system of the organism cannot be absolutely closed, no matter how much we try to isolate it, it will always react to the conditions we present to it. This reaction to the environment is always an organic part of the rhythmic system. On the whole, however, the rhythmic system reacts with amazing refinement and precision to the environment, providing for maximum adaptability of the organism.

We have tried in our book to demonstrate this multifaceted rhythm system of the organism, with its complex endogenous and exogenous interactions. It was not our aim to furnish exhaustive surveys on each of the problems, which would have required a much larger book.

The book is divided into two parts. The first deals with biological rhythms on different levels of biological organization, from cells to populations. The second part describes the properties of rhythms--daily, lunar and seasonal--that are the most related to the environment and important to space practice. This part also has a chapter on biological rhythms related to solar activity.

Authors who work independently in allied fields always have different opinions, a different style, different approaches to a question and its presentation. For this reason, we tried to reflect more fully the complexity, contradiction and acuity of current problems in biorhythmology.

The authors will consider their mission accomplished, if the book will help develop life support systems for space flights, if it discloses even more that life has not only a spatial structure, but an equally important time structure, and if it is instrumental in expanding continued research and generating heated discussion.

Conclusion

A quarter of a millennium has passed since the discovery made by de Meran. But it is only in the second half of our century that, finally, the significance of biorhythmology to basic biology and practice of human life was appreciated, and this discipline began to develop rapidly. Still, strictly speaking, the science of biorhythmology as such does not yet exist. There are only some of its fragments and efforts to tie them together.

It has now become very obvious that virtually all processes in the organism are rhythmic; some rhythms appear and are manifested independently, others are the result of integration of several rhythms. It is equally apparent that all of these rhythms interact with one another in some way or other, forming a more or less coordinated rhythmic system, time organization of a living thing. In a normal organism, these rhythms form an orderly and complex whole, like the sound of a symphonic orchestra.

However, it is not always by far that one can say something definite about the mechanisms of appearance of some biological rhythm, its regulation and lability, and as a rule, the longer the period of a rhythm, the less we know about its mechanism. It is relatively easy to create a mathematical or physical model that would describe, more or less satisfactorily, the properties of a biological rhythm. Numerous such models have been proposed and more than one interesting hypothesis has been expounded, but there is still no definitive solution.

The situation is even more complicated with respect to the study of the time organization of living systems. In the first place, different rhythms are the subject of research for different specialists limited to the narrow range of their problems. In the second place, the rhythms that we are accustomed to considering elementary are often in fact the result of complex interaction between many rhythms. For this reason, we are still far from having a real idea about the rhythmic structure of organisms.

The youth of our discipline is also reflected in the fact that it is called by different names. Even in the different chapters of this book, reference is made to biorhythmology in some cases, chronobiology in others. Of course, the teaching on time organization of living things is the foundation of our discipline, which should be called chronobiology, where the problem of biological rhythms is an extremely important but special one. Of course, one should not study only rhythmic phenomena, but all of the existing "trends," viewing rhythms as elements of ontogenesis and phylogenesis. But yet, we feel that it is more appropriate to use the term, "biorhythmology," which corresponds to the current state of our knowledge.

Also, a few words about the importance of our discipline today and in the future.

We have already started to become accustomed to conceptions that biorhythms are always superimposed over the studied biological processes, that one should pay attention to time of day and time of year in any investigation. We have yet to become used to the fact that biorhythms are the substance of the process itself, one of the mandatory elements of its mechanism.

The exceptional significance of biorhythmology in space biology and actual practice of space flights has been demonstrated in many sections of our book. Long-term manned space flights would be impossible without the study of mechanisms of coordination of rhythms with the environment and analysis of rhythm disturbances that occur under the influence of space flight factors.

But we hope that the conceptions of time organization of living things will have a substantial influence on future development of such disciplines as physiology and molecular biology, embryology and genetics, immunology and oncology, and many other branches of biology and medicine.

Contents

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TEXTBOOK ANALYZES WESTERN PROJECTIVE PERSONALITY MEASUREMENT TECHNIQUES

Moscow PROYEKTIVNYYE METODY ISSLEDOVANIYA LICHNOSTI in Russian 1980 (signed to press 3 Jul 80) pp 3-9

[Table of contents and foreword from book "Projective Methods of Personality Analysis", by Yelena Feodorovna Sokolova, Izdatel'stvo Moskovskogo universiteta, 15,100 copies, 176 pages]

[Text] Contents

Foreword

Projective techniques have begun enjoying broad application in many areas of psychological practice in connection with the growing demand for applied psychological analyses of the personality. But their use is not always justified by the objectives of the concrete analysis, and results are interpreted in categories adequate to ideas about the personality that have evolved in domestic psychology. Hence it follows that directly borrowing foreign methods of personality diagnosis without critical inspection of their theoretical basis may produce serious difficulties, both theoretical and practical. All of this makes lengthy and meticulous work necessary to develop a theory of the projective method based on the premises of Soviet psychology. The first steps in this direction presuppose, first of all, associating the principles and concepts making up the conceptual machinery of the projective method with the personality conceptions corresponding to it; second of all, distinguishing that psychological reality which, within the framework of the given conception, serves as the object of the projective method; and third and finally, describing this object in concepts that have been developed in Soviet psychology.

However, to what degree are the method or the particular techniques determined by psychological theory? The history of the projective method's development shows that it does not exist apart from personality theory; at the same time the relationship between the projective method and theory is not unambiguous and unchanging. Moreover, the relationships between one theory or another and some single technique are even more complex and indirect.* It cannot be doubted that to one degree or another, the birth of a method is prepared for by a theory already in existence, though this fact may not be fully recognized by the analysts themselves. In this case the impression arises that the technique is also nothing more than a fortunate discovery of its creator, who is often little concerned with theoretical explorations. The

*Following the convention of some authors, we will distinguish a *method* as a means of analysis derived from general theoretical ideas about the essence of the object under analysis, and *techniques* as the technical procedures by which the method is implemented with the purposes of refining or verifying our knowledge about the object (33).

paradox of this situation revealed itself with special obviousness when a few decades following the arisal of projective techniques, their relationship to the basic personality theories became the object of methodological reflex action--that is, this relationship transformed into a special research task. The situation is made even more complex by the fact that with time, a method acquires what seems to be relative independence from the theory that brought it into being, and it begins to "operate" in other conceptual systems. As a rule this promotes alteration of the entire conceptual machinery, and concurrently, change in our ideas about the objects under analysis. In turn, transformations of the method bring various schemes of analysis and interpretation of the individual techniques themselves into being as well. As an example despite the indisputable fact that both the projective method and the projective technique were created under the influence of psychoanalysis, the latter was not their sole theoretical basis: "New Look" experiments on the role of personality factors in perception, and the holistic and personological ideas of K. Levin and G. Allport affected, directly or indirectly, the corresponding conceptions of projection, the content of the interpretative schemes, and the personality models themselves. Consequently no matter how much the technical procedures used in implementation of a projective method (that is, the projective techniques) seem to be divorced from theory, they are all permeated by theory. Of course, this does not exclude the use of some particular technique independently of the theory which historically brought it into being--projective techniques are broadly employed abroad by proponents of behavioral psychology and Gestalt psychology, and representatives of the information approach. Nevertheless it would be important to emphasize that the ambiguity and the looseness of the relationships between theory, method, and "technique" do not at all mean that the latter may be employed apart from all theory. After all, when we interpret the results of projective techniques, we essentially build a model of the personality, and consequently this interpretation would be predetermined by the theory of which the experimental psychologist is a willing or unwilling follower.

And while we find some Western conceptions of the projective method to be debatable, the problems they touch upon doubtlessly deserve attention and further development. "In any science," Engels wrote,"incorrect ideas (if we disregard errors of observation) are, in the final analysis, incorrect ideas about correct facts. The facts remain, even if the ideas about them turn out to be false" (1, 20, 476). This is why the task of theoretically substantiating the projective methods within the framework of domestic psychology is so important and timely.

The projective method is oriented on the study of unconscious (or not fully realized) forms of motivation, and in this quality it is hardly the sole, specifically psychological method of penetrating into the most intimate area of the human mind. But the unconscious is significantly richer in its phenomenology, as well as in the possibilities for interpretation of its content, than had been imagined, for example, in classical psychoanalysis. "Meaningful experiences", "personal meaning", and other constructs revealing unconscious partiality of mental reflections may not come to light, even with direct referral to a subject's responses or observation of his behavior. Projective techniques allow us to study these personality constructs, which reveal themselves directly or in the form of different personality sets, indirectly, by modeling some living situations and relationships. While most psychological techniques are aimed at studying how man arrives at an objective reflection of the external world, projective techniques have the purpose of revealing unique "subjective deviations", and personal "interpretations", in which case the latter are far from always objective, though they are always personally meaninful as a rule.

Of course, the approach proposed here is not the only one possible. Theoretical and methodological substantiation of the projective method is important, but more is required. We also need to conduct further research on problems such as diagnosis of the individual style of the personality with the help of projective techniques, creation of schemes of analysis and interpretation within the framework of the activity approach, and many others. Efforts are being conducted in this direction by a group of colleagues and students of Moscow State University's department of psychology.

This book will acquaint students with the basic directions in projective analysis, with the debatable problems, and with the various approaches to their resolution, and it will help them arrive at an objective assessment of projective techniques, and reveal the possibilities of their application.

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DECISION MAKING AND AIR TRAFFIC CONTROL

Moscow PRINYATIYE RESHENIY CHELOVEKOM V AVIATSIONNYKH SISTEMAKH UPRAVLENIYA in Russian 1980 (signed to press 5 Feb 80) pp 2-9, 347-348

[Annotation, table of contents, foreword and introduction from book "Human Decision Making in Aviation Control Systems", by P. P. Novikov, Izdatel'stvo "Vozdushnyy transport", 2,830 copies, 348 pages]

[Text] Annotation

This book examines research on the activities of an air traffic controller and a pilot. A modeling approach to describing decision making, to experimental analysis of activity, to simulation of air traffic control and "pilot-aircraft" systems, and to the solution of the practical problems associated with organizing, automating, and providing ergonomic support to control systems in civil aviation is implemented.

The book is intended for engineers specializing in air traffic control, air traffic controllers and flight crews, developers of automated systems for aviation, students in their senior years at institutions of higher education, and specialists involved in analysis of decision making, systems analysis, and modeling.

Contents Page

Foreword

Control is now becoming one of the principal spheres of human activity, as a consequence of which we face a large number of new practical problems associated with algorithms, systems engineering, human factors analysis, and ergonomics and involved with the planning and improvement of this type of activity. The success with which these practical problems are solved depends on how deeply we subject the laws and unique features of human thinking accompanying problem solving to theoretical and experimental analysis.

This book examines the decision making problem in application to control systems in several aspects. First a certain conceptual model of human activity is formed, based on certain ideas concerning the structure, functional content, and hierarchical organization of decision making. Then follows an elaboration of the conceptual model, taking the form of a decision making model (DMM) described formally by complexly structured texts and dispositions. The next step involves experimental identification of the concepts and procedures of the DMM through analysis of human activity in real control systems and in the laboratory, using behavioral and electrophysiological techniques, and subjective evaluation and scaling methods.

The experimental results take the form of precise descriptions of DMM's for human activity in different real systems. The facts used here are taken from analysis of the activities of an air traffic controller and a pilot controlling an aircraft during landing. The corresponding DMM descriptions are called the CDMM--the controller decision making model, and the PDMM--the pilot decision making model.

The internal logic of the models is checked out through decision making simulation cycles run through digital computers. The results of the machine processing

experiments are also used to evaluate the adequacy of processes performed by the DMM and the individual in real conditions. Thus this book proposes and successively implements a modeling approach to analysis of human decision making, based on contemporary methods of experimental analysis of human activity, and on contemporary methods of formal description. The modeling results are an aid to understanding and refining the concepts, to predicting development of training processes, to abstracting, generalizing, accumulating, and utilizing experience, and to formation of habits and memories in complex activity, which is what decision making is.

The modeling approach, one of the important properties of which is that it offers a possibility for transforming a vague conceptual model into precise, explicitly modeled concepts, is extremely adequate to the practical tasks associated with planning and improving control systems of which man is an integral part. Use of this approach is what predetermined the content of the book's discussion of the use of DMM's to refine systems concepts, to describe the procedure for defining the control problems and the means of their solution, to evaluate systems, and to predict their behavior.

The author of the book is grateful to engineers A. P. Kulaichev and R. N. Suleymanov for their cooperation in running the decision making models, and to B. M. Borodenkov, A. N. Sumin, and L. S. Zryachikh, who took part in some of the experiments and provided considerable assistance in preparing the manuscript.

Introduction

The decision making problem is at the center of attention of many sciences--mathematics, logic, psychology, physiology, and philosophy. But even within the framework of an individual science we typically find a multiplicity of conceptions and approaches to it. This pertains first of all to definition of the "decision making" concept itself. Predominantly in mathematics and logic, and sometimes in psychological studies as well, decision making is completely identified with the means of problem solving. In physiology, meanwhile, decision making is usually defined as just a single act occurring within complex integrated activity. In application to human activity, this problem should be interpreted as thinking in the course of solving problems (formal and practical). The goal of studying this problem is to describe this thinking process and to resolve all issues associated with it.

Thinking is the highest product of the brain's work, it plays a role in different forms of activity, and it entails the individual's purposeful reflection of properties and relationships in the outside world, abstraction and generalization of sensory experience, suggestion of hypotheses, definition of problems and their solution, establishment of laws, and creative development of new ideas. Thinking became an object of experimental study in the late 19th and early 20th centuries (31, 80, 84, 85, 117). I. M. Sechenov founded the materialistic approach to research on thinking. His works are significant in that they revealed the means by which the behavior of the living organism is determined by properties of the objective world and by the mind through the brain's reflex activity. The structure of reflex activity includes mental components beginning with elementary levels of sensation and ending with the highest forms of mental activity--thinking.

I. P. Pavlov (90) subsequently made a major contribution to development of these ideas. He formulated a single approach to all forms of human behavior, and he demonstrated the basic possibility for assuming a scientific approach to analyzing the brain's physiological activity, which is at the basis of any mental phenomenon. Materialistic viewpoints on the nature and mechanisms of thinking are at the basis of thinking research in Russian and Soviet psychophysiology (23, 42, 57, 97, 102, 113). Thinking plays a real role in different forms of activity, manifesting itself as the individual's solution of concrete problems as he interacts with objective reality. Problem solving is the most frequently encountered form of thinking. Retrospective analysis of studies on activity would demonstrate the doubtless importance of the "problem solving" concept, since it is indispensable in all directions of research on thinking. However, it does require fundamental refinement. Problem solving is a directly observable, real product of thinking (97). But thinking itself cannot be completely reduced to just problem solving alone. The solution mechanism is a thinking process involving certain laws governing the dependence of analysis, synthesis, and generalization, which themselves must explain what occurs in problem solving. This is what makes it necessary to consider the thinking process when studying problem solving, and to examine all real problems associated with this. The integrated problem of analyzing thinking in the course of problem solving is sometimes referred to as the problem of human decision making. It is precisely in this sense that we will define decision making as a complex process of human information processing directed at problem solution.

In application to studying human decision making in control systems, there are a large number of structural, descriptive, strategic, heuristic, and other approaches (29, 35, 36, 37, 48, 93), in which this process is interpreted as operational activity (operational thinking). One book (93) defines operational thinking as "a process of establishment of a sequence of actions with objects being controlled, performed on the basis of dynamic modeling of these objects, their properties, and their mutual relationships."

Formalization and modeling are effective methods for studying decision making (5, 37, 91, 92, 96, 109, 117, 123). Among models that have been created and are presently being developed, we can come across models which integrate data from different areas of knowledge, and models locked within the framework of a single scientific discipline; models enjoying meticulous experimental verification, and models having no experimental grounds at all; models adequate to the object of modeling, and models superficially reflecting some of its significant aspects. Most works, with the exception of some in which singular or multicomponent reflexes, functional systems, and sets are modeled, simply described decision making without modeling its structural organization, though they did have a particular physiological or psychological conception at their basis. The first attempts at modeling the process were associated with development of heuristic programming, which is based on the maze hypothesis of psychology (42, 79, 142).

After heuristic programming was "defeated" in its attempts at becoming the "computer" theory of human thinking (87, 102), a new direction began to develop, which is now referred to as the "artifical intelligence" problem. On one hand modeling methods for solving problems falling within the natural intelligence sphere improved, and models of deductions, inductive and deductive conclusions (25, 119, 124, 126),

semantic memory and semantic representation of information (130, 148, 149, 150, 151), formation of concepts and generalizations (49, 95, 105, 130, 135, 148), development of strategies and plans (41, 70, 99, 104, 135, 147) and other objects were broadly discussed. Simultaneously, on the other hand, most models were developed apart from psychophysiological ideas and experimental analysis of human decision making, which is fully justified in the creation of "artificial intelligence" and which is highly problematic in terms of the attempts made in some publications to associate the latter with the mechanisms of brain function (for example attempts at reducing thinking to natural language models, and at identifying the two). However, use of precisely this class of models, which are structurally sophisticated and are supported by a diversity of means for describing structural levels and units, will apparently predetermine the direction that will be taken in the near future in theoretical and experimental analysis of human decision making by the methods of formalization and modeling.

Given the diversity of approaches to studying brain function, in most cases the brain is recognized, directly or indirectly, to be a complex system functioning as a single whole. This is in essence a systems approach (11, 16, 40, 53, 63, 69, 105, 108, 110). The basic principles of this approach to analysis of concrete real systems are as follows: A system is a class of terms having their own internal relationships; a system is said to be correctly represented if in addition to the terms, the class of their paired associationsis given; in addition to internal relationships, each term is typified by external relationships induced by their internal relationships and prescribed by the class of paired associations of terms--that is, each term plays the role of an "instrument" observing the properties of the other terms; each term is an abstract system (in the terms of general systems theory), and it may be described by any of the known organizational or formal methods for describing objects and systems. What we have here in fact is a transition from concrete to abstract systems and a return, following analysis of the abstract systems, to conclusions concerning the essence of the object under analysis.

The question of isolating a concrete real system is answered in application to decision making on the basis of the principle of process and function. Decision making is a real event, characterized by change of intrinsic states in time, and directed at altering the environment with the goal of solving the problem posed. Simultaneously it is a function of brain mechanisms dependent upon the anatomical and neurophysiological structure of the brain, the properties of the environment, and emotional and motivational factors.

On analyzing the studies of thinking activity occurring in the course of problem solution, we can assert that:

a) The class of terms in decision making, when viewed as a system, breaks down into at least three subclasses: psychophysiological, informational-logical, and experimental terms;

b) analysis of decision making may be said to be integrated only when it includes at least one representative from each subclass of terms.

Isolation of a subclass of psychophysiological terms is intuitively clear: Every psychological and physiological conception contains within itself a description of brain function given at one level of generalization or another. In most cases the terms of this subclass are described structurally, with the logical, operational and algorithmic approaches perhaps being an exception. The psychophysiological approach used here for isolating the different terms is based on representation of thinking as a structural-functional system. Abstraction, generalization, formation of concepts, learning, and accumulation and utilization of previous experience are the most important brain functions promoting successful solution of control problems. No research has yet been done on the neurophysiological mechanism responsible for this complex type of activity. Thus investigation and description of the mechanisms responsible for decision making is highly important. Analysis of signaling and analytical-synthetic activity, of memory organization, of mental habit formation, and of exercise of mental habits acquires special significance in this aspect.

Informational-logical terms correspond to formal models and descriptions of decision making. Representation of this subclass in integrated research is made indispensable by the need for reproducing, predicting, and obtaining precise quantitative characteristics of decision making. The language used to describe such terms must necessarily be formal: terminal (explicit or implicit) or purposeful. In our research, the informational-logical term, which we named the DMM, is selected on the basis of two requirements: structural and experimental identification of the DMM, and the formality of the procedures used to describe it. The DMM and its individual parts are represented as dispositional descriptions of problems and the methods of their solution. The level of detailed description of the DMM is selected to insure convenient running of the models in a computer, as a program written in problem-oriented language. The model is essentially a semiotic system having a developed hierarchical structure, a semantic memory, and the elements of deductive and inductive conclusions, learning, planning, and goal-setting.

Integrated research would not be complete without conducting an experiment to confirm the psychophysiological and informational-logical terms. The structural description of the experimental term is structurally formal. Obviously, the elements of the corresponding abstract system should include "inputs", "outputs", "the processing method", and "the representation method". In our research, the relationship between the structure of decision making by man and a DMM on one hand and change in the state of the object of control and in the behavioral components of activity on the background of electrographic processes on the other plays the dominant role. In addition, we make use of subjective analysis methods such as reports by the subjects themselves, questionnaires, evaluations, and subjective scaling.

Thus when we assume an integrated systems approach to analysis of decision making, we must represent, mutually coordinate, and work out the questions and reach a decision as to the way the process under analysis is to be structurally represented, as to the structure, semiotics, and procedures associated with the formal models, as to the organization and planning of the experimental research, as to the formalization techniques, and as to the relationship between the experimentally determined facts and our representations of decision making as structures and models. A large number of problems of outwardly purely technical nature arise in parallel (running the models, testing the adequacy of the models and human decision making, developing

the formal machinery of modeling, and so on), though they are not essentially an actual factor of the systems approach. In this aspect our choice of human activity in control systems as the object of research stemsnot only from the previously recognized practical significance of this problem, but also the conviction that man-machine systems are a rich experimental model for studying habits and intuition, logical conclusions and deductions, formation of concepts and memory, planning, and learning--all which make up the structural basis of thinking associated with problem solving.

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PSYCHIATRY

MEDICINAL PREPARATIONS USED IN PSYCHIATRY

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[Annotation, table of contents, and the chapters "Principles of Psychopharmacotherapy" and "Basic Objectives in Psychopharmacotherapy of Mental Diseases" from book "Medicinal Preparations Used in Psychiatry", edited by Prof G. Ya. Avrutskiy, Vsesoyuznoye kon"yunkturno-informatsionnoye byuro Glavnogo aptechnogo upravleniya Ministerstva zdravookhraneniya SSSR, Moskva, 20,000 copies, 208 pages]

[Text] This handbook contains data on drugs used in the USSR in psychiatric practice to treat patients with mental disorders. The principles of psychopharmacotherapy and modern clinical viewpoints on the use of psychotropic drugs are presented. The concepts "specifically psychotropic action" and "directed psychotropic activity" are analyzed, the general form and methods of psychopharmacotherapy are described, and the problem of medicinal pathomorphosis of psychoses is discussed.

The handbook contains descriptions of neuroleptics (aminazin, tizertsin, teralen, melleril, triftazin, mayeptil, moditen-depo, ethaperazine, frenolon, meterazine, neuleptil, haloperidol, trisedil, chlorprothixene, karbidin), tranquilizers (meprotan, trioxazine, elenium, seduxen, tazepam, eunoktin), antidepressants (melipramin, pirazidol, nuredal, indopan, tryptizol, phthoracizin, azafen), psychostimulators (sydnocarb, acephen), correctives (cyclodol, norakin), and lithium carbonate.

This publication includes medicinal preparations produced in the USSR and purchased abroad, as of 1 January 1978.

The description of each preparation includes brief pharmacological information, a detailed discussion of the unique features of its psychotropic action, recommendations on clinical use, and data on side-effects and complications.

The handbook is intended for psychiatric physicians and pharmacists.

Contents Page

Principles of Psychopharmacotherapy

In distinction from so-called shock methods (injection of insulin, EST--electroshock therapy), psychopharmacotherapy employs medicinal therapy primarily. Thus it has become possible to apply the forms and methods of pharmacotherapy and pharmacodynamics common in somatic medicine to psychiatry. As with all other pharmacotherapy, correct, clinically grounded establishment of indications for treatment is of special significance to achieving a therapeutic impact. But no matter how correctly the indications for initiating therapy are established, they lose all of their significance as the patient's state changes in response to therapy. As a result a preparation that is clearly indicated for a patient just beginning his therapy may turn out to be ineffective or even harmful in just a few days. This requires constant observation of the dynamic principle when conducting psychopharmacotherapy, which means constantly changing the treatment tactics depending on the dynamics of the patient's state. In the course of treatment, as a rule we observe nonuniform change in different psychopathological disorders: Some decrease in intensity while others remain unchanged, or they become even more intense. In each case the therapy must be systematically changed in accordance with daily assessments of the effectiveness of the given dose of a given medicine, plus meticulous clinical psychopathological analysis of all changes in status. A mandatory prerequisite is total individualization of therapy, with a consideration for the specific features of the patient's reaction.

The basic principles of the clinical action of psychotropic drugs must be followed when establishing indications in the course of therapy. Psychotropic drugs differ from all other medicines due to their so-called specifically psychotropic action, which expresses itself in typical somatic, autonomic, and mental disorders, ones which appear in the clinical pattern of psychosis due to the pharmacological properties of the preparation, and which are also encountered among healthy people.

Mental disorders which are always noted in the clinical pattern of psychosis during the time of therapy, and which disappear only after the therapy is withdrawn, have special significance. These psychopathological disturbances, the expressiveness of which usually depends on individual sensitivity to the preparation, dosage, stage of treatment, and so on, do not appear as distinct episodes, in distinction from insulin coma, instead in a sense intertwining with the symptoms of psychosis, which also experience changes, thus creating the impression of a chaotic combination of symptoms. Nevertheless this set of symptoms associated with the direct action of the preparation is highly typical, and therefore it may be isolated from the clinical pattern of psychosis and examined separately.

Inhibitory and activating effects arising in different combinations have been found to be the principal components of this set of symptoms. These effects occur in conjunction with a thymoleptic, thymoanaleptic, or thymodysleptic effect. Differences in the expressiveness of general and selective antipsychotic influence (upon psychosis in general and upon individual psychopathological disorders) is another typical trait of the specifically psychotropic action of these preparations. Different combinations of these components make up the individual spectrum of the psychopharmacological properties of each preparation, which determines the orientation of their psychotropic activity.

Thus aliphatic derivatives of the phenothiazine series (aminazin, tizertsin) differ from other neuroleptic drugs mainly due to dominance of the inhibitory components in their specifically psychotropic action. Aminazin elicits lethargy, intellectual and motor inhibition, passiveness, lack of initiative, neutral emotional reactions going as far as development of apathy coupled with asthenic phenomena and a subdued mood, and sometimes development of depression (Flugel's "apathoabulic syndrome" or Delet and Deniker's "psychoaffective indifference").

In addition to group properties common to all aliphatic derivatives, tizertsin has individual features. They include, first of all, significantly high expressiveness of the inhibitory components of specifically psychotropic action, both in the motor and intellectual sphere and in the emotional sphere; development of "emotional blockade" is much faster than with aminazin. Inhibition elicited by tizertsin is accompanied by sleepiness, often going as far as critical sleep, differing dramatically from narcotic sleep in its subjective and objective signs (including EEG data), and quite similar to physiological sleep. Overall inhibition is not so heavy as with aminazin; a subdued mood and, all the more so, depression are not observed. Owing to the inhibitory nature of specifically psychotropic action, aliphatic derivatives of the phenothiazine series are superior to all other neuroleptic drugs in the strength of their sedative action. These preparations are the ones usually able to curtail psychomotor arousal, with the sedative effect manifesting itself primarily along the lines of affective blockade, coupled with motor inhibition.

In this connection the main indication for using aminazin and tizertsin is a state of psychomotor arousal of varying origin. And, on the other hand, in the presence of states associated with motor inhibition (stupor, apathoabulia, and so on), the existing symptoms of psychosis in a sense merge with the lethargy and inhibition introduced into the clinical pattern by the specifically psychotropic properties of the preparation, which results in a worsening of condition. Thus "psychiatric" contraindications arise. For example aminazin treatment of patients having simple schizophrenia apart from aggravations or other forms coupled with expressive apathoabulic disorders is clearly harmful, amplifying the manifestations of schizophrenic alterations of the personality and thus preventing social and vocational rehabilitation. We would have to conclude from this that a course of aminazin therapy would be unsuitable, and that after arousal is curtailed, a switch must be made quickly to other neuroleptics having stronger selective and general antipsychotic action.

The main trait of preparations classified as piperazine derivatives of the phenothiazine series is presence of a stimulatory, activating element in their specifically psychotropic action. This manifests itself especially clearly in successive prescription of preparations with no break in the transition from aliphatic to piperazine derivatives.

Patients exhibit motor arousal, animation of facial expressions, activity, initiative, and a desire to act, and their emotional reactions become livelier, clearer, and more differentiated.

The individual properties of preparations in this group also differ significantly. Thus in terms of specifically psychotropic action, the stimulatory effect of

triftazine is less pronounced in comparison with other piperazine derivatives. It occurs in conjunction with distinct selective antipsychotic action, directed mainly against hallucinatory, hallucinatory-delirious, and delirious syndromes, which predetermines the specific psychotropic activity of the preparation. Therefore triftazin does not usually elicit a direct sedative effect. Its effect upon affective disturbances and arousal manifests itself only when the particular syndromes involved are directly associated with hallucinatory-paranoid phenomena, and if their reverse development begins with a decline in the intensity of hallucinations and delirium.

The stimulatory properties of the specifically psychotropic action of mayeptil are more strongly pronounced than those of triftazin, manifesting themselves as disinhibition, maliciousness, and sometimes euphoria. While it does not have selective antipsychotic influence upon specific psychopathological syndromes, mayeptil does have its strongest general antipsychotic action upon the clinical pattern of psychosis in general, often promoting a break in its course.

While possessing the general properties of their group, ethaperazine and similarly structured frenolon differ significantly from triftazin, metarazine, and mayeptil. The stimulatory influence associated with their specifically psychotropic action is not only significantly more pronounced than that of other piperazine derivatives, but it also combines with a typical thymoleptic (ethaperazine) and thymoanaleptic (frenolon) influence, which reflects itself in the spectrums of their psychotropic activity.

The general antipsychotic action of ethaperazine is more strongly pronounced than that of frenolon while its thymoanaleptic effect is less pronounced, owing to which it has a deeper influence in the presence of, for example, hallucinatory-delirious syndromes, especially ones occurring together with depression.

This mutual dependence between the psychopharmacological properties of the preparations and the spectrum of their psychotropic activity is applicable not only to phenothiazine derivatives but also to neuroleptic drugs of other chemical groups. Thus in the thioxanthene derivative group, chlorprothixene differs from sordinol, which has a piperazine ring in its side chain, in approximately the same way as aliphatic derivatives differ from piperazine derivatives of the phenothiazines. Preparations of the butyrophenone series have an even more pronounced stimulatory component in their specifically psychotropic action than do piperazine derivatives of the phenothiazine series, which is consistent with the greater depth of their elective and general antipsychotic action; at the same time, from the point of view of sedative effect and direct influence upon affect, they are inferior even to aliphatic derivatives.

In addition to having these general group qualities, haloperidol is typified by maximum expression of stimulation among its individual, specifically psychotropic properties; this is especially true of its motor component; however, its thymoanaleptic influence is not as great as that of frenolon and ethaperazine; but on the other hand its thymoanaleptic effect is devoid of the dysphoric action inherent to mayeptil, instead producing a positive mood background.

The psychopharmacological properties of a preparation correlate with the expressiveness of its general and especially of its selective antipsychotic action, oriented mainly at relieving hallucinatory and delirious disturbances.

The specifically psychotropic action of trisedil combines the characteristics of haloperidol and mayeptil: activation coupled with dominance of the motor component, and disinhibition coupled with dysphoria. The uniqueness of the preparation's psychotropic activity expresses itself when it is combined with the properties of haloperidol (its influence upon delirium and hallucinations) and mayeptil (its breaking action, its influence upon deficient symptoms and catatonic-hebephrenic disorders), which raises its effectiveness in the presence of a chronic, unfavorable disease course.

Summarizing the above, we can note that the series of neuroleptic drugs exhibits several trends: an increasing order of general antipsychotic action--aminazin, meterazine, trisedil, mayeptil; an increasing order of selective antipsychotic influence--aminazin, triftazin, haloperidol, trisedil; sedative properties--aminazin, tizertsin; stimulatory action with a thymoanaleptic component--meterazine, ethaperazine, frenolon.

All of these patterns of clinical action are typical not only of psycholeptic but also psychoanaleptic drugs. The specifically psychotropic properties of the representatives of this class of compounds are also the product of specific components, the main one being thymoanaleptic influence (corresponding to the antipsychotic effect of neuroleptics), which combines to different extents with the stimulatory or, on the other hand, the inhibitory component. Owing to this each preparation assumes an individual profile of psychopharmacological properties and, consequently, an individual spectrum of psychotropic action. Thus in terms of specifically psychotropic properties, melipramin has a distinct capability for elevating mood, which combines with less-pronounced activation; this corresponds to its maximal thymoanaleptic activity (in comparison with other antidepressants), and therefore its maximum effectiveness against the most typical endogenous, vital depressions coupled with inhibition. On the other hand the sedative component dominates in amitriptyline, which has antidepressant action equal to that of melipramin; this makes it especially effective against anxious-depressive states. In opposition to this, the stimulatory effect is sharply pronounced in the specifically psychotropic action of MAO inhibitors (nuredal), and it dominates over the thymoanaleptic effect, in connection with which the therapeutic impact of such drugs is most distinct in the presence of submelancholic states proceeding in conjunction with inhibition. Similarly, there is a clear relationship between inhibitory and euphoric influence in the specifically psychotropic properties of amitriptyline and its selective effectiveness against anxious-depressive states and other depressive syndromes combining with productive psychopathological symptoms; owing to this, the latter do not become aggravated, as sometimes happens with the use of MAO inhibitors, experiencing reduction instead.

Similar dependencies may be observed in the use of tranquilizers, which also vary in their specifically psychotropic influence. Thus the action of meprotan is dominated by its sedative, inhibitory component, as a consequence of which it exhibits more-pronounced psychotropic action in relation to neurotic and neurosis-like syndromes proceeding in conjunction with irritability and heightened excitability. In opposition to this, the combination of sedative and activating influence seen in trioxazine and seduxen corresponds to their greater tropism in relation to neurotic syndromes proceeding in conjunction with lethargy, inhibition, and submelancholic mood.

Only a few preparations were presented here as examples simply to demonstrate the basic patterns in the action of psychotropic drugs; descriptions of greater detail can be found in the appropriate sections of this book.

The present stage in the development of psychopharmacotherapy is typified by an ever-increasing assortment of psychotropic drugs, including original preparations created in this country. This demands constant improvement of the forms and methods of psychopharmacotherapy, and elimination of the stereotypic approach to therapy still encountered here and there, expressing itself as lengthy use of the same preparations in standard doses without a consideration for the changes occurring in the state of the patients or, on the other hand, groundless transitions from certain preparations to others before all of their therapeutic possibilities are exhausted.

In the final analysis, the success of therapy depends on the clinical and psychopharmacological qualifications of the physician and his ability to correctly analyze changes occurring in the clinical pattern and in the course of psychosis during treatment, and promptly stimulate favorable trends or break negative ones.

Thus, for example, one of the typical traits of the pathomorphosis of psychoses today is a sharp increase in the number of depressive states, which often have an atypical, diffuse, "masked" nature. This is usually associated with certain transformation of the clinical pattern of psychosis in response to prolonged neuroleptic therapy. The preferred neuroleptics used against productive psychopathological symptoms are unable to influence depression; they in a sense "filter out" the clinical pattern, as a result of which depression assumes the forefront, defining the state of the patient.

On the other hand such modifications in the clinical pattern mean an improved prognosis, inasmuch as the arisal and amplification of affective disorders is usually accompanied by a transition from a chronic course to a sporadic course in which times of longer and deeper remission are possible; on the other hand an opposite tendency may reveal itself--the duration of the attacks may become longer; in this case depression in a sense blocks the remaining psychopathological symptoms or, assuming the forefront, it dominates the state of the patient, preventing complete recovery and making social and vocational rehabilitation impossible. Such protracted cases of depression are frequently diagnosed as manifestations of a schizophrenic defect. Experience has shown that such states can easily be diagnosed in the clinic. Certain criteria are an aid in such diagnosis, one being the patient's own sense of a change having occurred (in distinction from the situation with apathoabulic disturbances existing as manifestations of schizoprenic alterations of the personality). The patients themselves complain of their lethargy, inactivity, lack of initiative, subdued mood, estrangement, and so on, and they seek help and support. Revelation of the elements of mental anesthesia and daily variations in affect are no less important.

Such changes in states, which are encountered so frequently in practice, require timely addition of antidepressants to the therapeutic program, and primarily amitriptyline, sometimes in rather large doses; this often results in significant improvement of the patient's state.

There is another possibility of incomplete recovery from psychosis, also associated with the unique features of the clinical action of neuroleptic drugs used over a long

period of time. I am referring to the mildly pronounced, torpid, extrapyramidal side-effects, mainly of the parkinsonian type, which usually arise among patients exhibiting organic deficiency or a pathologically altered background. These disturbances, which are outwardly indistinct and which often express themselves as hypokinesia, as a mildly pronounced rise in muscle tone, and as light tremor of fingers on outstretched hands, attests to extrapyramidal insufficiency, which may block the action of neuroleptics and hinder reduction of mildly pronounced but stable psychopathological symptoms. In these cases, this insufficiency is typified by the dominance of a diffuse pattern that may consist of the most diverse symptoms. Usually representing the rudimentary manifestations of previous psychosis, as a rule it is often accompanied, and frequently overshadowed, by general inhibition, lethargy, passiveness, hypochondriasis, and, on occasion, senesthopathy. Submelancholic mood is highly typical of such cases.

Being manifestations of medicinal pathomorphosis of psychoses, these and many other states representing incomplete recovery from psychosis are, in my opinion, one of the most important problems of clinical and practical psychiatry, considering their very high incidence and diversity. These patients often fail to attract the active attention of psychiatrists, especially in outpatient practice, they receive standard doses of neuroleptics in a course of maintenance therapy, and they remain unemployable. A certain neuroleptic drug is often prescribed to a patient "for preventive purposes", "just in case", and so on.

Such an approach could hardly be thought of as suitable, inasmuch as there must be substantiated indications for all medicinal therapy.

All of this requires persistent attention toward this sizeable category of patients, clinical study and classification of the disease, and development of methods for preventing and treating it.

Consequently considering the present state of our knowledge and the experience accumulated in clinical psychopharmacotherapy, we can assert that in addition to expanding and intensifying psychopharmacotherapy, we must also consider establishing another trend--sensibly restricting medicinal therapy when its therapeutic possibilities are exhausted. This pertains to lengthy use of neuroleptics, which promotes reduction of the acuity of the patient's condition and a transition to a more sluggish course, not only reducing the acuity of the psychopathological symptoms but also sometimes imparting permanence to some disturbances; thus we witness a general tendency of incomplete recovery from psychosis coupled with the arisal of monotonous, unique states lasting over a long period of time, ones which may be described as follows, paraphrasing Mauts' well known definition: "The psychosis is no longer, but remission is still to come."

Thus the notion that lengthy, sometimes perennial maintenance therapy with neuroleptics is necessary requires reexamination. Such therapy must be limited mainly to progressive forms of chronic schizophrenia--nuclear and paranoid, and only when the disease is obviously progressive, when productive psychopathological symptoms exhibit a tendency for expansion and complication. But even in these cases, therapy must be maximally intense, diverse, and individualized (growing doses of the preparation, substitution of neuroleptics, their combination with one another, their combination with antidepressants, alternation with courses of insulin therapy and EST, biological stimulation methods, and so on).

It should be considered that even these forms often acquire an attack-like course in modern psychopharmacotherapeutic practice. The possibility of remissions has become a reality even in cases of rather malignant juvenile schizophrenia in response to intensive and clinically justified therapy. The structure of the attacks exhibits unique shifts coupled with amplification of depressive components sensitive to the use of high antidepressant doses; careful analysis may reveal this situation, for example, in some forms of catatonic stupor, verbal hallucinosis, and so on. In contrast to this, a shift in the direction of a maniacal state coupled with more-natural behavior, reduced artificiality, normalization of facial expressions, and a reduction of "nonhuman" playfulness may be observed in the structure of some forms of stable hebephrenic arousal. A similar transformation may be observed in unfavorably proceeding paranoid and paraphrenic states, which must be caught in time.

But if no changes in the therapeutic tactics produce the desired results, doubt is cast over the suitability of prolonged neuroleptic therapy. A monotonous, unchanging clinical pattern lasting several months and absence of any sort of pronounced improvement in response to an increase in the doses, substitution of the neuroleptic, or addition of an antidepressant raises the question of at least temporarily withdrawing the neuroleptic, which often leads to noticeable improvement in the patient's state. If in some cases aggravation does occur, this "zig-zag" does make sense as a means for surmounting resistance to neuroleptics.

This also pertains to treatment of protracted depression with antidepressants. Also promising is the method of withdrawing psychotropic drugs suddenly and abruptly--completely withdrawing the preparations after first raising their dosages to the maximum. Retrospective study of patients experiencing improvement revealed that in the past, most exhibited a tendency for an attack-like course coupled with more or less pronounced affective disturbances. And it was only as a result of unjustifiably prolonged neuroleptic therapy that the tendency for remission faded away.

These and a large number of other clinical questions signify a new stage in deeper study of the patterns of prolonged psychopharmacotherapy, about which there is still much to learn.

I have dwelled on just a few of these problems in order to once again emphasize the complexity of the large number of problems arising in the treatment of each individual patient, and thus to substantiate the need for maximally individualizing therapy and surmounting all stereotypy. Therefore we naturally cannot claim to have illuminated all aspects of therapeutic tactics in this handbook; nevertheless the information it contains may serve as a basis for sensible, clinically justified therapy.

Basic Objectives in Pharmacotherapy of Mental Diseases

In the 20 years of its existence, psychopharmacotherapy gained a firm foothold in medical practice and now occupies one of the leading places in the treatment of nervous and mental diseases. Characterized by relative simplicity and safety of application, and combining general and selective action upon psychoses, psychotropic drugs have not only noticeably raised the effectiveness of therapy, but they have also made outpatient therapy much more possible, which has dramatically expanded the volume of psychiatric care.

Many forms and stages of mental diseases which required hospitalization before are now being treated successfully in psychoneurological dispensaries. This has especially important significance, since it makes an extensive, continuous program of medicinal, social, vocational, and rehabilitational influence possible. In this case each form of therapy potentiates the others, which doubtlessly raises the overall effectiveness of therapy.

Medicinal pathomorphosis of psychoses observed in recent years has led to a significant increase in the number of nonpsychotic states coupled with dominant neurosis-like states, psychopathy-like states, reduced hallucinatory-delirious states, different variants of depressive states, and others. In the overwhelming majority of cases, such patients remain outside the hospital, and they present a new and rather serious clinical, therapeutic, and social-vocational problem.

As a consequence we observe significant growth in the role of outpatient psychoneurological institutions, which must not only conduct maintenance therapy (that is, maintain the results of therapy achieved in the hospital), but also organize integrated, clinically justified treatment of this group of patients. Experience shows that the overall effectiveness of therapy rises significantly when outpatient care is expanded, when real continuity exists between hospital and dispensary care, when the outpatient stage of psychopharamacotherapy is viewed as being no less important than treatment inside the hospital, and when the patient is subjected to active, clinically differentiated treatment in conjunction with all measures of social and vocational readaptation.

This pertains mainly to prevention of recidivism and rehospitalization. In addition to an improved course of psychosis, an increase in the number of rehospitalizations has been noted in connection with the extensive use of psychotropic drugs. This is associated with changes in the clinical pattern and course of psychoses involving a shift from chronic to attack-like disease, making remission possible in patients who had formerly been kept in hospitals for long periods of time. At the same time these episodes of remission, especially ones arising in the course of chronic, progressive forms of schizophrenia, are typified by a certain degree of "adaptation" to the preparation being employed, and the length of such remission is associated with the quality of outpatient care. Fluctuations in state that arise in this connection (for example, a certain degree of actualization of delirium and hallucinations, intensification of depression, and so on) cannot always be interpreted as relapses, since they are often quickly curtailed by insignificantly raising the dose of the preparation, or by adding other drugs. However, the section physician-psychiatrist often makes no attempt to correct the patient's state in outpatient conditions, instead sending him to the hospital, where the same measures are implemented anyway; but the very fact of hospitalization causes a break in social and vocational adaptation, fills up expensive bed space, and worsens the overall results of therapy. And on the other hand, when a relapse is curtailed in a dispensary, the patient's presence in his accustomed environment--at work, in the family--results in quicker improvement of his condition, and further stabilization of remission.

It stands to reason that it is not easy to solve all clinical problems by dispensary treatment in all cases; however, the occasionally encountered practice of automatically sending patients to the hospital should be abandoned. This would require, first

of all, improvement of the knowledge of clinical psychiatry and psychopharmacology possessed by physicians employed in outpatient psychiatric institutions.

In recent years the psychopharmacology division of the RSFSR Ministry of Health Scientific Research Institute of Psychiatry in Moscow has done a great deal of work to improve the psychopharmacological skills of physicians through annual seminars in Moscow and other cities. Information bulletins and methodological publications, including this book, serve this purpose as well.

A mandatory prerequisite of raising the quality of therapy is further consolidation of the ties and continuity in the work of hospitals and dispensaries. In particular, medical information on patients being released from the hospital must be documented promptly, and the data must be complete. As a rule, the medical history contains a rather full description of the development of disease, the patient's somatic and mental status, and so on, but the dynamics of the patient's state in response to psychopharmacological influence and, most importantly, recommendations on outpatient therapy and rehabilitation are absent. And yet this is precisely the information that could help the dispensary physician to insure real continuity in the patient's subsequent treatment. It would seem to be suitable to expand the concluding part of the medical history with a detailed indication of the medicinal and rehabilitation measures necessary for stabilization of remission, and the particular therapeutic tactics to be employed in the event of aggravation.

In this connection, mention should be made of the tendency still witnessed in some hospitals for reducing the doses of psychotropic drugs to a minimum prior to the patient's release, a practice associated with previously existing directives which overstated the danger of side-effects outside the hospital and of other phenomena. This problem has now been studied and illuminated rather fully. Groundless mandatory reduction of dosage, especially in the presence of progressive psychoses, in connection with which a rather high level of clinical and social compensation persists with the use of relatively high doses of neuroleptics, invariably leads to a worsening of the patient's state, and a greater danger of a relapse following release.

No less important is the need for reexamining the commonly accepted criteria for establishing disability. In a significant number of cases, changes in clinical pattern arising in response to intensive psychopharmacotherapy are such that despite presence of residual psychopathological disorders--the ones which are no longer important and which do not dominate the behavior of patients--such patients not only can but also must work, since work is a powerful factor of further clinical and social-vocational compensation. Unjustified estrangement of patients from work diminishes the results of medicinal therapy and creates a real threat of recidivism.

Among the organizational problems, that of maintaining a regular supply of psychotropic drugs is important. Their assortment increased significantly in recent years, and industry has started producing original domestic preparations that are not inferior in their effectiveness to foreign preparations.

A major role in this complex work belongs to executives of local psychiatric institutions and pharmaceutical administrations. The USSR Ministry of Health has published methodological recommendations, which have doubtlessly played a positive role in improving the organization of requests for and supply of medicines.

The task now is to make sure that the quantity and assortment of preparations really necessary for complete therapy are really accounted for in the orders submitted. A tendency of excessively broad use of traditional preparations at the expense of new, improved ones has been noted in recent times. Thus owing to the use of other, more-powerful neuroleptics (triftazin, haloperidol, and so on), aminazin has lost much of its significance in long-term therapy, and it is now being used mainly to curtail psychomotor arisal of varying genesis, in relation to which it is more effective, as is true for tizertsin as well. In connection with the phenomena of lethargy, inhibition, and emotional indifference it elicits, prolonged use of aminazin often intensifies passiveness (for example among schizophrenics), hindering social and vocational readaptation of patients. At the same time, due to the weakness of its general and selective antipsychotic action, prolonged and groundless use of aminazin prevents prescription of more-powerful neuroleptics, and thus reduces the effectiveness of therapy.

The physician should also be cautioned against becoming carried away with new "fashionable" preparations, which are often prescribed not so much on the basis of clinical indications as due to a desire to display one's erudition. What extensive experience in psychopharmacotherapy really shows is that there are no good or bad, or weak or strong preparations, that instead there are preparations which are most effective against a concrete state at a given moment in relation to a given, concrete patient--that is, therapy must be based on strictly substantiated clinical indications.

I have only been able to touch upon some organizational problems in modern treatment of mental diseases which appear most important from my point of view. The solutions to many of these problems are still far away, and further work is required. This handbook, the materials of which reflect many years of work by the psychopharmacological center of the USSR Ministry of Health, supported by the RFSFR Ministry of Health Scientific Research Institute of Psychiatry in Moscow, was written with the purpose of broadening the psychopharmacological knowledge of physicians, helping them conduct clinically differentiated therapy, and thus promoting improvement of its effectiveness.

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INDIVIDUAL DISTINCTIONS OF HUMAN MEMORY (PSYCHOPHYSIOLOGICAL STUDY)

Moscow INDIVIDUAL'NYYE OSOBENNOSTI PAMYATI CHELOVEKA (PSIKHOFIZIOLOGICHESKOYE ISSLEDOVANIYE) in Russian 1980 (signed to press 18 Nov 80) pp 2-4, 151

[Annotation, foreword and table of contents from book "Individual Distinctions of Human Memory (Psychophysiological Study)", by E. A. Golubeva, Scientific Research Institute of General and Pedagogic Psychology, USSR Academy of Pedagogic Sciences, Izdatel'stvo "Pedagogika", 14,000 copies, 152 pages, illustrated]

[Text] This monograph submits new experimental data on problems of individual differences; there are descriptions of bioelectrical parameters by means of which stable distinctions of brain function are determined in adolescents and adults. Electroencephalographic methods are proposed for defining the different properties of the nervous system characterizing the modern level of research. The EEG parameters are compared to memory.

This book offers scientific substantiation of the need to consider individual psychophysiological differences when dealing with the distinctions of memory, its optimization in the course of learning and work.

It is intended for scientific workers in the fields of psychology, psychophysiology, physiology and pedagogics.

Foreword

Dedicated to the noble friendship and bright memory of Anatoliy Aleksandrovich Smirnov and Boris Mikhaylovich Teplov.

With all the diversity of theoretical and experimental studies dealing with the disclosure of cerebral mechanisms of mnemic function, there are very few publications concerned with the problem of the innate conditions of individual differences in human memory.

Yet the importance of working in this direction in the concepts of reflex theory of I. P. Pavlov and his typological conception had been stressed by B. M. Teplov as far back as the 1950's. Indeed, probably more than from any other mental function, we could have "expected" consistent relations to the stable characteristics

of higher nervous activity. This ensued primarily from the elements in common in physiological mechanisms of conditioned reflexes and association: "... a temporary association is the most universal physiological phenomenon in the animal kingdom and in ourselves. At the same time, it is mental, what psychologists call association, be it the formation of connections of all sorts of actions, impressions, or letters, words and thoughts".[151, Vol 3, Bk 2, p 325]

But the results of the first experimental comparisons of productivity of memory to properties of the nervous system were rather negative. This could have been attributed in part to the lack of separation between the psychological concepts of memory and learning, but mainly to the absence of integral characteristics of typological properties that are more adequate for comparison to human memory, the systemic organization of which is demonstrable in both retaining information and processing it.

Use of the EEG makes it possible to obtain such characteristics. The most important feature of such methods is that they broaden the possibility of interpreting indicators referable to the properties of the nervous system, thanks to the use of the advances in allied sciences, including neurophysiology, modern physiology of higher nervous activity and neuropsychology. This, in turn, helps gain somewhat better understanding of the nature of the properties of the nervous system.

However, before comparing stable individual EEG features to memory, it was necessary to show that they can be used as indicators of nervous system properties, and for this purpose they had to be compared to previously studied nonbioelectrical parameters.

Since the 1960's (1961-1979) we have concentrated chiefly on the study of unconditioned reflex features of the EEG related to information processes--reactive potentials (mainly reactions of alteration of rhythm and its harmonic elements) as indicators of nervous system properties: strength, equilibrium and lability; the study of correlations between bioelectrical characteristics and some individual psychological distinctions of human memory. And the properties of the nervous system are considered as the innate conditions for individual psychological differences in mnemic function.

At the present time, bioelectrical studies have been deployed of the specially human types of higher nervous activity, their relation to properties common to man and animals, and the role of both in forming the individual distinctions of cognitive processes, including memory.

This study was conducted in the directions headed by Ye. I. Boyko, B. M. Teplov and V. D. Nebylitsyn.

The author wishes to express her profound gratitude to all comrades who participated in the work, as well as to A. A. Smirnov, N. S. Leytes, Ye. N. Sokolov, V. I. Rozhdestvenskaya and A. N. Sokolov, who were very helpful in the course of the study and in writing it up.

Contents

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ELECTROPHYSIOLOGICAL CORRELATES OF MUTUAL RELATIONSHIPS EXISTING BETWEEN DESYNCHRONIZING AND SYNCHRONIZING BRAIN STRUCTURES DURING SLEEP AND WAKEFULNESS

Leningrad FIZIOLOGICHESKIY ZHURNAL SSSR IMENI I. M. SECHENOVA in Russian Vol 67, No 3, Mar 81 pp 364-370

[Article by D. A. Romanov, Division of Cerebrovascular Pathology, Scientific Research Institute of Neurology and Psychiatry imeni B. P. Protopopov, Ukrainian SSR Ministry of Public Health]

[Text] The characteristics of the long positive wave (P-wave) arising in response to stimulation of the basal preoptic region are studied; the mutual relationships existing between the P-wave and some structures of the brain's desynchronizing and synchronizing systems during sleep and wakefulness are analyzed. It is demonstrated that as the subject falls asleep, the amplitude and duration of the P-wave in the mesencephalic reticular formation, the central nucleus of the thalamus, and the posterior hypothalamus increase. Correlation is revealed between the expressiveness of the P-wave in the hippocampus and the total duration of paradoxical sleep. In comparison with wakefulness, the P-wave in the midbrain reticular formation and the central nucleus of the thalamus is reduced in this stage. The results are discussed from the standpoint of the functional ambiguity of the preoptic P-wave. The validity of using this potential as a correlate of mutual relationships in the system regulating sleep and wakefulness is substantiated.

Key words: Basal preoptic area, positive wave, sleep and wakefulness.

The system regulating sleep and wakefulness includes a sizeable number of structurally distinct formations, mutual relationships between which may be established with the help of various techniques, to include those based on some electrophysiological phenomena. One of them is the long positive wave (P-wave), which arises in structures at the meso-diencephalic level in response to isolated stimulation of the basal preoptic area (4, 7, 9)--one of the components of the brain's sleep-inducing system (17). The P-wave reflects postsynaptic reversible inhibition of a neuron ensemble, and in this connection it can serve as one of the indicators of the orientation and intensity of the influences exerted by the basal preoptic

area. Thus it has been established that hyperpolarization processes occurring on cell membranes, involving a decline or total cessation of their spike activity, correlate with the P-wave (5, 9, 19). As this phenomenon proceeds, a reduction in auditory evoked potentials (9) and in the negative phase of the primary somatosensory thalamic response (2) is observed. The existing information affords the grounds for suggesting that the functional significance of the P-wave varies (4); however, a correlation between its dynamics and the level of wakefulness has been studied only in acute experiments, predominantly on preparations in which the brain stem is sectioned, and with the use of pharmacological agents. We therefore made it our purpose to clarify the unique features of a P-wave developing in response to stimulation of the basal preoptic area during natural sleep and wakefulness, as recorded from structures of the brain's activating and sleep-inducing systems.

Methods

Chronic experiments were performed on 13 cats weighing 2.2-3 kg. Surgical preparations were made under nembutal anesthesia. Monopolar constantan electrodes with a diameter of 50 μ were inserted, on the basis of stereotaxic coordinates (11), into the hippocampus (F+3; L5; H+6), the central nucleus of the thalamus (correspondingly +9; 1; +1), the mesencephalic reticular formation (+2; 4; -2), and the posterior hypothalamus (+9.5; 1.5; -4). A bipolar stimulatory electrode with an interelectrode distance of 0.5-1 mm was located in the basal preoptic area (+14.5; 3; -4), ipsilaterally in relation to the recording electrodes. Steel needle electrodes were used to record the EEG. An electromyogram was recorded with the help of a silver plate implanted into the neck muscles. A steel screw in the frontal bone served as the indifferent electrode.

The experiment was performed 5-7 days after the surgical wounds healed. The animal was in a partially soundproof box illuminated by diffuse light. Polygraphic recording, which was performed during daytime from 1000 to 1800 hours, was initiated after a day of adaptation to the experimental conditions. The levels of wakefulness and the stages of sleep were determined, in accordance with the classification suggested by Dement and Kleitman (10), on the basis of data from an electrocorticogram, a hippocampogram, and an EMG. At the appropriate periods of sleep and wakefulness, the basal preoptic area was stimulated by square pulses with a duration of 0.5-1 msec and an amplitude of 5-12 volts. Individual responses were superimposed on an oscillograph screen, and then averaged according to Yemel'yanov's method (1). In order to obtain fuller information on the configuration and latent time of the potentials, in a number of experiments the latter were subjected to computer averaging with a "Minsk-22" computer (using 16 responses or more). The animals were killed following the experiments. Direct current was fed into the brain through implanted electrodes with the goal of producing electrolytic labels. The brain was fixed in 10 percent formalin solution. The locations of the electrode tips were determined from cross sections.

The experimental materials, including data on the structure of sleep, were subjected to statistical treatment.

Research Results

Stimulation of the animal's basal preoptic area during calm wakefulness caused arisal of a long positive wave in all analyzed structures. In a number of cases it was preceded by a shorter negative wave (N-wave) (Figure 1). A P-wave developing in response to paired stimuli with an interval of up to 10 msec between individual stimuli always had an amplitude that was larger than the potential produced in response to single stimulation of the basal preoptic area; we used this feature to identify the P-wave (2, 8). The configuration and the amplitude and temporal characteristics of the N-wave, and of the P-wave following it, were sufficiently stable in relation to different animals. The deviations that did occur in the parameters may have been the product of later initiation of the P-wave, and an increase or, on the other hand, absence of the N-wave: In the latter case the response began with a positive deflection (Figure 2). Investigation of computer-averaged potentials showed that during calm wakefulness, the shortest latent time is observed with a P-wave developing in the posterior hypothalamus (58±1.8 msec), followed by the latent time of the P-wave in the central nucleus of the thalamus--67.8±2.0 msec, and in the mesencephalic reticular formation--70.5 ± 1.8 msec. It was only after 77.1 ± 2.2 msec that the P-wave in the hippocampus attained its maximum. The amplitude of the P-wave was found to be greatest in this structure as well (136 μv on the average). Differences in amplitude of the P-wave of the central nucleus of the thalamus and the mesencephalic reticular formation were insignificant (correspondingly 115 and 92 μv; $p > 0.05$). In a number of cases a positive potential was not recorded in the rear hypothalamus during wakefulness, despite development of an initial N-wave (Figure 3).

When the animal achieved sleep of medium depth (stage III, as classified in (10)), at which time the EEG was dominated by slow waves with an amplitude of 200-250 μv and a duration on the order of 250 msec, occupying up to 50 percent of the duration of the period of analysis, stimulation of the basal preoptic areas by stimuli of the previous intensity and duration was resumed. In rare cases the animal reacted to the applied stimulus by jerking its head, without awakening. The increase in amplitude and duration of the P-wave during stage III sleep in comparison with wakefulness was found to be significant in relation to all studied structures except the hippocampus (Figure 3). A correlation was revealed here between the orientation of the dynamics of the P-wave in the hippocampus during the time of slow sleep and the total duration of paradoxical sleep. Thus in animals for which the amplitude of the P-wave decreased during stage III, a significant decrease in the duration of the paradoxical stage of sleep was observed as well (an average of 2.2 percent of the total recording time), while according to the literature (18) and our data for most animals, its duration during daytime is 11 percent and higher. Reduction of fast sleep was combined with a 12.2 percent increase in the total wakefulness time; meanwhile, the duration of the remaining stages of sleep changed insignificantly.

In stage III sleep, especially pronounced changes in the P-wave were detected with electrodes implanted in the posterior hypothalamus, in which the amplitude of this potential more than doubled, attaining 100-180 μv. The duration of the P-wave in this structure increased from 32 to 100 msec. The characteristics of the N-wave in stage III hardly changed at all (see table).

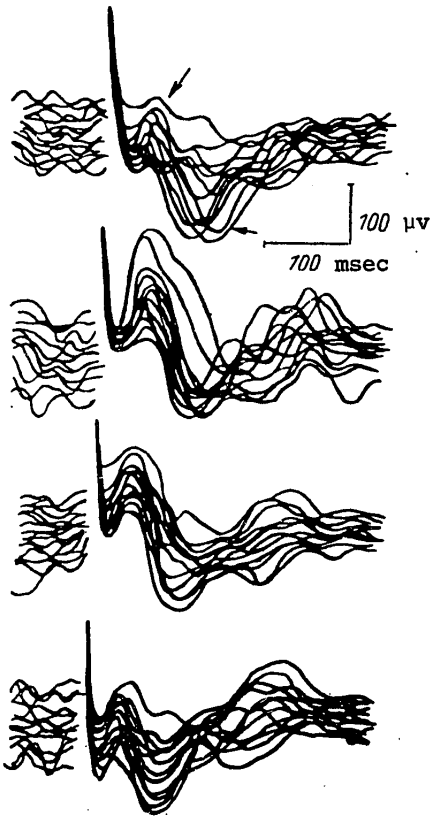

Figure 1. P-Wave Elicited by Single Stimulation of the Basal Preoptic Area During Calm Wakefulness: Points of contact (from top down): hippocampus, central nucleus of the thalamus, mesencephalic reticular formation, posterior hypothalamus. Downward deflection of the beam indicates a positive signal. Arrows indicate N- and P-waves.

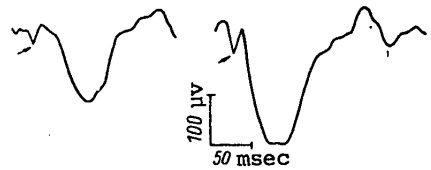

Figure 2. P-Wave of Preoptic Genesis in the Central Nucleus of the Thalamus (Left) and Posterior Hypothalamus (Right): Computer average of 16 single responses. Arrow indicates stimulation artifact

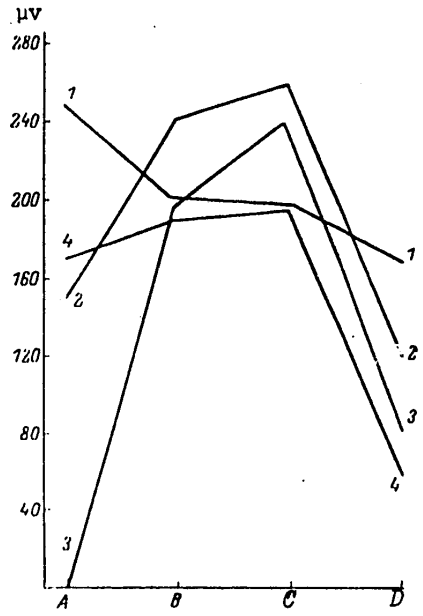

Figure 3. Dynamics of the Amplitude of a P-Wave Developing in Response to Stimulation of the Basal Preoptic Area During Sleep and Wakefulness (Cat No 22): *A*--wakefulness, *B*--sleep of medium depth, *C*--δ-sleep, *D*--paradoxical sleep; *1*--amplitude of the P-wave in the hippocampus, *2*--in the central thalamic nucleus, *3*--in the posterior hypothalamus, *4*--in the mesencephalic reticular formation

The transition to δ-sleep (stage IV), in which waves with an amplitude above 250 μv and a duration from 300 to 800 msec began to dominate, was typified by further significant increase in the P-wave. In some cases its amplitude reached 200 μv in the central thalamic nucleus, 200 μv in the mesencephalic reticular formation, and 240 μv in the posterior hypothalamus. The amplitude of the P-wave was reduced even in this stage among animals experiencing paradoxical sleep of shorter duration. In all studied structures, the amplitude of the N-wave increased somewhat, but the duration of the N-wave decreased significantly only in the posterior hypothalamus, as was true for the P-wave.

Onset of paradoxical sleep, which was deduced from a sharp drop in the amplitude of the EMG recorded from neck muscles, from desynchronization of the electrocorticogram at all points of contact, and from arisal of a θ-rhythm in the hippocampus and, in a number of cases, in the mesencephalic reticular formation, was accompanied by further change in the characteristics of the recorded potentials. This change included a decrease in both the amplitude and the duration of the P-wave in comparison with responses recorded during slow sleep. Only a reduction in amplitude was typical of the N-wave. It would be interesting to compare the response parameters for the fast

Parameters of the P- and N-Waves of the Potential Evoked by Single Stimulation of the Basal Preoptic Area During Sleep and Wakefulness

(1) Параметры	(2) Гиппокамп		(5) Срединный центр таламуса	
	амплитуда (3)	длительность (4)	амплитуда	длительность
		Р-волна (6)		
1	136 (100—250)	85 (60—120)	115 (60—150)	80 (60—100)
2	158 (120—200)	116 (50—200)*	153 (100—240)**	115 (75—160)*
3	180 (120—200)*	120 (80—180)*	192 (120—260)**	120 (85—180)*
4	116 (70—160)	90 (50—160)	78 (45—120)*	66 (40—80)*
		N-волна (7)		
1	100 (50—170)	22 (18—28)	106 (60—180)	31 (24—40)
2	122 (50—190)	30 (20—52)	109 (80—190)	31 (24—40)
3	129 (70—186)*	28 (18—34)	136 (90—235)*	29 (23—31)
4	64 (50—81)*	20 (18—22)	75 (38—163)*	30 (16—54)

(1) Параметры	(8) Мезенцефалическая ретикулярная формация		(9) задний гипоталамус	
	амплитуда	длительность	амплитуда	длительность
		Р-волна		
1	92 (60—170)	76 (50—110)	66 (0—150)	32 (0—60)
2	119 (80—190)**	104 (60—170)*	151 (100—180)**	100 (65—170)**
3	153 (120—200)**	104 (50—180)*	192 (140—240)**	112 (70—190)**
4	28 (0—60)**	56 (0—120)**	60 (0—120)	56 (0—80)
		N-волна		
1	107 (60—180)	26 (18—30)	144 (40—280)	28 (17—52)
2	113 (60—192)	27 (20—35)	156 (60—320)	31 (18—59)
3	149 (80—273)*	28 (25—31)	217 (80—360)*	39 (18—80)*
4	53 (0—80)*	16 (0—25)*	134 (30—280)	28 (18—51)

Note: The parameters of the P- and N-waves in each of the stages of sleep are compared with the same in the period of wakefulness; a single asterisk denotes changes with a probability of 0.05, and two asterisks indicate a probability of 0.01; 1--potential parameters during wakefulness, 2--during sleep of medium depth, 3--during δ-sleep, 4--during paradoxical sleep.

Key:
1. Parameters
2. Hippocampus
3. Amplitude
4. Duration
5. Central thalamic nucleus
6. P-wave
7. N-wave
8. Mesencephalic reticular formation
9. Posterior hypothalamus

sleep phase with waves observed during wakefulness. In this case the differences in the characteristics of the P-wave recorded from the hippocampus and posterior hypothalamus are insignificant. The only thing that attracts attention is the great stability of the responses in these structures. At the same time the amplitude of the P-wave in the central thalamic nucleus decreases by an average of 37 μv (32 percent), while its duration drops by 14 msec (18 percent). Even more significant are changes in the parameters of the P-wave in the mesencephalic reticular formation: Its amplitude drops by an average of 64 μv (70 percent), and its duration decreases by 30 msec (26 percent). In some cases as with the N-wave, the P-wave is not recorded in the mesencephalic reticular formation during paradoxical sleep.

Discussion of Results

The results show that changes in parameters of the P-wave originating in the preoptic area during the sleep-wakefulness cycle may reflect, to a certain extent, interaction of the basal preoptic area with structures of the sleep-inducing and activating systems of the brain, within which this wave arises. In this case we are able to reveal differences in the expressiveness and orientation of the influences exerted by the basal preoptic area during wakefulness and in each stage of sleep. Thus the low P-wave amplitude we discovered in the posterior hypothalamus during wakefulness and its increase as sleep develops can be explained by our present ideas about the reciprocal mutual relations existing between the desynchronizing machinery of the posterior hypothalamus and the sleep-inducing area of the forebrain (3). At the same time, the absence of significant changes in the N-wave, which represents arisal of an excitation at the recording point (5), attests to continued transmission of impulses from the basal preoptic area into the posterior hypothalamus, which in all probability indicates not only the dominance of the activity of its desynchronizing mechanisms, but also a decrease in their reactivity to the inhibitory influences of the basal preoptic area.

The similarity of the characteristics of the P-wave recorded from the posterior hypothalamus during wakefulness and paradoxical sleep presupposes a certain degree of sameness of mechanisms responsible for formation of this potential in these states, based in particular on the increase in activity of desynchronizing components in the brain. However, judging from the dynamics of the parameters of the P-wave in the mesencephalic reticular formation, the activity of its components differs in wakefulness and in paradoxical sleep. The amplitude and duration of the P-wave in the mesencephalic preoptic area are significantly reduced in this stage, while during wakefulness the P-wave is rather pronounced in this area. Therefore the impression is created that during paradoxical sleep, the mesencephalic reticular formation "slips away" from the inhibitory influences of the basal preoptic area, which may be explained by change in the orientation of forebrain influences, and by growth in the intrinsic activity of the mesencephalic reticular formation during this period. The latter apparently occurs in response to influences of the reticular nuclei of the pons (13), which also exists in competitive mutual relationships with the basal preoptic area, as was demonstrated in experiments in which neuron activity (14) and the P-wave (4) were recorded.

As in the mesencephalic reticular formation, reduction of the P-wave is observed during paradoxical sleep in comparison with wakefulness in the central thalamic

nucleus. The P-wave in this structure is known to be associated with reversible inhibition processes (8) lying at the basis of synchronization of the brain's electric activity (6); we are also aware of a relationship between desynchronization of the electrocorticogram in the period of fast sleep and suppression of the thalamocortical system in response to activation of the mesencephalic reticular formation (16). Therefore it seems probable that the high activity of its desynchronizing components exhibited in this stage of sleep limits the functions of thalamic synchronizing mechanisms even more, even in comparison with wakefulness.

The importance of hippocampal-preoptic-hypothalamic integration to modulation of paradoxical sleep (20) is confirmed by, in addition to the existing data on the similar disturbances occurring in this stage in response to isolated lesions of the basal preoptic area (15) or the hippocampus (12), the relationship established between the orientation of changes in the P-wave in the hippocampus and the total duration of paradoxical sleep. In this connection, and considering the fact that the dependence of the P-wave on fluctuations in the level of wakefulness or sleep is lower in the hippocampus than in other structures, we can hypothesize that the functional mutual relationships existing between the basal preoptic area and the hippocampus, one of the indicators of which is the P-wave, do not necessarily have an inhibitory or "stimulatory" nature.

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11004

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NEW BOOK SUBJECTS BRAIN-STRESS CORRELATES TO QUANTITATIVE ANALYSIS

Leningrad FIZIOLOGICHESKIY ZHURNAL SSSR IMENI I. M. SECHENOVA in Russian Vol 67, No 3, Mar 81 pp 473-474

[Review by V. G. Zilov of book "Korrelyatsionnyye pokazateli elektroentsefalogramm golovnogo mozga pri emotsional'nom stresse" (Brain EEG Correlation Indices in Emotional Stress), by A. M. Mamedov, Izd-vo ELM, Baku, 1979]

[Text] Doctor of Biological Sciences A. M. Mamedov's book is devoted to one of the important problems of neurophysiology and clinical medicine--intercentral mutual relationships existing among brain structures in the presence of emotional stresses.

Besides illuminating the concepts of domestic and foreign researchers on the mechanisms behind formation of emotions and development of emotional stress, in the first part of the book the author devoted his principal attention to analyzing cortico-subcortical cross correlations associated with formation of emotionally stressful states, the spatial-temporal organization of EEG potentials in cases of "signaling" and "nonsignaling" situations, and electrographic indicators recorded from the brain of animals predisposed to stress and resistant to stress. One of the chapters is devoted to an analysis of the statistical parameters of electroencephalograms recorded in response to different pharmacological substances--aminazin, phentanyl, and sombrevin.

The basic technique used by the author focuses the reader's attention on a typical feature of negative emotional stimuli--their capability for persisting for a long period of time in the central nervous system, even after cessation of the stimuli. It is emphasized that this feature, which has stabilization of excitations as its consequence, is the most dangerous to the organism. The author meticulously analyzes the dynamics of spatial-temporal cortico-subcortical mutual relationships of the brain with the correlation of autonomic indicators accompanying development of emotional stress. Data on the brain's pacemaker formations and their role in the formation of emotionally negative reactions are especially interesting. Correlation analysis of neurochemical mechanisms involving the use of a number of pharmacological agents exhibiting different orientations of action primarily demonstrated the complex integrated nature of stress reactions, revealing the important role played by the adrenergic system of the hypothalamoreticular complex in formation of emotionally stressful states.

Analysis of the conditions causing arisal of negative emotional excitations and of their transition to stable form demonstrated that besides physical factors, the purely informative characteristics of "conflict situations" play an important role in formation of an emotionally negative state.

The author persuasively shows that the degree of emotional stress depends on the amount of pragmatic information available--that is, information on the moment a painful "blow" is inflicted, permitting an animal in an experimental situation to prepare for the emotionally unpleasant stimulus in accordance with its formed acceptor of the results of action. The dynamics of autonomic indices and cross correlation analysis of electric activity recorded from cortico-subcortical formations confirmed that emotional arousal is significantly less pronounced in a "signaling" situation as a result of the animal's "prediction" of the moment of application of an emotionally unpleasant stimulus, than in a "nonsignaling" situation, in which the animal experiences a situation of uncertainty. It is precisely this sort of long-persisting situation of uncertainty that is the most dangerous to the human body as well.

A long-lasting conflict situation arising as a result of particular stressful influences produces an irreversible process, leading to formation of a new state in the brain, differing from normal, and typified by disturbed spatial-temporal mutual relationships between different structures of the brain. This brain state is accompanied by somato-autonomic disorders, which may be referred to as a "cerebrovisceral syndrome" of emotional stress.

The second part of the book examines some principles of the structure of automated systems intended for computer processing of biological information. Of special interest are systems in which a computer controls a complex experiment in real time, becoming an organic participant of the experiment. Such integrated systems, as follows from the review provided by the author, provide a framework for creating a single, optimally mated brain-computer complex in the future, one capable of effectively solving problems associated with the control of complex objects. Differences in the possibility computers and man have for solving complex problems are examined. Indicating the limited possibilities offered by mathematics and electronics in the creation of artificial intelligence in the full sense of this term, the author examines the question of using, in the future, integrated brain-computer systems in which the advantages of human intelligence would be united with the unique features of a computer.

A. M. Mamedov's book is doubtlessly timely and up to date. The results of his research, which was performed in its entirety with the assistance of a computer, and which involved the use of precise quantitative methods of analysis, broaden our present ideas about these mechanisms, and they provide indications of promising ways to conclusively solve the problems addressed.

11004
CSO: 1840/188

PSYCHOLOGY

EMOTIONS AND THOUGHT

Moscow EMOTSII I MYSHLENIYE in Russian 1980 (signed to press 29 Jan 80) pp 2-4, 192

[Annotation, foreword and table of contents from book "Emotions and Thought", by Igor' Aleksandrovich Vasil'yev, Valentin Leonidovich Popluzhnyy and Oleg Konstantinovich Tikhomirov, Izdatel'stvo Moskovskogo universiteta, 22,000 copies, 192 pages]

[Text] The authors of this collective monograph deal with the question of emotional regulation of thinking activity. An effort was made to consider the correlation between cognitive and emotional processes in the light of psychological systems analysis. In this regard, the role of emotional processes in goal setting and formation of meaning was demonstrated.

Foreword

This book sums up information about emotional regulation of thinking activity, and it describes some experimental psychological studies of the role of emotions in thinking. It so happened that thinking is most often investigated apart from a subject's motivations and emotions. With all the difference between theories of thinking as an analytical and synthetic process and the process of functioning of mental actions, they are united by the fact that psychological studies of thought do not include analysis of emotional processes. Also, psychology of emotions seldom includes fine analysis of a subject's cognitive acts. This did not happen by chance; it reflects the rift that exists in modern psychology between "cognitive psychology" and psychology of the personality.

Addition to psychology of the category of "object-related activity" makes it possible to overcome this rift and pose the question of emotional regulation of thought. In our opinion, formulation of such a question not only discloses new possibilities of productive analysis of thought and emotions, but permits development of general theory of activity.

In working on the problem of activity in psychology, questions of internal and, in particular, emotional regulation of activity, which is instrumental in its "self-advancement," "self-development," i.e., its creative nature, are the least studied. As a result, there is occasional incorrect equating of activity and its technical, operative components, absolutization of exogenous, "rigid" control of cognitive activity, i.e., ultimately "expulsion" of the subject from the activity he performs. As a result, not only is the actual conception of cognitive processes in man made poorer and it is more difficult to solve problems of practical importance, which

are related to education and upbringing, evaluation of the prospects of creating human intelligence in artificial systems, but grounds are provided for a critical attitude to the "activity-related" approach, as it is often called, in psychology.

In modern Soviet psychology, the "activity-related approach" is sometimes set against the "systems approach." In this regard, it must be noted that there may be at least three variants of the systems approach in modern psychology.

In the first place, it may refer to extension of principles of describing engineering systems to the area of psychological phenomena. Such a systems approach could result in a grossly mechanistic conception of man, viewed as a device that processes information in accordance with previously set algorithms.

In the second place, it could refer to efforts to interpret consciousness, activity and personality of man on the basis of physiological theory of a functional system. Such a systems approach results in underestimation of the qualitative uniqueness of man's conscious activity, as compared to organization of the behavioral act.

In the third place, it may refer to the study of mental phenomena in the system of human activities. Only this systems approach can be called actually psychological. We think that the contrasting of activity-related and systems approaches is based on a misunderstanding: "Activity is ... a system that has structure, its own internal transitions and transformations, its own development" [60, 82].

Psychology cannot be built by simply applying general system theory. The psychological systems approach should aid in gaining deeper knowledge of the nature of mental phenomena, patterns of their generation and function in man's real activities. This is the idea that we tried to apply to the specific area of research on emotional regulation of thinking activity.

Contents

10,657
CSO: 1840/999

PSYCHOLOGY IN PHYSICAL EDUCATION AND SPORTS

Moscow PSIKHOLOGIYA FIZICHESKOGO VOSPITANIYA I SPORTA in Russian 1979 (signed to press 11 Dec 79) pp 2-4, 143

[Annotation, introduction and table of contents from book "Psychology in Physical Education and Sports", edited by T. T. Dzhamgarov and A. Ts. Puni, Izdatel'stvo "Fizkul'tura i sport", 30,000 copies, 144 pages]

[Text] This manual is prepared for the use of pertinent psychological categories for students in physical culture institutions. It familiarizes future educators of physical education and sports with the subject, methods and current state of psychology in physical education and sports. It presents the psychological characteristics of sports activities, psychological problems related to training and education in physical education and sports and competition in sport and the socio-psychological aspects of physical education and sport activities.

All these relevant problems are examined in the light of current achievements in psychology, particularly sport psychology.

INTRODUCTION.

Education in psychology plays an important part in the training of physical culture cadres. It includes the study of general psychology, age-related psychology and the psychology of physical education and sports. General psychology is the basis for the students' psychology education, it provides them with information on the essence of the psyche--specifically arranged traits that reflect the objective world--on patterns of mental processes and the state and personality features of an individual as part of the socio-historical process. Age-related psychology reveals the pattern of ontogenetic mental development. The psychology of physical education and sports provides students with specific information on the psychological aspects of training, education and personal development during physical culture and sport activities, information on the psychological principles involved in training and competition in sports and the development of personality in a Soviet sportsman, as a citizen and subject equipped with special abilities that enable him to achieve a high level of proficiency in specific types of sports. The psychology course is intended for the professional and educational training of students who will be the future instructors of physical culture in the schools, and will teach physical education to trainers for various types of sports in the higher educational institutions.

This is the first manual that describes problems in physical education and sports that can be applied in the psychology program for students of physical culture institutes. Due to the small size of the manual, the reports on the investigated problems had to be brief. The reports on the psychology of physical education are printed in a limited form as they have not been fully developed yet. Most of the studies are linked to the psychology of sports.

Recently, another educational manual has been printed, entitled "The psychology of high achievement sports" edited by A. V. Rodionov. These two manuals will provide considerable help in the professional-educational preparation of students at a physical culture institute. The manual consists of six chapters.

Chapter 1 examines the topics of the subject on methods of psychology in physical education and sports and the importance of psychology as a component of higher hysical education. The chapter also contains a short outline on the development and current state of psychology in physical education and sports.

Chapter 2 deals with the psychological features of sport activities and discusses the following aspects: sport as one of the basic types of human activities, general psychological traits in sport activities, types of sport and competitive training and communication problems in sports.

Chapter 3 describes the problems of teaching and training, including the psychological principles involved in physical practice, tactical actions, personality development in physical education and sports and the psychological aspects of training of qualities of resoluteness.

Chapter 4 reports on the psychological aspects of competitive activities and of the psychological preparation of teams for contest, the level of emotional pre-contest stimulation and its regulation.

Chapter 5 deals with the topic of social psychology in physical education and sports. It includes the psychological meaning of terms like sport group, team, collective, management and leadership in sports, psychological climate and interpersonal relationships in the sport unit.

Chapter 6, the last chapter, examines the effect of stress on the mental condition of a person in physical training and in sports.

This manual has been assembled by the lecturers and scientific co-workers of the Department of Psychology of the P. F. Lesgaft Institute of Physical Culture of the Soviet Order of Lenin and of the Order of Red Star, and edited by professors T. T. Dzhamgarov and A. Ts. Puni.

Contributors: Docent D. Ya. Bogdanova, candidate of psychological sciences (chapter 5, 2.3); docent G. D. Gorbunov, candidate of psychological sciences (4.4; in collaboration with A. Ts. Puni - 6.1, 6.2, and 6.3); professor T. T. Dzhamgarov, doctor of psychological sciences (2.1, 2.2, 2.4, 2.5, 6.4); professor A. Ts. Puni, doctor of psychological sciences (chapter 1, 3.4, 4.1, 4.2, 4.3; in collaboration with E. N. Surkov, 3.1 and 3.2; in collaboration with

G. D. Gorbunov, 6.1, 6.2 and 6.3); docent B. N. Smirnov, candidate of educational sciences (3.3); E. N. Surkov, candidate of psychological sciences, senior scientific associate (3.1 and 3.2 in collaboration with A. Ts. Puni).

TABLE OF CONTENTS.

9680
CSO: 1840/1001

DEVELOPMENT OF PSYCHOLOGICAL SCIENCE AT THE PSYCHOLOGY DEPARTMENT OF MOSCOW UNIVERSITY

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 14: PSIKHOLOGIYA in Russian No 2, Apr-Jun 81 pp 3-9

[Article by A. A. Bodalev]

[Text] Documents examined and adopted by the 26th Congress of the Communist Party of the Soviet Union summarized the work of the Soviet people in the 10th Five-Year Plan and developed the plans for their forward motion in the immediate and more-remote future. These documents also deeply and thoroughly evaluated the work of Soviet scientists in the past five-year plan, and they clearly reflected the tasks to which Soviet science must subordinate its activity in the 11th Five-Year Plan. In the past five-year plan, psychologists of Moscow University participated actively and usefully in work on many problems of importance to our country; representatives of other areas of knowledge studying the laws and mechanisms defining the day-to-day life and activities of the individual and directly influencing all of his social characteristics were also encouraged to participate in scientific illumination of these problems, with a consideration for their specialties. Besides having general significance to science, the obtained results were a step forward in our understanding, from the positions of psychology, of the essence of formation of a number of human features characterizing man as an individual, his development as a personality, the problems of improving training and indoctrination, preparation for creative labor, raising the effectiveness of labor in different areas of the national economy, and preservation of the health of the Soviet individual.

The department illuminated the psychological mechanisms of both simpler and more-complex psychological phenomena, it traced the principal trends in formation of cognitive, emotional, and volitional spheres of the personality and their formation into an integral structure, it studied development of leanings and capabilities in the individual, "crystallization" of the core of the personality--the character, and the deviations in the general course of the personality's education, and it examined the personality as an object and a subject of learning, communication, and labor, all on the basis of the general psychological theory of activity, which was also the methodological foundation of all other studies performed by the department's scientists in 1976-1980.

Guiding themselves by this theory, into the creation of which A. N. Leont'yev invested a great deal of labor, interpreting the mind as a subjective reflection of

the objective world, something which develops in response to material, practical activity and supports this activity--activity which acquires the form of internal activity at the highest levels of its development and which basically has the same structure of external activity, the department's scientists conducted research on a broad spectrum of the most important problems of modern psychological science.

Research conducted in the 10th Five-Year Plan on color vision at the department under the guidance of Ye. N. Sokolov was of fundamental importance. A model of color vision capable of representing numerous shades of color on the surface of a sphere was successfully built and tested, and it was simultaneously demonstrated that the coordinate system of color vision consists of contrasting-color neurons (red-green, blue-yellow, and black-white). This research group also created an automated system for diagnosing color vision abnormalities with an on-line computer.

Working on the topic "Neuron Mechanisms of Memory and Learning", Ye. N. Sokolov and his colleagues studied the mechanism of neuron plasticity, and they demonstrated that the pacemaker mechanism, which exhibits endogenous plasticity, determines plasticity at the behavioral level, and that associative learning is an intracellular process of alteration of the reactivity of loci in the soma. It was also found that giant neurons may acquire additional integrative properties through independent generation of action potentials in individual axon branches.

Moreover this group developed a system for diagnosing the states of an individual, using objective electrophysiological indicators: the EEG, EKG, EMG, the rhythm assimilation reaction, and brain evoked potentials. In the course of its research, it found bioelectric correlates of different activation systems, interaction of which predetermines functional state. These experiments revealed the significance of individual human differences (extraversion-introversion, strength-weakness of nervous processes, etc.) to evaluation of the unique features of the EEG, EKG, and evoked potentials.

Research performed in the department in the last five-year plan by A. D. Logvinenko and his colleagues led to the creation of a theoretical model of psychophysical processes occurring in the human visual system; this model describes transformation of the visual image of a moving object. A given law of an object's motion is placed in correspondence with a linear operator describing changes experienced by the image in motion. This operator, interpreted in the language of three-dimensional frequencies, performs the function of a filter possessing certain characteristics, presence of which was confirmed through experimental study of recognition of moving images.

A. D. Logvinenko and his colleagues also developed the new concept of the informational spectrum of an image, and they experimentally studied the informational spectrum of a number of concrete images. Using the method of selective adaptation, they discovered the phenomenon of interaction between three-dimensional frequency channels in the human visual system, and they plotted the curves for interaction of these channels.

An extensive cycle of research devoted to the role of the motor system of the eyes in various tasks--perceptual, mental, motor, and so on--was completed under the guidance of Yu. B. Gippenreyter. The functions of eye movements, their place in

the structure of activity, and the mechanisms of their organization and control were studied in the course of this research; new, unique methods for evaluating visual process parameters such as the area of the operational visual field, stress, and voluntarism were created and successfully applied. A method for analyzing the structural units of activity was also developed. It was based on the idea of recording fixational opticokinetic nystagmus in association with perceptual, motor, and mental tasks, and recently the group successfully tested a new, more-sensitive and practically convenient procedure permitting solution of the same problems with the help of galvanic nystagmus.

Consistently relying upon the theory of activity being developed at the department, its scientists conducted research on the psychological mechanisms of goal-setting and of formation of the individual's motivations and needs, and the processes by which the individual masters social experience in the form of training and education.

It is namely from these positions that O. K. Tikhomirov and his colleagues completed research in the 10th Five-Year Plan which illuminated the basic forms of goal-setting and determined the conditions influencing the nature of formulated goals in intellectual activity, to include in problem solving involving the use of a computer in dialog mode. They also developed techniques for controlling goal-setting in a "dialog" with a computer, ones which broaden the possibilities for the individual's creativity, by way of increasing the total number of goals formulated and raising their originality. Studying the significance and place of unconscious mental phenomena in creativity, this same research group demonstrated that the range of unconscious phenomena traditionally studied in experimental psychology must be expanded by including unverbalized operational meanings.

In that same five-year plan, efforts were continued in a program initiated by A. N. Leont'yev to reveal the complex dependencies tying in the characteristics of activity in which an individual engages and the unique features in the development of his motivations--content, structure, dynamics, motive force, emotional valency, and so on (A. G. Asmolov, B. S. Bratus', V. K. Vilyunas, O. V. Ovchinnikova, V. V. Stolin, and others).

Also far-reaching and permeated by the principle of activity mediation was a cycle of research conducted at the department under the guidance of G. M. Andreyeva. It was demonstrated with great persuasiveness on the basis of materials describing many psychosocial phenomena observed among people involved in communications that the content and the structural and dynamic properties of these phenomena are governed predominantly not by the individual history of the communicating people, but rather by the nature and specific features of the social activity in which they engage. Using the example of analyzing interpersonal cognition, the researchers traced the relationship between such processes and the particular features of groups, intergroup relations, and social situations in which every personality finds itself every day.

Employing a system created and theoretically substantiated by P. Ya. Gal'perin, during the past five-year plan the department continued its planned formation, in the child and in the adult, of different types of cognitive activity having prescribed properties; concurrently, the relationship between the types of teaching and the course of a child's mental development were revealed, and the internal mechanisms responsible for development of a child's manifestations of mental activity

such as interiorization, combination, automation, and so on were discovered. Application of this method of directed development made it possible to develop highly generalized forms of attention in normal children and in children exhibiting retarded mental and speech development; it was also possible to develop the capacity of such children for systematic thinking when solving so-called "imagination problems".

The most significant factor characterizing the unceasing progress in Gal'perin's theory of planned formation of mental actions was the transition, clearly manifesting itself in this research, from study of the conditions and mechanisms governing formation of individual mental actions to investigation of systems of actions and different forms and types of real human activity. It is mainly in this context that in the past five-year plan, Gal'perin and his students scientifically illuminated the psychological conditions for formation of complex types of mental activity (using the example of some types of special activity), and the psychological mechanisms of combination. The procedure they developed turned out to be highly effective in solving the problems associated with nurturing high-precision and high-speed forms of special activity in ordinary and experimental conditions.

The system of methods created on the basis of the theory of planned formation was also used successfully in the past five-year plan to shape the thinking and speech of blind-and-dumb children, and in this case its application also made it possible to reveal a number of fundamental conditions predetermining the general course of mental development in the specific circumstances typical of the daily activities of a blind-and-dumb person.

Finally, in 1976-1980 Gal'perin's creatively working collective managed, on the basis of the theory of planned formation, to perform an encouraging search--were we to judge by the obtained results--for objective tools with which to diagnose human mental development and determine the real prospects of this development. Diagnosis of mental activity, performed on the basis of information accumulated by pedagogical psychologists and developing on the basis of the theory of planned formation, which provides a complete picture of the state of the form of activity under analysis and objectivizes its main characteristics, makes it possible to chart out, with maximum individualization, the course of further work with students serving as the subjects; as a rule this produces a high didactic impact.

Research aimed at revealing the psychological characteristics of instruction activity was continued in the past five-year plan under N. F. Talyzina's guidance. Following the general laws of knowledge assimilation, formation of this activity presupposes the conduct of such research in all stages typical of this process. The unique features of knowledge acquired through systemic orientation of students in their subject matter were described, and it was demonstrated that in this case, knowledge rises to the methodological level of generalization, bringing it closer to the modern theoretical form of scientific knowledge. Theoretical and experimental analysis aimed at clarifying the role played by other forms of activity in formation of usable knowledge was continued.

Research on mnemic activity, which has become traditional to this scientific group, was supplemented by investigation of the influence of long-term memory on short-term memory. Early forms of a child's memory were subjected to special analysis, and the conditions and stages of its development in joint objective and practical activity of a child and adult were revealed.

A system of differentiated indicators reflecting the level of an individual's moral consciousness and his preparedness to behave in accordance with consciously recognized norms was revealed by this scientific collective in the course of its effort to illuminate formation of the personality's moral qualities, and the psychological foundations of an individual's philosophy. Theoretical research was conducted concurrently on the conceptual apparatus required for systemic conceptualization of philosophical development, and the content of activity leading to successful orientation and deep assimilation of social values was determined. Moreover the scientific collective led by N. F. Talyzina received new data on a number of conditions promoting elevation of knowledge to the level of an individual's personal convictions.

Research aimed at clarifying the psychological conditions for raising the effectiveness of an individual's work with equipment, and at psychologically substantiating the ways for improving activity of the individual as a subject of different forms of labor occupied a significant place in the department's scientific efforts in 1976-1980. Under the guidance of V. P. Zinchenko, the department's engineering psychologists developed a conceptual scheme for functional-structural and microstructural analysis of control activity; this scheme was used as a basis for thoroughly studying the activity of an operator-manipulator, and developing experimental stands for movement analysis of fundamentally new design, and new variants of controls having no previous analogs.

The results of this research led to suggestion of an integrated variant of N. A. Bernshteyn's theory of movement structure and A. V. Zaporozhets' theory of movement development, and to resolution of the greatest conflict existing in modern habit psychology--the conflict between the theories of open and closed movement control loops. They concurrently demonstrated the quantum-wave nature of organization and implementation of a motor act, and presence of waves of psychological refraction in the spatial-temporal structure of a controlling action.

An extensive cycle of research was also conducted under V. P. Zinchenko's guidance on the topic "Theoretical and Methodological Principles of Planning the External and Internal Resources of Labor"; the processes studied included ones such as detection, information retrieval, short-term memorization, information selection, elementary logical transformations, preparation of information for problem solving, and so on. Methods of functional-structural and microstructural analysis of cognitive processes were developed and realistic ways of optimum planning of the internal resources of operator activity were outlined in the course of this research.

Working on a CEMA assignment in cooperation with other organizations, in 1976-1980 this scientific collective also conducted an extensive cycle of historic and theoretical-methodological research within the mainstream of the psychological theory of activity; the purpose of this research was to develop this theory, refine it, and determine its applications to the tasks of labor psychology, engineering psychology, and ergonomics.

During the 10th Five-Year Plan the department completed a series of studies having the purpose of neuropsychological analysis of psychological processes occurring in the presence of local brain injuries, and improvement of the system of rehabilitation of patients with such injuries. Recognition was subjected to experimental study in the course of this research (under the guidance of Ye. D. Khomskaya and L. S.

Tsvetkova). The research revealed the specifically mnemic element, the search element, and the decision making element. The rich phenomenology obtained in this case was analyzed from the standpoint of signal detection theory, and it was related to different brain structures with a consideration for the role of the left and right cerebral hemispheres in memory processes. Thus the group was able to establish that when the right hemisphere is injured, topological concepts are disturbed primarily, while with left-sided injuries disturbances in coordinate and projected concepts dominate. It was also revealed that space perception is supported not only by structures of just the right hemisphere (as is asserted by many researchers), but also by the joint work of both cerebral hemispheres, each of which makes its own specific contribution to the support of these processes.

In the course of this research, new methods for evaluating emotions and personality features were developed and tested successfully, and it was revealed that the right hemisphere is predominantly insusceptible to negative emotional influences, while the left is so to positive emotional influences. It was also determined that among patients having emotional and personality disorders, the influence of the emotional factor upon memorization and information processing is absent (or reduced).

A new, effective technique for evaluating the coherence of different bands of the EEG spectrum in the presence of intellectual tension was created in the course of psychophysiological investigation of disturbances in mental functions accompanying local brain injuries. This technique was used to demonstrate that when healthy people experience intellectual tension, dramatic growth occurs in the general interdependence of bioelectric processes. The local interdependence rises an especially great deal, in the form of an increase in the coherence of alpha and higher frequencies of the spectrum, predominantly in the frontal lobes. It was also revealed that the parameters of evoked potentials--mean amplitude, mean latent time, the extent of interhemispheric asymmetry recorded in the anterior divisions of the brain--reflect the emotional content of stimuli.

Concurrently the department's neuropsychologists developed and successfully tested new verbal and nonverbal methods of group therapy for patients with local brain injuries, and they created a standardized system of methods for objectively evaluating the dynamics of development of descriptive thinking in the presence of speech disturbances accompanying aphasia. An especially great deal of attention was devoted in the 10th Five-Year Plan to the psychosocial aspect of rehabilitation training, and to formulation of objective criteria for evaluating the effectiveness of this training.

Promising research was conducted at the department under B. V. Zeygarnik's guidance in the area of pathopsychology. The methodological tools of qualitative and quantitative evaluation of different parameters of goal formation were created. They were used to reveal the specific ways different groups of mental patients form end and intermediate goals, in comparison with normal people. Methods aimed at revealing motivational disorders in different types of patients were developed and tested, and the prognostic value of these methods was increased just as purposefully by this creative group in the past five-year plan. These researchers created a system for analyzing the internal picture of disease, one fundamentally new to pathopsychology; they used it to reveal individual types of formation of the internal picture of disease in the presence of different somatic illnesses. The proposed

methods for interpreting the internal picture of disease permit assessment of the effectiveness of medicinal therapy, and they may be used successfully in expert labor certification.

This creative collective also acquired new scientific facts in pathopsychological research on different age groups of children.

Were we to evaluate all that had been done by the department's scientists in the 10th Five-Year Plan, we would find it obvious that they made a substantial contribution to the development of all basic areas of psychological science and practice. This effort was described in detail in the article "Moscow University Psychologists Aid Practice", published in this journal (No 4, 1979, pages 64-70). But the tasks they face in the 11th Five-Year Plan are even greater. Documents adopted by the 26th Congress of the Communist Party of the Soviet Union obligate scientists to increase their participation in the work toward the goals formulated in the "Basic Directions of the USSR's Economic and Social Development in 1981-1985 and in the Period to 1990".

To psychologists of Moscow State University, this means intensively and extensively increasing their participation, in cooperation with scientists at other psychological centers, in creation of the psychological principles of formation of the communist personality, in development of a scientifically substantiated and practically effective system of personnel training, and mainly labor training, in revealing the psychological prerequisites for optimizing the individual and collective activity of the Soviet citizen in all spheres of his labor, in substantial justification, from the standpoint of the particular researcher's science, of the principles of designing more or less complex manipulators for different areas of the national economy, and in illuminating the psychological mechanisms of preserving and restoring the individual's health and normalizing his spiritual and physical life in the family, at home, and at rest.

Without weakening their attention to the general theory of their science, scientists of the Moscow State University's psychology department will actively participate in efforts to solve these problems in the new five-year plan, ones so important to the development of our society.

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PSYCHOLOGICAL STUDIES OF INTELLECTUAL SELF-REGULATION AND ACTIVITY

Moscow PSIKHOLOGICHESKIYE ISSLEDOVANIYA INTELLEKTUAL'NOY SAMOREGULYATSIY I AKTIVNOSTI in Russian 1980 (signed to press 25 Feb 80) pp 2-6, 208

[Annotation, introduction and table of contents from book "Psychological Studies of Intellectual Self-Regulation and Activity", edited by V. M. Rusalov and E. A. Golubeva, Izdatel'stvo "Nauka", 4500 copies, 208 pages]

[Text] This collective monograph contains the results of several years of studies of differential psychophysiology related to the neurophysiological bases of mental activity and self-regulation as the most common inherent prerequisites for overall capabilities (personal talent). The book reflects significant changes in the methodical and conceptual approach to the study of the neurophysiological mechanism of individual psychological differences.

This book is intended for psychologists, physiologists and educators.

INTRODUCTION

The progress achieved in differential psychophysiological sciences in the last decade prompted us to try to define one of the principal problems of psychology--the problem of inherent bases of human talent. We were motivated by these two considerations: First, the publication of theoretical and experimental studies dealing with the inner prerequisites for talent--mental activity and self-regulation (N. S. Leytes et al); second, a significant shift took place in the interpretation of the nature of the basic characteristics of the nervous system which induced us to investigate the so-called general characteristics of the human nervous system (V. D. Nebylitsyn et al).

This book describes the results of methodical differential psychophysiological studies of the neurophysiological bases for mental activity and self-regulation.

The studies presented in this book have one common objective: They aim at the investigation of the relationship between the neurophysiological characteristics of an individual (traditional features of the nervous system, integral electroencephalographic (EEG) parameters, activation, induced activity, hypoactivity of the brain, galvanic cutaneous reaction and others) and the formal-dynamic characteristics of mental activity and self-regulation at varying levels of mental

functions (perceptive, psychomotor, mnemic and intellectual). All the included studies have a similar theoretical basis and thus this publication appears as a monograph.

The book focuses primarily on comparison of the mental activity and self-regulation features with integral EEG parameters which are, according to V. M. Rusalov and M. B. Bodunov, potential indicators for the general characteristics of the nervous system. A distinctive feature of the EEG characteristics is their reflection of the integration level of the nerve processes in the brain. The identification of four separate factors in integral EEG parameters (space-time dependency of EEG processes, based on synchronization and coherency, energy of slow rhythms, activity of beta-2 and slow rhythm frequencies) in the structure of the electroencephalographic activity of the brain is, according to the authors, an important step toward the discovery of the nature and structure of the general features of the human nervous system.

Concepts of mental activity and self-regulation were further developed and reinforced. The activity and self-regulation of intellectual behavior of a person was realized for the first time in a stochastic environment (on a model of probability prediction, by V. M. Rusalov and S. A. Koshman). The factorial analysis of the formal-dynamic features of the probability prediction permitted the authors to identify two factors in the area of self-regulation--sensitivity to the random environment and plasticity of prognosticated self-regulation--and two additional independent factors in the area of activity, viz., speed of mental processes and variability in the rate of mental processes.

The use of factorial analysis helped considerably to define more accurately the existing concepts of the structure of activities and self-regulation in a determined environment. For example, M. V. Bodunov confirmed in his study the existence of three individual aspects of mental activity--speed, ergonomics and variability. The studies of A. V. Pasynkova confirmed two basic factors of psychomotor self-regulation (on a model measuring time intervals)--the factors of accuracy and stability.

Comparison of the formal-dynamic featurs of mental activity and self-regulation with integral EEG parameters produced a series of completely new data (works by V. M. Rusalov and S. A. Koshman; M. V. Bodunov and Pasynkova). For example, the level of space-time interrelation in the EEG processes affects positively the mental activity rate, and negatively the plasticity of self-regulation. Sensitivity to random environment showed a tendency to a positive link with the beta-2 activity.

Among the traditional traits of the nervous system, lability was found to have the strongest link with the formal-dynamic features of human behavior, especially the speed of mental processes, in a defined and a random environment.

The significance of the individual activation level, as a permanent feature of the nervous system, reflected by various forms of mental activity (solving mnemic tasks and learning activities), is described by A. V. Pasynkova et al. and S. A. Izyumova.

N. A. Aminov reports on the dynamics of mental states as one type of regulation of on-going activities. The author succeeded in establishing significant activity components by using a curve of skin resistance.

The typological prerequisites for involuntary and voluntary functions are discussed by E. A. Golubeva who compiled several experimental studies that indicate that a high level of voluntary and second signal reactions and successful academic performance are correlated with the slow (spontaneous and induced) rhythms in the electroencephalogram. Central or reversible inhibition is suggested as one of the possible mechanisms of voluntary self-regulation (according to I. M. Sechenov).

I. A. Levochkina investigated the involuntary mechanism of self-regulation and established the general self-regulatory factor responsible for the functional rearrangement of the nerve processes during reactions of varying degrees of complexity. A link has been established between the duration of individual sequelae after experimental inhibition induced by monotonous work, and the individual differences produced by two types of inhibitions—voluntary suppression of motor reaction to a conditional signal and the synchronization of alpha-rhythms in the EEG while being blindfolded.

N. A. Leonova compared extremely-low brain activities with features of the experiment. The arrangement of the mental and biological rhythms is considered to be the general regulatory mechanism for the entire human behavior.

The studies of N. S. Leites, E. A. Golubeva and B. R. Kadyrov are particularly useful for the analysis of the obtained psychophysiological correlations. They point out several indicators of the dynamics of mental activity, relatively simple in nature, but directly linked to the energy base; these indicators are directly proportional to the activation level. At the same time, numerous other indicators of the dynamics of mental activity that are more complex and conditional, are indirectly proportional to the activity level. An increase in the activity dynamics in hypo-activated test subjects (as compared to medium-activated) is due to a secondary compensating action. In other words, both activation poles proved beneficial for the dynamics of mental activities.

The above studies suggest that B. M. Teplov's indirect "evaluation" method, used for the features of the nervous system, should be fully extended to the manifestations of the nervous system during the dynamics of mental activities and self-regulation that are considered inherent prerequisites of general human capabilities (talent).

The studies reported in this book contain substantial information for widening our knowledge in the area of the neurophysiological bases of individual human behavior.

TABLE OF CONTENTS

9680
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