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BIOMEDICAL AND BEHAVIORAL SCIENCES

(FOUO 11/81)

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CONTENTS

PSYCHOLOGY

BIONICS

UDC 591.185.5:595.729

CHARACTERISTICS OF MOVEMENTS BY FEMALE *Gryllus bimaculatus* CRICKETS TOWARD THE SOURCE OF A CALLING SONG, AND THE DEPENDENCE OF ORIENTATION ACCURACY ON SIGNAL SPECTRUM

Leningrad ZHURNAL EVOLYUTSIONNOY BIOKHIMII I FIZIOLOGII in Russian Vol 17, No 1, Jan-Feb 81 (manuscript received 23 May 80) pp 25-32

[Article by J. Rheinlaender, V. F. Shuvalov, A. V. Popov and K. Kalmring, Institute of Evolutional Physiology and Biochemistry imeni I. M. Sechenov, USSR Academy of Sciences, Leningrad, and Ruhr University, Bochum (FRG)]

[Text] The orientational behavior of female crickets in relation to the source of male acoustic calling songs was studied in a round arena with a diameter of 140 cm, located in a soundproof chamber. The nature of movements made by females depends strongly on their condition, and it may be irregular or continuous. In both cases the females periodically deviated from their course as they moved. These deviations are limited to a ±50° sector, they occur irregularly, and they are corrected by turning motions. Correcting turns are made both after halts and during movement, such that females could determine the position of the sound source during movement as well. The greater the error angle, the greater the probability of turning in the direction of the source. The orientation error at the edge of the arena (within 30 cm of the emitter) does not exceed an average of several degrees.

Experiments with simulated calling songs differing in the content of high-frequency harmonics showed that presence of high-frequency components in the signal (10 and 15 kHz) does not improve orientation accuracy, and it does not generally hasten phonotaxis. The characteristics of phonotaxis are defined completely by the low-frequency component, 5 kHz. The results are compared with the properties of low-frequency ascending auditory neurons that transmit information to the brain. The orientation accuracy discovered in females may be the result of evaluation of the difference in the activity of symmetrical pairs of these neurons.

Introduction

Female crickets find males of their species by orienting on the acoustic calling signals emitted by the latter (1-7). Research on crickets of two species, one of which uses a calling song consisting of rarely repeating bursts (*Scapsipedus marginatus*), while the signal of the other is similar in structure to a trill (*Teleogryllus oceanicus*), showed that movement of females to the source is obviously discontinuous--that is, it consists of alternating short, usually straight runs, and halts lasting 250-400 msec. It is only during halts that females determine the position of the source, make correcting turns, and then begin their runs. During their movement, females do not perceive information on the position of the source, and they cannot purposefully correct their course. Before starting movement toward the source, females make scanning movements from side to side. Thus the orientation system of females may be described in general as a system with an open feedback (4,6).

The orientation accuracy of *S. marginatus* females is astoundingly low. They can determine only the side on which the emitter is located, but they cannot determine the necessary turning angle. *T. oceanicus* females can determine the required course direction angle rather accurately when the source is located in the forward sector from 0 to 30-40°; however, outside this sector the turning angles are weakly correlated with the error angle. In this case the orientation accuracy does not improve as sound intensity increases. However, there are grounds for hypothesizing that the described orientation mechanisms are not universal to all crickets, the signals of which may possess different properties.

No one has examined the dependence of the accuracy and effectiveness of female orientation on the spectral composition of the signal. But at the same time we know that cricket calling songs have a harmonic spectrum consisting of several components (8,9), and that there are several frequency channels in their auditory system which may evaluate these components relatively independently (10-13).

We posed the following objective in our work: 1) to study the nature of orientation by female *Gryllus bimaculatus* De Geer crickets, the signal of which consists of frequently repeating bursts; 2) to evaluate the influence of different spectral components of the signal on orientation accuracy; 3) to compare the available neurophysiological data with the characteristics of orientational behavior.

Materials and Methods

The experiments were performed with *G. bimaculatus* females from a laboratory population in the last larval instar phase. Each female was placed in an individual cage and raised until sexual maturity and arisal of well-pronounced positive phonotaxis toward the male calling song. The selection method was described earlier (4).

The experiments were performed in a round plywood arena with a diameter of 140 cm, located in a soundproof 5×5×5 meter echoless chamber at 20±1°C. Two loudspeakers (MSD-100, Japan) were located 30 cm from the edge of the arena 120° apart (Figure 1). A cage into which the female was placed before the start of the experiment was located in the center of the arena. Thirty seconds after the female was placed in the cage, an acoustic signal began to be reproduced through one of the emitters.

The female's movements were recorded by a movie camera mounted above the arena. The filming rate was two frames per second. The location of the female and the orientation of its body relative to the cage-emitter line were measured on each frame. Drawing the trajectory, we used arrows to designate the orientation of the long axis of the female's body at each moment in time. The effectiveness of female orientation was assessed on the basis of the following indicators: T_p--reaction time from the moment of emergence from the box (cage) to the moment the female reached the edge of the arena; ϕ_δ^0--angle of deviation from the line extending from the cage to the emitter at the edge of the arena; ϕ_{max}^0--maximum angle of deviation from the course while en route from the cage to the edge of the arena (the first 20 cm of the route from the cage were not counted, because some females wandered randomly prior to the start of purposeful motion toward the emitter); α^0--maximum error angle between the long axis of the body and the bearing to the emitter throughout the entire time of travel.

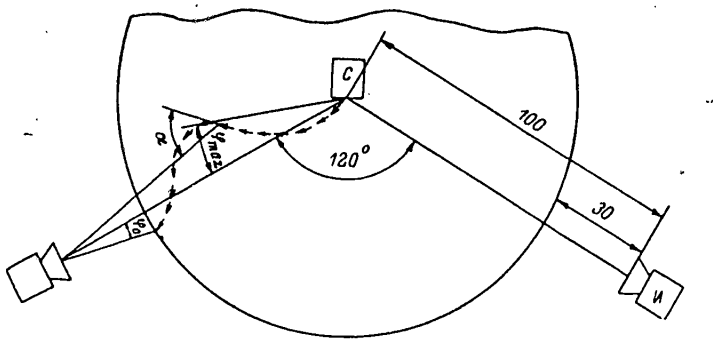

Figure 1. Experimental Arena and an Example of the Trajectory of a Female, With the Measured Angles Labeled: Arrows indicate the trajectory (the bearing of the arrow corresponds to the orientation of the long axis of the female's body at each moment in time); И--emitter, C--cage. Linear dimensions are given in centimeters. See the text for further explanation.

In the greater part of the experiments the intensity of the signal at the cage was 70 db relative to 0.00002 N/m^2. It increased to 82 db at the edge of the arena, which corresponds to the intensity of a song produced by a male in natural conditions from a distance of 0.2-1.0 meters (9). In two series of experiments the signal intensity was increased by 16 db. In this case the intensity of the signal at the edge of the arena attained a level corresponding to that of a signal heard several centimeters away from a singing male.

The signals consisted of computer-synthesized sounds with an envelope corresponding to the envelope of the male's calling song at the same temperature; the intensity of harmonic components was arbitrarily varied. The spectrum of the calling song contains three harmonic components--4-5, 9-10, and about 15 kHz (Figure 2). At a signal intensity of 25-40 db the level of the second and third harmonics is below the level of the main component.

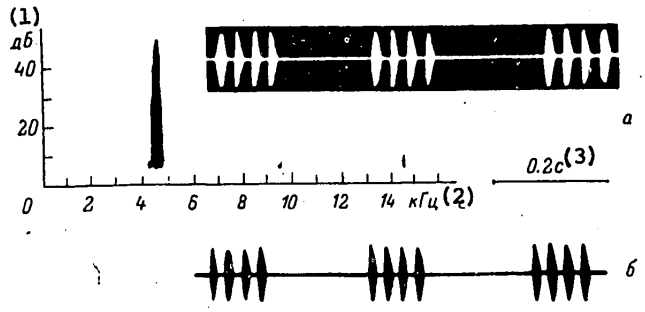

Figure 2. Calling Signal of a Male Cricket (*a*) and the Acoustic Model (*b*) Used in the Experiments: A spectral cross section of a calling song pulse is shown on the graph

Key:
1. db
2. kHz
3. Sec

Inasmuch as the high frequency components are often below the noise level in the natural conditions of biotopes experiencing a higher noise level (9), one of the models contained only the 5 kHz component (model 5/0--the digit following the slash line indicates attenuation in decibels). To reveal the role of high frequency components, their level was increased in two other models. The second model contains the 5 and 15 kHz (5/0 and 15/-10) while the third contains all three components (5/0, 10/-20, and 15/-10). The acoustic models were recorded and played back with a Nagra IV-s tape recorder.

Thirty females participated in the experiments. Each female was tested once a day for 10-14 days.

Results

The reaction of females to the test models did not differ in general characteristics from the reaction to a natural calling song. Orientation of females in relation to the sound source may be divided into three phases: 1) activation phase, 2) initial orientation phase, and 3) phonotaxis phase. The activation phase begins the moment the sound is turned on, and it continues until the moment the female exits from the box. Its duration varies within broad limits, from several seconds to dozens of seconds, apparently due to differences in motivation of the females.

After leaving the cage, in the overwhelming majority of cases the females halted at the bottom of the chute for several seconds and then turned in the direction of the emitter (the initial orientation phase). In this case we never noted "scanning movements" prior to the start of the purposeful run, as described for *Scapsipedus marginatus* (4) meaning that for *G. bimaculatus* they are not a mandatory component of orientation. The initial orientation phase was very short for some females, which headed for the source almost immediately, while individual specimens wandered randomly around the cage on leaving it, resolutely heading toward the emitter only after this.

The phonotaxis phase, or the phase of purposeful movement toward the source of the calling song, proceeds differently for different females. Young, timid females, especially when in the arena for the first time, travel the distance in short, often straight runs alternating with halts. After the sound is turned off, the nature of the movements does not change, meaning that the halts were not necessarily elicited by a need for course correction. As a rule the direction of movement changed somewhat after a halt even when the female was already facing the emitter. These turns far from always occur in the direction of the emitter, and consequently they are not necessarily correcting turns, being more likely a reflection of some sort of perturbations in the movement control system. The larger the error angle at the time of a halt, the greater is the probability of turning in the direction of the emitter.

Calmer, more-strongly motivated females move significantly more confidently, with fewer halts or without any at all; in this case their rate of movement gradually increases as they come closer to the emitter. Runs are not always strictly linear. On the contrary the female is frequently seen to periodically deviate from side to side in relation to the true course by an insignificant angle. Such oscillations about the true course are limited to a ±30-50° sector (see the values for angle α^0 in the table), while their amplitude is insignificant, inasmuch as the turns in different directions alternate with one another quickly. Owing to these the oscillations do not have a significant effect on the forward trajectory as a whole, appearing instead as oscillations in the orientation of the body relative to the principal direction of movement. Course correction occurs in these cases while on the move or after a halt, meaning that halts are not mandatory to a female's determination of the location of the sound source. Evidence of this can also be found in data from experiments in which the sound was produced first from one emitter and then (during the time of the female's movement toward it) through the other located opposite the former. In these cases at least some of the females turned quickly 180°, without halting their movement or with a few halts. These data also indicate that females confidently distinguish sounds coming from the rear from sounds coming from the front.

The trajectory of females toward the sound source varied within broad limits (Figure 3*a*). In most cases females headed toward the source with sufficient accuracy from the very beginning, without noticeable deviations to the sides (Figure 3*b*). Some females occasionally deviated significantly from the course to the emitter, later correcting their movement by means of one or several turns (Figure 3*c*). Certain females ran relatively straight, though at a certain angle to the source, and then corrected their course at the very edge of the arena (Figure 3*d*). The possibility is not excluded that pathological alterations were present in at least some of these insects, leading to interaural asymmetry.

On the whole the orientation accuracy of females, evaluated on the basis of their location at the end of the route (beside the edge of the arena), was sufficiently high. The averages for angle ϕ_0 do not usually exceed 6-7°. When the emitter was brought close to the edge of the arena, all females approached it, correcting small deviations in the final leg of the route.

Statistical treatment of the obtained material (see table and Figure 4) showed that presence of high-frequency components in the signal does not significantly improve orientation accuracy, and it does not accelerate phonotaxis. The contrary is more

Effectiveness of Orientation by Female Crickets
During Movement Toward the Source of a Calling Song

Model	T_p (sec)	ϕ_0^0	$\phi_{max}{}^0$	α^0	N,/sec·°	n
5/0	20.65±13.33	6.86±6.07	25.28±18.44	44.61±12.41	5.35±3.66	44
5/0 15.-10	16.21±7.38	10.36±7.36	27.76±20.92	54.31±18.15	4.49±1.05	39
5/0 10/-20 15/-10	26.6±23.8	6.42±7.46	22.22±17.73	42.02±15.85	4.84±1.27	53
5/0+16 db	15.72±5.48	6.0±5.36	15.33±9.41	39.00±11.0	5.17±0.78	14
5/0 15/-10+16 db	38.25±15.73	33.00±25.03	47.75±25.16	86.67±40.1	2.52±1.56	5

Note: The values given for each variable are $x \pm \sigma$; N--arbitrarily selected measure of the effectiveness of phonotaxis, which is a function of orientation accuracy (ϕ_0) and running time (T_p). $N = \ln 1/T_p \cdot \phi_0$. The larger N is, the more effective is phonotaxis; n--number of measurements. See text for further explanations.

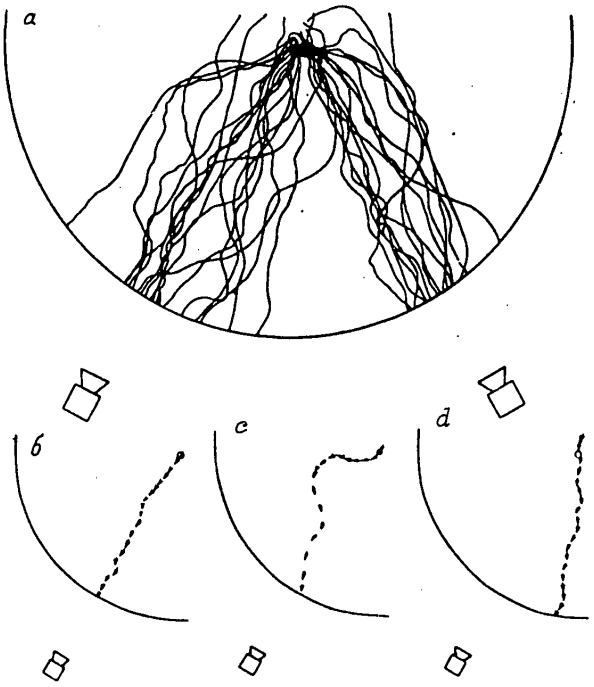

Figure 3. Trajectory of Females During Phonotaxis: see text for explanation

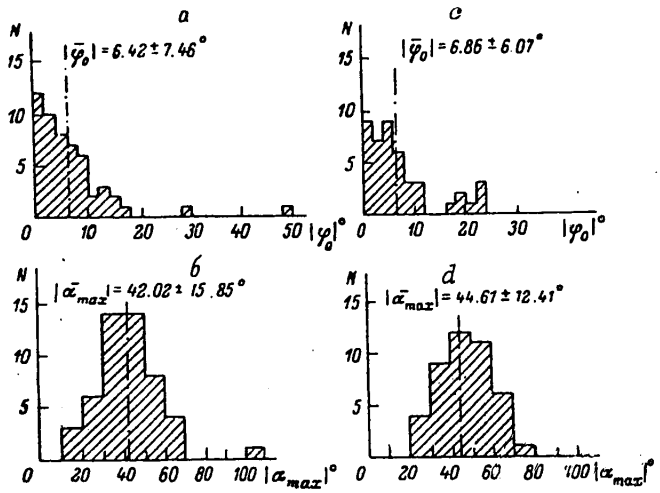

Figure 4. Distribution of Angles ϕ_0 and α in the Course of Phonotaxis Toward Models 5/0, 10/-20, 15/-10 (*a*,*b*) and 5/0 (*c*,*d*): *a*--$n = 53$, $\Delta\phi_0 = 2°$; *b*--$n = 50$, $\Delta\alpha_{max} = 10°$; *c*--$n = 44$, $\Delta\phi_0 = 2°$; *d*--$n = 42$, $\Delta\alpha_{max} = 10°$. *N*--number of runs

likely true. Angle α is significantly greater with model 5/0,15/-10 than with the other models. The differences in the rest of the parameters are insignificant. The accuracy of orientation on model 5/0 does not differ from that of orientation on a natural signal.

Raising signal intensity by 16 db significantly increased the effectiveness of phonotaxis toward model 5/0+16 db and, on the other hand, significantly decreased the accuracy of orientation on the model containing the high-frequency component (5/0 and 15/-10+16 db). In the latter case the females began rushing from side to side, as if searching for the source. This was accompanied by an increase in all orientation indicators (T_p, ϕ_0, ϕ_{max}, α; see table).

Discussion

The obtained data show that the orientation behavior of *G. bimaculatus* females differs dramatically from behavior described in the literature for *S. marginatus* and *T. oceanicus* (4,6) in having the capability for evaluating the position of the source and correcting course not only during halts but also while moving, and by absence of scanning movements before the start of phonotaxis. Wendlar et al. (7) recently came to similar conclusions in research on the orientation behavior of the field cricket, *Gryllus campestris*, the calling song of which is very similar in temporal organization to the signal produced by *G. bimaculatus* (8,9). The oscillatory deviations of the long body axis and the trajectory from the direction

to the sound source may be the result of random shifts or noises in the system controlling the movement of right and left legs. The randomness of these deviations and their significant individual variability argue in favor of such an interpretation. In any case, inasmuch as these deviations were altogether absent from many females, it may be hypothesized that oscillations are not a mandatory component of the guidance mechanism. Course correction compensating for random deviations of the long axis of the body from the direction to the target is apparently achieved by feedback signals. These signals may be dependent on the error angles. Obviously, the greater the error angle, the larger is the probability of a correcting instruction and its intensity; this probability approaches 1 as the error angle reaches its critical value. Our data showed that the maximum error angle for phonotaxis does not usually exceed 30-50°. Within the ±30-50° sector, the intensity of the correcting signal may be commensurate with the level of noises within the system, and this may explain the randomness and unpredictability of "minor" turns along the course to the goal.

Deflection of the long axis of the body from the direction to the emitter is accompanied by appearance of asymmetry in stimulation of the right and left auditory channels. Information on sound in different frequency bands is processed separately in the auditory system of crickets, beginning at the peripheral level and ending in the highest associative center in the protocerebrum. The calling signal is perceived by *G. bimaculatus* by means of receptors narrowly tuned to a frequency of 5 kHz and by second-order ascending neurons (LF-neurons), which transmit information on the signal to the protocerebrum and apparently play the decisive role in control of phonotaxis. The functional properties of these elements have been described earlier (11-14).

There is one LF-neuron on each side, and the relationship between the discharges contains information on the position of the sound source in space. Each of the LF-neurons is maximally sensitive to sound coming from the ipsilateral side (Figure 5). The difference in their discharges is obviously a function of the error angle. We can see from Figure 6 that the difference in the number of impulses produced in response to a calling song burst grows dramatically as the source shifts from forward position (0°) up to 80-90° to either side. At the critical error angle for phonotaxis (50°), the difference in the number of impulses contained in a discharge by these neurons in response to a calling song burst is 15-20 at average and high intensity. This corresponds to a difference in stimulation intensity on the order of 18-25 db, which greatly exceeds the differential intensity threshold of hearing which, judging from behavioral experiments, is about 2-3 db for *G. bimaculatus* (15). A difference in the number of impulses on the order of 2-4 per burst, which is what arises at error angles on the order of 3-7°, corresponds to the differential intensity threshold. This amount is well consistent with angle ϕ_0 (about 6°). At larger deviation angles a feedback signal should arise, the intensity of which is proportional to an error angle within up to 80-90° (if its intensity is governed by the difference in stimulation of LF-neurons).

LF-neurons react almost identically to sound from the front and from the back, and consequently there should be additional elements in the auditory system of crickets having differential sensitivity toward the back and toward the front. Similar elements have been discovered in locusts only in the protocerebrum (16). The acuity of their directional sensitivity grows as sound intensity increases. If crickets also have such elements, then our data indicating growth in orientation accuracy with increasing sound intensity receive a fully natural explanation.

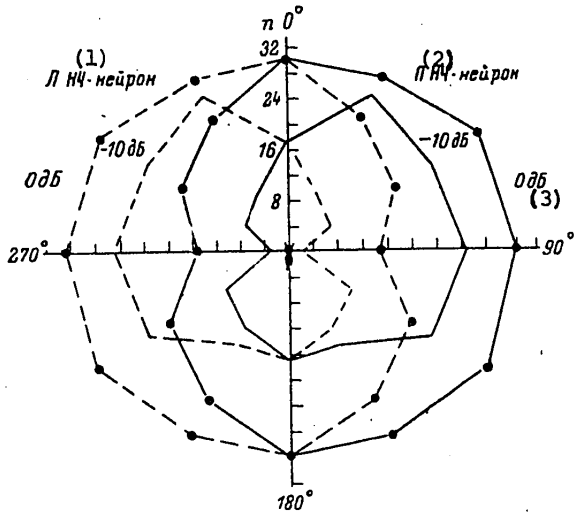

Figure 5. Characteristics of the Directional Sensitivity of a Symmetrical Pair of LF-Neurons of the Cricket's Ventral Nerve Chain in Response to the Action of a Calling Song Containing Bursts of Five Pulses: n--number of impulses contained in neuron responses to a calling song burst, recorded at the level of the protocerebrum from axons of LF-neurons (from experiments conducted in Bochum, the basic results of which were published earlier (11)). An intensity of 0 db corresponds to a signal intensity of 95 db relative to 0.00002 N/m^2. See text for further explanation.

Key:
1. Left LF-neuron
2. Right LF-neuron
3. db

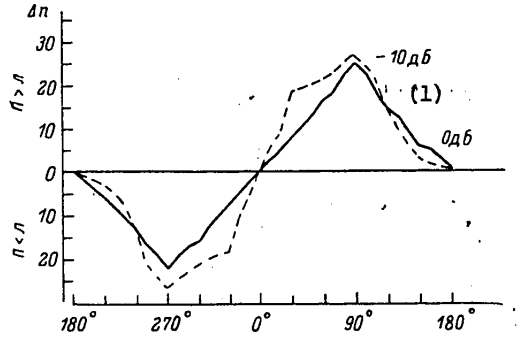

Figure 6. Dependence of the Difference in Responses (Δn) by the Same Pair of LF-Neurons on the Error Angle, Given the Same Signal Intensity as in Figure 5 (Evaluated on the Basis of the Number of Impulses in Response to a Calling Song Burst): see text for further explanation

Key:
1. db

Experiments with models having different spectral compositions showed that the characteristics of phonotaxis depend entirely on the first low-frequency maximum of the signal (5 kHz). High-frequency components influence neither the effectiveness of orientation nor the rate of phonotaxis, even if their level is significantly higher than in the natural signal. Sharp disturbance of orientation in the presence of a high-intensity signal with high-frequency components may be a reflection of a transition by the female from phonotaxis to a search for the male. In natural conditions the high-frequency components achieve their highest level only in direct proximity to a singing male.

The cricket orientation system may be of interest from the standpoint of bionics as an example of a guidance system used to assist movement.

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HANDBOOK OF SENSORY PHYSIOLOGY

Leningrad ZHURNAL EVOLYUTSIONNOY BIOKHIMII I FIZIOLOGII in Russian Vol 17, No 1, Jan-Feb 81 pp 103-104

[Review by F. Gribakin of book "Rukovodstvo po fiziologii organov chuvstv" [Handbook of Sensory Physiology], Volume VII/6A, "Vision in Invertebrates", Part A: "Invertebrate Photoreceptors", edited by Prof Kh. Autrum, Springer-Verlag, Berlin-Heidelberg-New York, 1979, 729 pages, 344 figures]

[Text] This book is the first part (A) of the next volume in a handbook of sensory physiology known the world over, containing basic information on the general physiological mechanisms of invertebrate photoreception. Special emphasis is placed on the fact, sometimes unfortunately disregarded, that invertebrate photoreceptors not only serve as models for studying the basic photoreception processes, but also owing to numerous special adaptations they have significant value to expanding our knowledge of ecology and evolution. This is reflected in the full title of the volume--"Comparative Physiology and Evolution of Invertebrate Vision".

All 12 chapters are written by top-class specialists. Readers of our journal would be interested to learn that the "Introduction" (Chapter 1, Prof Kh. Autrum) discusses, in particular, Ya. A. Vinnikov's idea that microvillous receptors are phylogenetically older than ciliary receptors; of course the editor of the volume himself feels that this supposition must be supported by further research. Chapter 2 (B. D'yen) is devoted to the physiological mechanisms of photoreception in the Protista. Chapter 3 (U. Miller) examines the optic properties of the eye's filtering media (aromatic amino acids, shielding pigments, and so on). Chapter 4, which is devoted to the physiology of invertebrate visual pigments, is extremely interesting. This chapter was written by Prof K. Khamdorf, who discovered that photoregeneration is the principal means of regeneration of rhodopsin in cephalopod mollusks and arthropods, while rhodopsin in vertebrates is regenerated by enzymatic mechanisms. Chapter 5, "The Physics of Vision in the Compound Eye", contains all of the basic information on the optics of photoreception by the invertebrate eye. The author of this chapter, presently a professor of applied mathematics at the University of Australia, A. U. Snayder, is essentially the "father" of photoreceptor optics, which grew up into an independent branch of knowledge in the last 15 years. Chapter 6, "The Receptor Potential of Invertebrate Visual Cells" (M. Yarvilekhto), contains contemporary data on the regeneration mechanisms of early and late receptor potential in arthropod photoreceptors. It goes on to examine the physiological mechanisms behind arisal of a false pupil, or a pseudopupil, in the compound eye. A purely optical phenomenon, the pseudopupil is

usually seen as a dark spot formed out of ommatidia oriented straight at the observer, and consequently not reflecting and not scattering light in this direction; the possibilities for capitalizing on this phenomenon as a valuable tool for studying the optic qualities of the eye and the properties of its photoreceptors and pigment cells are demonstrated (Chapter 7, D. Stavenga). Modern ideas are presented on the superposition and apposition of compound eyes (P. Kuntse, Chapter 8); the first subdivisions of the chapter rather extensively explain the classical viewpoints of Johannes Muller and Sigmund Ecksner. Chapter 9, "Spectral Sensitivity and Color Vision of Invertebrates" (R. Mentsel'), is a most extensive review summarizing, in one place, all that is known today about the spectral sensitivity of the photoreceptors of invertebrates, beginning with the Protista, and about the central mechanisms of color information processing, to include the behavioral aspects of the problem. Chapters 10 (M. Ioshida) and 11 (Miriam Bennett) are devoted to extraocular photoreception and its role in triggering and maintaining diurnal rhythms. Finally Chapter 12, "A Genetic Approach to the Visual System" (M. Geyzenberg), deals basically with research on vision of a classical object in genetics, mainly various eye mutants of *Drosophila*, since in the author's opinion only research on *Drosophila* fits within the framework of the term "genetic approach", even though the genetic literature on vision presentlyincludes organisms from halobacteria to the white tiger.

Evaluating the content of the volume as a whole, it should be stated that it is a superior source of contemporary data having fundamental significance today. Nevertheless a number of problems still remain outside the field of vision of the author collective (the ion mechanisms of generation of receptor potential, the genetic approach to studying vision in the honeybee, analysis of the electric field of a compound eye, and so on). We would hope that these aspects of the physiology of invertebrate vision would be reflected in the second part of Volume VII/6, which is now being prepared for publication. Unfortunately, the index of cited works by Soviet authors is not very large: As a rule only those works which are published in English in international journals are cited, which once again emphasizes the need for publishing in foreign sources.

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BIOTECHNOLOGY

ROLE OF BIOLOGICAL FACTORS IN FORMATION AND DEVELOPMENT OF MAN

Moscow VESTNIK AKADEMII NAUK SSSR in Russian No 6, Jun 81 pp 42-47

[Text of statements made by Academician A. D. Aleksandrov and Academician N. P. Dubinin]

[Text] As was already reported on the pages of VESTNIK AN SSSR [Vestnik of the USSR Academy of Sciences] (No 4, 1981, p 107), there was a session of the General Meeting of the USSR Academy of Sciences on 21 November 1980. At this session, Academician A. D. Aleksandrov spoke on the role of biological factors in the formation and development of man. Academician A. P. Aleksandrov, president of the USSR Academy of Sciences, then gave the floor to Academician N. P. Dubinin to respond to his points. In accordance with the request of the speakers, the text of their speeches is published below.

Academician A. D. Aleksandrov

Man is, to use the terms of philosophy, the carrier of two forms of movement of matter, "biological" and "social." But it is expressly the latter that distinguishes man. Within the same biological species and even the same race, people demonstrate an immense diversity of forms of activity, which they create and transmit to one another and to subsequent generations by means of direct and indirect communication. Since the brain is the source of the programs of these forms of endeavor, we can refer to the cerebral evolution of man in contrast to genetic evolution.

The enormous area of what is specifically human, human history, develops, of course, on the basis of genetically determined human distinctions and, first of all, the distinctions of the human brain. There, the same chief law common to all living organisms is in effect, according to which genes determine the possibility of development of traits of an organism, but this possibility is realized depending on conditions. However, especially man genetically represents merely a possibility that changes into reality through interaction between the genotype and conditions, mainly social ones. These conditions themselves are created and changed by the activities of people. For this reason, it can be stated that man (in the collective sense) created and continues to create himself on the basis of his specific genotype.

Thus, three factors affect the formation of man: genotype, living conditions and the transforming, creative endeavors of man himself.* The extremely complex

*"Creative endeavor" is used to construe any activity that is not performed according to a preset program.

correlation between them constitutes a fundamental and difficult problem about which the most varied views are expressed. Representatives of different special fields often exaggerate expressly what is closer to them, disregarding what is "alien" to them. Geneticists tend to underestimate the social factor, while sociologists do so for the genetic factor, as well as the creative factor in some cases, interpreting, for example, the personality as the passive product of existing social conditions.

The colossal extent, to which geneticists sometimes disregard the social factor, is indicated, for example, by an article by the well-known American geneticist, recipient of the Nobel prize, J. Lederberg, which was published at the time in LITERATURNAYA GAZETA [Literary Gazette] (No 20, 1969). There, among others, the following question was discussed: "Do the poor have proper [perfect] genes?" The answer being: "Perhaps genes do play some part in man's economic failures. For this reason, the excessive proliferation of the stratum of the poor could be eugenically harmful. But birth control among the poor will not yield results very soon.... Of course, it would be easiest to suggest another solution: let not the poor have any children at all. But if we were to take this route, we could go even farther: fight for eradication of poverty by means of physical extermination of all the poor. Although, perhaps, this would be more humane than to doom them to a hungry death."

This opinion is extremely instructive in many respects, and it should be discussed in detail, but unfortunately, we do not have space here to do it. We shall merely call attention to the blindness of this authoritative scientist who does not see that poverty is a social phenomenon and that for this reason it is simply absurd to discuss "eradication of poverty by means of physical extermination of all the poor" (incidentally, let us recall that Schubert and Van Gogh, for example, were paupers and, one would think, their poverty was related expressly to their genius, which compelled them to direct their efforts to an activity that yielded no economic success).

There is also a very obvious ethical aspect to such judgments. An important distinction of all sciences dealing with man, be it psychology or human genetics, is that it applies, in principle, to everyone, not excluding the researcher himself, and for this reason, in the sciences dealing with man the scientific position is particularly closely related to the ethical [moral] position. Of course, this does not mean that science must subordinate its objectivity to ethical goals. Marx wrote: "... a man who strives to adapt science to such a point of view that is not gleaned from science itself (no matter how much the latter was in error) but from the outside, toward a point of view that is dictated by interests that are alien to science, endogenous in relation to it--I call such a man 'inferior'."*

But one must clearly understand the human meaning of what is said and done in the science of man and there must be a warning signal in front of everyone who talks about man, particularly those who do so on behalf of science; "Be careful, people! Be objective to the utmost!" This applies in particular to statements made in the broad press.

*K. Marx and F. Engels, "Soch." [Works], Vol 26, Pt 2, p 125.

But here we read the article of Academician N. P. Dubinin, "Inheritance of Biological and Social Factors,"* where this warning is not heeded at all.

N. B. Dubinin wishes to develop the idea of Marx concerning the social essence of man, and he criticizes geneticists who exaggerate the role of the biological factor in man to the detriment of the social one. But he himself goes to an utter extreme.

His own idea is that it is absurd to search for an explanation of normal mental phenomena in any biological functions. He decisively denies that biological, genetic heredity has any influence on man's normal psyche and, in particular, writes: "Vulgar biologizational interpretation of mental functions as genetically determined traits constitutes idealism in comprehension of the problem of man. Authors who relate the human psyche directly to genes, attributing the mental properties of man ... to physiological functions of neurons of the brain, view themselves as materialists of the highest order. However, the human psyche cannot be found in either the function of genes or the function of neurons, for the simple reason that its level has gone beyond the boundaries of biology. To search for an explanation of mental phenomena in any biological functions is tantamount to attributing spiritual properties of all matter" (p 72).

But we know, for example, that sex is genetically determined, that the psyche of normal men and women is not the same, and that such mental differences are attributable, at least in part, to biological functions. Thus, the main thesis of the article, and one stated so categorically, is an overt contradiction to obvious facts.

The real problem is to examine which mental features, how and to what extent they depend on heredity or social conditions. But N. P. Dubinin closes this issue for normal people, leaving it to medical genetics only with regard to abnormal people.

However, it is beneficial to note that the very concepts of normal genotype, normal brain, normal psyche, that Academician N. P. Dubinin uses with such confidence, are not completely definite and imply demonstration of various aspects and gradations of normalcy and abnormality, which depend on the same genetic heredity. For this reason, the desire of Academician N. P. Dubinin to limit the influence of genes only to an "abnormal" psyche is invalid.

Further, we see from the statements quoted above that Academician N. P. Dubinin decisively denies a direct relationship of the psyche to neuronal functions in the brain. But, for example, the well-known effect of alcohol on the mind is apparently related to its effect on neuronal function in the brain, so that here too there is no validity to the idea of Academician N. P. Dubinin.

Indeed, the problem consists of investigating physiological, biochemical, physical structures and mechanisms that determine mental phenomena. N. B. Dubinin "closes" this problem also.

Let us recall, however, higher nervous activity, the types thereof established by I. P. Pavlov. He made the direct statement that certain temperaments correspond to these types, and that they are determined by the genotype. So that Pavlov

*See: KOMMUNIST, No 11, 1980.

maintains there is a direct relationship of the psyche to the genotype and brain neuron functions and, thus, is among the authors who "directly relate the psyche to genes." Let us assume that Pavlov was mistaken, but then he should be refuted with scientific arguments, and not disposed of in such a manner. Incidentally, it would appear that Pavlov was not mistaken here....

The problems that are directly related to man require utmost objectivity of judgments, utmost caution of conclusions and utmost attention in research. Questions of heredity, congenital or acquired traits, abilities or defects, questions of man's capabilities--they all emerge acutely in life, they affect living people, sometimes they create difficult situations and they merit the most serious discussion. This applies fully to the problem of abilities.

A socialist society is based on the principle of "from each according to his abilities," and for this reason the question of abilities is of basic importance to us, not only theoretically but practically, both on the level of society as a whole and of each man: how to best demonstrate and develop his abilities, what can be expected and demanded of him. N. P. Dubinin answers the question rather simply: "All normal people are capable of virtually unlimited spiritual development" (p 68). "Giftedness is the effective development of essential human traits combining a normal genotype with beneficial conditions for development thereof (i.e., chiefly the "'acquired nature' thereof)" (p 73). In other words, apparently with a normal genotype, the beneficial conditions can make a Lomonosov, Marx, Newton, Beethoven, Rafael, or someone else out of any child by providing for "virtually unlimited spiritual development." And if there are very few even less gifted people who develop from the multitude of children, it is the fault of their parents who did not provide the same conditions for them as were present for Lomonosov.

Incidentally, Academician N. P. Dubinin stipulated: "i.e., chiefly the 'acquired nature'." And this apparently means that "the inborn factor" also plays a part, if not the leading one. If this is so, does not N. P. Dubinin find himself among the "authors who related the human psyche directly to genes," at least to an insignificant degree? The question of being gifted requires investigation. But N. P. Dubinin, proceeding from his views, sweeps away in-depth studies of giftedness, whose authors try to demonstrate the potential abilities of man. Such studies have not yet advanced enough, but to abandon work in this direction would be extremely detrimental to the development of our society, as would abandonment in general of all three problems that N. P. Dubinin "closes."

Declaring loudly that he is speaking from the vantage points of Marxism, N. P. Dubinin considers this as grounds, from the very first lines of his article, to discredit people of a different mind stating that they are "undertaking an attempt at revision," and even trying to "abolish the Marxist teaching on the integral social essence of man, advancing the thesis that the genetic program supposedly controls the social behavior of people" (pp 62, 63).

He mentions the late Academician B. L. Astaurov as the first example of those "who did not escape this craze," and quotes an extensive passage where B. L. Astaurov writes about the significance of the law, according to which all of the properties of an adult organism, not excluding man and his psyche, depend on heredity and the environment. But N. P. Dubinin interprets recognition of this law as a "thesis," that supposedly the "genetic program controls the social behavior of

people." Confusing the concepts of "to be related [or dependent] and "to be controlled," he attributes to B. L. Astaurov something he did not say and, at the same time, involvement in efforts to "abolish Marxist teaching on the integral social essence of man."

Incidentally, N. P. Dubinin also attributes to Marx things that he did not write at all. It is expressly in the "Theses about Feurbach" that Marx states: "... the essence of man is not an abstraction inherent to a separate individual. In reality, it is the aggregate of all social relations."* N. P. Dubinin writes, with reference to man, that "in the words of K. Marx, he is the aggregate of all social relations" (p 62). But is it not clear that "man" and "essence of man," and in general any object and its essence are rather different concepts, so that to replace one with the other is to distort the author's thought. Let us also mention that Marx writes about the essence of man in its reality, of man in the collective sense, rather than an individual; let us compare this to the thesis, according to which genes determine the possibility of development of an individual's traits.... It is obvious that the contradiction that N.P. Dubinin wishes to see does not exist here.

However, it is not the inaccurate quotation or inadequate comprehension of some of the judgments of Marx that is the main point. The main point is that the article of Academician N. P. Dubinin, with all its claims of a Marxist position, is in reality something that is quite the opposite of Marxism.

The spirit of Marxism lies in systematic scientific attitude, concrete analysis, in-depth penetration into the entire aggregate of available facts referable to the problem under study. But in the article in question, only declarations are made with regard to the psyche of a normal man.

The spirit of Marxism lies in dialectics and, consequently, consideration of all associations, mediations and mutual transitions, to the extent of the unity of opposites. But in the article under discussion, the very thought of interaction between biological and social factors with reference to the psyche of normal man is rejected.

The spirit of Marxism lies in unconditional, specific humanism. But in the article in question, concrete analysis of human problems related to heredity (with a "normal" genotype) is replaced with abstract statements as to the unlimited abilities of man.

Furthermore, there is the question of principles of scientific research and scientific polemics. The main point is not referable to specific mistakes and absurdities per se. The main point is for something alien to science by virtue of methods of reasoning and approach to the problem not to replace research and scientific discussion of the most serious problems.

Academician N. P. Dubinin

I never denied the importance of problems of human genetics. Science has offered good proof of the effect of biological heredity on physical, neurodynamic and psychodynamic distinctions of man. At the present time, more than 2300 Mendelian traits have been studied. Moreover, questions of damage to biological heredity are being

*K. Marx and F. Engles, "Soch.," Vol 3, p 3.

raised with exceptional acuity at the present time. According to data for 1977-1980, 10.5% of the children in the world are born with genetic defects. Of these, 3% (according to the UN Organization) are born with inherited mental deficiency. There is a question of dynamic growth of the genetic burden under the influence of mutagens, which pollute the environment, and other factors. Much work is being done on this subject. I myself am a participant of many All-Union programs and, in particular, I head the section of "Genetic Aspects of the Problem of 'Man and the Biosphere'" of the USSR State Committee for Science and Technology, and am involved in the work of international committees dealing with the problem of the biological factor in man.

And, in the mentioned article, "Inheritance of Biological and Social Factors," in the journal KOMMUNIST (No 11, 1980), the significance of the biological factor is very clearly stated. Of course, each man is a distinctive genetic individual with his own properties, his own anatomical, physiological and biochemical features, with numerous distinctions, such as elements of the psyche, endocrine system, speed of neurodynamic processes, etc. But the point is how this is related to man's social essence: do variations of normal genotypes inherited from parents have a direct, adequate effect on social and human properties, on man's spiritual world? Efforts are being made to relate them in a fatal way. It has even been said that creation of a new man would be impossible without altering the genetic prerequisites of modern people.

Statements are being made that one can supposedly "predict" all of the potential spiritual abilities of each neonate on the basis of a study of his genes. It was written in LITERATURNAYA GAZETA (4 July 1980) that one can identify a future member of the Writers' Union at the embryonic stage, according to the set of "writer" genes received in the zygote after fertilization. Such statements are beyond the boundaries of science. In the presence of dialectics of social and biological factors, it is imperative to draw a distinct line between them, since the biological part of man is merely the lowest form of movement of matter. The essence of man is social. This idea is the basis for my article in KOMMUNIST.

I am deeply convinced that my point of view discloses real possibilities for the spiritual, social and industrial development of each man, while the vew of fatal genetic predetermination precludes these possibilities.

Moreover, the latter point of view is scientifically incorrect: we have no data to the effect that man's spiritual world, his work activities are biologically determined; in fact the specifics of man are created as the product of all social relations.

For this reason, we shall fight for the view that offers our people the opportunity of enormous social development on the basis of normal human heredity. The biological basis, being the lowest form of movement of matter in man, serves only as the prerequisite for him to enter into the social form of movement of matter. Consciousness, the spiritual world and ability to work do not appear in a child from his biology, but as a result of his active entrance into the world of social practice. Herein lie the enormous capabilities of pedagogics and psychology, that chief factor that should serve as the foundation of formation of new man by the conditions of the social environment.

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PHYSIOLOGY

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EFFECT OF ARTIFICIAL GRAVITATION IN SPACE FLIGHT ON RETENTION OF MOTOR HABITS BY ALBINO RATS

Moscow ZHURNAL VYSSHEY NERVNOY DEYATEL'NOSTI IMENI I. P. PAVLOVA in Russian Vol 31, No 2, Mar-Apr 81 (manuscript received 6 Mar 80) pp 261-266

[Article by N. N. Livshits, Z. I. Apanasenko, M. A. Kuznetsova and Ye. S. Meyzerov]

[Text] The goal of this project was to study the influence of artifical gravitational forces on some indicators of the higher nervous activity of albino rats in space flight. Certain changes in the behavioral reactions of animals following their exposure to space flight factors in biosatellites were noted by us earlier (3,4). Accelerations are known to have an effect on the central nervous system on earth (6,7, etc.), but there is no information in the literature on the action of these factors during orbital flight.

We studied behavior of animals in the first 2 weeks after the landing of a biosatellite aboard which artificial gravitation was created.

Methods

The conditions under which animals were maintained in a vivarium and aboard the biosatellite were published earlier, as was the complete program of clinical-biological research (1).

In addition to groups of animals studied in accordance with the complete program, there were a group of rats for which only higher nervous activity was investigated, and a group of rats studied in accordance with an abbreviated program containing only a third of the procedures included in the complete program (Table 1).

A maze devised by Ya. Dombrovskaya was used to study rat higher nervous activity. We recorded the number of refusals to run the maze, the time taken by the rat to move from the starting compartment to the feed compartment, and the mistakes made en route. We kept count of the number of times neurotic states arose, and of the number of disturbances in the normal dynamics of mistakes in the course of experiments. The research methods were described earlier (3). It should be pointed out that we attached special significance to the number of times rats refused to run the maze in our analysis of the results. Disturbances in higher nervous activity deduced from other indicators could be assessed at less than their true importance in the event of a significant increase in the number of refusals, because this would

Table 1. Characteristics of Experimental Conditions

Exposure Conditions		Group Symbols	No. of Animals in Group	Acceleration, g	Angular Velocity, Radians	Volume of Experimental Research
Aboard biosatellite	Motionless BIOS [not further identified]	ПН$_3$	5	0	0	Complete (all procedures
Kosmos-936	Centrifuge radius 320 mm	ПЦ$_2$	5	1	5.3	"
Mock-up on earth	Motionless BIOS	СН$_3$	5	1	0	"
	Centrifuge radius 320 mm	СЦ$_2$	4	1.4	5.3	Reduced (only higher nervous activity)
	Centrifuge radius 98 mm	Ц$_2^0$	4	1.1	5.3	Complete (all procedures)
Vivariums	Main group	ВК	6	1	0	"
	Additional group	ВК$_д$	18	1	0	Partial (1/3 procedures)
	Intact animals group (with no sensors implanted)	ВК$_и$	9	1	0	Reduced (only higher nervous activity)

mean that information about those animals which experienced the most significant changes in higher nervous activity would be excluded from the analyzed material.

Concurrently with recording the state of higher nervous activity, we used a five-point system to score the feeding activity of animals in the feed compartment of the maze. The lowest point score, 1, meant total absence of a reaction to the feeder. The highest, 5, signified fast eating of all of the feed. Intermediate point scores (2,3,4) corresponded to different degrees of weakening of the feeding reaction (not finishing all of the feed, slow feeding).

We began training the rats to find the feed in the maze 2 weeks before the flight, and stopped the training 5 days before the flight. The animals were distributed such that each rat in the experimental group had a partner in the control group with similar higher nervous activity indicators. The symbols used to refer to the different groups and descriptions of the effects to which they were exposed are shown in Table 1.

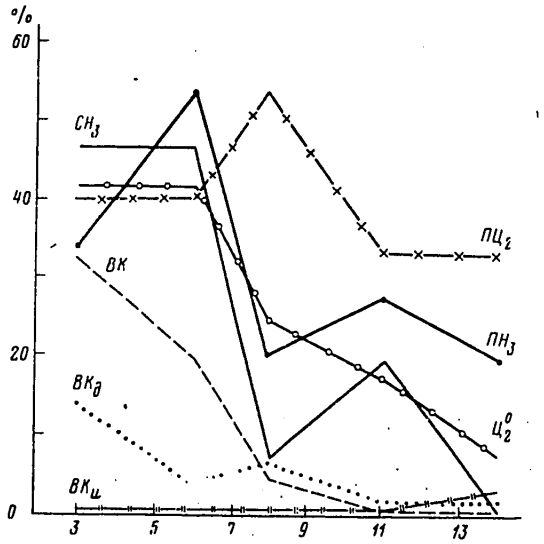

Figure 1. Refusals to Run the Maze in the Recovery Period: abscissa--days after landing; ordinate--refusals to run the mazes, percent. Letters beside the curves are the abbreviated names of the animal groups. See text for explanation.

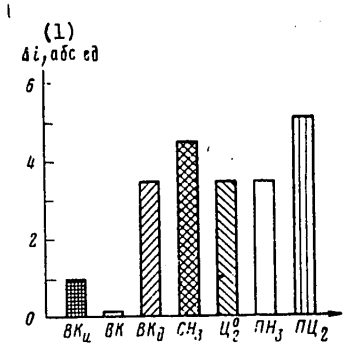

Figure 2. Mistakes in Recovery Period: abscissa--animal groups (see text and Table 1); ordinate--difference between group average for indicator under analysis in the testing period and two additional experiments performed subsequently

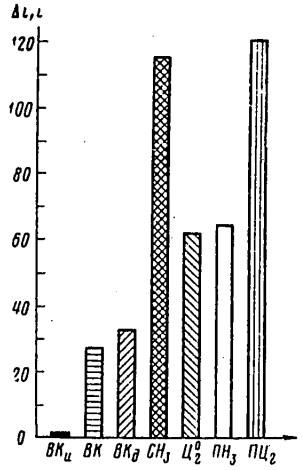

Figure 3. Maze Running Time in the Recovery Period: ordinate--time, sec. See Figure 2 for other symbols.

Key:
1. Absolute units

Body temperature sensors were implanted into the abdominal cavity of all animals (except group $ВК_{И}$) 2 weeks before the flight.

The maze tests were resumed 3 days after the biosatellite landed. For 16 days we studied the animals' capability for restoring and reinforcing the previously developed feed-seeking habit.

An experiment with a heightened functional load was performed on the 17th-18th days in order to study tiring of the higher divisions of the central nervous system. During this experiment the number of maze runs was increased to 16, and to avoid saturation of the animal, the number of individual reinforcement feedings was reduced correspondingly.

The results were treated statistically using algorithms for comparison of two processes, calling for dispersion analysis (5), and, in some cases, analysis on the basis of the "phi" and inversion tests.

Research Results and Discussion

The results of research on rats maintained in a vivarium showed that the behavioral habit previously developed in the maze was easily restored by intact animals, and with somewhat greater difficulty by rats subjected to surgery (implantation of sensors in the abdominal cavity). In this case the greatest difficulties were noted among animals tested in accordance with the complete program. This can be distinctly seen from change in the number of refusals (Figure 1), the maximum increase of which was recorded in group ВК, and the minimum of which was recorded in $ВК_{И}$ ($P < 0.05$). Changes in the number of refusals in group $ВК_{Д}$ were close to the indicators for group $ВК_{И}$; however, the rest of the parameters underwent significantly greater alteration than in the intact control ($ВК_{И}$). Differences in the number of mistakes (Figure 2) and time (Figure 3) were significant ($P < 0.05$).

Similar relationships in the change in the number of refusals recorded for control groups subjected to comparison were also revealed in the experiment with the heightened functional load.

Research conducted on animals maintained in a mock-up of the biosatellite also reveals certain difficulties in restoring the maze habit. All indicators for animals in group $СН_3$ changed for the worse, without exception, in comparison with the same indicators for animals maintained in vivariums (ВК). Differences between the groups were significant in relation to both the refusal criterion ($P < 0.001$) and the mistakes criterion and time ($P < 0.01$).

All of this indicates that neither surgery nor the load connected with the research nor presence in the biosatellite mock-up are indifferent to the state of higher nervous activity. It was for this reason that the behavioral indicators for animals that participated in the real space flight were compared with the indicators for groups ВК and $СН_3$.

The effect of flight upon the higher nervous activity of the rats was rather distinct. It was difficult for all animals to restore the maze habit, this result being most significant in the group subjected to artificial gravitation. The main differences entailed an increase in the number of mistakes (Figure 1). In the first 2 days of

the experiments the changes experienced in this indicator for group ПЦ$_2$, ПН$_3$, and СН$_2$ (mock-up control) did not differ significantly. But in the next three experiments the number of refusals gradually returned to its initial level for the control animals while remaining significantly high for animals that had been in flight; in this case it was noticeably higher ($P < 0.001$) for group ПЦ$_2$ than for group ПН$_3$ ($P < 0.01$). However, the differences between these two groups are insignificant due to the small number of animals involved.

Changes in the rest of the indicators also indicate greater difficulty in restoring the previously developed habit for animals in group ПЦ$_2$. These rats made more mistakes (Figure 2) and spent more time (Figure 3) to reach their goal than did rats in the control group. The differences are consistent, though they are statistically insignificant for our data ($P < 0.05$). Meanwhile, changes in these parameters for group ПН$_3$ were even smaller than for group СН$_3$. The number of neurotic phenomena increased identically for all animals exposed to space flight factors in the biosatellite. However, this increase for group ПЦ$_2$ was mainly the product of intensely pronounced neuroses, while in regard to group ПН$_3$ weak forms of neurotic states contributed significantly to this increase. The insufficiency of the experimental data precludes statistical comparison of these differences.

The experiment with the heightened functional load did not reveal differences in the behavior of the compared groups. Changes in the dynamics of mistakes made in the course of an experiment were also insignificant.

Among the terrestrial experiments, the one studying the higher nervous activity of animals in group Ц$_2^0$ was especially interesting. We might have expected that comparison of results obtained for animals in this and in the other groups would permit us to isolate the effect of angular velocity from the effect of centrifugation aboard the satellite. However, changes in the higher nervous activity of animals in group Ц$_2^0$, as implied by the indicators studied in this phase, were heterogeneous and insignificant; for this reason we were unable to make any certain conclusions at this time.

Investigation of the feeding activity of rats in the maze showed that changes in this activity did not correlate with disturbances in higher nervous activity (see Figure 1 and Table 2).

In the first 2 days of postflight testing, all animals exhibited a significant and practically identical decrease in feeding activity. Concurrently groups ВК$_И$ and ВК$_Д$ had significantly fewer refusals than other animals ($P < 0.05$). The main differences--and the significant ones as well--in the behavior of animals in groups ПН$_3$, ПЦ$_2$, and Ц$_2^0$ appear at the end of the testing period (the third through fifth experiments), when feeding activity in the maze had already returned to normal. In this case a smaller number of refusals tended to be recorded for animals exhibiting poorer feeding activity (group СН$_3$).

It should be emphasized that the most noticeable changes in higher nervous activity of animals subjected to centrifugation aboard the satellite occurred on the background of their higher feeding activity in the vivarium and faster weight gain, in comparison with rats in group ПН$_3$.

Table 2. Average Feeding Activity of Rats in the Maze (Points)

Period of Observation	Animal Groups							
	ВК$_И$	ВК$_П$	ВК	СН$_3$	СЦ$_2$	Ц$_2^0$	ПН$_3$	ПЦ$_2$
			Prior to Flight					
Last two experiments	4.4	4.6	4.1	4.4	4.4	4.6	4.6	4.5
			After Flight					
First two experiments (3d and 6th days)	3.0	3.4	3.9	2.7	4.9	3.7	3.3	3.7
Last three experiments (8th, 11th, and 14th days)	4.7	4.2	4.7	3.6	4.3	4.8	4.2	4.0

Note: The first two experiments are those performed on the 3d and 6th days after the flight's termination because experiments investigating higher nervous activity were not performed on the 4th and 5th days. The last three experiments were the ones performed on the 8th, 11th, and 14th days, and not on the 12th, 13th, and 14th days. Underlined figures represent the lowest feeding activity in the maze.

Thus the observed deviations in the behavioral reactions could not have been the product of postflight change in the level of their feeding motivation.

Analysis of the results shows that presence aboard Kosmos-936 and subsequent readaptation to terrestrial conditions hinder restoration of the previously developed habit of reaching the goal in the maze. We tentatively associated absence of such difficulties among animals with implanted body temperature transmitters following exposure to space flight factors aboard biosatellite Kosmos-782 with the specific, integrated influence of space flight factors and surgery. There are grounds for suggesting that the influence of the latter was reduced in our experiment in connection with the improvements in surgical techniques and with the unique features of the given stock of animals. The overall result of the integrated action of a number of factors, meanwhile, depends in many ways on the strength of action of each of the contributing factors (2). As comparison of the different control groups showed, implantation of foreign bodies into the abdominal cavity was not an indifferent factor either; however, it obviously did not mask the effects of the main factors of flight and readaptation.

Nor did artificial gravitation aboard the space ship reduce the degree of negative changes. A clear tendency for worsening of behavioral parameters was even noted among animals in group ПЦ$_2$. This is most probably associated with the fact that the possible positive influence of artificial gravity was suppressed by the negative influence of angular velocity upon higher nervous activity. The task the animals were required to perform in this phase of the research was rather simple: It entailed performance of a previously developed habit. Under these circumstances angular velocity could not elicit significant changes in the behavior of the animals. And in fact, the differences between groups Ц$_2^0$ and СН$_3$, which were subjected to corresponding influences (except for centrifugation), were small and irregular, while those between groups ПЦ$_2$ and ПН$_3$ were statistically insignificant, though clearly pronounced.

However, angular velocity did have an influence, and it was apparently sufficient to neutralize the possible positive action of artificial gravitation in flight.

Conclusions

Creation of artificial gravity aboard a biosatellite did not weaken the action of weightlessness upon higher nervous activity, which is apparently associated with the negative influence of the angular velocity arising upon centrifugation of the animals.

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REVIEW OF INTERVUZ COLLECTION 'PHYSIOLOGICAL BASES OF HUMAN FATIGUE'

Moscow USPEKHI FIZIOLOGICHESKIKH NAUK in Russian Vol 12, No 1, Jan-Mar 81 pp 138-140

[Review by A. Batuyev of book "Physiological Bases of Human Fatigue," an interVUZ collection, edited by Prof V. A. Baronenko, Izhevsk, 1978, 187 pages]

[Text] The problem of fatigue has gone far beyond the framework of biology. It has gained importance, not only with respect to determination of general physiological mechanisms of this state, but from the standpoint of solving specific problems of scientific organization of labor, which are directed toward safeguarding the health of workers, on the one hand, and improving the efficiency of production, on the other. The difficulties involved in solving all these problems are attributable to the lack of clearcut ideas about the mechanisms of fatigue and methods of diagnosing it.

In the foreword to this collection, the editor in chief justifiably mentions this as one of the reasons that make it necessary to continue investigation of physiological mechanisms, methods of detecting, predicting and preventing human fatigue during physical and mental work. In addition, the current status of the problem is briefly described in the foreword, as well as the implications of the purpose of this collection and the broad spectrum of issues it covers.

The main content of the collection is referable to experimental work performed by teams of scientists at Leningrad, Rostov, Kazan' and Udmurtskaya ASSR universities, which deals with the psychophysiological mechanisms, methods of predicting and detecting fatigue during mental and physical work. The collection consists of two parts. One deals with the study of mechanisms and principles of optimum combination of various work loads; the other pertains to research on the distinctive effects of acute and chronic loads on effectiveness of regulatory mechanisms of different functions.

In the first section of the collection, we were impressed by the following articles: "Predicting Efficiency of Work Fitness and Factors Determining It" (V. A. Baronenko et al.) and "Detection of Operator Fatigue" (A. B. Kogan et al.). The first, which is based on solid experimental data and mathematical modeling, validates the principle of optimization of body functions, which the authors call "the rule of behavior of regulatory systems" in response to a prolonged work load (mental and physical), the intensity of which does not exceed the range of the physiological norm. It appears to us that this principle discloses a new aspect of the mechanisms of optimizing body functions in the course of adaptation.

The second article defines the electrographic criteria of fatigue on the basis of a complex study of operator performance as a function of the principal properties of cortical processes, and an original thesis is expounded, to the effect that fatigue is based on functional disturbances referable more to integrative systems of the central nervous system than analyzer systems.

There is an interesting series of articles dealing with cortical mechanisms of fatigue from mental work. New facts, which were obtained by different methods, pertain to changes in structure of cortical activity in the presence of a visual or visual and motor work load. The article of L. N. Zefirov and I. L. Shcherbakova, "Dynamics of Time of Visual and Motor Reaction, and Parameters of Functional Asymmetry of the Brain During Mental Work as Related to Force of Neural Processes," broadens our knowledge about the distinctions of cortical activity during mental work as related to the main properties of the central nervous system, in particular the force of neural processes. The article by L. P. Pavlova et al., "Change in Structure of Cortical Activation in the Dynamics of Efficiency of Visual and Motor Tracking," gives us an idea about the electrographic correlates of fatigue and structural organization of cortical activity at different stages of operator efficiency [work fitness?]. In spite of the debatable nature of some of the theses in this work, in our opinion it enlarges upon known theoretical theses concerning the important role of associative frontal and parietal regions in structural organization of working mechanisms of brain activity.

The article of V. M. Chukhlantseva, "Fatigue or Biorhythms of Visual Function?" deals with an interesting topic. The author justifiably questions the validity of interpreting the decline of criteria of visual function of comparing (and any other functions) in the course of the work day and work week as a manifestation of fatigue, on the basis of extensive and well-analyzed data gathered on 220 workers under production conditions.

The article by O. V. Osipova and M. A. Val'kovskiy, "Effect of Combining Two Related Jobs on Efficiency of Lift Truck Operators," offers experimentally developed criteria for rating the occupational performance of drivers and specific advice to optimize work when related occupations are combined.

The second section of the collection is also of definite interest; it contains new facts on optimum modes of functional training of the body to perform physical work with great efficiency. The articles by O. V. Vinogradova and V. S. Aver'yanov "Electromyographic Study of Motion in Nonstationary Mode of Exercise With Self-Regulation," Yu. P. Malkov "Modes and Physiological Criteria of Readiness to Resume High-Speed Work," which deal with the search for optimum modes of rhythmic physical activity with voluntary regulation of pace and load, shed light on the important modulating role of the highest level of cortical activity, on the one hand, and determining function of preliminary exercises that are specific and similar to the expected type of work in creating the most flexible and, consequently, less tiring stereotype of regulation.

The possible means of immediate [speedy] physical stimulation of muscular work and validation of practical recommendations for use of these factors in optimum modes are discussed in the articles of G. S. Ryabkov, "Changes in Functional State of the Human Motor System Under the Influence of High-Frequency Vibration," and of Yu. P. Malkov and V. S. Topchiyan, "Effect of Rhythmic Electric Stimulation on Efficiency of Cyclic Work of Utmost Intensity."

At the same time, we must make some comments concerning some of the authors and editor of this collection. In this regard, we must mention, first of all, the article by L. K. Layzan, N. I. Gusev and Ye. A. Zub, "Cooperative Erythrocyte Resistance and Changes Therein With Physical Loads." Although the specific results obtained on man and the relevant conclusions are of practical interest, the contents of this article do not always conform with the special purpose of the collection. This applies, first of all, to the section on biorhythms of animal erythrocytes. Discussion of the obtained data goes far beyond the range of the tasks set forth. Some interesting facts were given in the article by V. I. Ryabenko and N. A. Chepelenko, "The Effects of a Physical Load on Erythrocyte Equilibrium of Athletes," where convincing conclusions were voiced, but there is inadequate presentation of factual material on the question of the effects of physical loads on erythropoietic function of metabolites of skeletal muscles. The article by R. A. Marinovich, "Description of the Combined Effect of Industrial Fatigue and Vibration," is too fragmentary.

In conclusion, it must be noted that the contents of most articles conform with the topic of the collection; most of the studies were conducted on a modern theoretical and methodological level, and they are notable for the timeliness [or importance] and novelty of formulated tasks and obtained results.

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RADIATION BIOLOGY

CONCLUSION FROM BOOK ON RADIATION BIOLOGY

Moscow PRODUKTY METABOLIZMA PRI RADIATSIONNYKH PORAZHENIYAKH in Russian 1980 (signed to press 18 Jan 80) pp 127-136

[Conclusion from book "Metabolic Products in the Presence of Radiation Lesions", by Leonid Andreyevich Tiunov and Viktor Vasil'yevich Kustov, Atomizdat, 1000 copies, 140 pages]

[Text] There has been development in recent years of research on the end products of metabolism in connection with the advances made in space biology and medicine. With reference to the task of space toxicology [15], we stressed that investigation of processes of synthesis and elimination by man of gaseous chemical compounds, which are formed in the course of normal metabolism, plays an important role with respect to forming the artificial atmosphere of pressurized cabins of aircraft. The longer the duration of space flights, the more important it will be to create an atmosphere in spacecraft that will be totally adequate for human requirements [5].

Several problems arise in developing systems to maintain the stability of such an artificial environment for man, and among them the problem of removing gaseous toxic substances, which are formed as a result of vital functions, from the cabin air is an important one. These substances include, first of all, carbon monoxide, acetone and ammonia. It is very interesting to study the dynamics of their elimination from the body, not only to solve problems of forming the artificial atmosphere of closed ecological systems, but to develop insulating space gear [6], as well as to investigate biological compatibility of crew members [19].

We have summarized in several surveys and monographs [15-17] data from the literature and the findings of our research on the main patterns of formation and elimination of the end gaseous products of metabolism of healthy organisms. It was established that the quantitative characteristics of eliminated gaseous metabolic products are related to the functional state of an organism. Consequently, estimation of eliminated metabolic products for cosmonauts can be made only with due consideration of the effect of space flight factors on this process. One of the main factors of space flights is ionizing radiation. In our studies of the effects of ionizing radiation on formation and elimination of gaseous metabolic products, we proceeded from the thesis that these compounds are not only and not so much the "waste" from vital functions--anthropotoxins, but substances that are necessary to the body, which play a certain biological role and perform certain physiological functions. This opinion is becoming increasingly widespread in the literature. For example, it was demonstrated that fixing of carbon dioxide, a typical representative of the end gaseous metabolic products, is not only the property of

plants and autotrophic bacteria, but animals. Carbon dioxide is involved in biosynthetic processes through the reactions of carboxylation of pyruvic and phosphoenolpyruvic acids, carboxylation of acetyl CoA to malonyl CoA. Carbon dioxide is used, along with ammonia, in synthesis of carbamoyl phosphate, which is needed for building pyrimidine bases. Stimulation of carbon dioxide uptake in animals elicits intensification of biosynthetic processes [7].

The metabolic products we studied (ammonia, acetone and carbon monoxide) are also mandatory components of a number of biochemical processes. In addition to the already mentioned participation in synthesis of carbamoyl phosphate, ammonia is needed for production of glutamic acid and it participates in diverse amination reactions.

Acetone is carboxylized to acetoacetic acid and through it participates in metabolism of tricarbon fragments. At the same time, along with β-hydroxybutyric acid, acetoacetic acid plays a rather important role, according to the latest data, in maintaining energy homeostasis [21].

Endogenous carbon monoxide participates in regulation of the rate of oxidative degradation of heme by inhibiting activity of hemoxygenase and cytochrome P-450. In view of these circumstances, it must be conceded that investigation of the effects of ionizing radiation on intensity of elimination of gaseous metabolic products not only characterizes the possibility of contamination of a closed ecological system by toxic agents, but permits evaluation of the functional state of the elements of metabolism related to production of the compounds under study.

Thus, aside from the widely used criteria, determined from analysis of blood and urine [29], parameters characterizing the intensity of elimination in exhaled air of gaseous metabolic products (for example, acetone, ammonia and carbon monoxide) could be additionally used as biochemical indicators of the condition of an organism in the presence of radiation lesions.

The results of our studies revealed that there is increased elimination of carbon monoxide when the body is exposed to ionizing radiation in a dosage that elicits development of mild and moderate radiation sickness. There is also a drop of blood ammonia level and total elimination thereof. There are phasic fluctuations in elimination of acetone. More intensive elimination of acetone for the first 3 days of radiation sickness of moderate severity is followed by a drastic decrease in elimination starting on the 5th day. On the 10th postradiation day, there is another increase in acetone elimination, which reaches a maximum on the 12th day of sickness. Phasic fluctuations in hormonal activity and changes in carbohydrate and lipid metabolism correspond to these phasic fluctuations.

In the presence of mild radiation sickness, there is a moderate increase in acetone elimination with insignificant elevation of ketone body level in blood on the 10th day of sickness. Finally, acute radiation elicits elevation of endogenous hydrogen peroxide level in tissues.

The observed changes in levels and elimination of gaseous metabolic products are related to radiation dose. The earliest changes are demonstrable in elimination of endogenous carbon monoxide. An increase in elimination of this metabolite by white rats begins on the 3d day after delivery of 100 R radiation. With increase in radiation dosage to 300 R, intensified elimination of carbon monoxide is

associated with inhibited elimination of ammonia and decline of its level in blood. Concurrently there is an increase in elimination of acetone. After exposure to ^{60}Co γ-radiation in a dosage of 650 R, white rats present increased elimination of endogenous carbon monoxide, diminished elimination of ammonia and phasic fluctuations in elimination of acetone.

Thus, determination of changes in amounts of eliminated gaseous metabolic products could be used to diagnose and prognosticate the course of radiation lesions. At the same time, these data are of interest for analysis of correlation between various metabolic pathways under the influence of ionizing radiation, which could play some role in the pathogenesis of radiation lesions.

Relevant chapters contain a comprehensive analysis of the possible causes of change in intensity of elimination of various gaseous metabolic products by animals under the influence of ionizing radiation. Here, we shall try to consider the correlation between these causes.

Electron microscopy revealed that ionizing radiation elicits a substantial increase in liver peroxisomes [28], i.e., microbodies in which hydrogen peroxide is metabolized. In addition, x-radiation demonstrated severe inhibition of catalase synthesis [11] in the liver, the rate of which diminished by 2.6 times [12]. These data in the literature reinforce data concerning the increase in hydrogen peroxide content of tissues of irradiated animals, due to increased endogenous production thereof and the effect of ionizing radiation. Interaction between hydrogen peroxide and lipids raises the levels of lipid peroxides. Peroxide compounds may have a deleterious effect on the membranes of lysosomes, mitochondria and the endoplasmic reticulum. Damage to mitochondrial membranes by lipid peroxides leads to a change in their function [27]. Mitochondrial enzymes are disorganized, and this applies to those related to ammonia metabolism. Thus, there is a decrease in activity of mitochondiral phosphate-dependent glutaminase, which retards production of ammonia from glutamine. At the same time, activity of mitochondrial ornithine carbamoyl transferase increases by several times, which leads to faster involvement of ammonia in the reaction of carbamoyl phosphate synthesis. These circumstances, along with inhibition of processes of oxidative deamination and decreased activity of mitochondiral monoamine oxidases [8], enable us to conceive of a possible mechanism of decline of blood ammonia level, which reflects changes in nitrogen metabolism in the presence of radiation lesions [1].

These disturbances are related to changes in carbohydrate metabolism, which lead to disturbances in production and elimination of acetone. Indeed, a low ammonia level inhibits the process of amination of α-ketoglutaric acid, which is a component of the Krebs citric acid cycle. A change in NAD:NAD·H ratio, which occurs because of changes in energy level of mitochondria, is also instrumental in inhibition of amination. Impairment of α-ketoglutarate metabolism is associated with functional changes in the tricarboxylic acid cycle and processes of utilization of acetyl CoA. Its level in tissues undergoes phasic fluctuations. CoA content decreases by 45-56% 3 h after exposing rats to x-radiation in a dose of 800 R, and there is also a decrease in acetylation. However, after 1 day, there is an increase in acetylation [18]. Changes in formation and elimination of acetone in irradiated animals are a reflection of these findings.

The disturbances referable to carbohydrate metabolism in the presence of radiation sickness are characterized by intensification of gluconeogenesis and change in

function of the pentose pathway of glucose conversion [30]. In a number of instances, an increase was observed in activity of glucose-6-phosphate dehydrogenase [13] and a change in yield of NADP•H that is needed for the function of glutathione reductase which, along with glutathioneperoxidase, regulates the level of reduced glutathione and endogenous hydrogen peroxide in the cell.

The increase in endogenous hydrogen peroxide in irradiated erythrocytes is instrumental in production of methemoglobin [2] and, by impairing hemolytic resistance of cells, accelerates the process of their destruction [25]. In the liver and spleen, hydrogen peroxide is involved in oxidative degradation of heme, and with a break in the latter's porphyrin ring there is formation of endogenous carbon monoxide.

Thus, the changes we observed in content and elimination of gaseous metabolic products is a manifestation of interrelated structural and metabolic disturbances inherent in the effect of ionizing radiation on animals and man.

Typical radioprotective agents, which attenuate the severity of radiation lesions, modify the process of elimination of gaseous metabolic products. Thus, cystamine inhibits the rate of elimination of endogenous carbon monoxide. Mexamine, however, which does not affect elimination of carbon monoxide, does affect the level of ammonia in blood and its elimination.

Virtually the most important finding is inhibition of production of endogenous carbon monoxide by cystamine. The mechanism of this inhibition is apparently related to the capacity of amino thiols and, first of all, cystamine, to increase the amount of reduced glutathione in the body [24]. It is known that administration of cystamine raises the level of sulfhydryl groups, intensifies reactions of their metabolism and causes release of protein-bound reduced glutathione [31]. The rise in level of reduced glutathione activates the rate of the glutathione peroxidase reaction associated with utilization of endogenous hydrogen peroxide for oxidation G = SH. The greater use of endogenous hydrogen peroxide results in lowering of its level and restricts its participation in oxidative degradation of heme, which is apparently what inhibits production of endogenous carbon monoxide.

At the same time, normobaric hyperoxia causes increased elimination of endogenous carbon monoxide. It is known that, in the presence of hyperoxia, there is more intensive production of peroxide compounds, in particular, hydrogen peroxide [10], which, as we have noted in Chapter 4, plays a substantial role in formation of endogenous carbon monoxide. The build-up of exogenous hydrogen peroxide due to hyperoxia is compensated by inhibited production of endogenous H_2O_2. The excess of hydrogen peroxide depresses superoxide dismutase activity and thereby retards endogenous production of peroxide. Thus, the overall level of peroxide compounds does not change appreciably. Such self-regulation is possible only with a specific level of hyperoxia. In our experiments, 45% oxygen in the atmosphere did not affect elimination of carbon monoxide. However, an increase to 96% oxygen elicited a malfunction in the mechanism of self-regulation of peroxide level, which was manifested by increased production of endogenous carbon monoxide.

A study of the chronic effects of a low dose of ionizing radiation on elimination of gaseous metabolic products demonstrated some specific distinctions. Thus, unlike acute radiation sickness, the chronic exposure to a low dose of ionizing radiation causes greater elimination of ammonia. This could be attributable to either developmental distinctions of intestinal flora in the presence of a

long-term sluggish process or distinctive disturbances of nitrogen metabolism with this form of radiation sickness. Experiments on mongrel dogs exposed to different doses of ^{60}Co γ-radiation revealed changes 1 to 4 years later in glutamic acid content and activity of enzymes involved in its metabolism. As a result, it was noted that there is a possibility of accumulation of ammonia [22].

There are also distinctive features to elimination of acetone under the chronic effect of low doses of ionizing radiation. In the case of acute radiation lesions, elimination of acetone is phasic, an increase being followed by drastic decrease, depending on observation time and radiation dosage, in rate of elimination. With chronic exposure to low doses, throughout the 2-month observation period animals presented some increase in elimination of acetone, followed by significant decrease by the end of the experiment (in the 3d month). Thus, in this case too, we see a phasic pattern of elimination of acetone. The differences are only quantitative. The phases last for months rather than days.

In relevant sections of this book we have discussed in detail the mechanism of metabolic disturbances upon which are based the changes in acetone elimination in irradiated animals. We can add here only that the decrease in elimination of acetone by white rats in the 3d month of exposure to ^{60}Co γ-radiation conforms with information in the literature concerning a decrease in coenzyme A content of organs of animals submitted to chronic irradiation [20].

Finally, comparing elimination of carbon monoxide by animals submitted to acute and chronic irradiation, it should be noted that in both cases elimination increases due to intensification of catabolism of porphyrin structures, breaks in tetrapyrrole rings of which are associated with production of carbon monoxide. The similarity of the reaction of elimination of carbon monoxide with both acute radiation lesions and under the long-term effect of low doses of ionizing radiation is indicative of its low specificity. This is corroborated by information in the literature to the effect that increased breakdown of porphyrin structures and impairment of their metabolism occur not only in the presence of clinically marked anemia and porphyria [9], but under the effects of various environmental factors [23]. Intensification of porphyrin metabolism, manifested by porphyrinemia, porphyrinuria and increased elimination of carbon monoxide, is observed in the presence of the most diverse diseases of the blood, respiratory organs, cardiovascular system and liver, and it is interpreted as a compensatory reaction of the organism [3]. Evidently, one should consider intensification of oxidative degradation of heme as a nonspecific reaction to all sorts of factors associated with increase in levels of endogenous hydrogen peroxide and other peroxide compounds in the body. This reaction can also be considered a defense reaction to some extent, since, as has been indicated above, endogenous production of carbon monoxide inhibits the activity of hemoxygenase and cytochrome P-450, which inhibits the process of destruction of the porphyrin ring. Moreover, accumulation of endogenous carbon monoxide could inhibit the activity not only of cytochrome P-450, but cytochrome c and cytochromoxidase. This slows down the function of both the mitochondrial and microsomal chain of electron transport and reduces production of endogenous hydrogen peroxide. However, in this case, as in several others, it is very difficult to draw a distinct line between compensatory and damaging reactions.

Our data indicative of increased elimination of carbon monoxide under the influence of both acute and chronic radiation allows us to concur with the authors of [3] who

consider the changes in porphyrin metabolism to be an expression of stereotypic nonspecific reactions that enable the organism to maintain homeostasis.

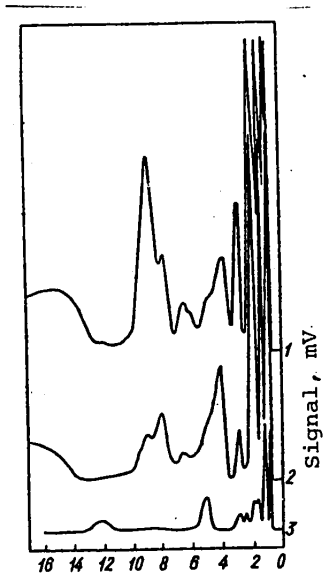

Figure 3.1.
Chromatograms of hydrocarbon complex demonstrated in experiments with white rats 1 month after exposure to ^{60}Co γ-radiation
1) background
2) complex of substances eliminated by experimental animals

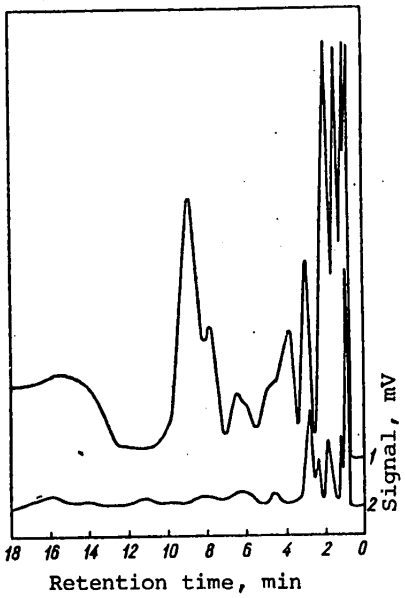

Figure 3.2.
Chromatograms of hydrocarbon complex demonstrated in experiments with white rats 3 months after exposure to ^{60}Co γ-radiation
1) background
2) complex of substances eliminated by experimental animals (each point indicates 3 min)

It is expedient to make a correlation analysis of data obtained from studies of intact and irradiated animals to assess the significance of the observed changes in intensity of elimination of gaseous metabolic products in the presence of radiation lesions. The fact of the matter is that elimination of metabolic products reflects rhythmic fluctuations in enzyme activity, permeability of biological membranes, concentration of substrates, and it occurs synchronously. Disruption of synchronization of biochemical reactions to environmental factors is indicative of pathology. This was demonstrated in experiments with vinyl acetate and in our tests with freon $114B_2$ [26].

The study of degree of synchronization of elimination of gaseous metabolic products by intact and irradiated animals by means of correlation analysis revealed that there is a close correlation between the rhythm of elimination of carbon monoxide and ammonia in intact animals. The coefficient of rank correlation, calculated from the results of 3-month experiments was found to equal 0.55 ($P = 0.05$).

Desynchronization of elimination of these gaseous metabolites was demonstrated in the case of long-term exposure to low doses of ionizing radiation. The coefficient

of rank correlation dropped to unreliable values. Consequently, the demonstrated changes in intensity of elimination of some gaseous metabolic products by white rats exposed to ^{60}Co γ-quanta for 3 months at a dose rate of 100 mR/day are not indifferent to the organism and reflect appreciable changes in metabolism.

Table 1. Characteristics of time of retention of elements of the hydrocarbon complex

Peak No	Background prior to study	Control group			Irradiated rats		
		after 1 month	after 2 mos.	after 3 mos.	after 1 month	after 2 mos.	after 3 mos.
I	9	9	9	9	9	9	9
2	II	-	I2	I3	I3	I2	I2
3	I5	I4	I6	-	I7	-	-
4	I9	I3	I8	I8	-	I8	I8
5	-	-	-	-	20	-	-
6	-	-	24	-	-	24	-
7	-	-	27	27	26	28	28
8	30	30	-	30	30	-	-
9	38	4I	-	-	-	-	-
I0	48	-	46	-	-	48	47
II	-	-	-	5I	5I	-	-
I2	65	64	-	-	-	-	6I
I3	-	-	-	70	-	-	-
I4	78	80	-	-	-	80	80
I5	88	90	-	-	-	-	-
I6	-	-	-	-	-	-	II2
I7	-	-	-	II7	I23	-	-
I8	I55	-	-	-	-	-	I60
I9	-	-	-	-	-	-	-
20	-	I80	-	-	-	-	-
2I	-	-	-	-	-	-	-

In our work, we studied elimination by irradiated animals of three gaseous metabolic products--carbon monoxide, acetone and ammonia. We deemed it expedient to supplement these data with chromatographic studies of the entire hydrocarbon complex of compounds eliminated by white rats during chronic exposure to low doses of ionizing radiation.

The chromatographic studies were conducted by D. T. Lazurenko and R. S. Apukhtina [4] on a KhV-1 chromatograph with ionization-flame detector. Nitrogen served as the carrier gas and polyethyl glycol ether of adipinic acid served as the liquid phase. The column temperature was 100°C. The set of gaseous products eliminated by the animals was sorbed with brand SKT activated carbon. The carbon was desorbed at a temperature of 350°C. The gas mixture in a nitrogen medium was blown through the chromatograph column, where it was separated into components. The results of these chromatographic studies are illustrated in Figures 3.1, 3.2 and in Table 1. According to these figures and table, the compounds demonstrable in the background studies are then observed in experimental and control animals over a 3-month observation period. The only exceptions were peak No 9, which was absent in irradiated animals, and peak No 16 which, on the contrary, was demonstrable only in experimental white rats.

The chromatographic results confirmed those obtained previously. They indicate that there are changes in elimination of gaseous metabolic products under the influence of long-term exposure to low doses of ionizing radiation. These changes were qualified as moderate in the case of 3-month exposure to γ-radiation at a dose rate of 100 mR/day.

In conclusion, it should be noted that our work is merely the first stage on the way toward working on the problem of elimination of gaseous metabolic products under the influence of environmental factors. We demonstrated, on the example of ionizing radiation, that gaseous metabolic products may be indicators of severity of deleterious effects and, to some extent, of the nature of metabolic changes. At the same time, the obtained material permits prediction of the nature of changes in the artificial atmosphere of closed ecological systems as a result of passage into it of gaseous metabolic products.

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HUMAN FACTORS

UDC: 629.7.06(082):629.7.018.2.001.2

SIMULATOR SYSTEMS

Moscow TRENAZHERNYYE SISTEMY in Russian 1981 (signed to press 18 Nov 80) pp 2, 6-8, 252-254

[Annotation, introduction and table of contents from book "Simulator Systems", by Valentin Yefimovich Shukshunov, Yuriy Aleksandrovich Bakulov, Vladimir Nikolayevich Grigorenko, Aleksandr Viktorovich Golovkov, Vladimir Pavlovich Dykan', Aleksandr Grigor'yevich Dushenko, Vladimir Vasil'yevich Zverev, Sergey Ivanovich Pototskiy, Ivan Nikolayevich Pochkayev and Georgiy Stepanovich Shonin, Izdatel'stvo "Mashinostroyeniye", 2600 copies, 256 pages]

[Text] This book deals with problems of designing simulator systems. It discusses the principles involved in building multiple user simulator systems, problems of providing flexibility, viability, functional additions and stage by stage development of such systems. The advantages of using such systems at major educational centers for vocational training of operators are demonstrated, as compared to simulators for single individuals.

This book is intended for scientific and engineering-technical workers concerned with development of use of simulator systems for different purposes.

Introduction

Numerous problems arise in developing modern, complex automated complexes and systems, the most difficult one being the task of assuring high efficiency of interaction between man and the automated part of the system.

When controlling large dynamic complexes, the problem of formation of the required level of occupational training of the operator is advanced to the fore.

The most effective means of occupational training of operators are simulators, which create the illusion of controlling real objects. Simulators have played and continue to play a special role in training operators of moving objects--on the ground, sea, air and in space. There is no doubt that simulators will become even more widespread in the future. However, the complexity and high cost of simulators make it imperative to search for a more efficient way of using them. This is particularly important when furnishing simulators to major operator training centers. There are wide applications for simulators in various areas of human endeavor, and they are the most effective means of mass scale operator training.

It is not effective to furnish major operator training centers [OTC] large numbers of self-contained simulators. Experience has shown that the self-contained [autonomous] simulator use index [time] constitutes only 30-50%.

As we know, organization of multiple user computer centers, computer systems and computer networks is a means of improving the efficiency of using computer technology. One can improve the efficiency of simulator technology by creating simulator complexes and systems of collective [group] use. The practical implementation of this direction in simulator building is related primarily to assuring the technical, software and data compatibility of simulators and design of software and hardware based on principles of modular, standardized and unitized construction.

The supply of equipment to OTC's with simulator systems with software and hardware compatibility provides the conditions for combining them into a single simulator network. This permits organization of immediate exchange of information between different simulator systems of different OTC's and control centers of, for example, flying vehicles, as well as joint operation thereof when it is necessary to work out unforeseen situations.

A network of simulator systems refers to the aggregate of multiple user simulator systems of OTC's, systems of exchange of data and subscriber centers, combined to improve the efficiency of using simulator equipment.

Creation of simulator systems and networks provides for the fullest and most effective use of the entire armamentarium of resources for professional training of operators.

Simulator systems are notable for a flexible structure, possibility of concurrent operation of different subsystems and channels, and a high degree of viability. These features of simulator systems make it possible to easily readjust them and train operators for new or updated systems.

Future development of simulator systems is related to standardization, not only of different elements, but the simulator system as a whole, which makes it possible to expedite the supply of simulator equipment to OTC's and lower the cost of designing them. The principles expounded in this book concerning construction of simulator systems are universal, and they can be used as the basis for developing simulator systems for different specialized purposes.

This book is one of the first attempts to cover fully and systematically a number of problems related to the design and operation of group use simulator systems operating on a real-time scale.

Contents

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PSYCHOLOGY

MEETING OF SCIENTIFIC COUNCIL ON PSYCHIATRY OF USSR ACADEMY OF MEDICAL SCIENCES PRESIDIUM

Moscow ZHURNAL NEVROPATOLOGII I PSIKHIATRII IMENI S. S. KORSAKOVA
in Russian Vol 81, No 2, Feb 81 pp 148-149

[Article by Ye. K. Lobova, Moscow]

[Text] On 23-24 April 1980 in Moscow, at the Psychiatric Institute of the USSR Academy of Medical Sciences, the all-union-level Problem Commissions, "Primary Mental Disorders" and "Biological Investigations of Mental Illnesses," held a joint conference devoted to discussion of the present status and to the outlook for development of the most important directions taken by scientific investigations in psychiatry in Siberia and the Far East. Participating in the work of the conference, in addition to the members of the two commissions, were leading specialists of those areas and the heads of psychiatry departments at the medical institutes: V. S. Brichenko (Blagoveshchensk), P. V. Mikhalev (Vladivostok), R. Kh. Gazin (Irkutsk), L. I. Kiseleva (Krasnoyarsk), A. A. Kornilov (Kemerovo), Ts. P. Korolenko (Novosibirsk), S. N. Larin (Omsk), E. D. Krasik (Tomsk), G. F. Kolotilin (Khabarovsk), Yu. A. Mileykovskiy (Chita) and A. S. Staritsin (Chelyabinsk).

In opening the conference, M. E. Vartanyan, chairman of the Problem Commission, "Biological Investigations of Mental Illnesses," emphasized that it was one of the first conferences whose goal was to impart information on the status of scientific research in psychiatry in Siberia, to make known the most up-to-date orientations and prospects for their development in each of the institutions of the area and to discuss possibilities for developing integrated scientific work based on programs of an all-union and regional scale. He also stated that coordination of scientific investigations in Siberia and the Far East will be brought about with the participation of the Psychiatric Institute of the USSR Academy of Medical Sciences, a branch of which is expected to be opened in Tomsk.

In the course of the conference, representatives of the above-named departments of psychiatry reported on the history of their founding, trends in studies being carried out, the results obtained and projects for the next five-year plan. It was pointed out that, in recent years, a concerted effort has been made in rayons of Siberia and the Far East to create a network of psychiatric institutions and scientific centers for the training of highly qualified cadres of physicians and

scientists who would make a significant contribution both to working out some theoretical problems in the science of psychiatry and to solving a number of extremely important practical problems. At the Psychiatry Department of Tomsk Medical Institute (the oldest in Siberia and the Far East) the main orientation of scientific research is clinical, epidemiological, and organizational aspects of the rehabilitation of mental patients. E. D. Krasik pointed out in his report that chief consideration has been given to two disorders--schizophrenia and alcoholism. As a result of research in these areas, clinical evidence for "industrial" rehabilitation has been made precise; new forms and methods have been worked out to organize the work schedule and daily life of patients in industrial enterprises and at agricultural sites; a specialized rehabilitation center with traveling teams has been organized as well as a patient dormitory and the first specialized psychotherapeutic student service in the country has been set up. Likewise, at the department, research on the biological bases of mental disorders has been initiated (immunological research on schizophrenia with favorable outcome is being carried out) and development of rehabilitation programs with a pathogenetic basis has begun.

In Ts. P. Korolenko's report, information on the development of new approaches to the pharmacotherapy (in particular, with atropine) of some forms of mental disturbance in alcoholism was presented.

Another facet of research is that related to the study of the mechanism of action of psychotropic drugs as it affects subcellular structures (lysosomes) of the liver and brain. It was pointed out that there occurs, with administration of phenothiazine derivatives, an accumulation of these agents in the cited subcellular structures and that this accumulation may trigger the onset of pharmacotherapy-related complications and side effects.

A. S. Staritsyn reported on research in the department that he heads, the subject of which is the immune biological reactivity of schizophrenia patients and their offspring.

In a number of reports it was emphasized that the Siberian and Far Eastern region of the country is distinguished by various climatic and geographic factors and occupational and dwelling-related aspects (importance of the population's migration, necessity of acclimatization and so forth). Of special importance in this regard is the study of so-called territorial pathology. Problems of this type are being investigated at the Psychiatry Department of the Vladivostok Institute (Head: P. V. Mikheyev). This institute was the first in our country where research was devoted to anaphylactic psychoses originating in stings of the toxic jellyfish Gonionemus in those swimming in the sea. At present, the department's efforts are directed at studying the epidemiology of oligophrenia on the littoral and of immunological changes in the psychopathic disorders and the cerebral form of toxoplasmosis. Part of this research, for example, that concerning the immunogenetic profile of nonspecific reactivity in these patients and its correlation with the severity of the psychosis, has already been worked out and brought to light.

V. S. Brichenko reported on psychic disadaptation, a problem being investigated by a group within the department. As a model, reactive states were chosen. Research on the problem of psychogenic disorders will assist organizations providing specialized aid to this group of patients and, likewise, help introduce into practice measures to prevent psychic disadaptation.

S. N. Larin reported on joint efforts on the part of the departments of biochemistry, histology and forensic medicine directed at the search for biochemical tests suitable for implementing control of the onset of disturbances in metabolic processes in the treatment of chronic alcoholism. Introducing such a series of tests into clinical practice carried on by specialists in narcotics addiction could provide concrete assistance in evaluating the efficacy of pharmacotherapy.

A. A. Kornilov elucidated the progress of work on the problem presented by psychic disorders arising in a remote period of occult cranio-cerebral trauma that is of great relevancy today for the Kuznetsk Basin, where the great mass of the population is employed in the coal industry.

According to a report by L. I. Kiseleva, the Psychiatry Department at Krasnoyarsk Medical Institute is participating in the realization of a major program called "keeping intact the labor resources of the kray." In the context of this program, the study of the status of diagnosis of mental disorder in the Kray is intended, as is the development of clinically significant aspects of diagnosis of neuroses and neurosis-like conditions.

Presentations by R. Kh. Gazin, G. F. Kolotilin, and Yu. A. Mileykovskiy elucidated research done by groups within their respective departments on the problems of alcoholism and narcomania. Many of these studies are directed at solving practical problems in the treatment and prevention of these disorders.

In the discussion, a favorable reception was given the research being carried on in the institutions of Siberia and the Far East and questions in the further improvement of its organization were discussed. There was recognition of integrated regional and, also, special-purpose scientific programs being realized under the direction of head institutions for the more fruitful form of planning and conduct of research that they represent.

In summing up the conference, R. A. Nadzharov, chairman of the problem commission, "Primary Mental Disorders," noted that each psychiatric department of a given region now ought certainly to occupy an honored place in the nation's psychiatry. Psychiatry departments are not only centers for the training of specialists but also the highest-ranking consultative centers providing psychiatric aid to the population of the respective areas. Future successful development of scientific investigations in the departments will depend in many ways on improvement of research organization, which ought above all to be directed at raising the methodological level of projects. There was analysis, in this light, of the possibilities

of using the group method in clinical research. Attention was also given to the necessity of developing studies directed to organizing and putting on a scientific basis new forms of psychiatric aid adequate to the conditions of a given region.

The questions discussed found expression in the resolution adopted at the conference.

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BOOK ON HIGHER NEURON ACTIVITY REPUBLISHED

Moscow ZHURNAL VYSSHEY NERVNOY DEYATEL'NOSTI IMENI I. P. PAVLOVA in Russian Vol 31, No 2, Mar-Apr 81 pp 435-436

[Review by G. A. Voronina of book "Fiziologiya vysshey nervnoy deyatel'nosti i psikhologiya (uchebnoye posobiye po fakul'tativnomu kursu dlya uchashchikhsya IX-X klassov shkoly)" [Physiology of Higher Nervous Activity and Psychology (Training Manual in an Elective Course for Students in Grades IX-X)] by L. G. Voronin, V. N. Kolbanovskiy and R. D. Mash, 2d revised edition, Moscow, Izdatel'stvo "Prosveshcheniye", 1977, 223 pages]

[Text] This manual is intended for schoolchildren showing an interest in studying one of the most complex functions of the body--higher nervous activity. It reveals the basic laws governing the work of the brain associated with physiological perception of the surrounding world and reaction to it.

The authors had the difficult task of explaining the most complex problems of higher nervous activity and psychology from deeply scientific positions, and at the same time presenting them in attractive form. They were able to do this because, being leading specialists in higher nervous activity, psychology, and pedagogics, they worked cooperatively on the manual. The authors were united by a common objective--explaining the material from modern scientific positions and presenting it in such a way that it would rouse the thinking of the reader, and educate him. From the first chapter to the last, the manual considers development of the individual into a comprehensively developed builder of communist society. The lively, interesting, and persuasive material of the book forms, in the young generation, a conscious attitude toward solution of vitally important problems in social relations.

Citing I. P. Pavlov's statement that "physiology must teach people not only how to work, relax, eat, and so on correctly--that is, usefully and pleasantly--but also to think, feel, and desire correctly", the authors emphasized the purposefulness of all learning. In particular the book offers recommendations to the reader on how to work with the training manual. It suggests deep study of the basic material, reading of supplementary literature, and performance of psychological experiments, observations, independent study assignments, and exercises by which to train memory, observation, and attention. The structure itself of the training manual promotes this. Each chapter ends with a sufficient number of well-conceived questions.

Presenting a large number of experiments and assignments for independent study, the authors devote attention to the elements of research, and to nurturing, in the students, a quality which was valued highly by I. P. Pavlov in his research on higher nervous activity--the "powers of observation". The book suggests assignments for developing conditioned reflexes, and differentiated and extinctive inhibition (chapters V, VI), exercises by which to train memory, observation, and attention (chapters IX, X), and so on. To make the reader more attentive toward the subject, the titles of subsections in the individual chapters of the manual are given in a somewhat unusual riddle form: "Biological Amplifiers" (Chapter II), "Is It True That Another's Soul is Unfathomable?" (Chapter VII), and "Two mirrors (Chapter VII), or in the form of questions: "How Do We Perceive Time?" (Chapter VIII), "What is Homeostasis?" (Chapter VI), and "What Can We Do To Improve Memory?" (Chapter IX). As a result the student develops a desire to find the answers to these questions, to think about them, to analyze the facts, and to test his own knowledge.

The authors included, in the training manual, an examination of the existing theories and hypotheses on brain activity, ones which encourage scientific thinking. They point out the questions about higher nervous activity that are still problematic, the ones that are in the research stage, and ones requiring clarification of their mechanism. Chapter IV presents hypotheses on the internal mechanisms of unconditioned and conditioned reflexes, Chapter VI examines feedback mechanisms, and so on. Schoolchildren must know that science still has unsolved problems, and that new research and new discoveries are needed. The modern generation will be a participant in new discoveries, but this would require much persistent study and work.

Complying with the principle of historicism in the development of science, the authors examined the original data from research on higher nervous activity in Chapter I, "At the Dawn of the Science of the Brain". Such illumination of the science of higher nervous activity and acquaintance with the works of outstanding domestic physiologists--I. M. Sechenov, I. P. Pavlov, N. Ye. Vvedenskiy, A. A. Ukhtomskiy, L. A. Orbeli, P. K. Anokhin, and others--promotes formation of a materialistic understanding of the world in the schoolchild, and helps him to assimilate the course of general biology. Statements by the classicists of Marxism-Leninism--Marx, Engels, and Lenin--cited in this book also aid in attainment of this objective.

The book is written with clearly understandable language, and it is richly illustrated with facts. It would be of interest not only to schoolchildren but also to college students, teachers, and nonspecialists desiring to learn about the physiology of the brain.

Unfortunately the ion-membrane theory is not examined intelligibly or with sufficient detail, and there are no graphical illustrations of it. We must admit low satisfaction with Figure 9 illustrating the discharges of a single neuron; some scientific terms, for example parabiosis and others, are left undefined.

On the whole the book is an extremely important and necessary pedagogical aid which has withstood the test of time and which has rightfully been given a high evaluation by schoolchildren, specialists in education, and college students.

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SOCIALIST COUNTRIES HOLD YOUTH CONDITIONED REFLEX ACTIVITY SEMINAR

Moscow ZHURNAL VYSSHEY NERVNOY DETATEL'NOSTI IMENI I. P. PAVLOVA in Russian Vol 31, No 2, Mar-Apr 81 pp 437-438

[Article by P. V. Simonov: "International School-Seminar of Young Specialists From Socialist Countries, 'Neurophysiological Aspects of Conditioned Reflex Activity'"]

[Text] An international school-seminar devoted to the neurophysiological (predominantly cellular and synaptic) mechanisms and neurochemical substrates of conditioned reflex activity conducted lessons on 1-9 Decem - 1980 in the Estonian "Noorus" International Center (in Ust'-Narva). The opening of the school was initiated by the Council of Young Scientists of the USSR Academy of Sciences Institute of Higher Nervous Activity and Neurophysiology. During the Eighth Session of the "Intermozg" Problematic Commission for Multilateral Cooperation, the school was included in the agenda of the commission. Much assistance in organizing the school was rendered by the Division of Scientific Youth of the Komsomol Central Committee, the Commission for Work With Youth under the presidium of the USSR Academy of Sciences, and the "Sputnik" International Youth Tourism Bureau.

USSR Academy of Sciences Corresponding Member, Armenian SSR Academy of Sciences Academician E. A. Asratyan was appointed scientific director of the school. His assistants were Doctor of Medical Sciences U. G. Gasanov and Candidate of Biological Sciences S. I. Shumikhina. The acting secretary was Candidate of Biological Sciences N. S. Kurova. Among the members of the organizing committee, special notice should be made of the work of Candidate of Biological Sciences A. S. Pivovarov (Department of Physiology of Higher Nervous Activity, Moscow State University), and A. V. Khokhlov (USSR Academy of Medical Sciences Brain Institute).

Participants of the school included about 100 young specialists from Hungary, the GDR, Poland, the USSR, and Czechoslovakia. The school program included lectures by prominent scientists from the countries participating in the multilaterial cooperation effort , to include Prof S. Dimov (Bulgaria), Prof Ye. Grasht'yan (Hungary), Prof Kh. Mattiyes (GDR), Prof F. Klinberg (GDR), and Prof B. Zhernitskiy (Poland). The lecturing staff from our country included M. Ye. Varga, U. G. Gasanov, N. S. Kositsyn, R. I. Kruglikov, P. V. Simonov, S. N. Khayutin, I. A. Shevelev, G. I. Shul'gina, and V. L. Ezrokhi (USSR Academy of Sciences Institute of Higher Nervous Activity and Neurophysiology), L. Kh. Allikmets (Tartu State University), Ye. A. Gromova (USSR Academy of Sciences Institute of Biological Physics), and L. L. Voronin and V. G. Skrebitskiy (USSR Academy of Medical Sciences Brain Institute).

More than 30 young specialists spoke in seminars devoted to the neurochemical substrates of learning and memory, and to cellular, synaptic, and systemic mechanisms of conditioned reflex activity. Roundtable discussions on internal inhibition and the neurochemistry of memory were very successful. I would like to make note of the lively, active nature of these discussions, which indicated the high theoretical and professional level of the young specialists, their knowledge of current scientific literature, and their facility with the experimental material. Some of the reports given at the seminars may quite easily be expanded into independent lectures.

The school persuasively showed that as a central phenomenon of higher nervous (mental) activity and behavior, the conditioned reflex is at the focus of attention in research by the young generation of specialists studying the most complex manifestations of integrated brain activity. It is the heuristic key to understanding the cellular, synaptic, and neurochemical mechanisms of the broadest range of phenomena including learning and memory, motivations and emotions, the adaptive plasticity of sensory systems (analyzers), and the ontogenesis and phylogenesis of behavior. The arsenal of methods for studying conditioned reflex activity is expanding and growing richer with every year owing to the use of the latest achievements of general neurophysiology and neurochemistry, electron microscopy, and computer technology.

The school participants heard two lectures organized by the Komsomol Central Committee Division of Scientific Youth: by D. G. Ioseliani on the tasks of the councils of young scientists, and by G. Kh. Shingarova on the methodological aspects of the "brain and mind" problem. The school was held in an exceptionally warm, friendly atmosphere of communication between young people and their peers and senior comrades from fraternal countries. During time off from the lessons, the young people acquainted themselves with the historical points of interest in Tallin, Narva, and Tartu, and with the life and achievements of the Estonian SSR.

The wish that schools of young specialists would become one of the traditional forms of multilateral cooperation in the "Intermozg" program was stated in the concluding session. This proposal, which was supported by the heads of the national delegations, will be examined at a regular session of the Problematic Commission in spring 1982, at which time a long-range plan for conducting such schools in the next few years will be compiled.

The success of the school-seminar was promoted to a great extent by the favorable conditions created for its participants by the collective of the "Noorus" center, by the high culture of services provided, by clear organization, and by the hospitality displayed toward lecturing professors and young scientists. The school's organizing committee expresses its sincere gratefulness to center director V. F. Bakunin, assistant director V. G. Kanashchenko, assistant for culture and education V. G. Krishner, and senior administrator N. V. Markova.

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