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USSR Report

LIFE SCIENCES

BIOMEDICAL AND BEHAVIORAL SCIENCES

(FOUO 12/81)

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BIOCHEMISTRY

UDC 578.2

RECOMBINANT ORIGIN OF THE EPIDEMIC INFLUENZA VIRUS STRAIN A/USSR/90/77

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 257, No 3, 1981 pp 721-724

[Article by Yu. V. Kozlov, A. A. Shilov, A. G. Kurmanova, V. G. Gorbulev, Ya. M. Selivanov, V. M. Zhdanov, and Academician A. A. Bayev, USSR Academy of Sciences Institute of Molecular Biology and USSR Academy of Medical Sciences Institute of Virology imeni D. I. Ivanovskiy, Moscow]

[Text] Unusually high variability is typical of the influenza virus, and it is mainly this unique feature that makes control of this infection's spread difficult. Two basic forms of antigenic variability of influenza virus are distinguished--antigenic drift and antigenic shift. Insignificant and gradual change in the antigenic properties of proteins making up the viral membrane--hemagglutinin (HA) and neuraminidase (NA)--is commonly referred to as antigenic drift. The pressure of antibodies in a partially immune host population is apparently the mechanism that defines the selection direction for a virus that has undergone alteration in the course of drift. Arisal of a virus having new antigenic properties is referred to as antigenic shift. Appearance of such a "new" virus elicits the periodically arising pandemics of influenza. It is believed that the arisal of new pandemic virus strains is associated with recombination of different viruses. Inasmuch as influenza virus has a segmented genome represented by eight separate RNA fragments coding different virus-specific proteins, recombination is interpreted in this case as simple redistribution of fragments (genes), responsible for coding surface antigens, between different viruses circulating in the same host . There is now sufficient information demonstrating such a mechanism for arisal of new serotypes of influenza virus (1,2).

In the last few decades the serotypes of circulating human influenza virus have included H1N1 (1946-1956), H2N2 (1957-1968) and H3N2 (from 1968 to the present). In 1977 an epidemic of serotype H1N1 virus arose, embracing the entire Northern Hemisphere (3). Arisal of this epidemic strain, one having the same serotype as the virus that appeared in 1946-1956 and which had already circulated in this generation, was a surprise, inasmuch as a large proportion of the population more than 20 years old had already had antibodies to this virus.

It was demonstrated by serological methods (5) and by means of oligonucleotide analysis of total viral RNA (6,7) that the influenza virus strains revealed in 1977 (A/USSR/90/77) and a number of Chinese strains have more similarity to strains isolated in 1950 (A/FW/1/50) than to later (A/FM/1/47) or more recent strains (A/C/1/56, A/Denver/1/57) of the same serotype, H1N1. Nevertheless the question as to the mechanism behind arisal of the new epidemic strain USSR/90/77 remains unclear.

Our objective was to reveal the genetic kinship of the new (A/USSR/90/77) and old (A/FM/1/47 and A/FW/1/50) strains of serotype H1N1 influenza virus by comparing the structure of individual genes by the method of oligonucleotide analysis. This method permits highly precise analysis of insignificant differences in the structure of compared RNA molecules, and it does not require significant quantities of material.

Fragments of viral genome RNA were separated by electrophoresis in 1.6 percent agarose or 2.8 percent acrylamide gel. We were unable to achieve sufficiently good separation of genes P_1 and P_3, and for this reason they were analyzed together. RNA fragments eluted from gel were processed with T_1 RNAase and alkaline phosphatase. The obtained oligonucleotides were labeled at their 5'-ends with γ-P^{32}-ATP and polynucleotide kinase. Labeled T_1-oligonucleotides were subjected to double electrophoresis in polyacrylamide gel, and to autoradiography. The position of the oligonucleotide on the fingerprint depends strictly on its length and on its nucleotide composition; this is why any substitutions in the RNA under analysis are easy to determine from change in position, disappearance, or appearance of a new oligonucleotide. The double electrophoresis system we developed provides for optimum resolution of oligonucleotides more than 10 members long, and thus it permits us to analyze a sizeable sequence of each gene. Because oligonucleotides are distributed statistically in the analyzed RNA, it may be presumed that they reliably represent the entire sequence of the analyzed RNA.

We obtained oligonucleotide maps (fingerprints) from the individual genes of three influenza virus strains: USSR/90/77, FW/1/50, and FM/1/47. Figure 1 [figures not reproduced] shows the fingerprints of M genes from the three studied strains, and a diagram representing the distribution of the analyzed oligonucleotides. It is easy to see that the distribution patterns of the oligonucleotides of M genes are extremely similar for strains USSR and FM, and that they differ significantly from the pattern for the M gene of strain FW. A different situation is observed for NP genes. The fingerprints of NP genes from strains USSR and FW are very similar, and they differ significantly from the fingerprint of the NP gene from strain FM (Figure 2). The fingerprints of other genes, which were obtained in similar fashion, are not presented in this paper.

Table 1 was compiled from an analysis of the fingerprints of individual genes from the the analyzed influenza virus strains. For the convenience of analysis, the virus strain under analysis, USSR/90/77, was compared in pairs with earlier isolates of the virus--FW/1/50 and FM/1/47. It follows from the table that the number of oligonucleotides common to strains USSR/90/77 and FW/1/50 is significantly greater than that common to USSR/90/77 and FM/1/47. This law extends to all genes, with the exception of genes coding M proteins. Inasmuch as the proportion of a genome represented in analyzed oligonucleotides differs for different genes, the percentage of substituted bases in the analyzed part of the gene must be assessed on the basis of additional calculations. This magnitude is a stricter reflection of the degree of structural similarity (or divergence) of compared genes, inasmuch as it reflects the number of base substitutions for every 100 nucleotides of the compared sequences. Because this magnitude is minimal for genes $P_1 + P_3$, P_2, NP, and NS of USSR and FW isolates, these genes have significant structural similarity. Genes P_2 and NP of these two strains have maximum structural similarity--their percentages of base substitution are 0.35 and 0.33 respectively. Genes HA and NA of these two strains diverged somewhat more greatly, which is well consistent with published data on the high rate of variability of these two genes, which are responsible for antigenic drift of the virus (9).

Table 1

RNA Fragment (Gene)	Analyzed Pairs of Virus Strains	Distribution of Analyzed Oligonucleotides (No. of Oligonucleotides) USSR+*	USSR−**	Total	Proportion of Gene Represented In Analyzed Oligonucleotides, %	Minimum No. of Base Substitutions in Oligonucleotides No.***	Percentage****
$P_1 + P_3$	USSR/FW	12	6	72	28	15	1.05
	USSR/FM	29	22	55		40	2.8
P_2	USSR/FW	1	3	56		3	0.35
	USSR/FM	12	15	45	34.5	21	2.5
	USSR/FW	7	10	28	29.5	13	2.3
HA	USSR/FM	17	13	18		23	4.0
	USSR/FW	3	8	41	42.5	9	1.5
NH	USSR/FM	11	11	33		16	2.6
	USSR/FW	2	1	36	38	2	0.33
NP	USSR/FM	23	12	15		29	4.8
M	USSR/FW	15	8	10	48	19	4.8
	USSR/FM	4	4	21		6	1.5
	USSR/FW	5	3	24	66	6	1.4
NS	USSR/FM	8	9	21		13	3.0

* $USSR^+$--number of oligonucleotides found in the given gene of strain USSR/90/77 but absent in the corresponding gene of strain FW/1/50 or FM/1/47.

**$USSR^-$--number of oligonucleotides found in the given gene of strain FW/1/50 or FM/1/47 but absent from the corresponding gene of strain USSR/90/77.

***The minimum number of base substitutions was computed in accordance with the the procedure described by Palese (6).

****The percentage of base substitutions was calculated on the basis of the proportion of sequences of the given gene represented in the analyzed oligonucleotides. This magnitude typifies the number of base substitutions for every 100 bases of the analyzed sequence, and it reflects the degree of divergence of the compared genes. The calculations were made on the basis of information on the molecular weight of influenza virus genes, provided in (12). The dimensions of oligonucleotides were determined by means of incomplete alkaline hydrolysis of eluted oligonucleotide, followed by electrophoretic separation of the products in polyacrylamide gel.

Comparing the percentages of base substitutions for the M gene of USSR strain in relation to strains FW and FM, we can see that it is significantly closer to that of the 1947 isolate--FM/1/47--than to FW/1/50.

Thus all genes, except for the M gene of influenza virus strain USSR/90/77, have structural similarity with strain FW/1/50, and they differ significantly from those of strain FM/1/47.

Obviously the new virus arose as a result of recombination of the earlier strain FW/1/50, or its drift variant, with another virus having an M gene structurally closer to that of strain FM/1/47. As a result of such recombination (exchange of genes), the new virus, which retained seven genes of the parent strain FW/1/50,

obtained a new M gene. Thus our data unambiguously indicate that epidemic influenza virus strain USSR/90/77 came about as a result of recombination (exchange of genes) between earlier strains FW/1/50 and FM/1/47.

The sort of selective advantages the recombinant virus obtained as a result remain unclear. The biological significance of recombination in relation to the M gene of this virus is not clear. These questions require further research.

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BIOTECHNOLOGY

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METHOD OF SIMULATING HEMODYNAMIC EFFECTS OF WEIGHTLESSNESS AND REFINEMENT OF THE CHIBIS PROTECTIVE VACUUM SUIT USED IN THIS METHOD

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA BIOLOGICHESKAYA in Russian No 3, May-Jun 81 (manuscript received 24 Jun 80) pp 443-445

[Article by E. V. Lapayev, G. I. Pavlov, V. G. Voloshin and V. Ye. Grishanov]

[Text] The acute period of adaptation to weightlessness is associated with shifting of blood to the upper half of the body. A method of simulating this condition is described in this article, which involves creation of excess pressure in the Chibis [or Chybis] protective vacuum suit [PVS] after it was improved.

It is known that there is redistribution of blood and body fluids to the upper half of the body in weightlessness, and this causes a number of adverse reactions in a cosmonauts, including vestibular disturbances (Bryanov et al., 1975). It is necessary to simulate these phenomena on earth to develop the means of preventing these reactions and to study the phenomenology thereof.

One usually uses antiorthostatic body position (head-down tilt) at different angles and for different periods of time for this purpose. However, it is impossible to combine such a technique with vestibular studies, since there are no tables with a sufficient angle of inclination, and one cannot investigate such parameters as, for example, resistance of the vestibular analyzer to Coriolis accelerations.

Use of an anti-G suit (AGS) for redistribution of blood to the upper half of the body also fails to yield the desired results, since the area of compensation in the garment constitutes 50% of the body surface and there are open sections (buttocks, perineum, etc.) in which blood is deposited, rather than shifting up.

We propose a method of simulating the hemodynamic effects of weightlessness that does not have such flaws. It consists of placing the lower half of the subject into a protective [or prophylactic] vacuum garment (PVS), the Chibis (Genin et al., 1973; Barer et al., 1975), in which one creates graded positive air pressure. Since the human body in the PVS is surrounded by a single air pillow, this pressure is transmitted uniformly to all parts of the body and causes migration of blood to the upper half of the body. At the same time, the Chibis PVS (stiff, airtight "trousers") is small and permits placing the subject on various research stands, for example, vestibulometric ones, in any position.

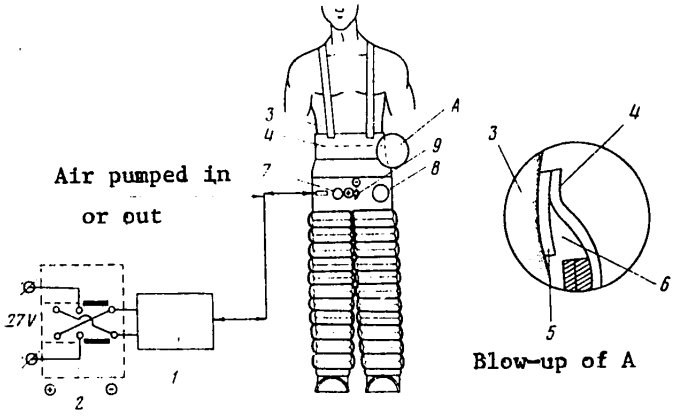

Figure 1. General diagram of the Chibis garment, elements of improvement of system of connecting micropump to the sealing shutter

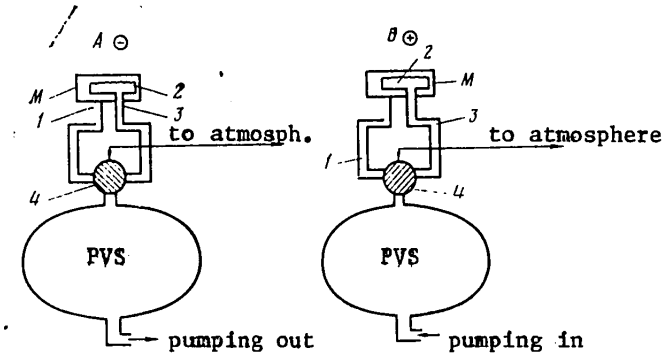

Figure 2. Diagram of manometer connection to measure excess pressure

The proposed method involves refinement of the Chibis PVS so that both positive and negative pressure (in relation to ambient level) can be regulated in it. The purpose of refinement is to provide for the following: operation of the MRD-2G micropump in two modes--pumping air in and out; to render the garment airtight [seal it] at the subject's waistline when there is excess or negative pressure; ability to monitor the variable pressure using the same instrument.

Figures 1 and 2 illustrate the essential elements of the improvement. Figure 1 illustrates the general scheme of operation of the garment, as well as elements of improvement of the system of operating the micropump and sealing shutter.

When turned on in the regular mode, micropump (1) only pumps air out of the PVS. In our improved version, it is turned on by switch (2), which makes it possible

Figure 3.
Subject wearing Chibis garment in a vestibulometric chair

to alter the polarity on the motor coils and thereby cause air to be either pumped in or out of the PVS. In the (-) position it operates in the pumping out mode and in the (+) position in the pumping in mode.

In the regular variant, sealing the Chibis garment around the subject's body (3) is provided by a rubber shutter (4) executed in the form of a valve that is pressed to the body when negative pressure is created in the PVS; it allows excess amounts of air to pass freely into the garment. To render the PVS airtight in the presence of excess pressure, an additional circular valve (5) is pasted over the perimeter of the inner edge of shutter (4). When excess pressure is created, when the gas reaches space (6) between valves (4) and (5) it presses valve (5) to the body and reliably seals the PVS.

Valve (7), which permits smooth change or delivery of air from the atmosphere (when pressure is negative in the PVS), or release thereof into the atmosphere (with excess pressure), is used to regulate the levels of excess and negative pressure in the PVS.

Manometer [pressure gauge] (8) is used to monitor the negative pressure in the regular variant. In order to allow us to measure excess pressure with the same gauge, we installed valve (9), the connection of which is illustrated in detail in Figure 2.

We installed a series produced instrument as manometer M in the PVS, which has an airtight compartment that is connected with the inside of the PVS by means of coupling (1). The inside of the membrane chamber (2) opens into the atmosphere through coupling (3) in the regular variant. When negative pressure is created in the PVS, the pressure drops in the cavity of M and the membrane chamber (2) expands, and this is indicated by a pointer.

With our refinement of the instrument, M is connected to the PVS by valve (4), which has two independent pneumatic channels.

In position A (-), the valve provides for the regular mode of connecting the manometer: coupling (1) is connected to the PVS, coupling (3) goes out to the atmosphere and the gauge measures negative pressure.

In position B (+), coupling (3) is connected to the inside of the PVS, while coupling (1) and the interior of M goes into the atmosphere. When excess pressure is created in the PVS, the membrane chamber (2) expands and the gauge measures excess pressure.

The proposed method of simulating the hemodynamic effects of weightlessness by means of a modified Chibis PVS has been used with success in our experimental tests (Figure 3), which enabled us to obtain a number of theoretically important data concerning the dependence of vestibular analyzer function on altered hemodynamics.

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PHYSIOLOGY

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SLEEP AND MENTAL FITNESS

Moscow FIZIOLOGIYA CHELOVEKA in Russian Vol 6, No 6, Nov-Dec 80 pp 1094-1101

[Article by I. S. Kandror and V. S. Rotenberg, All-Union Scientific Research Institute of Railroad Hygiene, Moscow, and First Moscow Medical Institute, submitted 13 Jul 79]

[Text] The dependence of the level of man's fitness for work on integrity, duration and quality of sleep is not only common knowledge from self-observations, but it is confirmed by numerous experimental studies of the effect of sleep deprivation [1-4]. However, the mere statement of such a dependence is not enough to solve many problems of industrial physiology and hygiene. It is imperative to identify the specific physiological processes in the organism that occur during normal nocturnal sleep and have an effect on man's overall functional state and, in particular, his fitness for work during the subsequent waking period.

Until recently, it was not quite clear as to what sleep is as a state of the brain and what processes are involved in restoring the fitness of a tired man after proper sleep. We do not know how various changes in sleeping and waking schedule affect these processes. Yet these are questions of basic significance to industrial physiology and hygiene, since without answers to them it is impossible to determine which changes in the schedule are permissible without detriment to man's health and fitness for work. At the present time, realistic opportunities have emerged for investigation of these matters, since conceptions are already beginning to form about some factors that affect human fitness. At the same time, experimental data about the structural organization of sleep and functional significance of its different phases and stages are accumulating rapidly.

A number of psychological studies have demonstrated that both physical and mental fitness of a healthy man are largely determined by the force of a subject's motivation (interest) for a given activity, his level of wakefulness (i.e., degree of activity), direction and stability of attention, mnestic capacities and capacity for solving problems creatively. The relationship is found to be complex and nonlinear between motivation and level of activity, on the one hand, and fitness, on the other: fitness for work diminishes, not only when the wakefulness level and motivation are low, but when there is excessively high motivation and excessive (unproductive) activity. This function is sometimes called the "law of Yerkes-Dodson." This happens not only in a state of marked neurotic anxiety, but in healthy individuals in a state of severe emotional excitement. Psychological stress disorganizes occupational performance, does not permit concentrating on its subject, leads to failure or error, as well as autonomic changes which, in turn, become a hindrance

to normal performance. All these circumstances ultimately diminish significantly an individual's fitness and reliability. Thus, for each type of productive activity there is apparently its own optimum of activity, with reduction of which drowsiness and boredom appear and surpassing of which causes errors due to hastiness, and both are dangerous to production.

In order to discuss in the most general form the question of a link between the above factors and sleep, we must briefly describe the current conceptions on the structure and function of sleep.

Studies of the last few decades have shown that nocturnal sleep is divided into several phases or stages [5], and that it by no means constitutes a passive state of the brain, rather it is an active one. On the whole, the number of actively functioning neurons in the brain during sleep is not smaller than in a waking state, and it is even greater in some phases of sleep (rapid sleep) than in a tense waking state.

As we know, two distinct phases are clearly differentiated in sleep, so-called slow and rapid (paradoxical or REM). Both phases differ, not only in their electrophysiological manifestations, but psychological ones, and they alternate during the night, forming 4-5 cycles.

We still do not have an exhaustive idea about the functional role of the different sleep phases and cycles. However, there are some rather convincing data to the effect that there are differences between the functional significance of different phases of sleep. Thus, many researchers [6, 7] mention the important role of delta sleep in organization of mnestic functions (memory functions). It was demonstrated that this sleep phase has a beneficial effect on recall of material memorized before sleeping. Symptoms of selective deprivation thereof are also indicative of such a function of delta sleep: tired ["jaded"] feeling, increased fatigability, diminished attention, worsening of mood, well-being and sleepiness [8]. These symptoms can be interpreted as the result of being overloaded with information, which makes it difficult to perceive and screen new information.

In the opinion of a number of researchers, the function of rapid sleep is to psychologically stabilize the personality, eliminate neurotic anxiety, elicit emotional adaptation to unusual and highly significant information [9]. Rapid sleep is considered to be among the main mechanisms of psychological defense, which permits resolution of intrapsychic conflicts (struggle between motives) and thus is instrumental in reducing excessive emotional stress [10-12].

In view of this role of rapid sleep, its significance to psychological adaptation depends largely on personality distinctions. This phase of sleep most probably does not play a particularly important role and is often reduced in highly active, optimistic and sthenic subjects, who tend to overlook negative information, who are free of internal conflicts and actively overcome external barriers. This may also be associated with decrease in total duration of sleep, which does not have an adverse effect on their fitness for work [13].

Conversely, rapid sleep is particularly necessary for sensitive personalities, who tend to fix on complex psychological shadings of interpersonal relations, who are vulnerable to negative information, profoundly emotional about conflicts, anxious

and are subject to frequent worsening of mood. As a rule their rapid sleep is longer and saturated with dreams [13]. In the presence of functional inadequacy of the "rapid sleep--dreams" system, the risk of development of neurotic states grows higher for such subjects [14]. Even an insignificant, chronic reduction in total sleeping time diminishes fitness of these individuals.

The above data enable us to now turn to concrete analysis of correlations between changes in sleep and fitness in the presence of various functional states and changes in work, rest and sleep schedule.

Let us first discuss the results of experiments involving total deprivation of sleep for several days and gradual reduction of total duration of sleep.

In the former case, weakening of higher mental functions was observed [4, 15, 16], capacity to concentrate attention, orientation in a new situation and adaptation to it. This is largely related to unsurmountable sleepiness, when reactions to exogenous stimuli are delayed are lacking entirely. With longer complete deprivation, one observes disorders in the affective area as well: groundless irritability, aggressiveness, suspicion, etc., which diminishes work fitness drastically, in particular due to diminished interest in solving the presented problems. It is important to indicate that while sleepiness and diminished attention are more or less euqally inherent in different subjects, the thresholds of onset of affective disorders and their intensity are quite variable, and they apparently depend on the role of sleep, particularly its rapid phase, in processes of emotional stabilization in a given subject. Thus, individuals with a high level of self-control perform work involving detection of a signal in the presence of noise better after sleep deprivation than individuals who are very impulsive. The latter also present more marked mnestic disorders, i.e., impaired ability to retain and recall [17].

During the first night of recovery, emotionally stable individuals show an increase in delta sleep and, only later, of rapid sleep, while in those with emotional instability there is often compensatory increase at first in expressly rapid sleep [18].

While fitness for work can diminish very drastically with total sleep deprivation, gradual reduction of overall sleeping time (to a certain minimum level) does not, according to some authors [19, 20], necessarily lead to a significant decline of fitness during the waking period. Reduction of sleeping time to 5.5 h per day is critical. In the case of a 5-h and particularly 4-h sleep schedule, the subjects present an appreciable deterioration of mood, they tire rapidly, soon become irritable and they are unable to concentrate on their work. It becomes very difficult for them to sustain a waking state. The results reported in the literature of polygraph studies revealed that, in the case of 5.5-h sleep, there was a reduction in duration of all sleep stages, as compared to the background period, but especially of the rapid sleep stage. With the change to a 4-h sleep period, rapid sleep diminished even more, there was drastic reduction of the second stage, but relative increase in duration of the fourth stage. After changing to a normal sleep schedule, fitness and well-being reached their initial levels as early as the third day, although total duration of sleep was still shorter than before the experiment for a long time (because of falling asleep 1-1.5 h later). A check of sleep structure on the 10th recovery night revealed that total duration of sleep was still somewhat shorter and there was reduction of the rapid sleep phase. It appeared that the subjects were indeed able to change to a shorter sleep schedule.

However, one must take into consideration the following circumstances: when sleep is reduced to 5 and 4 h, there is relative compensatory increase in delta sleep due to reduction of rapid sleep and, as we mentioned above, this is far from being always harmless for many subjects. Moreover, it is apparent that one cannot excessively generalize data obtained on a small number of subjects. Finally, one must take into consideration the data of researchers [21, 22] who report that, although there was an effect of initial "return" of delta sleep in the recovery night after a reduced 5.5-h sleep period, there was a decline of fitness in the daytime during the period of reduced sleep schedule even when the reduction of the fourth stage was quite negligible, as compared to the background period. This is apparently indicative of the fact that with artificial reduction of sleep the most urgent need is to satisfy the delta sleep requirement. For this reason, we cannot rule out the possibility that restoration of impaired balance after long-term gradual reduction is also a long-term process and the 10th recovery night is not yet informative enough. The opinion has also been voiced [23] that even if sleep reduction does not cause diminished fitness for work in the immediate period, it may be deleterious to health at a later time, and if chronic adjustment to a 5-h sleep schedule per day is possible, one cannot yet determine the "price" that the body pays for such adjustment.

Indeed, there are data [24] to the effect that successful performance of psychological tasks in the case of chronic shortage of sleep is associated with strain on the body's energy systems, and this is apparently necessary to compensate for the impaired organization of information during sleep. Naiton [23] stresses that each subject has his own individual limit of sleep reduction, and it may be believed that this is largely determined by the individual rapid sleep requirements.

The above data indicate that, in a number of cases, the body tries to compensate first of all for delta sleep when sleep is reduced, not only at the expense of other stages of slow sleep, but even rapid sleep. However, this is by no means indicative of the low functional significance of rapid sleep.

With reference to the correlations between sleep structure and work fitness in the case of both normal and altered sleep schedule, it must be borne in mind that emotional tension of the neurotic anxiety type has the most marked effect on creative activity, on solving problems that require an original approach, when it is not enough to base oneself solely on acquired skills and knowledge acquired previously. In view of the role of rapid sleep in compensation of neurotic anxiety, we can assume that the rapid sleep phase plays a particularly important part in solving expressly such problems, particularly among highly sensitive subjects.

Indeed, experiments with rapid sleep deprivation [25, 26] revealed that selective deprivation of this phase worsens performance of tasks that require creative (divergent) thinking and has virtually no effect on tasks that require a formal and logical approach or simple retention.

Our studies [27] revealed that those who react with excessively rigid emotional excitement to emotional stress in a waking state and cope worse with solving logic problems regain their productivity rapidly after compensatory increase in the rapid sleep phase.

In individuals engaged in the intensive study of a foreign language (by the so-called "immersion" method), an increase in rapid sleep phase, as compared to the base level, was associated with better achievement in assimilating linguistic material

without signs of increased stress, unlike those in whom there was no such increase in this phase of sleep [28]. At the same time, healthy, insensitive people who usually have a short sleep period and relatively short rapid sleep phase under ordinary working conditions present good fitness for work and cope easily with standard psychological tests [29].

Hence, it should be concluded that the consequences of different changes in the sleep pattern are different for different individuals, depending on their personality distinctions, current condition and nature of activity.

Occupational activity is often related to a specific work schedule, regular or irregular alternation of day and night shifts of different duration or working only on the evening or night shift. According to many researchers [30-33], daytime sleep is much shorter than usual when one works on the night shift. A somewhat unexpected finding was that this is associated with a tendency toward reduction of delta sleep, particularly during the first half of the daytime sleep period, and increase in rapid sleep phase. Some authors [34] believe that this distinction is determined by circadian rhythm (hence the relative increase in this phase in the premorning hours of sleep), whereas the duration of delta sleep is determined by overall duration of wakefulness prior to sleeping [35] (the authors refer to the fact that, even after many years of a distorted schedule, rapid sleep is particularly frequent and prolonged in the early morning hours).

However, our findings are indicative of the no less importance of another factor--degree of individual adjustment to night work. There is primary compensation of expressly delta sleep and the structure of sleep as a whole is virtually the same as the usual structure in individuals who are well-adjusted to night work and have no tendency toward anxiety reactions, whose need for rapid sleep is relatively minimal. In individuals who are subjectively inadequately adjusted to work on the night shift, the need for rapid sleep is greater, and this is manifested by its primary "return" after night work, at the expense of reduction of delta sleep. The latency period of rapid sleep is reduced during daytime sleep in cases where the night shift is subjectively rated as being more tense. And this is how it is rated mainly by individuals who are not quite adjusted to night work. As was to be expected, mental fitness and so-called psychoproductivity (stability of attention, cancellation test, etc.) is substantially lower in such individuals than in well-adapted ones, on the basis of all of the foregoing.

There is a correlation between level of fitness and representation of delta sleep after a decline of emotional tension and general normalization of sleep structure (for example, as a result of a course of electrosleep treatment). In this case, fitness for work increases and autonomic changes revert to normal.

Thus, the data submitted above are indicative of the important role of structural organization of sleep in sustaining a normal level of work fitness in man, with due consideration of characterological traits and nature of work performed by the subject.

However, it would be wrong to consider on this basis that there is a direct link between duration and quality of sleep, on the one hand, and fitness for work, on the other: the results of experimental studies do not confirm this. In one study [36], the sleep schedule was excessively changed for 10 subjects: sleep time was extended to 11 h per day (from 2100 to 0800 hours); total sleep time was retained but shifted over the circadian rhythm (sleeping from 2100 to 0500 hours or from

0300 to 1100 hours) and, finally, it was reduced to 5 h (from 0300 to 0800 hours). The structure of sleep on the usual schedule, sleeping from 2400 to 0800 hours, was also studied. Each schedule was kept for 1 week, after which the subjects slept on their usual schedule for 7 days. It was found that the precision and speed of performance were considerably lower, while negative affective changes were greater with all of the altered sleep schedules. The diminished work fitness was not due to either the change in total duration of sleep or structure of prior sleep. Worsening of well-being, as well as diminished fitness with increase in duration of sleep, were the unexpected results of this study.

Indeed, if we consider that the main function of sleep is for the optimum organization of information, elimination of information overload and elimination of nonproductive emotional tension, it is incomprehensible why excessive sleep can have an adverse effect.

The hypothesis has been expounded [36] that the optimum level of effective function in a waking state may depend more on the correct rhythm of the "sleeping-waking" cycle and particularly on bedtime, than on total duration and structure of sleep. The role of circadian rhythm is also stressed by the fact that certain times of day were observed when changes in sleep schedule had a particular effect on fitness for work and well-being. Thus, the largest number of mistakes in attention tests were referable to noon and afternoon (about 1200 and 1700 hours), but not in the morning.

It is known, that a distinct rhythm is observed in many physiological functions, which are related in some way to fitness for work, when there is a normal sleeping and waking schedule. It is also known that physiological rhythms are found to be somewhat shifted in phase in so-called "larks" and "owls," i.e., individuals whose peak activity is referable to morning or evening hours [37].

It would be logical to assume that there is a close correlation between these physiological and psychological rhythms, which determine fitness for work, on the one hand, and the circadian "sleeping-waking" rhythm, on the other. At any rate, it has been shown [38] that differences in rhythm of secretion of epinephrine, body temperature and performance of "owls" and "larks" level off or disappear entirely with 72 h of sleep deprivation. Consequently, in those cases where such differences are present, they are perhaps mediated by the "sleeping-waking" circadian rhythm. However, an artificial change in this rhythm, be it longer sleep, earlier falling asleep or later awakening, could affect the dynamics of physiological and psychological functions and, consequently, fitness for work. In particular, in the case of waking up late, the subject could sleep through the time of day that is optimum for his efficiency, just like early falling asleep could disrupt the natural cycle of physiological processes and reduce efficiency on the following day in an individual with peak activity in the evenings.

Several studies [38] did not take into consideration the possible differences in peak of activity between subjects. Yet it is necessary to consider this when studying the effects of the sleep schedule on fitness and general well-being of people. Staying awake during a period that is biologically intended for sleep, like sleeping at a time intended for being awake (daytime sleep when working on a night shift) may not be physiologically satisfactory, even if deviations from the norm are not demonstrable with regard to objective signs, for example, sleep structure.

Thus, it is mandatory to consider the fact that changes in sleep schedule could have an adverse effect, not only on fitness for work but health (frequency and severity of diseases) because this is associated with discoordination of many other rhythmic functions of the body.

But, just as it would be a mistake to overlook this circumstance, it would be wrong to underestimate the functional role of the change in sleep structure described above. The fact remains: when there is selective deprivation referable to different phases of sleep, the overall "sleeping--waking" cycle and rhythm occasionally fail to change, while the effect of such deprivation on fitness for work is significant.

In various extreme situations and in the presence of neurotic states, the sleep schedule may not change as a whole, but its structure could vary over a certain range and show a correlation with changes in fitness. Thus, in the presence of neurosis, the shortage of delta sleep is related to rapid progression of asthenic symptoms. Evidently, not all changes in the sleep schedule have the same effect on an individual's condition during the subsequent waking period.

For this reason, the conception of the effect of altered sleep schedule on physiological and psychological functions must not compete with conceptions of the role of altered structure of sleep itself, but enlarge upon them.

Such an approach to the physiological study and hygienic evaluation of work in shifts and night work could deepen significantly our understanding of the nature of changes in the entire organism that are associated with such work and enable us to develop with better validation the appropriate recommendations.

Conclusion

There is every reason to supplement the traditional studies of industrial physiology and hygiene with in-depth investigation of the relationship between sleep and the waking state, their reciprocal effect on one another, with the use of modern polygraphic techniques.

First of all, it is interesting to examine these correlations in people engaged in intensive mental labor, operators performing important control functions, workers on alternate morning, day and night shifts and those working only at night for many years. The main question is whether any adaptive changes occur and how they are manifested. Are there individual or other differences in ability to adjust to shift work or only night work? If so, which is quite probable, is it possible to find methods of vocational screening of individuals who adjust easily and define contraindications for those who react to such a schedule with particular difficulty and morbidity, whose reliability is drastically diminished when they work under such conditions?

It is also interesting to investigate the preferred duration of working on the same shift in order to cause the least discoordination of working and living schedule in relation to the natural fluctuations of physiological functions. What is the physiological value of brief sleep, frequent naps, when working at night, when this is admissible with regard to working conditions, and how does this affect fitness for work? Finally, what is the link between a change in phases of sleep and waking state, and the rhythms of many other physiological functions?

But one must be fully aware of the fact of the immense difficulties involved in organizing such studies under real living conditions.

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SENSIBILITY OF AUDITORY AND TACTILE SENSORY SYSTEMS WHEN STIMULATED SEPARATELY AND TOGETHER

Moscow FIZIOLOGIYA CHELOVEKA in Russian Vol 6, No 6, Nov-Dec 80 pp 1131-1133

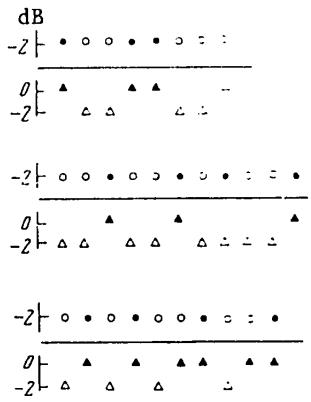
[Article by N. Yu. Alekseyenko, Institute of Higher Nervous Activity and Neurophysiology, USSR Academy of Sciences, Moscow, submitted 10 Oct 79]

[Text] Studies of the significance of motor activity to spatial hearing established that proprioceptive impulsation associated with head movement affects not only perception of the direction of the sound source but absolute sensibility of the auditory system [1, 2]. In this regard, the question arose as to whether this effect on hearing thresholds is specific to proprioception, to which the auditory system is functionally closely linked under conditions of integral human and animal behavior, or whether other sensory systems have the same effect on hearing. Previously obtained data concerning the modulating effect of cutaneous sensibility on spatial hearing [3] suggest the possibility of the latter's effect on auditory thresholds.

To check this hypothesis, experiments were conducted to examine the effect of cutaneous sensibility on hearing, in which the subject was presented with audio and cutaneous stimuli of varying intensity simultaneously: threshold, supraliminal and subliminal for both modalities, in different combinations of these intensities, and determination was made of audibility of the audio signal contained in each combination.

Audio stimuli, consisting of 0.2 ms clicks, were delivered in a free acoustic field by an ESU-1 stimulator through a TD-6 electrodynamic telephone. Electrocutaneous stimulation was delivered by means of pulses of current of the same duration from the same stimulator to the skin of the forearm through silver cup electrodes with electroconductive paste. Both stimuli were used simultaneously. Their intensity was regulated by attenuators.

The subject was kept in a dark, sound-proof chamber. At the start of the test, we measured the thresholds of audio and cutaneous stimuli separately, after which they were used together at intensities of -2 to +4 dB in relation to the established thresholds, with intervals of about 15 s between combinations. The different combinations were used in random order. Each experiment involved 70 to 150 combinations of stimuli with a 5-10-min rest break. After each combination, the subject was instructed to report whether he heard a sound and felt stimulation of the skin ("Sound," "Skin"). In all, we conducted 28 experiments on 9 healthy subjects 19-22 years of age.



Effect of cutaneous sensibility on auditory sensibility (schematic depiction of fragments of three experiments)
Audio stimuli: black circles--audible, white--inaudible; black triangles--perceptible electrocutaneous stimuli, white--imperceptible.
Y-axis, intensity of stimuli as related to perception threshold, dB

In the vast majority of these tests (23 out of 28), there was distinct elevation of auditory sensibility under the influence of supraliminal (perceptible) cutaneous stimulation. Thus, when combined with subliminal electrocutaneous stimuli, the clicks delivered at the intensities we chose were heard by the subjects in 38% of a total of 690 presentations, whereas in combinations with supraliminal cutaneous stimulation they were heard in 63%. Thus, the increase in auditory sensibility was distinct and reliable, although it did not occur with each presentation.

The Figure illustrates some examples of such changes, where there is schematic rendition of fragments of three tests with three subjects. We see that with the use of clicks of the same intensity, they were not heard (white circles) in combinations where there was no cutaneous sensation (white triangles), whereas in the combinations where electric stimuli were perceptible (black triangles) the same clicks were audible (black circles), with the exception of two cases.

Thus, it was discovered that the capacity to affect auditory sensibility is not inherent specifically to proprioception, but other sensory systems, in this case the cutaneous one.

It must be noted that some researchers [4, 5] observed elevation of the auditory threshold under the influence of cutaneous stimulation. Evidently, this is related to the fact that they specially used strong electrocutaneous stimuli that have a masking effect on signals of other modalities.

As for the structural bases of the effect we observed, according to data in the literature there are several possibilities. For example, stimulation of the skin of a cat's paw altered neuronal activity in its cochlear nuclei [6, 7], inferior lamina tecti mesencephali [6, 8], internal geniculate body [6], its large-cell part [9] and primary auditory cortex [10]. On the basis of evoked potentials, overlapping of cutaneous and auditory projections was demonstrated in the anterior ectosylvian gyrus [11]. These two modalities also interact in multisensory cortical regions [12, 13]. However, it must be stipulated that, unlike our psychophysical experiments, these electrophysiological data were indicative of predominantly inhibitory effects of cutaneous stimulation on hearing.

Let us also mention that we demonstrated the opposite effect, and an even stronger one at that, in the course of our experiments, i.e., the influence of audible sounds on cutaneous sensibility. Subjects perceived isolated cutaneous stimuli in 30% of the cases (562 deliveries without audible sounds), and in combination

with audible clicks (325 presentations) they did so in 79% of the cases. These findings conform with previously published data [14].

Conclusion

A study was made of the effect of mild tactile stimulation on auditory sensibility. Stimuli of both modalities were delivered either separately or simultaneously. In the case of concurrent tactile (supraliminal) and sonic stimulation, the auditory thresholds were reliably lower than with audio stimulation alone. Thus, mild tactile excitation increased excitability of the auditory system.

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DYNAMICS OF PSYCHOPHYSIOLOGICAL AND CARDIOVASCULAR PARAMETERS DURING OPERATOR WORK IN THE ANTICIPATION AND TRACKING MODE

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[Article by N. I. Sapova and T. A. Pavlova, Leningrad, submitted 11 Nov 79]

[Text] An operator's work at a control console is related to the necessity of perceiving and processing information on an extremely tight time schedule and making appropriate decisions on this basis. During performance of operator work, a man can be subject to the influence of a number of adverse factors, which alter the operator's functional state and efficiency [fitness for work] [1-4]. For this reason, industrial physiologists are confronted with the task of observing the condition of operators during work in order to detect early adverse signs of changes in them and to prevent such adverse changes.

Our objective was to investigate the functional changes in the human body in the course of operator work for 4 h in the mode of anticipation and tracking, with differing density of signal input per watch [work period] and under different ambient microclimate conditions.

Methods

A total of 10 people (men) 20 to 33 years of age, who had not been engaged previously in operator work, participated in the studies. Their duties consisted of prompt detection and tracking of an illuminated dot on a television screen. The tests were conducted in a small sound-proof chamber. The first and second tests were conducted under ordinary conditions (temperature 22±1°C, humidity 40-60%), the third at an air temperature of 43±1°C (with the same humidity). The density of signal delivery constituted 160 in the first test, and 16 signals per watch in the second and third. In the first test, the intervals between signals ranged from 20 s to 5 min, in the second and third from 30 s to 50 min, with tracking time of 20 s. Prior to the tests, the subjects were trained many times in operator work at a console.

The well-being of the subjects was evaluated by means of interrogation following a specific outline before and after work. We studied the direct indicators of operator efficiency--number of errors (misses) referable to signals, as well as the quality of tracking (integral tracking error).

Specially developed "Search" equipment was used to study the dynamics of mental efficiency of the operators. An instrument generated groups of audio signals for

several successive intervals each lasting 5 s, at a constant frequency of pulses within an interval and increasing frequency from interval to interval. The duration of the sonic pulse was constant, and it constituted 80 ms.

The method of counting signals (CC) under conditions of time shortage consisted of determining the maximum signal frequency at which the subject could correctly count the total number thereof per group. The subject was instructed in advance to keep track of the number of signals by mentally listing the sequential number of each of them. He was to call out loud the total number of signals in each group. The maximum number of pulses counted correctly by the subject served as the indicator [parameter]. For the method of dividing attention (DA) under conditions of shortage of time, the subject was asked to keep track of the number of audio signals as in the preceding test. Concurrently with the audio signals, photic signals were delivered in the same intervals. The number of photic pulses per group was set at random (from 3 to 6). The duration of photic pulses constituted 80 ms. In response to each photic pulse the subject had to touch the sensory plate on the instrument with his right index finger right after appearance of the light. Performance of this task was rated according to maximum number of audio signals correctly counted by the subject, provided he also reacted properly to the photic signals.

The substance of the operative [immediate] memory (OM) method under conditions of shortage of time consisted of determining the threshold frequency of two types of audio signals alternating in random order, at which the subject was capable of correctly counting the number of both types separately. The instrument generated audio signals lasting 160 ms for several successive intervals lasting 10 s. In each group, the higher frequency (1000 Hz) signals alternated with lower frequency (400 Hz) signals. The order of delivery of high and low signals in each group was set by a transmitter of random numbers. The subject was asked to count the number of high and low signals separately in each group, listing mentally the sequential number of each. The maximum number of high and low audio signals that were counted correctly in 10 s was taken as the threshold value.

In the examination of the cardiovascular system, arterial pressure (AP) was measured by the Korotkov method with a Bedmonitor instrument by remote control. The electrocardiogram was taken in the D-S lead [5]. Phase analysis of cardiac function was performed by means of concurrent registration of the EKG, sphygmogram of the carotid artery and seismocardiogram. The polycardiograms (PKG) were interpreted by the method described by V. L. Karpman [6]. An original design of the Periodometer instrument was used to record intervalocardiography (IKG). This instrument is based on the principle of time and amplitude conversion of EKG R-R intervals recorded in the form of vertical lines with an automatic tracer. The stationary segments were evaluated according to mean values of R-R intervals, sinus arrythmia (SA), determined as the difference between maximum and minimum R-R intervals within the selected epoch of analysis (3 min), as well as analysis of amplitude of respiratory waves of cardiac rhythm (RA), which was calculated for five respiratory cycles. The rheoencephalogram (REG) was recorded in the left frontomastoidal lead and the rheovasogram (RVG) of the lower extremities from the left lower leg. The rheograms were interpreted by the conventional method [7]. Stroke (SV) and minute (MV) volumes of the heart were determined by the method of integral rheography of the body (IBR) using the formula from the works of M. I. Tishchenko [8]. The above-mentioned physiological processes were recorded

with the subject in seated position. The REG, RVG, IBR and PKG were analyzed in 20 successive cardiac cycles. Variability was defined as the difference between maximum and minimum values of parameters within this epoch of analysis.

The orthostatic test and Martin's test (20 squats in 30 s), with registration of IKG and AP, were performed before and after the watch. Transient processes in these tests were evaluated with the use of some of the theses of theory of automatic regulation, taking into consideration the distinctions of regulation of heart rhythm in a living organism. We determined the following: duration of transient process from the start of the load to establishment of a new quasistationary level (t); reaction to load (r)--difference between initial duration of cardiac cycles and duration with a load (Martin's test) or standing (orthostatic test); overregulation (r_1)--difference between minimal duration of cardiac cycles in the transitory period and new quasistationary level; area of regulation (S)--area circumscribed by the curve of the transient process and line of the new quasistationary level.

G. Drishel proposed that the concept of quality of regulation, which refers to the reciprocal of the area of regulation, be applied in biology [9]. However, as shown by our experience, reduction of the area of regulation involves great strain for the body and cannot be considered a positive phenomenon, whereas in engineering such a reduction is indicative of better regulation of the system. On the basis of data submitted by D. N. Menitskiy [10], the reaction to a load characterizes excitability, duration of the transient process--lability, whereas overregulation is indicative of equilibrium of nervous processes in the regulatory centers of the organism.

Results

All of the subjects who participated in the tests noted that operator work is tiring, due to the monotony and uniformity of the surroundings. There were complaints of headache, sharp pain in the eyes, which were more marked in the third test. The subjects also reported that it was difficult to sustain the working position.

Studies of efficiency of operator performance revealed that the number of missed signals per watch constituted 1.1-1.6 in all of the tests. The largest number of missed signals due to distraction was noted at high ambient temperature (2.9 signals). Tracking error (motor component of work) diminished toward the end of the watch in all of the tests (the "finish-line dash" effect).

In order to assess the changes in mental fitness under the influence of a 4-h watch in the mode of information tracking, the background results of psychophysiological studies were compared to those obtained for the operators after the watch. The initial CC value for the operator group constituted 19.6 signals. After working for 4 h, there was a tendency toward decline of CC parameters in all of the tests. The change in the divided attention parameter was more substantial. Thus, after the second test, the value of this parameter was 13.2% lower ($p<0.02$) and after the third test it was 12.8% lower ($p<0.01$), as compared to the base value (17.5 signals). The OM span did not undergo appreciable change under ordinary microclimate conditions. But at high air temperature, operator work elicited a reliable 6.0% de tabulation of high and low audio signals, as compared to background data (11.7 signals, $p<0.05$).

Thus, the work periods with exposure to high air temperature elicited more significant changes in functional state of the brain systems that implemented the function of analyzer systems in performing these psychophysiological tests. This was confirmed by the significant decline of parameters of OM in the third test, there being no changes when the work period was associated with optimum ambient temperature. On the whole, the described changes in psychophysiological parameters were indicative of the fact that the set of experimental factors (operator work, hypokinesia, sensory deprivation and others) led to moderate decline of mental efficiency.

The pulse rate decreased starting in the 2d hour of the watch: from 73-76 to 62-69 beats/min ($p<0.01$) in the first and second tests, and from 90 to 82-86/min in the third ($p<0.05$). SA increased by the end of the watch from 210-220 to 260-320 ms ($p<0.01$) in the tests under ordinary microclimate conditions. During the watch period RA increased (from 54 to 70 ms, $p<0.01$) in the first test, remained unchanged in the second and diminished somewhat in the third (from 30-40 to 20-25 ms, $p<0.05$). There were signs of accentuated tonus of cerebral vessels under the influence of high ambient temperature, as compared to data obtained under normal microclimate conditions (the anacrotic phase of the REG increased from 110-127 to 150-192 ms, while the dicrotic index increased from 73-78 to 83-95%, $p<0.01$). The increase in minute influx of blood into these vessels occurred solely due to quickening of the pulse. Delivery of blood to vessels of the brain and lower leg remained at a rather stable level during the watch. In the third test, the tonus of leg vessels increased during the watch: anacrotic phase of the RVG increased from 105 to 157-169 ms and dicrotic index rose from 22 to 42-60% ($p<0.05$). This was associated with increased variability of pulsed delivery of blood to these vessels, from 1.8 to 3.0 Ω^{-2} and anacrotic phase from 68 to 106 ms ($p<0.05$), which was indicative of instability of vascular tonus. The increase in SV and MV of the heart in the third test, as compared to the first and second, was reliable but insignificant. We failed to demonstrate appreciable changes in phase structure of the cardiac cycle in the course of the watch. In all of the tests, we found elevation of diastolic AP to 76-87 mm Hg toward the end of the watch, versus 71-75 mm Hg before it ($p<0.05$).

No changes were demonstrable in regulation of cardiac rhythm (according to IKG data) during the subjects' performance of the orthostatic test in the first and second experiments, whereas in the third t increased from 37 to 54 s and r from 164 to 194 ms ($P<0.05$) toward the end of the watch. The quality of regulation of heart rhythm during this test remained unchanged in all cases. During performance of Martin's test, there was an increase in duration of cardiac cycles during the exercise period from 500-510 to 550-560 ms (C_n), as well as in r from 170-173 ms to 274-291 ms ($p<0.01$) in the first and second experiments. S increased from 0.96 to 1.90 s^2 and from 8.22 to 9.21 s^2 ($p<0.05$) during the load and in the recovery period, respectively. Under the influence of the hyperthermia factor, the main changes were referable to recovery t, which reached 147 toward the end of the watch, as compared to 114 s before the start of the watch ($p<0.05$). From the very first 15-20 min of exposure to air temperature of 43°C, there was decrease in S_n (to 480-485 ms) and r (to 114-119); recovery t extended to 114-117 ms, versus 101-110 ms in the first and second tests ($p<0.05$), while S diminished: to 0.49-0.91 s^2 with the load and to 5.55-9.21 s^2 in the recovery period ($p<0.05$-0.01).

Thus, in all of the experiments there was the same tendency toward slowing of the pulse, which could be attributed to hypokinesia, sensory deprivation and the

monotony of the effects of stimuli when performing operator work. This was also indicated by the increase in arrhythmia in the first and second tests. The increase in RA in the first test was probably related to the great nervous and emotional stress in the operator with the rather high density of signal input. Decrease therein in the third experiment could be attributed to diminished correlation between cardiac and respiratory centers during exposure to high temperature. In all of the tests, the optimum level of blood supply to the brain was retained. The increase in tonus of leg vessels in the third experiment was a reflection of the adaptation reaction directed toward maintaining the necessary venous return to the heart during exposure to the heat load. However, this was not enough to maintain optimum SV and MV. The increased instability of vascular tonus in the leg must be considered an adverse factor.

The studies revealed that the quality of regulation of cardiac rhythm in the presence of such a minor load as getting up did not change under the influence of operator work or the conditions under which it was performed, while the Martin test demonstrated heightened excitability of centers regulating the cardiac rhythm under normal microclimate conditions. These data were indicative of diminished regulatory influences on cardiac rhythm ("dysbalance" of regulation). We observed a decrease in lability of nervous processes in centers controlling the heart rate after the watch under the influence of high air temperature. The effect of high temperature was manifested by a significant strain in regulation of heart rhythm during the Martin test (diminished area of regulation), which was associated with diminished excitability in these centers.

Conclusions

1. Operator work in the anticipation and tracking mode for 4 h leads to decline of the functional state of the brain; the chief causes of this decline are the monotonous effect of stimuli, relative sensory deprivation and hypokinesia.

2. An operator copes with his duties at high ambient temperature (43°C), but there is slight decrease in his efficiency. However, functional changes (poorer well-being, strained regulation of cardiac rhythm, diminished OM span and others) were more marked under these conditions, as compared to work in a comfortable microclimate.

3. For this form of operator work, the functional state and reliability of operator performance are virtually unrelated to the density of delivery of information.

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EVALUATING OPERATOR STRESS ON THE BASIS OF STATISTICAL CHARACTERISTICS OF AN ELECTROCARDIOGRAM

Moscow FIZIOLOGIYA CHELOVEKA in Russian Vol 7, No 1, Jan-Feb 81 pp 81-86

[Article by V. V. Romanov, V. M. L'vov, Yu. I. Smirnov and Yu. I. Shorokhov, Kalinin Polytechnical Institute, submitted 23 Nov 79]

[Text] Evaluation of operator stress during work constitutes a rather complex task, which is important to practice. It is necessary to have knowledge about this to set work load standards, to optimize work algorithms, validate optimum work and rest schedules, etc. The characteristics of the cardiovascular system are generally used in the physiological and hygienic literature as informative indicators of stress [1-3]. Most often, one uses the pulse rate which, according to [4], shows a clear correlation with the importance of the performed task. Such characteristics as the autocorrelation function of R-R intervals [5], their spectrum [6], etc., are also quite informative. In this respect, changes in variability [standard deviation] of R-R intervals is of particular interest.

It was already noted in the literature that there is a decrease in variability with increase in heart rate, which is inherent in a state of stress. It was proven that there is a correlation between heart rate and size of neuropsychological load [7]. The link between these parameters is the most distinct when there is an appreciable increase in heart rate, which justifies our referring to an inverse relationship between pulse rate and its scatter [8]. Sinus arrhythmia, which is the main component of scatter [9] [or variability], diminishes substantially in states of stress and fatigue [10]. This fact served as grounds to elaborate a special indicator of stress, SABS, which is calculated as the sum of moduluses of difference between adjacent R-R intervals related to the unit of time [11]. The high informativeness of this parameter was checked during performance of psychological tests [12] and repeatedly confirmed by other authors [13, 14]. However, analysis of data in the literature and the results of our own studies shows that it is imperative to consider the pulse rate also when assessing the degree of stress. The stress index (SI), which is calculated as the quotient from dividing the amplitude of R-R interval mode by double the product of variation range and mode [15], constitutes, to some extent, a complex evaluation of these components.

With reference to approaches to evaluation of stress, which are based on EKG characteristics, we must mention the use of so-called slow waves for this purpose. Some authors relate appearance of such waves and change in their characteristics to operator stress [16, 17] and fatigue [18, 19].

The foregoing served as the basis for experimental verification of the informativeness of the parameters in question, as well as characteristics of slow waves, for evaluation of operator stress and elaboration of an indicator that would remain informative as well in studying relatively brief (of the order of 2-3 min) work operations.

Methods

These studies were conducted on 6 male subjects 19-22 years of age. We regarded the R-R intervals to the nearest hundredths of seconds in the course of discrete sensorimotor work creating different levels of stress [tension]. The degree of tension was changed by altering the speed of delivery of light signals to subjects, who had undergone previous training, in reactions of choice from three alternatives. The first mode of presentation constituted 20 signals/min, the second--30, the third--40, the fourth--60 and the fifth mode--80 signals/min. The tests were conducted in the mornings. The subjects worked for about 5 min in each mode. We submitted to statistical processing 73 arrays [blocks], each of which consisted of about 250 values of R-R intervals. We determined mathematical expectation, standard deviation, mode, median, as well as third and fourth moments. We plotted a graph of the dynamics of R-R intervals and distribution curves (variational pulsograms) for each array.

Results and Discussion

As a result of analysis of intervalograms, we determined that any increase in rate of delivery of signals usually led to acceleration of the pulse. The change to a new functional mode of the cardiovascular system lasted about 20-40 s. For this reason, we did not take into consideration the results for the first minute of the test in our subsequent analysis.

Figure 1 illustrates typical intervalograms for one of the subjects; it shows that an increase in intensity of work elicited a decrease in R-R intervals (the most marked with high-speed delivery of signals) and drastic decrease in amplitude of respiratory waves (the most marked when changing from a state of rest to performance of the test).

In the case of delivery of signals at high speed, some runs clearly show slow components (slow waves) lasting 15-40 s (Figure 2).

Analysis of the intervalograms led us to assume that there were slow waves as well in the subjects in their initial state. A method of calculating mathematical expectation and standard deviation of duration of R-R intervals involving the method of sliding mean with gradual increase in averaging interval was proposed for quantitative estimation of these waves. Mathematical expectation (M_{cc}) was calculated using the following formula:

$$M_{cc} = \frac{\sum_{i=1}^{N-T+1} \frac{\sum_{j=i}^{i+T-1} x_j}{T}}{N-T+1}.$$

Standard deviation (δ_{cc}) was calculated with the following formula:

$$\delta_{cc} = \sqrt{\frac{\sum_{i=1}^{N-T+1}\left(\frac{\sum_{j=i}^{i+T-1} x_j^2}{T} - M_{cc}^2\right)}{N-T+1}},$$

where N is the length of the sample, T is the averaging interval, x_j is the element of the sample (i, j = $\overline{1, N}$).

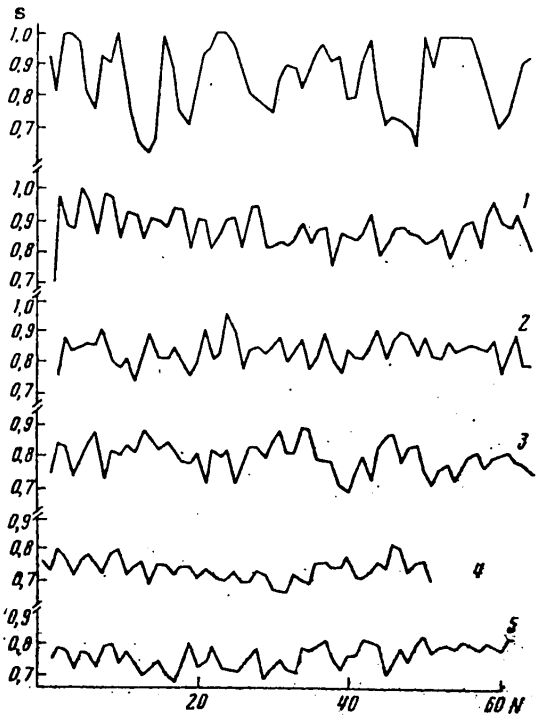

Figure 1. Dynamics of R-R intervals during continuous sensorimotor activity as a function of speed of delivery of signals. X-axis, number of R-R intervals; y-axis, magnitude of R-R intervals, s

1) background
2) 1-20 signals/min
3) 30 signals/min
4) 40 signals/min
5) 60 signals/min
6) 80 signals/min

With small intervals of averaging, the standard deviation would describe respiratory arrhythmia and with increase in the interval its values are also affected by slow waves.

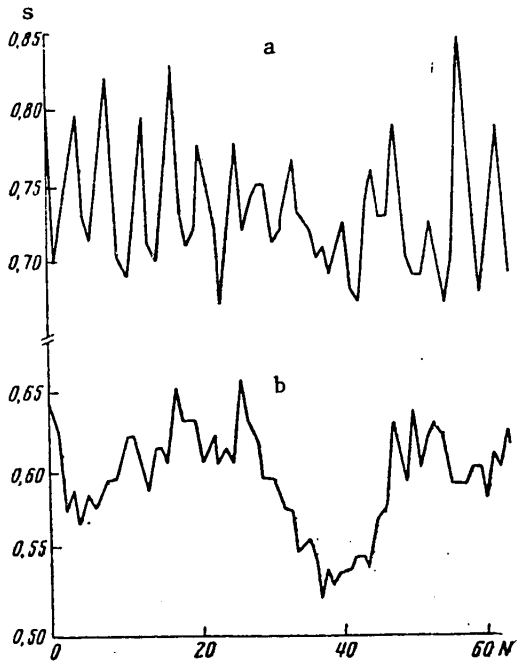

Figure 2. Dynamics of R-R intervals in base state (a) and during delivery of 80 signals per min (b). X-axis, number of R-R intervals; y-axis, magnitude of R-R intervals, s

The Table lists the averaged values of mathematical expectation and standard deviation of R-R intervals. There was virtual coincidence of values for mathematical expectation calculated by the usual method (M) and method of sliding mean (M_{cc}). This table lists the value for the averaging interval corresponding to 10 values of R-R.

Averaged values of statistical characteristics of R-R intervals, ms

Feature	Background	Work mode				
		1	2	3	4	5
Number of arrays	12	12	12	13	11	13
M, M_{cc}	841	884	884	835	811	791
δ	99	88	73	69	69	74
δ_{cc}	64	60	52	48	46	44

The statistical reliability of the obtained changes in M and δ was tested by the sign criterion. The decrease in M and M_{cc} was found to be reliable in the fourth

and fifth modes of work, as compared to the background and the first three modes. The decrease in δ_{cc} was reliable for the third, fourth and fifth modes, as compared to the background, first and second modes. In this case, the difference between δ_{cc} in the third, fourth and fifth modes was also found to be reliable. The confidence probability constituted 0.95-0.99.

The Table shows that the mean value of δ_{cc} was always lower than the values of δ (by 30-39%).

It was interesting to compare the value of δ_{cc} in the base state and in stress with different averaging intervals. Figure 3 illustrates the results of processing 10 pairs of arrays recorded at rest and in the fifth mode on five subjects. We see that, starting with the first averaging interval and to the interval containing nine values of R-R, the difference between δ_{cc} at rest and in a state of stress increased from 120 to 210 ms. With greater averaging intervals (9 to 120 R-R values), we failed to observe appreciable changes in the obtained ratios. Averaging intervals containing 3-9 values of R-R were in the range of 2.5-8 s, which corresponds to the duration of the respiratory waves [20].

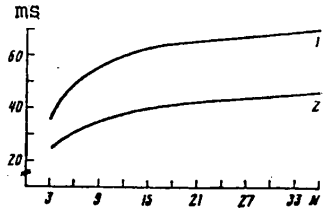

Figure 3. Dynamics of change in mean standard deviation as a function of averaging interval in base state (1) and stress (2). X-axis, number of R-R intervals; y-axis, standard deviation, ms

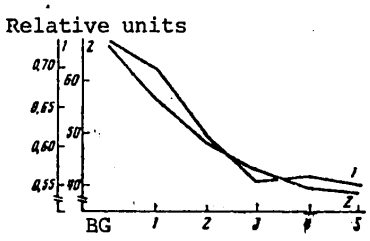

Figure 4. Dynamics of changes in SABS (1) and PS as a function of work mode. X-axis, work mode (see Figure 1); y-axis, SABS and PS in relative units

Key: BG) background

Thus, analysis of the components of the variability revealed that a state of stress was characterized primarily by a decrease in respiratory arrhythmia. However, slow waves (of the order of several tens of seconds) changed insignificantly with increase in stress. The increase in share thereof in a state of stress was attributable to the decrease in respiratory arrhythmia. The changes in respiratory arrhythmia were measured the most accurately by means of parameters of scatter, calculated by the sliding mean method. The results of this study warrant the proposal for evaluation of operator stress of a parameter that integrates the changes in heart rate and its dispersion. One variant of such a parameter of stress (PS) could be the product of mathematical expectation of R-R intervals multiplied by their scatter, obtained by the sliding mean method. Figure 4 illustrates the change in values of PS (relative units) as a function of degree of tension created by different speeds of delivery of signals. For the sake of comparison, the same figure illustrates the dynamics of the SABS parameter (relative units). This figure shows that SABS was informative only for moderate stress, when reduction of respiratory arrhythmia was the principal feature in reactions of the cardiovascular system. It is desirable to use the PS to evaluate the higher levels of stress, in the presence of which faster pulse was also present.

N. A. Bernshteyn stated [21] that: "The functions of scatter in each instance are a sort of reflection of the processes in which they figure." From this point of view, one can study processes of cardiovascular system control on the basis of the dynamics of structure of scatter of heart rate. The nature of changes in the variational pulsograms warrant the belief that marked sympathotonia [22] is one of the main neurophysiological mechanisms of regulation of the heart rate in the presence of stress. We also obtained similar changes in variational pulsograms. Several authors relate the change in scatter of R-R intervals to intensification of the central, cortical component of control [23]. The quicker pulse has also been attributed to the influence of the sympathetic nervous system and changes in its scatter to the influence of the vagus [24].

We feel that the decrease in respiratory arrhythmia could be interpreted as the consequence of firmer central control in a state of stress, which compensates for the effects of short-change environmental changes [25]. From the standpoint of functional system theory, this means that there is "inhibition," depression of a set of adaptive reactions to changes in conditions of cardiovascular system function caused by respiration.

Conclusions

1. The state of stress is characterized by drastic reduction of respiratory arrhythmia and quickening of the pulse. Maximum changes in respiratory arrhythmia correspond to the change from a resting state to moderate tension. Significant quickening of the pulse is observed when there is substantial increase in tension.

2. It is desirable to use the parameter, which integrates unidirectional changes in mathematical expectation and scatter of duration of R-R intervals, calculated by the method of sliding mean with averaging interval of the order of 8-10 s, to assess operator stress in the course of work. The product of the above-mentioned statistical characteristics of the EKG is proposed as one of the variants of such a parameter.

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COMPARATIVE CHARACTERISTICS OF MAN'S RESISTANCE TO PROLONGED EXPOSURE TO ACCELERATIONS VARYING IN GRAVITY GRADIENTS

Moscow FIZIOLOGIYA CHELOVEKA in Russian Vol 7, No 1, Jan-Feb 81
(manuscript received 18 Sep 78) pp 87-90

[Article by I. F. Vil'-Vil'yams, Moscow]

[Text] At the present time, the idea of using rotation on a short-arm centrifuge aboard spacecraft in order to simulate gravity effects in weightlessness is being discussed by Soviet and foreign authors [1-4]. However, there is no information in the literature concerning the comparative resistance of the organism to long-term "head-pelvis" low levels of acceleration varying in gravity gradients (changes in overloads along the longitudinal axis of the body). It is of considerable interest to study this in order to work on the problem of using a short-arm radius during space flights.

Our objective here was to study the general condition of the body and reactions of the cardiovascular system during long-term exposure to longitudinally directed "head-pelvis" accelerations of 1-2 G with different gradients of overloads within the body.

Methods

We submit here the results of 495 tests involving 58 healthy male volunteers submitted to rotation on centrifuge with medium (7.25 m) and short arm. The radius of rotation on the short-arm centrifuge was determined according to the subject's height (average of 1.74 m). The axis of rotation was on eye level. There was zero G in the region of the bridge of the nose.

The first series (86 studies involving 25 men) was conducted on a centrifuge with medium sized arm. Accelerations in the "head-pelvis" direction constituted 1, 1.5 and 2 G in different tests. The resultant accelerations, with consideration of earth's gravity, constituted 1.4, 1.8 and 2.2 G, respectively. The gravity gradient between the head and the legs constituted 20%. The subjects were rotated for 60 to 90 min.

In the second series (409 tests on 33 subjects) we used a short-arm centrifuge. We created accelerations of 0.8, 1.2 and 1.6 G at foot level. The resultant accelerations constituted 1.3, 1.6 and 1.9 G, respectively. The gravity gradient constituted 100%, according to Piemme [3]. Exposure to acceleration lasted 40-60 min. The subject's head was immobilized, his motor activity and flow of visual stimuli (rotation in a dark room) were restricted in order to reduce the vestibular effects of rotation on the centrifuge.

In all of the tests, we recorded the electrocardiogram in the Neba leads; in some cases we recorded pulsed filling of earlobe vessels by the photoplethysmographic method (PPG) and arterial pressure (AP) in vessels of the earlobe, as well as AP in the brachial artery by the method of Korotkov.

The data were processed by the method of Student.

Results and Discussion

We observed a decrease in resistance to accelerations (Table 1) in 14 out of 495 tests (2.8% of all cases). Resistance to accelerations diminished more often with rotation on medium-arm centrifuge than with the use of a short-arm centrifuge. Thus, in the first series, diminished resistance was noted in 5 out of 86 cases (5.8%). In most cases, this was observed with stable level of acceleration throughout rotation. The limited resistance to accelerations in the range of 1-2 G during rotation on the medium-arm centrifuge was related to impairment of regional circulation in vessels of the head. This was manifested by a decrease in PPG amplitude in earlobe vessels to the isoelectric line or drop of AP in earlobe vessels to below 40 mm Hg. In one case, these signs were associated with peripheral vision disorders in the form of the so-called "gray veil" and, in one case, appearance of cardiac dysrhythmia in the form of migration of source of rhythm in the sinus node.

Table 1. Main signs of diminished human resistance to "head-pelvis" accelerations of 1-2 G lasting 60-90 min on medium- and short-arm centrifuges

Centrifuge arm, m	Accelerations, G	Number of tests	Main signs of diminished resistance to accelerations		
			subjective complaints	cardiac arrhythmia	decline to isoline of pulse amplitude in earlobe vessels
Medium--7.25	from 0.8 to 1*	42	--	--	--
	1	11	--	--	1
	1.5	21	--	--	4
	from 1 to 2*	12	--	--	--
	Total	86	--	--	5
Short--1.74	0.8	113	--	--	--
	1.2	120	--	--	--
	1.6	140	8	1	--
	from 1.2 to 1.6*	36	--	--	--
	Total	409	8	1	--
Totals for both series		495	8	1	5

*Tests in which acceleration level was unstable.

With rotation on the short-arm centrifuge, diminished resistance to accelerations was noted in 9 out of 409 cases (2.2%). All of these cases were referable to exposure to 1.6 G accelerations. The chief complaints limiting resistance to accelerations on the short-arm centrifuge were general weakness, nausea and vertigo. In 8 cases, these subjective complaints were associated with impairment of cardiac rhythm in the form of relative bradycardia (slowing of heart rate by 20-30 beats/min). They preceded the decline in amplitude of PPG of earlobe vessels in the range of

25-30% of the base value, In this series of tests, we failed to demonstrate a drastic decline of amplitude of PPG of earlobe vessels to the isoelectric line or vision disorders in any of the cases. Rotation was stopped for one subject due to appearance of isolated left ventricular extrasystoles. Typically enough, the decrease in resistance to accelerations during rotation on the short-arm centrifuge developed reliably later (on the average after 22 min 20 s±2 min 56 s) than during rotation on the medium-arm centrifuge (on the average after 10 min 49 s±3 min 34 s).

Table 2. Heart rate and pressure in brachial artery during exposure to head-pelvis accelerations of 1-2 G for 60-90 min on medium- and short-arm centrifuges (M±m)

Centrifuge arm, m	Accelerations, G	Heart rate, beats/min	Arterial pressure, mm Hg		
			systolic	diastolic	pulse
Medium--7.25	1	81±3.9 (11)	--	--	--
	1.5	91±3.3 (21)*	114±4.1 (12)	73±3.4 (12)	42±1.7 (12)
Short--1.74	0.8	76±0.8 (113)	112±2.2 (5)	66±2.4 (5)	47±2.7 (5)
	1.2	84±1.0 (120)*	117±2.9 (4)	73±5.4 (4)	46±2.7 (5)
	1.6	93±3.9 (140)*	112±3.4 (6)	74±2.2 (6)	44±4.3 (4)

*$p<0.05$, as compared to 1 or 0.8 G. Number of cases given in parentheses.

A comparison of parameters of systemic circulation in the two series of tests with comparable levels of accelerations failed to demonstrate appreciable differences. The heart rate was in the range of 76-93 beats/min depending on the acceleration level. AP of the brachial artery was in the normal range (Table 2).

We consider it possible to relate the difference in nature of circulatory changes in the first and second series to the difference in gravity gradient over the longitudinal body axis. Thus, in view of the low gravity gradient (20%) during rotation on the medium-arm centrifuge, the accelerations in the region of the head were similar to those, to which the lower limbs were exposed. When the mechanisms of compensation for gravity-related redistribution of blood were inadequate, this led to impairment of regional circulation in vessels of the head and appearance of symptoms that characterize man's resistance to head-pelvis accelerations [5-7]. With exposure to accelerations with a high gravity gradient under our experimental conditions, there was no appreciable impairment of regional circulation in head vessels due to the fact that the accelerations were insignificant in the head region. The associated changes, which were observed in the subjects' general condition, were consistent with vestibular disturbances [8]. It is known that a high gravity gradient makes it possible for occurrence of Coriolis accelerations, even when man makes minor movements along the radius of the main rotation [9].

Conclusion

Our studies demonstrated that man has a high degree of resistance to long-term (90 min) head-pelvis accelerations in the range of 1-2 G during rotation on medium- and

short-arm centrifuges. A decrease in resistance to accelerations on the medium-arm centrifuge was noted in 5.8% in connection with disturbances of regional circulation in vessels of the head. A decrease in such resistance on the short-arm centrifuge was demonstrated in 2.2%, in connection with vestibular disturbances.

These data warrant the recommendation that a short-arm centrifuge be used as a means of preventing the effects of weightlessness during space flights.

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FUNCTIONAL MOBILITY OF THE VISUAL ANALYZER

Moscow FIZIOLOGIYA CHELOVEKA in Russian Vol 7, No 1, Jan-Feb 81 (manuscript received 24 Sep 79) pp 29-33

[Article by V. I. Shostak and Ye. B. Stepanyan, Military Medical Academy imeni S. M. Kirov]

[Text] Investigation of the functional mobility of the human visual analyzer (often referred to in the literature as its lability), performed with the use of a method for determining the critical flicker fusion frequency (CFFF), or the critical interval of discreteness, has been one of the traditional objects of classical physiological optics. It has been demonstrated that the CFFF depends on the state of adaptation, the brightness and area of the flickering light source, its spectral composition, its location on the retina, and so on (1-3). At the same time, an analysis of published data would show that in most cases this information cannot be used for the purposes of ophthalmological ergonomics due to significant differences in the experimental techniques, failure to subject the experimental material to concrete statistical treatment, the limited range of studied parameters, and so on. On this basis, in order to permit study of the functional mobility of the human visual analyzer, we made it our objective to analyze the dependence of the CFFF on the brightness of a flickering light, its area, its spectral composition, and its location on the retina.

Methods

A specially created experimental device was used as the source of flickering light flashes. It consisted of a type ST-5 stroboscopic tachometer with an ISSh-15 flash lamp, offering a possibility for smooth frequency adjustment in the range from 0 to 50 Hz with a precision of up to 0.1 Hz. This system generated light pulses 1.5 μsec long with an energy of 0.025 j (according to the machine specifications), which was discretely weakened by neutral light filters. The light flashes were projected onto the screen of a test object, the angular dimensions of which were changed with an aperture within 1 and 20°. The spectral composition was varied with the help of KS-11, SS-5, and ZS-11 light filters, and with neutral filters equalized in relation to subjective brightness. The test object was located 0.5 meters from the main junction point of the subject's eye, and it could be viewed at 0, 15, 30, 45, 60, 75, and 90° angles outward from the visual axis (except at 15°, this region was studied inward from the visual axis so as to preclude projection of the test object upon the blind spot). The experiments were conducted on the background of stabilized

twilight adaptation (illumination at the level of the pupil was 0.01 lux). Thus there were a total of 89 variants of lighting conditions. Thirty-three experiments were performed on eight subjects having normal vision, monocularly (on 16 eyes).

Research Results and Discussion

The research made it possible to describe the dependence of the size of the CFFF on the parameters analyzed, and these laws were found to be significantly different from those previously established.

The influence of the test object's brightness was revealed with the greatest clarity. In full accordance with the Ferry-Porter law (4,5), in our experiments the CFFF grew in proportion to the logarithm of the intensity of light stimulation (this was true for a centrally projected white light source with an angular dimension of 8°). When brightness was increased by 0.75 and 1.5 logarithmic units, the CFFF grew from 31.3 ± 2.0 Hz to, respectively, 37.5 ± 1.8 and 43.2 ± 1.7 Hz.

The dependence of the CFFF on the angular dimensions of the source was less clear-cut. For central vision, it was as shown in Figure 1--that is, more complex than had been indicated previously (6). For white, green, and blue, close to exponential growth was observed for the CFFF, while for red, the maximum was noted at a source angular dimension of 4°.

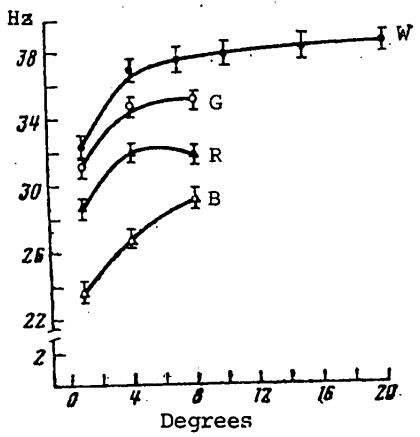

Figure 1. Dependence of the CFFF on Angular Dimensions of White (W), Green (G), Red (K) and Blue (B) Color Stimuli, for Central Vision. Ordinate--CFFF in Hz, abscissa--stimulus angular dimension, degrees

A certain regularity can also be noted in the dependence of the CFFF on color. At source angular dimensions of 8 and 4° (in situations involving equalized subjective brightness), irrespective of how the test object was projected on the retina, the fusion frequency decreased as white-green-red-blue. However, at a source angular dimension of 1° this sequence changed in relation to projection on the periphery of the retina (beginning with 30°): Red shifted to last place, and on the extreme periphery, green was found to be in first place ($p > 0.95$, according to the sign test).

Experiments showed that the angular dimensions of the source and its spectral composition had a significant effect on the nature of the dependence of CFFF on projection of a flickering light source on the retina. Thus in particular, the law established earlier (7,8) is fully applicable to white light (Figure 2) for a 1° test object: The CFFF decreases as we move away from the center of the field of vision. However, as the dimensions of the test object grow the dependence changes fundamentally. The highest fusion frequencies are found in areas 45° from the center of the retina, beyond which a decrease is observed toward the periphery of the field of vision.

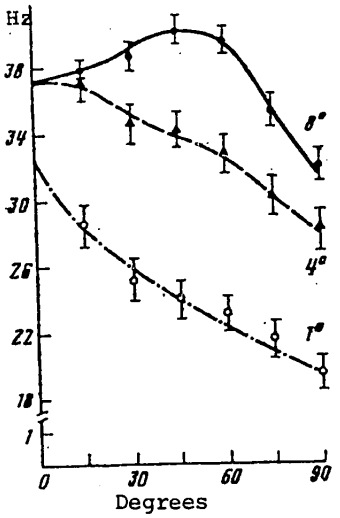

Figure 2. Dependence of CFFF on the Position of a White Light Stimulus in the Field of Vision, in Relation to Different Source Angular Dimensions: Numbers accompanying the curves show the dimensions of the source in degrees. Abscissa--location of stimulus within the field of vision

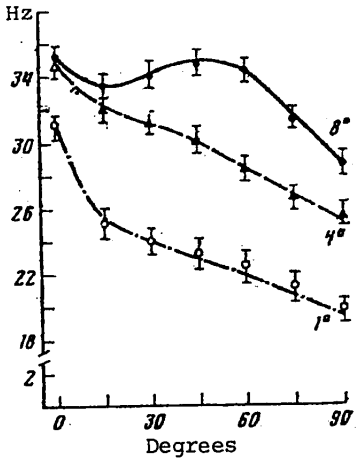

Figure 3. Dependence of CFFF on the Position of a Green Light Stimulus Within the Field of Vision, in Relation to Different Source Angular Dimensions: See Figure 2 for explanation

Dependencies of a different nature are typical of green light (Figure 3). At low angular dimensions of the test object (1°), a pronounced decrease in the CFFF was noted together with a transition from central to peripheral vision. This coincided with the beginning of achromatic perception of the green light source. As the dimensions of the test object increase, two zones of maximum CFFF were discovered: in the center of the visual field, and at a 45° angle in relation to its periphery. The zone of chromatic perception of green light typically broadened significantly in this case as well.

Investigation of the fusion frequency for red light flashes (Figure 4) also revealed the influence of angular dimensions: With respect to small dimensions, there was a sharp decrease in the CFFF upon transition from central to peripheral vision, while with respect to large dimensions this decrease was much less pronounced, and it was sufficiently noticeable only in the extreme periphery.

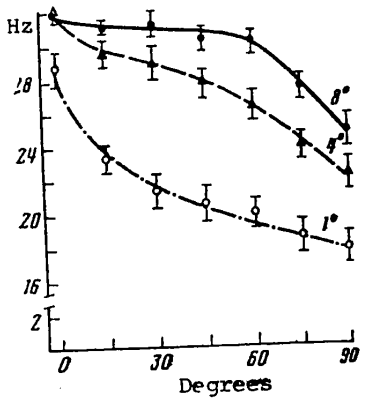

Figure 4. Dependence of the CFFF on the Position of a Red Light Stimulus Within the Field of Vision, in Relation to Different Source Angular Dimensions. See Figure 2 for explanation

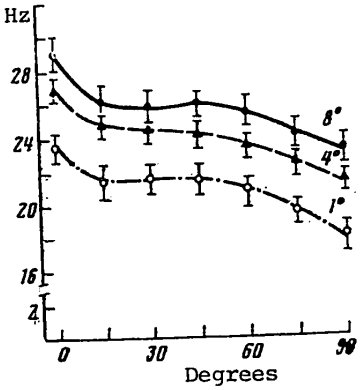

Figure 5. Dependence of CFFF on the Position of a Blue Light Stimulus Within the Field of Vision, in Relation to Different Source Angular Dimensions. See Figure 2 for explanation

Dependencies of a different sort were discovered for blue light (Figure 5). The influence of the test object's angular dimensions was lowest in this case. The highest CFFF's were observed for foveal vision in relation to all of the employed surface areas of the flickering light source; it remained practically constant in the zone from 15 to 45° in relation to the periphery of the retina, behind which it gradually decreased.

Thus the experimental data show that the human visualizer is a complex heterochronous system. This heterochronicity is apparently the product of differences in the functional mobility of elements, both in vertical morphology from receptors to cortical structures, and horizontally in systems with a parallel orientation, connected with different light-sensitive formations and with different sections of the retina. Temporal and spatial summation is obviously one of the concrete neurophysiological mechanisms reponsible for a given CFFF magnitude. These processes can explain growth in the CFFF in response to an increase in the intensity and angular dimensions of the light stimulus. For subjective discrimination of individual pulses to occur, a certain stimulation intensity must be achieved, one which is above the threshold existing for a background of trace phenomena, following the action of the preceding pulse.

Differences between individual afferent systems of the analyzer are very significant, manifesting themselves both in differences in the CFFF's for foveal and peripheral vision, and in color differentiation. An analysis of the experimental material would lead to the conclusion that given limited possibilities for spatial summation, functional mobility is higher for phototopic than for scototopic elements, and as was noted earlier, a decreasing series as green-red-blue is typical with the former. Reduction of the number and complete absence of cones in the periphery of the retina is naturally consistent with a decrease in the CFFF.

As the angular dimensions of the test object increase and, consequently, as the possibilities for spatial summation grow, the relationship changes. These experiments provide the grounds for suggesting that under these conditions, scototopic structures possess a higher capability for discrimination. This may explain the fact that portions of the retina 45-60° away from the center of the retina were associated with greater CFFF's in relation to white and green (the zone of high rod spectral sensitivity) stimuli having an angular dimension of 8°. It would be easy to explain, from this same point of view, the absence of such growth in relation to red and blue stimuli, in relation to which rods are less sensitive. Perhaps these peripheral portions of the retina, for which relatively low absolute sensitivity, very low resolution (visual acuity), and almost total absence of color sensation are typical, perform functions similar to motion detectors--that is, essentially distinct on-off reactions to poorly pronounced trace processes.

Conclusion

It may be suggested that the functional mobility of the human visual analyzer, assessed in relation to its capability for discriminating a light flicker, is a property that is differentiated in relation to different structural elements of the sensory system, and that is dependent on temporal and spatial summation of these elements.

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COORDINATION OF EYE-HEAD MOVEMENTS IN THE GAZE FIXATION REACTION

Moscow FIZIOLOGIYA CHELOVEKA in Russian Vol 7, No 1, Jan-Feb 81 (manuscript received 28 Jan 80) pp 34-39

[Article by I. B. Kozlovskaya, Yu. V. Kreydich, A. A. Repin and V. A. Barmin]

[Text] The sudden appearance of an object in the peripheral field of vision is known to elicit a successive chain of movements consisting of saccadic eye movement in the direction of the object, turning of the head in the same direction and slow counterrotation of the eyes, which compensates for head movement and thus stabilizes the image of the object on the retina. It has been demonstrated that in primates, eye-head coordination is achieved by a system of vestibulo-oculomotor associations with the participation of visual and proprioceptive afferent inputs (1-4). Research by a number of authors on various animals established that the coefficient of amplification in the vestibulo-oculomotor loop is determined by a system of vestibulo-cerebellar projections (5,6). The available published information permits the hypothesis that organization of active human eye-head coordination in gaze fixation upon a visual object is similar to that in animals.

This report offers a quantitative description of the parameters of gaze fixation in an individual performing a standard motor task, in conditions practically similar to those described in (1-4).

Methods

Experiments were performed on 13 healthy subjects of both sexes from 25 to 40 years old.

The subjects were placed before a white arched screen with a diameter of 60 cm. Light targets with a width of 1 radian were presented within a 120° arc at 20° increments 30 cm from the subject's eye; this permitted investigation of gaze fixation in three standard positions (20,40,60°) on each side.

The motor task was to fix the gaze on the presented visual target as quickly and precisely as possible. The gaze was always shifted from a standard position, for which purpose a central light target, used as the zero reference point, was projected onto the screen. Peripheral light stimuli were presented in random order to preclude positional and temporal learning. Horizontal eye and head movements and an electromyogram of the neck muscles (m. splenius) were recorded during the experiment.

Electro-oculography was used to record horizontal eye movements. Electro-oculographic potentials were picked off by silver-plated disc electrodes; the signal was amplified by a general-purpose amplifier with a passband from 0 to 30 Hz and a time constant of 5 sec. Turning of the head was recorded by means of a precision potentiometer the central stem of which was secured to a helmet on the subject's head. Recordings were made with a bridge circuit; its output signal, which was proportional to head rotation, was recorded by a general-purpose amplifier. The electromyogram of the neck muscles was recorded with cutaneous surface electrodes (the interelectrode distance was 3 cm). The parameters were recorded on a four-channel YeMT-34 (struynyy mingograf) at a rate of 50 mm/sec. Thus the system's resolution was 10 msec.

The gaze shift trajectory was plotted graphically by summating the amplitudes of the eye and head movements at each point. The eye, head and gaze movement curves were used to analyze the latent periods, amplitudes and maximum angular velocities, and the temporal characteristics of the EMG. The significance of the data was determined by Student's test.

Research Results

When targets were flashed to subjects in our experiments, they quickly turned their gaze toward the presented visual stimulus. Coordinated eye-head movement exhibited strict spatial and temporal interaction (Figure 1). Activity of neck agonist muscles responsible for head movement arose first, with a latent period of 150-180 msec. The amplitude and duration of the EMG depended on the head rotation angle, and they increased as the movement amplitude increased. Saccadic movement in the direction of the visual stimulus began 10-80 msec later. A unique set of saccadic movement amplitudes corresponded to each position of the light stimulus; as the angular distance to the target increased, the average amplitude grew, but it remained less than the angular distance by an amount ΔA (Figure 2). The absolute value of ΔA grew as the amplitude of gaze shift increased, averaging from 2 to 24° (Table 1). The duration of saccadic eye movement exhibited a clear dependence upon amplitude, and it varied within 30 and 170 msec.

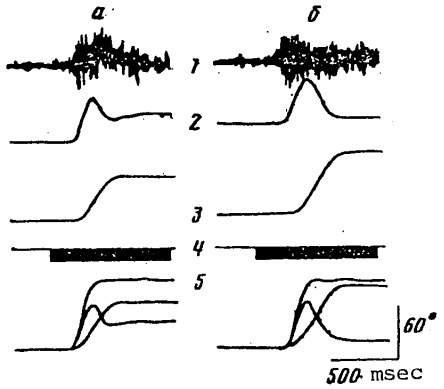

Figure 1. Interaction Between Eye and Head Movements of Subject Groups I (*а*) and II (*б*) in Response to a Light Target: *1*--electromyogram of neck agonist muscles turning the head; *2*--saccadic movement; *3*--turning of the head; *4*--light target presentation mark; *5*--summated gaze curve

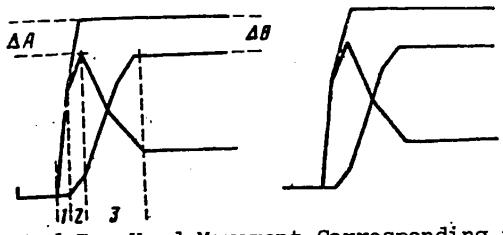

Figure 2. Coordinated Eye-Head Movement Corresponding to Spatial-Temporal Interaction: *1-3*--first, second, and third periods; ΔA--difference in amplitudes of saccadic movement and gaze shift; ΔB--difference in amplitudes of head and gaze rotation

Table 1. Amplitude Parameters of Gaze Fixation Components for Two Groups of Healthy Subjects Presented a Light Target on the Right

Target Position, Degrees	Group	Amplitude, Degrees: Saccadic Movement	Head Rotation	Gaze Movement	ΔA Degrees	ΔB Degrees
20	I	19 ± 2.0	21 ± 3.0	20 ± 1.9	+1	-1
	II	18 ± 2.2	23 ± 4.5	20 ± 1.8	+2	-3
40	I	29 ± 4.5	34 ± 5.6	40 ± 2.5	+11	+6
	II	28 ± 4.7	41 ± 6.4	40 ± 2.6	+12	-1
60	I	36 ± 5.8	44 ± 7.1	60 ± 3.1	+24	+16
	II	38 ± 5.5	53 ± 6.6	59 ± 7.9	+22	+7

Note: A--difference between saccadic movement amplitude and the amplitude of gaze shift in response to a visual stimulus, degrees; B--difference between head movement amplitude and gaze shift, degrees

Table 2. Temporal Characteristics of Gaze Fixation in Two Groups of Healthy Subjects Presented a Light Target on the Right

Target Position, Degrees	Group	Latent Periods, msec: EMG Activity	Saccadic Movement	Head Rotation	Gaze Fixation Time, msec
20	I	170 ± 36	180 ± 26	225 ± 34	300 ± 87
	II	185 ± 30	175 ± 30	240 ± 35	320 ± 97
40	I	160 ± 34	175 ± 28	215 ± 32	340 ± 83
	II	185 ± 35	180 ± 32	245 ± 36	380 ± 91
60	I	160 ± 35	190 ± 32	215 ± 35	380 ± 96
	II	180 ± 42	195 ± 39	235 ± 34	410 ± 95

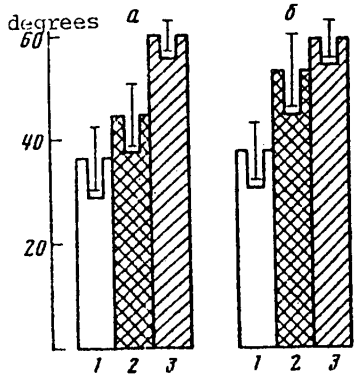

Figure 3. Amplitude Characteristics of Saccadic Movements (*1*), Head Rotation (*2*) and Gaze Shift (*3*) in Subject Groups I (*a*) and II (*b*) Presented a Target at 60°: ordinate--movement amplitude, degrees

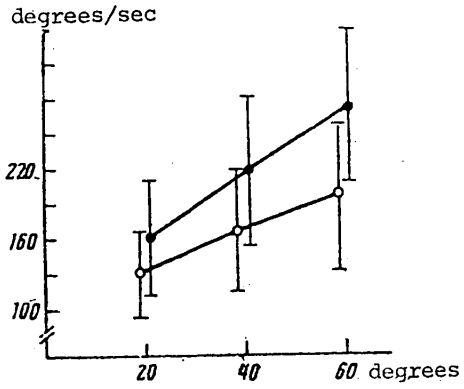

Figure 4. Relationship Between Maximum Angular Velocities of Head Rotations in the Two Groups of Subjects: abscissa--visual target presentation angle, degrees; ordinate--angular velocity of head rotation, degrees/sec. Open circles--subject group I; filled circles--group II

The second component of the reaction--head rotation--began 40-80 msec after the appearance of activity in the neck muscles, which corresponded to 0-60 msec from the beginning of saccadic movement. The amplitude of head rotations increased as the distance to the target increased. Analysis of the amplitudes showed that a subject employs two tactics to complete the task (Figure 3), as implied by the significant differences in the parameters of head motion ($p \leq 0.01$). In group I the head movement amplitude is low, being close in absolute value to the amplitude of saccadic movements; in group II the amplitude of head movement is high, being close to the angular distance to the target, or even exceeding it (ΔB, Table 1). In correspondence with the situation with the amplitudes in this case, the intervals between the beginning of eye and head movements (Table 2) and the maximum angular velocities of head rotation and eye counterrotation (Figure 4) differed significantly ($p \leq 0.01$). In group I saccadic eye movements appeared 20-50 msec after arisal of an EMG in the neck muscles; this was followed 10-30 msec later by turning of the head a small amount, usually at low speed; in group II saccadic eye movements appeared earlier--from 0 to 10 msec after the beginning of the EMG spike, while head movement began later, 40-70 msec after the beginning of saccadic movement. In this case head rotation proceeded at higher speed, and it was distinguished by high amplitude.

Differences in the eye and head movement parameters for these groups did not have any reflection on the accuracy and swiftness of gaze fixation: In both groups the gaze was fixed precisely on target within 100-300 msec after the beginning of saccadic movement (depending on the location of the presented visual stimulus). Gaze fixation was usually accompanied by signs of under- or over-adjustment, expressed as "overshooting" or "undershooting" of the gaze; however, the size of the error was insignificant, remaining within the limits of the method's precision.

Three periods were distinctly revealed in the gaze fixation curve, corresponding to spatial-temporal interaction of eye and head movements (Figure 2). In the first period, which lasted from the beginning of saccadic movement to the beginning of head movement, gaze shift was completely the product of saccadic eye movement. The duration of this period varied from 0 to 80 msec. In the second period--from the beginning of head rotation to the end of saccadic eye movement--gaze shift was the product of simple summation of the amplitudes of eye and head movements in each moment in time. In this case the speed of head rotation continually increased while the rate of saccadic movement, which was constant at the beginning of the period, gradually dropped. The third period lasted from the end of saccadic movement to the end of head movement. After saccadic movement ended, the gaze reached the target, having traveled distance ΔA, and the image of the object was projected on the region of the fovea, where it became stabilized. Fixation and stabilization of the gaze was also achieved by summation of the amplitudes of eye and head movement; however, in distinction from the situation in the second period, these movements occurred in different directions. The head moved in the direction of the target while the eyes performed counterrotation.

In normal conditions, correspondence between the maximum rate of eye counterrotation and the maximum rate of head rotation is maintained by the vestibulo-oculomotor reflex, and it is referred to as the coefficient of its amplification (7-9). The rates and parameters of head movement and eye counterrotation differ distinctly in our two groups. In group I the rate of head movement was low, and the trajectory of counterrotation was above the equilibrium position of the eyes. The equilibrium, or zero position, determined by recording the corneoretinal potential, corresponds to the central position. In group II the rate of eye movement was higher, and the trajectory of counterrotation was level with the equilibrium point, or below it. However, given all the differences, the coefficient of amplification of the vestibulo-oculomotor reflex varied insignificantly in our experiments, from 0.95 to 1.05.

Discussion of Results

Experiments demonstrated the closeness of the basic parameters of gaze fixation in man and primates (1-4). The agreement in fixation parameters also implies closeness of structural and functional organization of gaze fixation. As in animals, interaction of eye and head movements in man was distinguished by a standard pattern: No matter what the angle of presentation of the visual target, the sequence of reaction components was constant, although the relationships between components within the fixation reaction were not rigid. In this case we distinguished two tactics for coordinating eye and head movements, apparently reflecting extreme positions in the interaction of the reaction components. In the first case the head movements (in relation to saccadic movements) began earlier, they were performed slowly, and in amplitude they were commensurate with saccadic movements. In the second case head rotation, which came somewhat later in time, was performed at high speed and amplitude. One dominant type of interaction was observed for each subject in the experiment, but this was not a hard rule: The same subject could display both tactics within a single experiment.

It was demonstrated (1-4) that the eye and head motion parameters are programed independently in primates. Precise coordination of the components of the gaze fixation reaction employs a feedback mechanism, and it is achieved with the assistance of a vestibular afferent input. Our data show that the reaction components are programed independently in man as well: As we can see from figures 3 and 4, the

amplitudes and rates of head movement in the two groups of subjects differed significantly, while the eye movement parameters remained unchanged. The dependence we revealed between the amplitude and rate of head movement is of certain interest: The later head movements arose, the greater was their amplitude and speed, and the lower their precision. As in experiments performed on primates (1-4), the parameters of the reaction's third component (eye counterrotation) were fully dependent on the rate of head movement. It was demonstrated that coordination of the parameters of head movements in the third phase is achieved almost entirely (by 90 percent) by a vestibular "input", which is a function of the vestibulo-oculomotor reflex (VOR) (1-4). In our experiments $K_{\text{VOR amplification}}$, defined as the ratio between the maximum rates of eye counterrotation and head rotation (7-10), was close to 1.0 irrespective of the head movement rate. This permits the hypothesis that vestibular afferentation makes a significant contribution to coordination of the components of the gaze fixation reaction in man.

Conclusion

The experiments demonstrated the closeness of organization of the gaze fixation reaction parameters in man and primates. Similarity of spatial-temporal interaction permitted the hypothesis that the mechanisms of the reaction's control are identical.

Two types of solutions to the motor tasks were distinguished in our analysis of the parameters of gaze fixation in man: In the first, head movement began earlier, it proceeded at a low rate, and its amplitude was commensurate with that of saccadic eye movements; in the second, rotation of the head was somewhat behind in time, and it proceeded at high speed and amplitude. The eye motion parameters did not differ in this case. This permits the conclusion that as in primates, the parameters of head movements and saccadic eye movements are programed independently in man.

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PSYCHOLOGY

EIGHTH TRANSCAUCASIAN CONFERENCE OF PSYCHOLOGISTS

Moscow VOPROSY PSIKHOLOGII in Russian No 2, Mar-Apr 81 pp 178-179

[Article by Ye. V. Shchedrina, Moscow]

[Text] The regularly scheduled Transcaucasian conference of psychologists convened from 22 to 24 October 1980 in Yerevan.* This is now a traditional form of meetings of Armenian, Georgian and Azerbaijani scientists, to which psychologists from other republics of our country are also invited.

This conference, which was dedicated to the 60th anniversary of Soviet power in Transcaucasian republics, included discussion of reports dealing with the most diverse branches of psychological science. In all it consisted of 10 sections: general psychology, age-related and pedagogic, VUZ, social psychology, psychology of sensory and perceptual processes, industrial and engineering psychology, personality psychology, psychophysiology, psychology of thinking and speech, psychology of learning speech and language.

The opening remarks at this conference were delivered by S. T. Akhumyan, Armenian minister of education. He noted the special role of psychology in the matter of teaching and upbringing new generations. Great interest was displayed in the paper of B. F. Lomov concerning the current status and prospects of development of Soviet psychology. A. A. Akopyan, Sh. A. Nadirashvili and A. S. Bayramov dealt with the main directions and prospects of development of psychological science in Armenian, Georgian and Azerbaijan SSR, respectively.

One of the largest was the section of general psychology and personality psychology. R. T. Sakvarelidze (Tbilisi), M. S. Beliashvili (Tbilisi), O. M. Tutundzhyan (Yerevan), I. V. Imedadze (Tbilisi) and A. G. Asmolov (Moscow) raised some important issues of theory of activity, its relation to theory of set, possibility of using the systems approach to studies of set, multimotivation of activity. Representatives of the Georgian school of psychologists stressed that there are no grounds to set theory of sets against theory of activity: both postulate the same methodological task of overcoming the "postulate of spontaneity." The reports of V. G. Norakidze (Tbilisi) and Z. S. Dzhaparidze (Tbilisi) were interesting; they dealt with the possibility of drawing a psychological personality profile on the basis of conversations with an individual, studying his biography and experimentation (using

*The proceedings of this conference are covered in the collection, "Tezisy VIII Zakavkazskoy konferentsii psikhologov" [Summaries of Papers Delivered at 8th Transcaucasian Conference of Psychologists], edited by A. A. Akopyan et al., Yerevan, 1980, 383 pp.

the method of fixed set and projection methods); also of interest were the following: D. N. Abramyan and M. R. Madatyan (Yerevan), who compared scientific and artistic creativity, R. F. Ibragimbekova (Baku) who discussed intermodal relations in the structure of esthetic perception, as well as V. V. Semenov (Moscow) who discussed self-awareness in twins.

At the section of industrial and engineering psychology, in essence there were reports on specific investigations of various problems of engineering psychology. V. S. Agavelyan (Yerevan) discussed the psychophysiological mechanisms of forecasting accurate tracking in undeterminate systems; V. A. Moroz (Syktyvkar) dealt with the results of expert engineering psychological evaluation of the quality of dock cranes, V. V. Pogosyan (Yerevan) talked about formation of technical design skills through educational production work of students at vocational and technical schools; Ye. A. Mileryan (Yerevan) was concerned with the problem of upgrading vocational training of students at vocational and technical schools; D. N. Makhmudov (Yerevan) discussed the functional state of workers in the chemical industry.

Many papers dealt with a discussion of problems of psychophysiology. An attempt at studying spatial synchronization of the EEG by the twin method was described in the paper of I. V. Ravich-Shcherbo (Moscow). T. M. Merabishvili (Tbilisi) submitted a model of correlation between biogenic, psychogenic and sociogenic distinctions of man. Z. I. Bigvava (Tbilisi) demonstrated the main determinants of control and checking motor behavior, on the basis of set theory. Sh. A. Nadirashvili (Tbilisi) told about the distinctions of visual estimation of the magnitude of movement in the sensorimotor field and the role of set-related influences in this process. M. A. Rogovskaya (Tbilisi) discussed the set-related nature of perception of the speed of movement of an object. G. V. Kiriya, L. K. Chkoniya and N. V. Bakhtadze (Tbilisi) reported on experimental data, which showed that, unlike an "intracategory" retrieval, "intercategory" search leads to reduction of time required to find a target. V. I. Belopol'skiy (Moscow) discussed the dynamics of the functional field of vision in the process of reading.

The topics covered in the section of social psychology were quite broad. Questions of national consciousness [awareness] were raised in the paper of I. N. Mamedov (Kirovabad). A. A. Alizade and S. F. Shabanov (Baku) spoke about ethical and psychological aspects of interpersonal evaluation. L. B. Arakelyan and A. P. Ayran (Yerevan) dwelled on adaptation of individuals 60 years of age to retirement. Sh. A. Nadirashvili and D. G. Goguadze (Tbilisi) submitted a classification of forms of human behavior and activity based on the principle of action directed at an object; they made a distinction between different levels of complexity of behavior from the standpoint of involvement in it of various mental processes. The papers of S. D. Arzumanyan (Yerevan) and G. A. Magradze (Tbilisi) dealt with the sociopsychological study of law-breaking behavior. I. Sh. Khavtasi (Tbilisi) talked about the properties of interpersonal relations that determine the durability and stability of marriage.

This list, which is far from a complete one, of papers delivered at the conference shows that psychological research is gaining strength in the Transcaucasian republics, both in the sense of experimental work and in the sense of building the theoretical foundations of this work. It is hoped that the next conference of Transcaucasian psychologists, which will convene in Baku in 1982, will demonstrate further development of psychological science in Transcaucasia.

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METHODS FOR ANALYZING PSYCHOPHYSIOLOGICAL CAUSES OF ERRONEOUS ACTIONS THAT VIOLATED THE REGULATIONS FOR FLYING AND OPERATING AVIATION EQUIPMENT CAUSING FLIGHT ACCIDENTS, AND PRECONDITIONS THEREOF

Moscow METODIKA PO ANALIZU PSIKHOFIZIOLOGICHESKIKH PRICHIN OSHIBOCHNYKH DEYSTVIY, NARUSHENIY PRAVIL POLETOV I EKSPLUATATSII AVIATEKHNIKI, OBUSLOVIVSHIKH LETNYYE PROISSHESTVIYA I PREDPOSYLKI K NIM in Russian 1978 (signed to press 12 Dec 78) pp 1-16

[Complete translation of pamphlet "Methods for Analyzing Pyschophysiological Causes of Erroneous Actions That Violated the Regulations for Flying and Operating Aviation Equipment Causing Flight Accidents, and Preconditions Thereof", compiled by A. I. Ustinova, I. A. Tsvetkov and I. S. Anitova, Ministry of Civil Aviation, State "Order of Red Banner of Labor" Scientific Research Institute of the Civil Aviation, 90 copies, 16 pages]

[Text] 1. General Theses

Psychophysiological analysis of the findings from investigations of aviation accidents [incidents] over a period of many years indicates that in about 50% of the cases referable to gas-turbine aircraft and over 70% of those referable to light airplanes they are related to some distinctions or other of the pilot's personality and quality of professional training.

At the same time, there is limited involvement of physicians of detachments, expert physicians in flight safety and psychologists of VLEK [committees for expert medical certification of flight personnel] in studying the causes of crew errors and related flight accidents.

As a result, the records of analysis of flight incidents contain virtually no evaluation of psychophysiological causes of erroneous actions, let alone their relation to individual personality traits of the pilot and fitness of crew members.

At the present time, we know the most typical and more frequently recurring errors of flight crews that lead to accidents or damage [breakage] to aircraft.

Thus, a typical error made by crews of gas-turbine aircraft at take-off is poor timing, most often a delay, of the captain's order to discontinue the take-off when there are malfunctions and wrong choice of time to decelerate the aircraft. During landings, errors are referable to incorrect calculation and failure to hold the main landing parameters (speed, glide path and course) or setting the engine at the wrong mode in the prelanding approach path, as well as errors in making decisions about performing a second circle if safety of the flight is endangered.

The main cause of flight accidents in light aircraft (Ai-2) is referable to failure to hold a safe altitude and to consider weather minimum, turning in a steep bank at minimum altitude and high flying speed.

The following are among the typical violations of flight regulations by crews: making the decision to land under meteorological conditions that are poorer than the set minimum, failing to hold the minimum descent altitude in the absence of visual contact with the ground, failure to perform the full range of mandatory checks prior to take-off and landing.

Medical examination of the characteristics and results of interrogating crew members, radio traffic, explanatory memoranda, medical charts, information about prior flight and work load, etc., made it possible to determine the following probable causes of crew errors: diminished emotional stability and effect of stress factors when flight conditions became more complicated, manifested by rigidity, confusion and slow performance of necessary actions; partial decline of efficiency as a result of fatigue, which is usually manifested by diminished attention, accuracy of movements and slowing of nervous and mental processes; inadequate coordination of actions among the crew, passive attitude of copilot, delayed execution of orders, as well as delayed reporting by the captain of changes in flight conditions; lack of firm skills in piloting or worsening thereof under the influence of deconditioning, violation of preflight regimen and other causes.

It must be noted that there is an aggregate of several causative factors, rather than only one, in each specific case, and they are sometimes aggravated by errors and flaws in control of the flight by the air traffic controllers.

Flight accidents that are linked to violations on the part of crews of established flight regulations are most often attributable to certain adverse personality traits in the pilot: unwarranted exaggerated self-appraisal of his professional skill, high pretensions in the presence of minimal experience, inadequate development of sense of duty and responsibility for safety of the flight.

The foregoing confirms the need for physicians of detachments, expert physicians in flight safety and psychologists of VLEK to be actively involved in determining the causes of crew errors, placing blame for the accident, damage or precondition for a flight accident.

The experience in investigating aircraft accidents related to the personal factor enables us to recommend a working system for analyzing the causes of errors or violations of flight regulations causing accidents or preconditions for them.

A special medical chart, illustrated in the "Textbook for Medical Support of Flights in the Civil Aviation," 1978 (Appendix 13) could serve as such a system.

A unified civil aviation system for keeping records of and analyzing the causes of crew errors resulting in a flight accident or precondition for it would permit summarization of accumulated results of such analysis, prediction of tendencies with regard to nature of errors made by crew members, with due consideration of the specifics of the flight detachment [or squadron], control and civil aviation as a whole in order to develop preventive measures.

2. Investigation of Circumstances of a Flight Accident and Nature of Crew Errors

Immediately after learning about the circumstances and causes of damage or precondition and determination of the blame laid on the crew (or controller), according to the results of interrogating crew members, explanatory notes and radio traffic between the controller and crew, the physician of the detachment or the expert physician on flight safety ascertains whether there were any concomitant psychophysiological causes for the error or violation.

For this purpose, one uses information from the flight booklet, flight file [log?], personal file, flight mission, medical booklet, outpatient charts and, for determination of individual psychological personality traits of a crew member who has committed an error, the physician also uses the observations of the commander of the flight unit [podrazdeleniye].

3. Investigation of Probable Link Between Erroneous Action and Physical Condition of a Crew Member

The physician obtains the minimum amount of data for analysis of the causative link between an error and health status from examination of the medical records of the crew member who made the mistake and from a conversation in the course of an unscheduled examination.

It should be noted that it is not always an easy task to detect partial decrease in efficiency of a crew member in flight due to deviations in his health status and relate an error to it, in view of the tendency that some people have to dissimulate, as well as the possibility of having been treated at institutions other than those of the civil aviation and taking medication during flights.

At the same time, establishment of a trusting relationship between the physician and crew members or the pilot's family would help gain important additional information.

A partial decline of efficiency of a crew member in flight could be detected from certain indirect signs, for example, absence or delayed reaction of the aircraft captain to the correct and insistent advice of other crew members, failure to perform a number of simple but necessary actions, repeated violation of flight regulations within a short period of time, nonproductivity of thinking, etc. One should be particularly mindful of flight accidents where an error was made by an experienced pilot suffering from such chronic diseases as essential hypertension, neurocirculatory dystonia, which causes development of fatigue. It is also imperative to take into consideration age-related changes, including those in the cardiovascular system and sense organs, which could affect perception and processing of information.

Thus, in spite of the fact that the process of determining the causative link between an erroneous action and partial decline of efficiency, as well as between the latter and deviations in physical condition, is quite complex, determination of such a fact is the first step in a physician's work to determine the cause of an error. Determination of such a link must lead to implementation of preventive measures, for example, introduction of new, more sensitive methods of examination and pinpointing a diagnosis, as well as medical supervision of the main physiological systems during simulator tests on individuals who had performed erroneous actions in the past.

4. Analysis of Causative Link Between Errors (Violations) and Individual Psychological Personality Traits of the Pilot Involved in Flight Accident

Determination of the probable link between errors, let alone violations of flight regulations, and characterological personality traits, and state of the main mental functions is a difficult but necessary task for preventive purposes.

Analysis of the findings of investigation of causes and circumstances of the incident can furnish the following data. For example, if the aircraft captain violated more than one flight regulations in one trip, this shows that he has personality traits that are unfavorable for the flying profession:diminished sense of duty and responsibility for flight safety.

The captain's stubborn performance of incorrect actions, inadequate commands or absence of necessary actions in a complicated flight situation, in spite of early [prompt] remarks by other crew members, are an indirect indication of such negative personality traits as conceit, diminished critical attitude and stubbornness.

Making the decision to land or take off at less than minimum weather is indicative of unwarranted overestimation of one's professional skills.

The needed information about the pilot's personality and his temperament can be obtained from explanatory notes, results of interrogation, from which one can determine with some share of probability such traits as prevarication, uncritical attitude toward one's own mistakes or, on the contrary, truthfulness, lucid and logical thinking, admission of one's blame and explanation thereof.

Radio traffic can yield valuable information about the emotional state of the aircraft captain prior to the emergency situation and during its development. Conclusions are made on the basis of the form of answers, their logic, fullness, etc.

Interpersonal realtions among the crew, coordination of actions and psychological climate within the crew can be evaluated by the commander of the flight unit, who can provide the necessary information on this score to the physician.

There must be determination of the degree of such personality traits in the pilot as critical attitude toward one's own actions, objectivity of evaluating others, composure and dynamism under difficult conditions, volitional qualities, emotional stability and other traits that are important to the flying profession. It must be borne in mind that touchiness could change from a temporary reaction reflecting inconsistency between the objective attitude of another and one's self-appraisal to a personality and temperament trait. When analyzing "discipline," it is necessary to discern the degree of persistence, will power, high-mindedness, which characterize the pilot's personality and could be detected by the captain in the course of work and communication.

To assess the relations between crew members during a flight and under ordinary conditions, one can use information obtained from different crew members in the course of conversations, determining the interpersonal relations among the crew from the standpoint of standards of Soviet conduct [morals], which is characterized by exactingness based on trust, fairness, sincerity, kindness and mutual respect. By using such questions as "With whom would you like to fly?" or "If a new crew were to be formed, which of these crew members would you like to keep?" one can

gain sociological arguments for the interpersonal professional relations among the crew. But the detachment physician can augment it with personal observations of relations between crew members in the preventorium, detachment, mess hall and under other circumstances, thus forming a more accurate picture of the crew as a group.

All of the available data pertaining to dynamic observation of of the pilot's psychological status, conducted by a psychologist, must be thoroughly analyzed to determine the true causes of error or violation of flight regulations by the crew, which caused the flight accident.

Special psychological tests are made to determine the orientation of the personality (exacting attitude, adequacy of self-appraisal), intellectual traits (speed of mental processes, quick-wittedness, ability to operate with spatial concepts), attention (ability to concentrate in the presence of interference, to distribute and switch attention), emotional traits (emotional stability, excitability), immediate [dynamic] recall of crew member who caused the flight accident. One should assess the main mental functions on four levels: 1) high, when most assignments are performed with an "excellent" rating; 2) quite high--most assignments are performed well; 3) average--satisfactory performance; 4) low level of main mental functions, when most assignments referable to the main methods are rated as "unsatisfactory."

The final conclusions as to the pilot's personality traits must be based on the aggregate of data obtained from analysis of findings of investigation of the incident and experimental psychological tests.

5. Determination of Probable Causative Links Between Flight Accidents and Schedule of Flight Work and Rest Periods for the Crew

Analysis of the work schedule preceding a flight accident is made in order to determine whether there is a link between the error and fitness at the time of a given trip. Fitness [efficiency] depends, as we know, on the physical condition and prior rest to eliminate all signs of fatigue.

Studies of the findings from investigation of flight accidents over a period of many years established that either a long (over 11 hours) work load in performing flights in the preceding day or intensive flight work for the 2-3 preceding months (15% more than the maximum permissible monthly flying time) preceded a flight accident related to pilot error or errror committed by another crew member in a certain percentage of cases. Exceeding the monthly flight load on aircraft with gas-turbine engines was associated in a number of cases, with more frequent flights and briefer preflight rest periods. There may be cumulative fatigue, partial decline of some mental functions, slower visual perception and change in other physiological functions involved in maintaining the proper level of human fitness and productivity of mental processes as a result of intensive flight work.

When determining the probable link between erroneous action by a crew member and fatigue, as well as diminished efficiency in flight, the physician of the detachment or expert physician in flight safety must obtain exhaustive information about the following: flying time over the last 3 months (monthly); duration of preflight rest period, conditions thereof and sleeping time; flying time and total work time on the day of the accident; flying time and number of landings over the last 3 days; time of arrival at airport prior to flight; time spent on traveling from home to work.

The following serve as the chief sources of information on the flight work schedule:

1. Flight book [log?] showing the monthly flight load.

2. Flight assignments, which record the time of take-off and landing, duration of each flight, number of trips, total work load for the preceding day if there were trip flights.

3. Chart of flights, which is prepared by the chief of staff of the detachment for each month. But it must be borne in mind that the flight work schedule is not always followed, so that information based on flight missions for the preceding month that are in the planning department is more accurate.

It is imperative to take into consideration the time of day, during which the flight was made. Night flights, particularly when they involve a change in time zone and long-term trips, are associated with greater fatigue than day flights. A significant change in time zone (up to 7 h) affects the quality of preflight rest, and renders it poorer, while sleep is not as deep.

6. Analysis of Link Between Pilot Error and Professional Training

Analysis of flight accidents over a period of many years revealed that there was some connection between errors and professional experience, particularly experience as an aircraft captain. In some cases, erroneous action was observed among aircraft captains who had been away from flight work for a time, i.e., in cases of deconditioning and loss of piloting skills.

The records of an investigation usually indicates that there is a link between the flight accident and inadequate pilot training. Recommendations for preventive measures include the necessity of advancing professional knowhow of the aircraft captain who was to blame for a flight accident, which is an indirect indication of inadequate experience in cases when this is not directly stated.

It must be noted that the link between a flight accident and professional skill, i.e., inadequate piloting techniques, is established by the commanders of flight units or pilot specialists. The detachment physician is not competent to settle such questions. However, he needs to have certain information about flight training, the process of learning to fly and quality of performance by a crew member who was to blame for a flight accident.

It is important to determine when a crew member was transferred to new equipment, if there was such a transfer. There may be a link between pilot error and negative transfer of old skills to new equipment.

7. Formulation of Conclusion Concerning the Causes of Erroneous Action and Measures to Prevent Analogous Instances

Analysis of the records of investigation of flight accidents related to the personal [human] factor revealed that, in each specific case, more than one causative factors are found, which together caused the accident or damage to the aircraft. Aside from personality-related causes depending on crew members, the emergency situation is usually related to external aggravating factors: more difficult meteorological conditions, infractions referable to flight control, insufficient

information aboard the aircraft concerning its position in relation to the landing strip, landing signals, etc. For this reason, the physician must note in his conclusion these external circumstances that contributed to or caused pilot error. There must also be a list of probable causes related to health status (if such a link has been established), flight work schedule, individual psychological personality distinctions of the pilot, i.e., the negative traits and inconsistencies of mental functions (attention, memory and others), to which they are related.

Determination is made of the prime causes among the established causative factors and, accordingly, preventive measures are offered. They may be directed at improving rest conditions, diet of flight personnel, introduction of more modern methods of detecting early stages of diseases, implementation of a set of health-improving measures both during flight work and time off, if a link has been established between the error and physical condition, age-related changes in physiological functions of the pilot who made the error.

It is necessary to intensify control of work load when flaws have been demonstrated in the pilot's work and rest schedule prior to the accident, which made it potentially possible for him to be overtired and less efficient.

The range of fluctuation of the main parameters of physiological functions during training is determined through simulator tests, i.e., determination must be made of the "price" of work operations under ordinary and difficult flight conditions on the simulator.

In cases where the violations were committed by young pilots on light aircraft operating away from the main bases, it is imperative to elaborate a set of measures, including effective monitoring of working and living conditions, duration of work with toxic chemicals or other materials that have an adverse effect on the body. In addition, specialized training before referral to independent work is needed for a certain category of young pilots.

If personality traits that are unfavorable for the flying profession or negative individual psychological traits are detected as the probable causes of violations and related flight accidents, it is necessary to work out a set of preventive measures, which include in addition to educational work, training of mental functions important to flight work, such as attention span, speed of switching and distributing attention, increased reaction speed, sensitivity of visual function, including improvement of night vision by means of diet and vitamins.

A critical attitude toward evaluation of professional skill by the pilot himself can be achieved by being more exacting in routine flight tests, which preclude exaggerated appraisals, and testing pilot performance under more difficult flying conditions. It is imperative to recommend more difficult sets of training flights on the simulator for experienced pilots, which require broad distribution of attention and emotional stability.

8. Records and Accountability Referable to Investigation of Causes of Error and Prevention Thereof

The primary data from an investigation of flight crew errors are entered on medical charts (Appendix 1) for the purpose of keeping a record thereof and accumulating such data; the charts are for each crew member who permitted the error.

This permits systematic detection of causes and circumstances of errors related to the personal factor and elaboration of preventive measures to be implemented directly in each aviation unit, with due consideration of the specific conditions of the base and flight work.

It is desirable to report the summarized data to the ...SU [first letter illegible, SU--special administration?] on the attached forms (Appendices 2, 3, 4) in order to detect the most typical and recurring causes of pilot error, as well as to use more effective preventive measures on the scale of the civil aviation.

Appendix 1.

MEDICAL CHART

K/k [aircraft captain
Type of aircraft
Date of accident

No	Questions		Answers
	1		2
1.	Designation, brief description of conditions and causes of accident with indication of guilty party		
2.	Birth dates of all crew members K/k		Copilot: Navigator: Engineer: Radio operator:
3.	Total flying time, flying time on indicated type of aircraft as aircraft captain K/k		Copilot: Navigator: Engineer: Radio operator:
4.	Health status of crew member who made error	Date and conclusion of last VLEK	
		Restrictions	
		Chronic diseases	
		Visual acuity, both eyes	
		Refraction, night vision	
		Hearing, both ears	
		Bad habits (smoking, etc.)	
5.	Work and rest regimen	Logged hours in 3 months preceding accident	
		Preflight rest time	
		Logged hours and landings on day of accident	
		Logged hours and landings on day before accident	
		Time work stopped on day before accident	
		Adverse effect of flight factors on day of accident	
		Living conditions(underline)	Separate apartment, room in communal apartment, ...[illegible]
		Time of arrival at airport before flight	

Appendix 1, continued.

	1	2
6. Professional performance	Types of aircraft worked with	
	Date of last rating	
	Date of last rating for minimum weather	
	Rating for theoretical(numerator) and flight(denominator)training: a) upon graduation from flying school b) upon graduation from last advanced flying school (UTO [expansion unknown]	
	Overall rating at last flight check	
	Prior flight accidents and pre-conditions (at fault of crew member), causes	
	Rating of performance under difficult flying conditions (underline)	Actions are: accurate, prompt, delayed, do not conform entirely with situation
	Date this crew was formed	
7. Individual psychological personality traits	Attitude toward flight work (underline)	Desire to fly: strong, moderate, mild
	Commanding skills (underline)	Good, moderate, poor
	Positive traits Underline: 2 traits well-marked 1 " moderately intermittent " mildly	1) volitional; 2) sense of personal responsibility; 3) discipline; 4) truthfulness; 5) principled; 6) self-criticism; 7) purposefulness; 8) independence of thought in action; 9) ability to concentrate, distribute and switch attention; 10) stability; 11) gregariousness; neatness, and other (write in):
	Underline any existing negative personality traits	1) excessive self-confidence; 2) hasty decisions; 3) uncritical attitude toward own mistakes; 4) stubbornness; 5) quick temper; 6) inadequate initiative and ability to overcome difficulties; 7) individualism, desire to be in the limelight and other (write in):
	Existence of conflict situations (at work or home) before starting this trip	

Note: Lines 2 and 3 are filled in for all crew members and the rest for the one who committed the error or infraction. The base material is: Flight booklet, flight file [log?], flight assignment, medical booklet, outpatient chart. Line 7 is filled out together with the squadron commander.

Date.....

Unit physician.....

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Appendix 2. PRECONDITIONS FOR FLIGHT ACCIDENTS

No	Nature of precondition	Number of cases: aircraft with gas-turbine engine	Number of cases: aircraft with propeller engine	Of these, cases of worsening of crew member's well-being
1	Flight in sick condition			
2	Flight after violation of preflight regimen for: work and rest; diet; intake of alcohol			
3	Effect of flight factors and poor hygienic conditions: Effect of altitude, decompression; Extraneous impurities in air atmosphere; Adverse temperature conditions; Noise of vibration, accelerations			
4	Illusions in flight			
5	Flying without preflight medical check			
6	Others			

Appendix 3. DATA ABOUT ERRORS OF FLIGHT CREW EXAMINED BY MEDICAL SERVICE

No	Surname, name, patronymic, job (crew member)	Type of aircraft	Brief circumstances of error conditions and consequences	Nature of error	Recommendations and steps taken by the medical service

Appendix 4. MEASURES TO PREVENT FLIGHT ACCIDENTS AND PRECONDITIONS

No	Measures	Number of cases: pilot	crew member	flight attendant
1	Grounding pilots (crew members) at preflight examination: in morbid state; violation of regimen: work and rest; diet [or mealtime]; intake of alcohol			
	Total grounded			
2	Eliminated flaws in flight training and support, which have adverse effect on physical or mental status of flight personnel: unsatisfactory conditions for rest; excessive flight work load; mental trauma, conflict situations; other flaws			
	Total flaws eliminated			
3	Flaws detected in conditions at the work place, clothing, protective gear, use of oxygen, ambient temperature, exceeding flight factor levels, etc.			

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PSYCHOLOGY OF COGNITION DISCUSSED AT THE TWENTY-SECOND INTERNATIONAL PSYCHOLOGICAL CONGRESS

Moscow VOPROSY PSIKHOLOGII in Russian No 2, Mar-Apr 81 pp 176-178

[Article by N. I. Chuprikova, Moscow]

[Text] There were about 15 symposiums, more than 20 special topic meetings and 9 lectures dealing with problems of psychology of cognition at the recent psychological congress. As a whole, the submitted data offered virtually a complete panorama of the main directions of research, achievements and prospects for the immediate future in this branch of psychological science.

In the lecture of Prof F. Kliks, president, he outlined the main evolutionary line of development of processes of cognition and learning in the animal kingdom and some of the important elements characterizing development of congition in the anthropogenetic process with the transition from animals to man. He singled out four basic processes inherent in man's cognitive activity (sensory abstraction, combination and connection of elements, consolidation of information, shortening the chains of mental operations). These processes make it possible to simplify complex problems, render them solvable, and they constitute the basis for increasing man's intellectual capacities. The text of the lecture of F. Kliks was published in PSIKHOLOGICHESKIY ZHURNAL (No 6, 1980).

Four lectures dealt with the role of cognition in regulation of man's behavior and activity. They were delivered by D. Derner (FRG)--"Cognitive Processes and Organization of Activity," V. Heker (GDR)--"Regulation of Activity: Structures of Mental Representation Controlling Behavioral Acts Determined by the Problem," T. Iritani (Japan)--"Role of Cognition and Communication in the Process of Exchange of Opinions," Ya. Reykovskiy (Poland)--"Cognitive Space and Regulation of Social Behavior." The lecture of B. F. Lomov (USSR), "Levels of Anticipation in the Structure of Man's Activity," was related to the same cycle, to some degree. The lectures of H. Ukert (FRG) and J. Hoffman (GDR) dealt with basic problems of the highest levels of human cognition.

H. Simon, one of the prominent specialists in the field of cognitive processes, delivered a lecture on the objectives and tasks of psychology of cognition. His lecture explained the hierarchic structure of cognitive processes, which consists of three levels: neurophysiological processes, elementary informative processes and complex cognitive processes. Simon referred to the last level problem solving, comprehension of language, formation of concepts and education. The author mentioned, among the most important advances of recent years, development of theory

of adaptive systems, development of computer programs making use of semantic information, and development of theory of discoveries, which made it possible to reproduce a number of outstanding discoveries in the history of physics and chemistry. In his opinion, in the next few years such problems as the mechanisms of various types of learning, understanding natural language and the process of discovery of scientific laws should undergo the most intensive development.

Let us now discuss the symposiums dealing with problems of psychology of cognition. What many of them had in common was the fact that they concentrated in some way or other on problems of complex cognitive structures formed in the process of learning, which are the basis of processing current sensory and verbal information.

The symposium entitled "Multidimensional Scaling and Individual Differences" (organized by T. Indov, Japan) dealt with discussion of the problem of forms and metrics of multidimensional scales, which is being worked on intensively in modern psychophysics. This symposium focused on the question of the correct structural and mathematical expression of the wide spectrum of individual differences in evaluating the degree of similarity or difference between complex stimulus objects that have many features. In this regard, there was discussion of the means and algorithms of expressing individual data, as well as the question of the number and nature of parameters used by different people to assess the degree of similarity or difference between the same complex objects.

In most of the papers delivered at the symposium entitled "Psychophysical Evaluations and Perceptual Classification" (organized by H. Geisler, GDR), there was validation of the need for in-depth investigation of perceptual representation of complex object stimuli and mechanisms of adequately developed processes of decision making occurring in these structures and serving to identify and determine the degree of resemblance or difference thereof. The second direction covered in a paper at this symposium was related to theoretical and experimental substantiation of the diversified dependence of the structure and dynamics of sensory perceptive processes on the nature of problems being solved by man.

The symposium on "Multiple Coding and Stages of Information Processing" (organized by I. Taiwing, Canada) dealt essentially with various aspects of coding complex visual objects and their representation in memory. An effort was made to superimpose this representation on the structure of ascending sensory systems of the brain. Several papers offered substantiation of the fact that object coding could vary on the level of short-term and long-term memory, and that the real representation of an object depends on the nature of man's cognitive activity in relation to that object. Some papers discussed also questions of representation of concepts, nonverbal and verbal codes, i.e., issues that were the special topic of another symposium also--"Cognition and Memory" (organized by F. Kliks, GDR). This symposium concentrated on two interrelated problems. The first was the nature of representation of concepts in man's long-term memory. There was discussion of problems of storage of different concepts, including their graphic and abstract components, and the correlations between these different representations in the overall structure of long-term memory. The second problem was the correlation between experimental data and theoretical models. There was discussion of the two main directions of modeling long-term memory--stationary and deductive models. There was also discussion of the role of schematization and the role of the memory systems in comprehension of speech. The last of these issues was the subject of comprehensive discussion as well at a special symposium, "Sources of Understanding Speech" (organized by A. Flores D'Arcais, Netherlands).

It spoke about the information that is necessary and actually used to understand speech and how expressly this information is processed. Several sources of such information were singled out: visual and audio verbal signals forming a statement, knowledge about the meanings of words stored in long-term memory, knowledge about the intentions of the speaker or writer, signals from the entire context of the communication situation. As for information processes, there was discussion of whether one can single out different levels of processing of information in phrase form, does this processing occur simultaneously or successively, does it proceed from top to bottom or bottom to top. Most papers recognized the fact that recognition of words and relation thereof to specific meanings in long-term memory is the basis of the fundamental process of understanding a statement. At the same time, it was stressed that the main complexity of this process lies in the fact that both recognition of words and retrieval of their meaning depend on the semantic and syntactic structure of the entire statement. Several papers submitted experimental data on the effect of the context factor on comprehension, the role of knowledge about the topic of the statement, effect of speed of making the statement on processing of relevant information and fixing thereof in memory.

A special symposium, entitled "Concept of Information in Psychology" (organized by I. Mitternekker, Austria), was held in view of the wide use of the term, "information," in modern cognitive psychology. Theoretical papers delivered at this symposium indicated that the term, "information," has virtually ceased to be used in psychology in the last few years in the sense attributed to it by Shannon, and that it is used exclusively to refer to complex processes and functions pertaining to processing of sensory and verbal signals. At the same time, the concept of information is becoming the cardinal basic concept of psychological science dealing with the process of assimilating and exchanging knowledge, unlike all other sciences dealing with processes of exchange of energy. At this symposium, there was also discussion of processing of semantic information in cognitive processes of man and the role of man's activity to counteract the growth of entropy.

There was a special symposium on "Interindividual Differences in Cognitive Processes" (organized by G. Klaus, GDR). It dealt with theoretical and methodological problems of sources and methods of detecting individual differences in cognitive processes and, in particular, differences in intelligence. There was discussion of cognitive styles and strategies, individual differences in semantic networks and processes of active attention as an element of cognitive activity. In addition, the relation of the nature of cognitive processes and mental development of individuals to the nature of the culture in which they are reared was the topic of discussion in several papers delivered at the symposium on "Intercultural Differences--Theory and Methods" (organized by G. Yakhoda, Great Britain).

The symposium entitled "Cognitive Processes and Eye Movements"(organized by P. Fraisse, France) dealt with an important methodological issue. There was comprehensive and in-depth discussion of the question of information about structure and dynamics of the cognitive process, which can be obtained on the basis of analysis of eye movements. Experimental data were submitted indicating that eye movements are controlled by various cognitive factors, that one can differentiate between processes related to solving arithmetic problems and spatial orientation problems on the basis of differences in eye movements. At the same time, it was noted that eye movements have their own dynamics, and for this reason there is no unequivocal conformity between patterns of eye movements and cognitive processes, in the structure of which they occur.

The symposium, "Cognition and Communication" (organized by B. F. Lomov, USSR) dealt with a pressing topic of modern psychology. It was stressed there that communication should be viewed as an inseparable element of man's cognitive functions, that there are profound internal links between psychology of cognition and social psychology. The contents of the papers delivered at this symposium were concerned with the following main problems: 1) distinctions of cognitive processes during communication; 2) perception, memory and decision making during communication; 3) communication and mental development. There was another symposium that was closely linked with this one in its contents, entitled "Decision Making Processes in Groups" (organized by H. Brandstetter, Austria).

A special symposium dealt with the psychology of creativity (organized by G. Davis, United States). It dealt with the problem of typical features of the creative personality and psychodiagnostics of creative capacities and creative potential, as well as the intimate psychological nature of creative processes and distinctions of their occurrence (role of conclusions by analogy, distinctions of advancing and checking hypotheses, etc.). New tests were offered to determine creative abilities, particularly in children and young people. There were reports on methods of studying complex processes of "spontaneous [natural] cognition," which involve laboratory experiments, where 10 or more hours may be required to solve some problem, on the one hand, and which are based on thorough examination of notebooks, outlines [abstracts], rough drafts of thinkers and scientists who have made an appreciable contribution to the development of science, on the other hand.

There was rather broad representation at this congress of studies dealing with the diverse correlations between cognitive and other mental processes in man. The following symposiums dealt with these topics: "Cognitive Psychology and Goal-Oriented Training" (organized by R. Glaser, United States), "Role of Cognition in Development of Emotions and Motivations" (organized by A. V. Zaporozhets, USSR), "Cognitive and Motivational Aspects of Goal-Oriented Actions" (organized by V. Hekker, GDR). There was a special symposium to deal with the link between psychology of cognitive processes and work in the field of artificial intelligence (organized by G. Howe, Great Britain).

Special topic meetings of the same or similar names were directly connected with and constituted a continuation of virtually all of the above-listed symposiums. Among the topical meetings that were less related to the contents of the symposiums, we shall mention the following: "Structure and Comprehension of Literary Texts," "Text Comprehension and Learning," "Reading and Communication," "Imagination and Perception Processes," "Reproduction and Recognition," "Memory for Faces," "Problem Solving," "Social Aspects of Perception and Cognition."

In spite of the diversity of topics, many problems of psychology of cognition that were discussed at this congress concentrate more or less on the same central problem of storing knowledge in man's long-term memory. Evidently, this is a problem of structure and principles of organization of long-term memory, which began to be studied in psychology comprehensively about 10 years, and which is now acquiring increasing importance. The papers reported many new experimental facts and voiced many original views, some of which shed utterly new light on many aspects of this problem.

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26TH CPSU CONGRESS AND TASKS FOR PSYCHOLOGICAL SCIENCE

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[Article by Academician Aleksey Aleksandrovich Bodalev, doctor of psychological sciences, secretary of the Department of Psychology and Age-Related Physiology at the USSR Academy of Pedagogic Sciences and professor at Moscow State University]

[Text] The documents that were approved at the 26th Congress of the Communist Party of the Soviet Union summarized the labor achievements of the Soviet people under the 10th Five-Year Plan and elaborated the plans for advancement in the immediate and more distant future. This congress discussed and evaluated achievements referable to construction of the material and technical base of communism, continued development of socialistic public relations, shaping the new man and, at the same time, it defined and approved the program for economic and social development of the USSR under the 11th Five-Year Plan and for the 1980's as a wbole, which provides for constant elevation of the material and cultural standard of living, creation of optimum conditions for comprehensive development of the personality on the basis of continued increase in effectiveness of all social production, an increase in productivity of labor, growth of social and labor activities of Soviet people.

There was in-depth and comprehensive evaluation in the congress documents of the results of the work done by Soviet scientists in the past five-year period, as well as vivid reflection of the problems, to the solution of which Soviet science must subordinate its work under the 11th Five-Year Plan.

This congress, having commented on the importance of theoretical and applied developments of Soviet scientists for the purpose of more efficient use of natural resources in the national economy and, at the same time, to preserve the environment, refine the technology and augment industrial and agricultural production, to improve organization and management of all areas of life of Soviet society, continued improvement of the entire system of public education and culture, organization of the entire life style of Soviet people and to strengthen their physical condition, spelled out the routes for further increasing the role of science in creating the material and technical base of communism and solving social problems that are important to our nation.

During the past 5-year period, scientists representing Soviet psychology participated actively and beneficially in the work on many of the problems important to our country. To provide scientific elucidation of these problems it was necessary to call upon representatives of other disciplines, with consideration of their field, who investigated the patterns and mechanisms that determine man's life and deeds,

and which have a direct influence on all his social characteristics. The results obtained from these studies, in addition to their general scientific significance, constituted another step toward understanding, from the standpoint of psychology, the substance of the problems of shaping the most important features of man which characterize him as an individual, comprehensive development as a personality, problems of improving the process of educating and training him, preparing him for creative labor and augmenting the fruit of such labor in different branches of the national economy, and safeguarding the health of Soviet man.

There is also a broader range of closely interrelated problems, the solution of which is important in order to reach the goals set for the people by the party, which were formulated in the documents of the congress for all social sciences and, in particular, psychology under the next five-year plan.

The nation has now headed on the course of wise and economical use of natural, material and manpower resources, continued increase in productivity of labor. Under such conditions, psychologists must increase the volume and improve the quality of the scientific work they are doing, which is directed toward determination of the psychophysiological and psychological factors that affect the efficiency of work processes. From the vantage point of their discipline, they must participate, much more actively than before, in determining the means of improving organization of production, designing and developing technology that conforms best to man's abilities, alleviates his labor and preserves his health. They must continue, just as extensively the research begun in the preceding 5-year period related to the need to develop robot technology: in-depth investigation of the function of sensory and perceptual systems of animals and their behavior in connection with the design of robots with elements of artificial intelligence; they must intensify research on the "eye-hand," "ear-hand" and other functional systems, followed by utilization of their findings in developing the different types of manipulators needed by the national economy. It is also imperative to activate the search for optimum modes of interaction between man and multilevel controls of the robot type.

In the next 5-year period, it will be equally necessary for psychologists to work, who formulate the specifications for a man's features when he is to be hired for a specific type of work, who would furnish exact criteria and effective methods for professional screening, propose refined psychological and psychophysiological instrumentation that would permit exact determination of the condition of a man engaged in work.

The documents of the 26th CPSU Congress spell out the conditions that are capable of increasing the productivity of labor, strengthening creatively the active attitude toward labor, and they stress the need for improving the effectiveness of the system of material and moral incentives, intensifying the stimulating role of wages.

Psychologists must also participate in this concrete problem, which was discussed at the congress of our party. Without losing any time, it is important to plan well at the present time and to deploy on a much broader scale than under the last 5-year plan the investigation of motivation and need aspects of people engaged in different types of work, as well as to discern changes in their value orientation related to age, sex, marital status, distinctions of work groups of which they become members. Determination must be made of the nature of social

factors that inspire the greatest increase in work activity, that affect their creative mood and form their general position in life.

Speaking of steps aimed at improving the working conditions for the Soviet people, the Congress documents noted the importance of creating a moral and psychological climate that would be instrumental in developing a communistic attitude toward work, arouse a desire for creativity, for strengthening work discipline in the group, fighting for its honor and treasuring it in each industrial group--plant, shop, kolkhoz and sovkhoz.

Thus, in the area of group problems, psychological science is also faced with a broad field of action: to study vigorously and extensively the mechanisms of influences of the group on the personality, its motivation, mood, deeds and its behavior as a whole, then objectivize it for practitioners, by systematically shedding light on the patterns of formation of a socialistic group.

The decisions of the congress orient all groups of enterprises and institutions, their party, komsomol and trade-union organizations toward forming a high degree of social and labor activity in each member, toward transformation of the socialist competition into an effective tool for inspiring and securing such activities.

Wide opportunities are being offered to psychologists, when they become involved in solving this problem also, for both research and formulation of recommendations to practical workers, which will permit organization and deployment of competition in groups and between groups, with due consideration of their sociopsychological characteristics.

In the documents of the 26th Congress of the Communist Party of the Soviet Union, much space is devoted to questions of further refinement of management of the national economy, enlarging the role of planning as the central element of management, implementation of the task of blending centralized management with economic independence and initiative of enterprises in the interests of the cause, problems of increasing the importance of worker groups in management, improving the style and methods of management on the basis of Leninist principles of management.

In the last 5-year period, psychologists participated in an interesting and useful way in the comprehensive development, from the vantage point of their discipline, of conditions to optimize the operation of the management mechanism in different elements of our society, to prevent decline of its effectiveness.

Under the new 5-year plan, one should continue to develop, both in depth and breadth, this important area of psychological science. In addition to development of its methodology and theory, there must be active and purposeful work on development of methods needed for demonstration and evaluation of phenomena and patterns within the competence of psychology of management, analysis of psychological factors instrumental in improving the effectiveness of management, making management decisions and implementing them; in collaboration with sociologists, economists and pedagogues, they should define the criteria for screening and placement of management personnel, develop psychologically validated methodological manuals aimed at advancing the qualifications of workers in the management field.

In defining the main directions of economic and social development of our country in 1981-1985 and up to 1990, the 26th Congress devoted much attention to outlining

the means of comprehensive and harmonious development of the personality of Soviet man, continued strengthening and enrichment of the socialistic life style.

In the last 5-year period, Soviet psychologists activated work directed at disclosing the patterns of formation of the communist personality. They traced the role of the system of endeavors, in which the personality is involved, in development of its cognitive, emotional and volitional areas. Following the principle of the complex approach to studies of the personality, they identified the correlations that exist between ideological-political, mental, ethical, work-related, esthetic and physical development of man and, together with pedagogues, they determined the conditions and circumstances that are instrumental in forming an active position in life [or vital position] for each Soviet man, intolerance of flaws and ability to correct them. Soviet psychologists put considerable effort in the preceding 5-year period into development of criteria for development of the personality, as well as into developing the means of determining and predicting its development.

Under the current 5-year plan, the started work must be continued and multiplied in a worthy fashion. There must be development of age-related standards of personality development, clearer determination of the main mechanisms of such development with systematic use of the systems approach, demonstration of interaction of all factors that cause irreversible changes in meaning-related and formal characteristics of the personality and determine the type of its development, as well as the level of such development that it reaches.

Under the 11th Five-Year Plan, special attention must be given to sufficient deployment of studies of the patterns of formation of man's needs, his abilities and tendencies, his temperament, because in the last 5-year period, in spite of their obvious applied implications, such studies were curtailed without justification. While the enormous advances made by our country in preparing new generations for life and work were noted in the approved documents, the party is appealing for further improvement of the system of public education in the current 5-year period, as well as of the system of instruction and upbringing of our country. The party has mentioned the importance of creating conditions for gradual change to educating children in preparatory grades of general education schools starting at the age of 6 years. It also mentions the need to improve vocational training in school and intensification of work pertaining to vocational guidance of young people.

The party has called just as forcefully for improvement of all elements of cadre training, at vocational and technical schools, secondary specialized educational institutions and VUZ's.

Under the 10th Five-Year Plan, psychologists worked vigorously and purposefully on many problems of pedagogic psychology, the importance of which is constantly increasing as the task of building of communism grows increasingly complex. A search was pursued for reserves to develop students by means of psychologically optimum organization of education; innovative use was made of the formative experiment to eliminate excessive loads on students; more attention was given to the system of working with students used by outstanding teachers, so that this too would lead to deeper knowledge about the laws of formation of the mental and ethical aspects of the child, adolescent and youth.

Studies of formation of world outlook in students through the system of all disciplines taught in school also occupied an appreciable place in the work of psychologists. Investigation of specific personality changes that vocational training organized in schools make in its formation was elevated to a higher level. There was a significant number of interesting psychological studies dealing with the distinctions of introducing children in kindergarten into school education, as well as the logic of formation of different traits in the student's personality under the influence of games, socially useful activities, communication organized in a different way, etc.

Studies having promising objectives were begun on problems of psychology of vocational and technical training of young people, instruction thereof in work specialties, psychology of higher education and others.

Evidently, all of the above-mentioned directions of research must be continued under the 11th Five-Year Plan. But, at the same time, taking into consideration the decisions of the 26th Congress, a decisive change must be made in working on all of the main problems of psychology of education. Psychologists must demonstrate all of the complexity of psychological mechanisms of formation of communistic conviction, creative attitude toward work, initiative and independence, both in the process of studying and all other forms of schoolchild activities, students at vocational and technical institutions, tekhnikums and VUZ's. The problem of optimum combination of work training and secondary education of young people attending vocational and technical schools must also be considered by psychologists. Finally, work directed toward establishing the theoretical and methodological foundation of the vocational counseling and vocational guidance service for young people must be pursued on a scale that is consistent with the interests of our cause, and real efforts must be made to create such a service in different parts of our country with the assistance of psychologists.

Considerable significance is attributed in the documents of this Congress to strengthening the Soviet family institution as the most important unit ["cell"] of Soviet society. Under the 10th Five-Year Plan, Soviet psychologists worked on a number of psychological problems of the family, but the scope of this work obviously failed to conform with the demands of the times.

Under the current 5-year plan, this flaw must be actively eliminated, and complex investigation must cover all of the main problems of the modern Soviet family: preparation for family life, inception and preservation of the young family, child upbringing in the home, elimination of intrafamily conflicts, establishment of socially optimum ties between the family and other institutions of society, etc.

The decisions of the recent 26th Congress devoted special attention to steps directed toward prolonging the life and period of gainful employment of people.

The obvious achievements in building the material and technical base of communism, which has established a socialist life style in our society, and the conquests of the Soviet health care system have a beneficial effect on strengthening the health of Soviet people, they lead to prolongation of their life and are instrumental in extending the period of active work.

At the present time, it is important to strengthen these trends, through the planned alliance of practice and science, and to actively work on continued preservation

and strengthening of the health of Soviet people and activation of their fitness for work over a longer period of time. Psychologists must also make their optimum contribution to the solution of this socially significant problem. Some of these problems require the involvement not only of medical psychologists, but specialists in industrial psychology, age-related and pedagogic psychology, specialists in social psychology, psychophysiology, as well as representatives of other branches of psychology.

Thus, the decisions of the 26th Congress of the Communist Party of the Soviet Union put a wide range of new, socially significant tasks not only to the social and natural sciences considered as a whole, but specifically to psychological science.

There is still very very much for psychologists to do to cope with this important social commitment. Deployment of research on the problems formulated in the documents of this congress is only one of the directions of the enormous job that must be done.

As it aims scientists toward solving practical problems, our party constantly teaches us that the utmost results can be obtained only on the basis of working on the fundamental theoretical problems of science. For this reason, the second direction of work of psychologists of utmost importance in the new 5-year period is to advance methodology and theory of psychological science to a new and higher level, as a precondition for success in applied studies.

The deployed research, both theoretical and applied, must be well-planned to reach the required results, scientific resources must be placed with much thought, and the latter also applies to assigning the head scientific teams and co-executor organizations called upon to work on specific scientific problems.

Since, at the present time, the success of many studies of man as an individual, personality, subject and object of activity depends largely on how complex they are, it is important to promptly single out the problems that psychologists can solve only by means of integration of efforts of scientists in allied displines, and to take care of coordinating their work on solving these problems.

Of course, there should also be definition, in good time, of the forms in which it is proposed to "materialize" the results of research, and the means of introducing the obtained results into practice should be worked out just as thoroughly.

The Presidium of the USSR Society of Psychologists, Institute of Psychology of the USSR Academy of Sciences, Institute of General and Pedagogic Psychology of the USSR Academy of Pedagogic Sciences, which dispose of significant numbers of scientific personnel, the pyschology faculties of Moscow State University and Leningrad State University, joining forces, must apparently assume the role of coordinators of all work that is planned in the area of Soviet psychology under the 11th Five-Year Plan.

The 26th CPSU Congress made a comprehensive analysis and summarization of the development of Soviet society, the party and state in the last 5 years; it defined the general line of development of all areas of Soviet life in the coming years. It has formulated the tasks for Soviet science at this new stage of advancement of our society toward communism. Soviet psychologists will make every effort to make a worthy contribution to the solution of these problems, which are important to our society.

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