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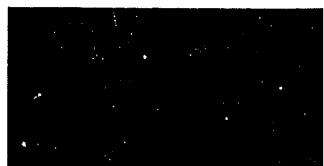
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TRANSLATIONS ON USSR SCIENCE AND TECHNOLOGY  
BIOMEDICAL AND BEHAVIORAL SCIENCES  
(FOUO 6/79)



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PSYCHOLOGY

CHANGES IN SPEECH CHARACTERISTICS IN THE PRESENCE OF EMOTIONAL STRESS

Moscow VOPROSY PSIKHOLOGII in Russian No 6, 1978 pp 76-85

[Article by E. L. Nosenko, Laboratory of Psycholinguistics, Dnepropetrovsk University]

[Text] Against the background of continuous increase in demands made of man by modern industry, the problem of finding the way to diagnose the condition of an operator and to evaluate his reliability while working under complex conditions is acquiring great scientific and practical importance.

The use of the speech channel is particularly valuable for purposes of monitoring man's condition, since it is readily accessible to observation no matter how complex the conditions under which man works.

The method of identifying man's state described in this article is based on comparison of so-called background speech characteristics, i.e., the characteristics that are typical for an individual under ordinary working conditions, to the corresponding speech features in the presence of emotio-genic situations. Such comparison is made for an entire set of quantitative and qualitative indices, the informativeness of which as indicators of changes in the speaker's state was tested experimentally.

It should be noted that only some of the changes in intonational features of the verbal signal associated with a state of emotional stress have been more or less thoroughly investigated and described in the literature [2, 4, 9, 15, 18], and these changes were tracked within the framework of the same words and phrases (isolated from the flow of speech) uttered by the speaker in different states.

As for studies, in which an effort was made to record changes not only in intonation but a number of other characteristics of speech in the presence of emotional tension (temporal, syntactic and others [3, 17], they were based on rather limited experimental material obtained chiefly under laboratory conditions. Emotional tension was artificially stimulated in the speakers (for example, by imposing a time limit on their statement).

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In this investigation, we analyzed an entire set of quantitative and qualitative changes occurring in man's speech with onset of a state of emotional tension, on the basis of diverse verbal material obtained in real emotiogenic situations.

## Methods

A comparative psycholinguistic analysis was made of the speech of 95 subjects (university students, civil aviation traffic controllers, patients admitted to a surgical clinic for serious surgery, servicemen) in emotiogenic and ordinary situations. We used a differentiated approach to selection of emotiogenic situations for each group of subjects, on the basis of the conception we adhere to that an emotiogenic situation does not exist as such, but depends on the value an individual places on his activity and his manifestations under some life situation or other [8]. For example, the situation of an important test (as opposed to a routine laboratory seminar situation) was used for the group secondary school graduates and university students; for the controller group, the situation consisted of performing test assignments, in the presence of an authoritative commission, to determine their professional fitness for work involving receipt and transmission of verbal communications against the background of noise and verbal interference (as opposite to the situation where the subjects perform an exercise series of analogous tests); for the group of surgical patients, the situation involved conversing with the surgeon just prior to the operation, before premedication (as opposed to talking with a patient after successful surgery, on the eve of discharging him from the clinic); for the group of servicemen, the situation involved performance of their professional duties in an atmosphere of increased personal responsibility for their outcome, combined with the factor of a danger of disruption of activity due to possible exogenous intervention. The verbal reports of subjects in this group on the progression of their occupational activities in an emotiogenic situation were compared to the reports on performing analogous activities in a situation when the subject bore considerably less personal responsibility and was informed of the lower probability of disruption of activities.

## Results

We demonstrated statistically significant differences in a number of psychophysiological indices in the above-listed situations, in the same subjects. For example, in the student group (52 people) the differences between a test situation and routine class were substantial, with respect to pulse rate, GSR [galvanic skin reflex], arterial pressure and perspiration of the palms\* according to the criterion of Wilcoxon, with  $\alpha < 0.01$  ( $Z = 5.125$  for pulse, 4.936 for AP [arterial pressure], 2.215 for GSR and 2.877 for

\*A portable Mishchuk apparatus was used to measure perspiration and GSR; a pulsotachometer was used to take the pulse and AP was measured with a sphygmomanometer.

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perspiration). In the group of surgical patients (12 people) the differences in intensity of tremor of the hands\* are also substantial, with  $\alpha < 0.01$  ( $Z = 2.562$ ). In the group of servicemen (19 people), in addition to substantial differences in GSR ( $\alpha < 0.01$ ;  $Z = 2.759$ ), we demonstrated differences in degree of perception of verbal information in an emotiogenic and ordinary situation ( $\alpha < 0.01$ ;  $Z = 3.314$ ). In the controller group (12 people), we recorded substantial differences in quality of performing Burdon's cancellation tests ( $\alpha < 0.01$ ;  $Z = 3.353$ ).

Determination of onset of emotional tension in emotiogenic situations was made on the basis of the above-mentioned differences in the psychophysiological parameters of the subjects, as well as their reports.

A comparative analysis of the speech of the subjects in an ordinary situation and in a state of emotional tension revealed the following:

Speech in a state of emotional stress is characterized by difficulty in formulating thoughts and choosing words to express them, manifested by an increase in number and duration of hesitations, work searching, semantically irrelevant repetitions, "heavy" pauses, searching and descriptive gestures associated with speech. Reduction of diversity of vocabulary is also one of the manifestations of these difficulties. In addition, there are substantial changes in performance of verbal operations that require conscious control. In particular, there is more contrasting than usual manifestation in speech of tendencies toward syncretism in the area of structural syntax (i.e., incomplete morphological formulation of words in a phrase, according to syntactic "obligations") and separation in the area of actual syntax (consisting of the fact that the sequences of words that could be syntactically continuous chains are separated into individual syntagma connected by means of simple apposition). The increase in number of syntactically and logically incomplete phrases, impaired integrity of superphrase [?] entities and an increase in number of uncorrected errors are also indicative of poorer conscious control of the quality of lexical and grammatical formulation of statements in a state of emotional stress.

In the presence of emotional tension, there is activation of spontaneous verbal manifestations; there is a sharp increase in number of ordinary statements, "parasite" words and clichés. These ordinary statements are articulated at a faster rate than in speech occurring in an ordinary state, and this leads to changes in rate of articulation. There is a substantial increase in number of noncommunicative gestures associated with speech, and the speaker is not aware of their appearance. The presence of difficulty in choosing words and formulating thoughts, on the one hand, and activation of spontaneous manifestations, on the other, lead to sharp fluctuations in the overall rate of speech at different segments of the train of speech, and fluctuations in frequency of the fundamental tone are also involved, to some extent.

\*Dynamic tremor was measured with an ADKD-2 instrument (measuring the number of contacts).



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Difficulties in perceiving speech also arise under the influence of emotional stress: diminished fullness and adequacy of perception of verbal information, especially in the presence of interference, and appearance of audioverbal perseveration. We recorded a substantial decrease in fullness of perception of verbal inquiries in a state of emotional stress, as compared to an ordinary state (especially in the presence of noise) among airport controllers (the differences are substantial according to the criterion of Wilcoxon, with  $\alpha < 0.01$ ;  $Z = 2.2290$ ), servicemen ( $\alpha < 0.01$ ;  $Z = 3.314$ ) and students ( $\alpha < 0.01$ ;  $Z = 2.134$ ). In some cases, in the presence of emotional stress, there is simplification of purposeful activity to extract meaning from traces imprinted in sensory memory, such as perception of speech in an ordinary state, to the level of echolalic (perceptive resonance) behavior. For example, the same stimulus phrase, "Leaves fall in the autumn," perceived in the presence of noise is repeated by the same subjects as "Leaves fly in the autumn" in an ordinary state and "Laziness occurs in the autumn" when in a state of emotional stress.\*

The tendency toward simplification is demonstrable in the presence of emotional stress when performing all types of verbal activity. The vocabulary of verbal speech becomes poorer and more stereotypic; verbal associations are "shallower"; hypotheses concerning the meaning of something read are made hastily and inadequately; reproduction of information heard becomes echolalic.

Speech in the presence of emotional tension is characterized by superemphasized actualization of the intent of the statement. It is manifested by the predominant use of words with a distinct positive or negative connotation (such as "very good--absolutely no good") and with semantic absolutism (such as "always--never"). The increased number of emphatic gestures, superlatives, words singled out by logical stress, etc., are also indicative of superemphatic actualization. We recorded the most substantial differences in the index of semantic absolutism [categoricity] when we compared the preoperative and postoperative interviews with surgical patients ( $\alpha < 0.01$ ;  $Z = -3.175$ ).

On the basis of analysis of the above-mentioned distinctions of speech in the presence of emotional stress, we singled out a number of indices that could be submitted to quantitative evaluation, and they can be used for comparative analysis of the speech of the same subjects in different situations for the purpose of identifying their state. Some of these indices are listed below.

#### 1. Mean Size of Speech Segment Uttered Without Hesitations

To measure this index, as well as other temporal characteristics of speech, we developed and now use a portable "speech automatism analyzer," which records the duration of pauses between words, "pure speech" time and number of pauses of any specified duration, in particular the number of hesitations [1]. The mean length of a segment of speech is calculated by dividing

\*Translator's note: the last phrase bears some alphabetical relation to the first, in Russian.

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the time of "pure speech" (or number of words in the statement) by the number of hesitations.\*

According to this parameter, statistically significant differences were demonstrated between the verbal statements of all groups of our subjects in a state of emotional stress and ordinary state. For example, while a hesitation appeared on the average every 1.9 s in the airport controllers in an ordinary state, this interval decreased to 1.4 s in the presence of emotional tension, and this indicated that there was an increase in number of hesitations and, consequently, appearance in speech of difficulty in formulating thoughts and operational choice of words to express them. In the course of the preoperative interview, when surgical patients experienced extreme emotional stress, the hesitations occurred every 3.6 words, whereas during the postoperative interview, the day before their discharge, pauses of this type appeared much less often, on the average every 4.3 words. An analogous trend was also found in the speech of students (mean size of speech segment without pauses constituted 3.7 words in an ordinary state and 3.1 words in a state of emotional stress), as well as servicemen (in whom the mean length of a speech segment decreased from 3.8 words under ordinary conditions to 3.3 words with emotional stress).

## 2. Rate of Articulation\*\*

This refers to the ratio of number of syllables in the statement to the time required to utter them (i.e., "pure" speech time). The most vivid differences in articulation rate can be illustrated by comparing the verbal statements of airport controllers in an ordinary state and in a state of emotional stress. The mean rate of articulation in this group of subjects constituted 8.7 syllables/s in the presence of emotional tension and 6.2 syllables/s in their usual state (the differences are substantial according to Wilcoxon's criterion, with  $\alpha < 0.01$ ;  $Z = 2.230$ ). In some of the subjects in this group, the rate of articulation doubled in the presence of stress, as compared to an ordinary state (from 5 to 10 syllables/s).

## 3. Latency Period of Verbal Reaction

According to the data for the controller group, where this parameter is of particular interest, the mean latency period of the verbal reaction increases from 1.1 s in the ordinary state to 1.9 s in the presence of tension in some controllers, whereas in other subjects it drops from 1.7 s to 1.3 s in the presence of emotional stress, and this reflects the distinctive features of emotional verbal reactions of subjects with the excitatory

\*Like F. Goldman-Eisler [15], we considered pauses lasting 250 ms or more to be hesitations.

\*\*Together with engineers A. A. Chugay and O. N. Karpov [13], we developed a basically new instrumentation method for measuring articulation rate, based on counting the number of alternate noise and tone sounds per unit time of pronounced speech.

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and inhibitory type of emotional tension (please refer to [10] for more details on this score).

4. Range of Fluctuations in Rate of Speech in the Course of a Verbal Statement

This parameter is convenient for quantitative evaluation; it describes two types of changes in different directions, which occur in speech under the influence of stress, namely: onset of difficulties in operational choice of words leading to an increase in number of pauses and slowing of speech, and animation of spontaneous speech activity associated with an increase in rate of speech. The wider the range of fluctuations in speech rate at different segments of the "train" of speech, the greater the probability that the speaker is experiencing emotional stress. According to the data we obtained, the ratio of rate of speech of our subjects averaged for time intervals of 10 s constituted 1:2 and even 1:3 at different times in a state of emotional stress.

5. Duration of interval, after which areas appear in the flow of speech where the frequency of the fundamental tone of voice is higher than the mean, typical frequency for a given speaker.

The mean duration of this interval constitutes 0.53 s in the speech of airport controllers in an ordinary state and it is 0.38 s in the presence of emotional stress.

6. Number of signs of uncertainty (semantically irrelevant repetitions, reformulations, "heavy pauses," incomplete words or phrases) per 100 words: Substantial differences were demonstrated in this parameter between verbal statements in the presence of emotional stress and without it in all groups of subjects, with a high level of significance of differences.

For example, according to the data we obtained, the mean number of signs of uncertainty per 100 words of speech in the statements of patients constituted 8.6 in the presence of emotional stress and 4.8 without it (the differences are substantial according to the criterion of Wilcoxon, with  $\alpha < 0.01$ ;  $Z = 3.002$ ). The number of elements of uncertainty increased by more than 2 times in the speech of servicemen in the presence of emotional stress, as compared to an ordinary state.

7. Coefficient of diversity of speech vocabulary, which characterizes the ratio of different words in statements to total number of words:

In students, for example, this coefficient fluctuates from a mean of 3.7 in an ordinary state to 2.9 in the presence of emotional stress (the differences are substantial, with  $\alpha < 0.01$ ;  $Z = 3.100$ ).

8. Mean number of gestures (per 100 uttered words), associated with speech, in particular searching and noncommunicative gestures:

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There is a substantial increase in number of gestures in the presence of stress, as compared to the ordinary state, in the speech of students in a foreign language, proficiency in which has not reached an adequate level of automatism. For example, while students make an average of up to 6 gestures per 100 words in narrating something they read in a routine class, when so doing in a test situation the number of gestures almost doubles, reaching 11.

9. Mean number of syntactically incomplete phrases in verbal statements: According to our findings, there was a particularly marked increase in number of interrupted phrases in the presence of emotional stress in students and controllers (from 8-9% of the total number of phrases under ordinary conditions to 20-23% in the presence of stress).

10. Mean number of mistakes (slip of the tongue, paraphasia) in speech:\* The number of slips and paraphasias ranged from 1.7 in a normal state to 2.5 per 100 words in the presence of emotional tension in all of the groups. As we have already indicated, there is a sharp increase in number of speech perception errors in the presence of noise and verbal interference, as well as the number of linguistic mistakes made in a foreign language. The latter ranges from 3-6 per 100 words in an ordinary situation to 6-10 in the presence of stress, depending on the proficiency in the foreign language, and the lower the knowledge of the latter, the more mistakes are made when speaking in emotiogenic situations (as compared to speech in an ordinary situation). This serves as convincing experimental confirmation of the fact that the components of activity that require conscious control of quality of expression are particularly affected in the presence of emotional stress (with lack of proficiency in a foreign language a significant part of operations related to lexical and grammatic formulation of states is not automated to an adequate extent and is performed under the control of voluntary attention).

## Discussion

In view of the fact that the quantitative and qualitative changes in speech characteristics in the presence of emotional stress are manifested rather distinctly in all groups of subjects involved in our experimental study, it may be assumed that these changes do not occur by chance, and that they reflect some common patterns of intellectual activity when in a state of emotional stress.

Impaired orientation when performing a complex intellectual activity and appearance of difficulties in reaching the goal of the activity may be considered to be one of these typical patterns. In speech, this is manifested by the following: a) oversimplification of the perception process: instead of meaningful phrases presented for auditory perception in the presence of noise, the subjects perceive a meaningless set of words in the

\*A more comprehensive list of speech characteristics that could be used to identify emotional states is given in the article of A. A. Leont'yev and E. L. Nosenko [7].

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presence of emotional stress, whereas in an ordinary situation the same phrases can be reproduced, though not always exactly, but in the form of meaningful series of words; b) in the form of an increase in logically incomplete phrases in verbal states in a state of stress, as well as impaired integrity of superphrase entities due to surfacing incidental associations; c) in the form of an increase, as compared to a normal situation, in number of inadequate (chance) associations in performing associative tests.

An individual appears to forget the purpose of his activity when in a state of emotional stress. The following finding, which we demonstrated in the course of experimental investigation, can serve as a graphic illustration of this statement: When performing an assignment involving reading of a text with concurrent filling of blanks in it with the required words, our subjects (students) not infrequently read the entire text aloud without inserting any words or even making searching pauses where the blanks occurred in the presence of stress. Such instances were totally absent when reading analogous texts in an ordinary situation.

Aside from forgetting the objectives of activity, the diminished effectiveness of intellectual performance is also manifested by deterioration of situational afferentation, i.e., insufficient consideration of factors that would permit making the decision as to how best to perform the action. In verbal speech, this is reflected in the following: a) in the form of a choice of words that are not suitable within the context, for example, in answer to the question "What figures do you see in picture No 3?" the controller states "On the horiz...\* on horizon number three I see a star, triangle, circle"; b) in the form of impaired dominance of a name within the framework of superphrase entity, for example, to the question "What did you hear as you went to your work place?" the subject answers "Well, it is hard to hear the sounds. They are walking behind me ... I only hear the squeaking of shoes." The pronoun "they" is not dominant here, since the noun it replaces (people, friends) was not used in the prior context.

The fact we established, that of formation of inadequate hypotheses by the subjects when reading partially distorted texts, could serve as a convincing example of inadequate situational afferentation when performing an activity in a state of emotional stress.

Late appearance of the triggering stimulus, which determines when something prompted by motivation and situation should be done, constitutes the further impairment of intellectual activity in the presence of stress. The subjects' efforts to reproduce what they heard on the basis of one or two words taken from the entire phrase, when perceiving speech in a state of emotional stress, are a reflection, in our opinion, of delay in initiation of triggering stimulus.

\*The wrong start "in horiz..." indicates that the speaker apparently considers the choice of this word to be unsatisfactory, but cannot immediately recall the required word.

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One of the typical patterns of organization of intellectual activity in the presence of emotional stress is, as shown by our analysis of speech distinctions of subjects in such a state, the sharp decrease in critical attitude toward one's own behavior. In our opinion, this is attributable to the fact that difficulties arise in the presence of stress in implementing yet another stage of the intellectual act, that of comparing the results of action to the original intent, and this is apparently related to generalized excitation of those parts of the brain that are involved in integration of emotional states [5, 14] and are responsible for implementing normal function of the system of detecting mistakes.

It must be stressed that worsening of conscious control of quality of performance in the presence of stress was manifested simultaneously in our subjects, both in verbal speech and other forms of intellectual activity. For example, in the presence of emotional stress, there was a substantial increase in number of erroneously perceived inquiries and reactions to a so-called false call signal, as compared to an ordinary situation; there was a decline of coefficient of accuracy in working on cancellation tables.

Comparative psycholinguistic analysis of speech distinctions of the same subjects in an ordinary situation and in the presence of emotional stress enabled us to discover one more specific distinction of organization of intellectual activity in the presence of stress, which is related to the uniqueness of motivation of activity in such a state.

Since a state of emotional stress arises as a specific form of reflection by the subject of an inconsistency between his vital needs (motives) and success or possibility of successful performance of corresponding activity, it appears obvious that a subject in such a state strives to have the most radical influence on the behavior of his interlocutor in the direction required for the speaker, to form in his interlocutor the attitude to the subject of conversation that is needed by the speaker. We relate the increase in number of lexical entities with the significance of semantic absolutism, with distinct positive or negative connotation, to expressly this distinctions in motivation of activity in the presence of stress; this also applies to diverse emphatic elements, words singled out by logical stress, as well as emphatic and descriptive gestures.

The distinctions of motivation of activity in the presence of stress also cause a tendency toward alteration of activity, as manifested by excessive acceleration and simplification thereof. In speech, this is also indicated by simplification of structural syntax; the speaker does not "read out" (in the term of A. A. Leont'yev [5]) all of the "grammatical obligations" in the course of his statement, as well as the more stereotypic vocabulary reflecting a tendency toward dimplification of the work retrieval process for adequate expression of thoughts, the intermittent syntactic train as a result of separating the statement into syntagma linked by the apposition method, increase in number of mistakes of concordance of linguistic entities of an anticipatory origin that the speaker does not correct, as compared to speech in an ordinary situation (such as "As compared to 1965 in 1978....") and substantial increase in articulation rate.

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However, expression of the tendency toward faster activity in the presence of emotional stress is inhibited due to deterioration of immediate recall in such a state, which leads to difficulty in choice of words for adequate expression of thoughts and related increase in number of searching pauses, as well as slower speech at some segments of the verbal train.

Evidently, deterioration of immediate recall reflects an impairment of the process of fixing and activating traces of impressions that reach the organism, which is inherent in emotional stress and which is due to changes in the nature of interaction between the cerebral cortex and subcortical structures,\* that occur in the presence of stress. The many auditory and verbal perseverations, which reached 6-10 per 100 words spoken by our subjects, are indicative of disturbances in trace activity of the cortex in the presence of stress.

Conclusion

The results of this investigation indicate that there are substantial changes in many speech characteristics under the influence of emotional stress, as compared to the same speech characteristics in a calm state. The speech characteristics that can be submitted to quantitative evaluation, which are informative from the standpoint of reflecting emotional stress, can be recorded for identification of emotional stress and detection of situations, under the influence of which it appears, as well as to determine which subject of speech induces emotional tension in the speaker.

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\*It may be assumed that attenuation of the inhibitory effect of the cortex on subcortical structures in the presence of stress [5] is related to the phenomenon of activation of spontaneous manifestations in speech (an increase in number of "parasite" words, clichés, habitual statements, non-communicative gestures, etc.).

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PSYCHOLOGY

SIGNAL FREQUENCY IN A PROBABILISTIC ENVIRONMENT AND STRATEGY OF OPERATOR BEHAVIOR

Moscow VOPROSY PSIKHOLOGII in Russian No 6, 1978 pp 120-124

[Article by L. I. Peresleni, Scientific Research Institute of Defectology (study of handicapped children), USSR Academy of Pedagogical Sciences, Moscow]

[Text] The unwaning interest in the study of processes of probabilistic forecasting is attributable to the fact that the methodological procedures used make it possible to come closer to comprehension of the mechanisms of mental phenomena that play a substantial role in cognitive activity. Motor reaction time is the most informative parameter, which permits evaluation of formation of adjustment or readiness for perception of events varying in probability. It has been demonstrated that the reaction time (RT) in response to signals delivered with a high probability is shorter than RT for signals that are less probable [4, 6, 8, 9, 11, 15, 16, 18, 19 and others].

In one of our studies [7], it was found that RT to a signal delivered less often was reliably longer than RT for a frequent signal in children 8-9 years of age, in whom we recorded the motor responses to two vibrotactile stimuli delivered with different probability. The obtained data led us to the conclusion that the process of probabilistic forecasting is already formed in the youngest school children. Moreover, it was demonstrated that there is less distinct development of probabilistic forecasting in mentally retarded children.

A study of age-related dynamics of psychophysical parameters of children, with both normal and retarded intellectual development, revealed a decrease in difference between RT in response to frequent and occasional signals in older school children.

According to the obtained data, we should have demonstrated deterioration of processes of probabilistic forecasting in ontogenesis. However, it is difficult to assume that behavior becomes less adaptive in the course of ontogenetic development. The data in the literature [1, 3, 8 and others] warrant the belief that the observed leveling off of differences in RT with frequent and infrequent signals could be related to another factor, a greater diversity of behavior strategies that appears with accumulation of life

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experiences. To test this hypothesis, we conducted a series of studies with adult subjects, recording RT under the same experimental conditions as were present in the survey of the younger school children.

Methods

The study was conducted with adults 20-35 years of age (11 people). We delivered alternate signals (let us designate one of them as "signal A" and the other as "signal B") through two vibrators, one of which was attached to the left arm and the other, to the symmetrical part of the right.

The subjects were instructed to depress "as quickly as possible and without making mistakes" the left button on the recording device with the left index finger as soon as they felt the vibration signal on the left arm. Upon feeling the signal on the right arm, the subjects were to press the right button with the index finger of the right hand. The fingers were kept over the buttons during the test.

We recorded the RT of choice by means of a modified chronoreflexometer with an accuracy of 1 ms. Preparatory signals were not used. Headphones were used through which white noise was delivered to mask the sounds from the vibrators and external interference.

Two series of experiments were conducted. In the first series, the probability (P) of delivery of each signal was as follows:  $P[A] = 0.5$  and  $P[B] = 0.5$ ; in the second series conducted on another day:  $P[A] = 0.8$  and  $P[B] = 0.2$ . For some subjects, we used  $P[A] = 0.2$  and  $P[B] = 0.8$ . A total of 100 signals were delivered in the first series and 125, in the second. The interval between stimuli constituted about 5 s. There was some brief training prior to the first series.

Results

Table 1 lists the arithmetic mean values of RT (in ms) for the group of adult subjects and, for the purpose of comparison, data are listed for 8-year-old children with normal intellectual development [7].

Table 1. Mean data on RT (ms) in response to alternate signals

Age (years)	Number of subj.	1st series ( $P[A]=P[B]=0.5$ )		2d series ( $P[A]=0.8; P[B]=0.2$ )	
		RT[A]	RT[B]	RT[A]	RT[B]
8-9	13	412	424	346	403
20-35	11	259	261	240	259

In both series, we recorded shorter RT in the adult group for both stimuli, as compared to the school children. The difference between RT[A] and RT[B] in the first series, when equally probable stimuli were delivered, was

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statistically insignificant in both groups. In the second series, the difference between RT for stimuli presented at a different frequency probability constituted 57 ms in children 8-9 years of age and 19 ms in adults, the former difference being statistically reliable ( $p < 0.05$ ) and the latter insignificant ( $p > 0.05$ ).

In view of the fact that adults presented shorter RT, it is expedient to calculate the above difference in relative units (percentage of mean RT for a frequent stimulus). We found that in relative units as well, this difference was less by one-half in adults than in children.

Thus, the differences between mean RT in response to frequent and infrequent stimuli, as recorded under our conditions, level off with age.

It is expedient to pursue analysis in two directions, to demonstrate the causes of this fact: 1) analysis of the program we used for delivery of stimuli; 2) analysis of possible behavioral strategies of the subjects under the specified experimental conditions.

The program for delivery of signals used in the second series of studies was prepared on the basis of the table of random numbers, and it consisted of the following sequence:

AAABAAAAAAAAABBAABAAAAABABAAABAAAAAAAAAAAAAAAABAAABAAAAABBAAAA  
AAAAAAAAAAAAAAAABABAAAAABAAAAAABAAAAAABAAAAAABAAAAAABAAAAA  
BAAAAAB

The main feature of this program was, as we have already indicated above, as follows:  $P[A] = 0.8$ ;  $P[B] = 0.2$ . However, in the sequence in question, one can also single out a feature such as probability (or, more precisely, frequency) of appearance of a certain number of repetitions of the same stimulus. Let us call such appearance of the same signal several times in succession a "block." There may be one to 14 signals per block for signal A, whereas B is never encountered more than twice in succession. In the above sequence, there is a total of 40 blocks of signal A and B (20 of each type of signal).

Table 2 shows the number of blocks consisting of different numbers of A and B signals, as well as the probability of their appearance in the above-indicated sequence (program).

On the basis of the foregoing and tabular numbers, the sequence used is characterized by the following probability correlations:

- (1)  $P[A] > P[B]$ .
- (2)  $\{P[A(3-5)] > P[A(1-2)]\} = \{P[A(6-8)] > P[A(9-14)]\}$ .
- (3)  $P[B(1)] > P[B(2)]$ .

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Table 2. Frequency characteristics of sequence of signals

Signal	Number of signals per block	Number of blocks	Probability (P) of appearance of block in program
A	1 and 2	4	0.1
	3 and 5	10	0.25
	6-8	4	0.1
	9-14	2	0.50
B	1	15	0.37
	2	5	0.13

In the correlations between probabilities given,  $A(j)$  and  $B(j)$  refer to blocks of  $j$  elements of signals A and B,  $j$  having the value of 1, 2, ... 14, according to number of signals in the blocks.

In addition to the above correlations, it is purposeful to consider other distinctions of the program.

In this sequence, there are four types of transitions: from signal A to signal A, which we shall designate as  $\{A \rightarrow A\}$ ; from signal A to signal B-- $\{A \rightarrow B\}$ ; from signal B to signal A-- $\{B \rightarrow A\}$ ; from signal B to signal B-- $\{B \rightarrow B\}$ . In all, there are 124 transitions in the sequence. The arbitrary probability of transitions of the above four types is not the same. Thus, the probability of appearance of B after the third, fourth or fifth A is higher than the arbitrary probability of B after the ninth to fourteenth signal A. Let us refer to the arbitrary probability of B after the third-fifth A as  $P[B/A_{3-5}]$  and the arbitrary probability of B after the ninth-fourteenth A as  $P[B/A_{9-14}]$ . In this program,  $P[B/A_{3-5}] = 0.08$  and  $P[B/A_{9-14}] = 0.02$ . Moreover, of interest are the correlations between arbitrary probabilities of the most informative transitions  $\{B_1 \rightarrow A\}$  and  $\{B_1 \rightarrow B_2\}$ . In the above program,  $P[A/B_1] = 0.11$  and  $P[B_2/B_1] = 0.04$ .

Thus, we can add two more probability correlations to the above three:

$$(4) P[B/A_{3-5}] > P[B/A_{9-14}].$$

$$(5) P[A/B_1] > P[B_2/B_1].$$

While the 2d and 3d correlations of probabilities refer to evaluation of a sequence consisting of blocks of a different number of repeated signals, i.e., attention is focused on the length of a series of A or B signals, the 4th and 5th correlations refer to evaluation of the incidence of transitions from one signal to the other. In the latter cases, the emphasis is on appearance of signal B.

It may be assumed that, if there is a correlation between the subjects' reactions and probability of presentation of alternative signals, according to

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the five probability correlations discussed, analysis of experimental data should demonstrate the five following correlations between the subjects' RT:

a)  $RT[A] < RT[B]$ .

b)  $\{RT[A(3-5)] < RT[A(1-2)]\} = \{RT[A(6-8)] < RT[A(9-14)]\}$ , where  $RT[A(3-5)]$  is the mean RT for the 3d-5th A signal in blocks of 3-5 signals;  $RT[A(1-2)]$  is the mean RT for signal A in blocks of 1 and 2 A signals, etc.

c)  $RT[B(1)] < RT[B(2)]$ .

d)  $RT[B] - RT[A_{3-5}] < RT[B] - RT[A_{9-14}]$ .

e)  $RT[A] - RT[B_1] < RT[B_2] - RT[B_1]$ .

As we have already indicated, in children 8-9 years of age, the arithmetic mean RT for the infrequent signal was significantly ( $p < 0.05$ ) longer than the RT for a frequent signal. At the same time, additional analysis of the experimental material revealed that such correlations between probabilities as (2), (3) and (5), and accordingly TR correlations such as (b), (c) and (e) are not demonstrable. But difference  $RT[B] - RT[A_{3-5}]$  [condition (d)] is smaller than  $RT[B] - RT[A_{9-14}]$ , according to probability correlation (4); however, this difference is not great (statistically unreliable).

Analysis of individual data revealed that correlation (a) applied to 92% of the children, (c) to 15% and (d) to 39%.

In adult subjects, the differences for all five correlations (according to mean values) did not reach reliable levels. However, upon consideration of individual data, we found that correlation (a) applied to 60% of the adult subjects, (b) to 10%, (c) to 60%, (d) to 30% and (e) to 30%. Thus, while children do not take into consideration all probability correlations in signal sequences, over half the adult subjects (60%) considered the 1st and 3d correlation, while one-third of the subjects considered the 4th and 5th, i.e., there was expression of all correlations, but not by all subjects. This indicates that adult subjects make a finer analysis of the probabilistic features of the stimulus sequence.

We examined the characteristics of time parameters of reactions as a function of probability characteristics of sequences of stimuli. However, according to data in the literature, the above-discussed special and general functions, as well as others similar to them, cannot be analyzed apart from the strategy of behavior, which is determined by the instructions that were given and the life experience of the subjects.

The instruction that was given, "answer as quickly as possible and without making mistakes," determines three possible behavior strategies in the subjects: 1) anticipation of frequent signal, which could save reaction time; 2) anticipation of infrequent signal, which could aid in mistake-free reaction; 3) anticipation of both frequent and infrequent signals, which could aid in fulfilling both parts of the instructions.

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It is unquestionable that the choice of the first strategy should aid in reducing RT[A], as compared to RT[B] [correlation (a)].

With the choice of the second strategy, all the other correlations should prevail, but especially (c). Anticipation of infrequent signal B should aid in consideration of the higher frequency of appearance of the unrepeated signal B and infrequent occurrence thereof twice in succession. Such a behavior strategy is based on consideration of probabilistic features of sequences of stimuli; however, being on the alert for the infrequent signal will lead to neutralization of differences between RT in response to frequent and infrequent signals.

The subjects' choice of the third strategy could also result in leveling off of differences between arithmetic mean values of RT[A] and RT[B], although this does not rule out the possibility of fine analysis of stimulus sequences and consideration of some of the above probability correlations, particularly the one in (2). Moreover, the length of a block within the framework of a specified probability of presentation of signals and chosen strategy of behavior may be important to a number of subjects.

All of the foregoing indicates that the use of the instructions, "answer as quickly as possible and without mistakes," and use of a random sequence of signals, such as the one discussed, does not rule out the possibility of expression by the subjects of different strategies of behavior, each of which is related, to some extent or other, to the probability of presentation of the stimuli. The most elementary strategy is the one that makes the subjects ready to react to the frequent signal. Expressly this strategy was selected by the young school children under our experimental conditions. In addition, analysis of individual data revealed that, in the group of adults, this strategy was more often chosen by the younger subjects (19-20 years old). The different behavior strategies selected by adult subjects determined changes in RT in different directions, in response to the frequent and infrequent signals, as a result of which, in turn, there was leveling off of differences between mean group values of RT referable to the frequent and infrequent signals.

In view of the foregoing, the contradictions encountered in literature sources are interesting. Using a randomized sequence, regardless of the probabilistic correlations between alternative signals, there is a repetition of two, three or more identical signals (blocks). First P. Bertelson [13, 14], and later S. Kornblum [17], R. Remington [20], Ye. P. Krinchik, P. D. Mednikarov [4] and others described the "repetition effect," which consisted of shortening of RT in response to a repeated stimulus. At the same time, J. Williams [21] demonstrated the opposite tendency. According to the data submitted in this work, the repetition effect could consist of extension, rather than reduction, of RT. Analogous facts are cited by M. A. Tsiskaridze and V. A. Ivannikov [12]. Both our data and those in the literature warrant the belief that these contractions could be based on the distinctions of interaction between the sequence and number of alternative signals presented,

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and the subject's behavior strategy, which was formed in the course of the experiment.

The consistent changes in RT as a function of correlation between probabilities of delivery of alternative signals and prior experience of the subject, as expressed by the choice of a given behavior strategy, compel us to call attention to the theses of I. M. Feygenberg [10], indicating a link between probabilistic forecasting and memory processes.

From this point of view, of interest are the works [1, 2, 5 and others], in which it was shown that readiness or preadjustment to perception of events occurring with a different probability is formed largely on the basis of prior experience.

Analysis of the accumulated facts leads to the conclusion that the effectiveness of remembering the sequences of current events is determined by the direction and level of preadjustment (or selective adjustment) of the reception systems of the brain. This selective adjustment is, in turn, determined by instructions, which are the code signal (or signal code) that triggers retrieval from memory of the engrams consistent with a given situation. There is "superposition" of traces of prior experience over traces of current events. The operator's strategy of behavior is a reflection of this process.

With increase in importance of the situation to the subject, there is intensification of processes of remembering and retrieving information from memory.

Our results indicate that the experimental set-ups that have become very popular in the study of probabilistic forecasting are of interest for demonstration of distinctions of formation of selective adjustment for perception in ontogenesis.

The choice of an adequate strategy of behavior by the subject, determined by the instructions, and pattern of alternation (or probability) of events, can serve as a diagnostic and even prognostic indicator for differentiating between the norm and mental deficiency.

According to all of the foregoing, the methodological procedures used in experiments dealing with probabilistic forecasting and methods of analyzing experimental data (both quantitative and qualitative) are very important to the study of the significant aspects of mental activity under normal conditions and nature of disturbances therein in the presence of mental defects.

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PSYCHOLOGY

A PORTABLE INSTRUMENT FOR SEPARATE RECORDING OF TONIC AND PHASIC REACTIONS OF ELECTRICAL RESISTANCE OF THE SKIN

Moscow VOPROSY PSIKHOLOGII in Russian No 6, 1978 pp 125-128

[Article by Kh. Yu. Butkevich, Yu. G. Spivak and I. A. Semochkin, Moscow Institute of Railroad Engineers]

[Text] As we know, changes in electrical resistance of the skin (ERS) are manifested in two forms, tonic and phasic. Phasic reactions consist of brief (lasting 1-5 s) decrease in cutaneous resistance by fractions of a percentage point to a few percentage points in relation to the tonic component. These phasic bursts may occur either spontaneously or after delivery of some stimulus. In the latter case, the phasic reaction reflects the emotional significance of the stimulus. Tonic reactions are manifested by slow build-up of skin resistance with development of inhibition and marked reduction of ERS with activation.

Of course, when using electrodes to record ERS, only one signal is present, which is the sum of the tonic and phasic components. A bridge circuit is mainly used to record ERS, and it permits measurement only of the overall change in resistance, without separating it into components [2]. The method of Ye. N. Sokolov, in which an electropotentiometer is used as the measuring instrument [1], does not permit separate recording of ERS components.

In this article, we shall describe an instrument, which we developed, for singling out and recording the tonic and phasic components of ERS.

As we know, ERS can be measured by passing either direct or alternating current through the skin. In most studies, preference is given to alternating current. From the standpoint of technical execution, this is the most convenient method. For this reason, at the first stage of developing the instrument for recording ERS we considered the variant using alternating current.

These studies revealed that there is significant and uniform decrease in resistance in the course of continuous ERS recording for several hours in a subject who was asleep according to encephalographic data.

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According to the latest data on the physiological nature of ERS, one would think that prolonged exposure to alternating current alters the cutaneous receptors in some way, and sensitization thereof is reflected in the ERS level. For this reason, the results are not distorted in the case of taking brief readings using alternating current, whereas in the case of prolonged measurement the tonic component declines regardless of the physiological state. For this reason, we abandoned the use of alternating current and recorded the ERS using direct current.

We selected a current considerably lower than the prethreshold level, not exceeding  $10 \mu\text{A}$ , to be passed through the electrodes. The measuring circuit of the instrument was so built as to have a voltage not exceeding 1 V in the electrodes, which does not lead to polarization phenomena.

We should specially discuss questions related to the electrodes. We know of a wide variety of electrodes and methods of applying them. One generally uses current-conducting paste to record bioelectrical processes, to reduce interelectrode resistance and make a good contact with the skin, or else the space between the electrodes and skin is filled with current-conducting fluid. The requirement of rather low interelectrode resistance is due to the relatively low input resistance (no more than  $1 \text{ M}\Omega$ ) in the recording equipment that is manufactured.

Various artificial methods of lowering interelectrode resistance when measuring ERS distort the actual changes in skin resistance. This occurs the most substantially in long-term experiments, when interelectrode resistance does not remain constant and changes independently of ERS changes, due to changes in properties of the paste or fluid used. For this reason, we believe it necessary to use dry electrodes to record ERS.

In our opinion, the terminal phalanges of the fingers are the most convenient place, from the standpoint of ease of applying electrodes and simplicity of their design. In this case, the electrode consists of a tapered ring with a spring-loaded contact on the inside, with an overall area of at least  $1 \text{ cm}^2$ , which comes in contact with the pad of the terminal phalanx. Such a design provides for good ventilation in the contact zone, which rules out the possibility of reduction of ERS as a result of accumulation of perspiration under the electrodes.

When using electrodes of this type, in our experiments ERS did not exceed  $2.5 \text{ M}\Omega$  with  $0.2 \mu\text{A}$  current in the electrodes. Hence, when using dry electrodes, one must have an equivalent input resistance in the recording instrument of at least several dozen  $\text{M}\Omega$ .

The main specifications for the recording apparatus amount to provisions for a high input equivalent resistance and minimum distortions when separating the ERS signal into the tonic and phasic components.

Optimum separation of the ERS signal into components is related to the problem of reasonable choice of parameters of filters.

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The signals of tonic and phasic components are nonperiodic, their spectra are continuous and, consequently, overlapping. However, in view of the substantially different nature of changes in tonic and phasic components and, consequently, different shape of spectra of these signals, it is possible to make a frequency separation of the ERS signal into components.

The signal of the phasic component can be isolated from the signal of the tonic component by means of an upper-frequency filter (UFF). The UFF cut-off frequency should be determined on the basis of the condition that the tonic component cannot pass through and minimum distortion of the phasic pulse. In order to determine the optimal cut-off frequency, we must know the shape of the signals of both ERS components and define their spectra. On the basis of our experimental studies and data in the literature, the tonic component with ERS build-up can be approximately described by an exponent with time constant  $\tau$ , and the phasic pulse, in a rough approximation, by the "quadratic cosine" function in the range of  $-t/2$  to  $t/2$ , where  $t$  is the duration of the pulse at the base.

It was experimentally established that, with maximum rate of build-up of the tonic component, the value of  $\tau$  does not exceed 180 s, and the maximum duration of the phasic pulse can be considered to equal 5 s.

The equations for the spectra of the tonic and phasic components are:

$$G_T(\omega) = \frac{1}{\tau\omega \sqrt{1/\tau^2 + \omega^2}}, \quad G_P(\omega) = \frac{4\pi^2}{(\tau\omega)^2 4\pi^2 \tau^2 - \omega^2} \text{Sin}^2 \omega t$$

where  $\omega$  is the angular frequency. The curves of these spectra, for  $\tau = 180$  s and  $t = 5$  s, are illustrated in Figure 1.

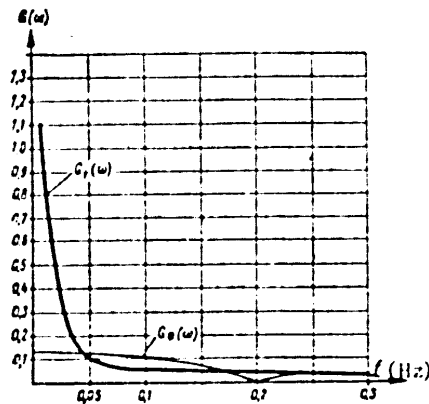


Figure 1. Curves of spectra of tonic  $G_T(\omega)$  and phasic  $G_P(\omega)$  components of ERS

Figure 1 shows that most of the energy of the signal of the tonic component is contained in the frequency range of 0 to 0.05 Hz, while the energy of the phasic pulse lasting 5 s is in the range of 0 to several tenths of a Hz. In view of the above stipulation concerning choice of UFF cut-off frequency, we conclude that the optimum UFF cut-off frequency is in the range of 0.05 Hz.

However, it should be noted that the upper-frequency filter causes relatively little distortion of phasic pulses of less than 5 s. Most of the spectrum of longer lasting

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pulses is in the range of frequencies below 0.05 Hz, i.e., in the range of the spectrum of the tonic component. For this reason, pulses of more than 5 s would be subject to substantial distortion.

As we have stated, the phasic reaction constitutes a few percentage points of the tonic one, i.e., it differs substantially in amplitude. For this reason, the ERS signal picked up by the electrodes (overall ERS signal) can be considered approximately as the signal of the tonic component.

The flowchart of the portable instrument for separate recording of the two ERS components is illustrated in Figure 2.

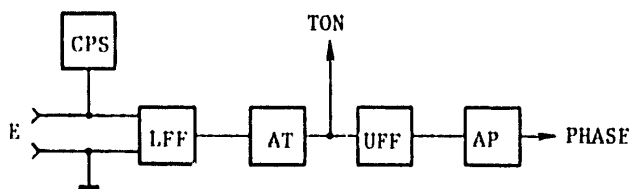


Figure 2. Block diagram of portable instrument for separate recording of tonic and phasic ERS reactions

Conversion of ERS into voltage occurs as follows: A controlled power source (CPS) sets the constant level of direct current through the electrodes (E). In this case, the voltage in the electrodes is proportional to the ERS. To rule out the deterrent influence of bioelectrical potentials of the skin (galvanic skin response, according to Tarkhanov) and polarization of electrodes, we selected 1 V as the maximum voltage in the electrodes.

According to the results of our studies, ERS in the terminal phalanges of the fingers, using dry electrodes in the form of tapered rings with an internal spring-loaded contact adjacent to the finger pad, is in the range of 10 k $\Omega$  to 2.5 M $\Omega$  in different individuals.

The signal from the electrodes passes through the lower-frequency filter (LFF) to the input of amplifier (AT) of the tonic component. The LFF is designed to provide protection against industrial interference. The signal from the output of AT is fed to the TON output terminal, to which one of the channels of the automatic recording device is connected.

Since there are low-amplitude phasic pulses in the overall ERS signal, to isolate them this signal is passed through the UFF then amplified by amplifier (AP) of the phasic component and fed to the PHASES output terminal, to which the other channel of the automatic recording device is connected.

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The ERS recorder is a portable instrument, the general appearance of which is illustrated in Figure 3.

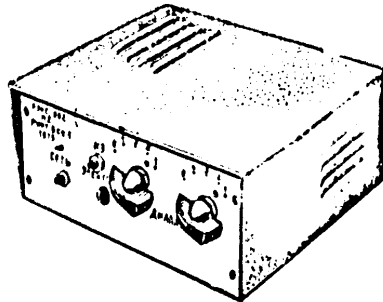


Figure 3.  
Portable instrument for separate recording of tonic and phasic ESR reactions

This instrument is powered by 220 V, 50 Hz alternating current. On the front panel are the following: "line" tumbler [сеть in Figure 3], K3 button to short out the electrodes, "electrode" [электр] outlet and two switches to select the ranges [диапаз] of measurement of tonic and phasic reactions, "ton" and "phase." On the back panel are the "ton" and "phase" terminals to connect an automatic tracing device of any type with input resistance of at least 1 kΩ.

Several specimens of the portable two-channel ERS recorder were built in accordance with the block diagram by the Moscow Institute of Railroad Engineers, and they are now in use. One of them was used in a study, in collaboration with the All-Union Scientific Research Institute of Railroad Engineers, of the problem of continuous automatic monitoring of level of wakefulness on the basis of ERS parameters. Quantitative values of ERS parameters were obtained--relative increment of tonic reaction and interval between two adjacent pulses of the phasic reaction--characterizing different levels of wakefulness.

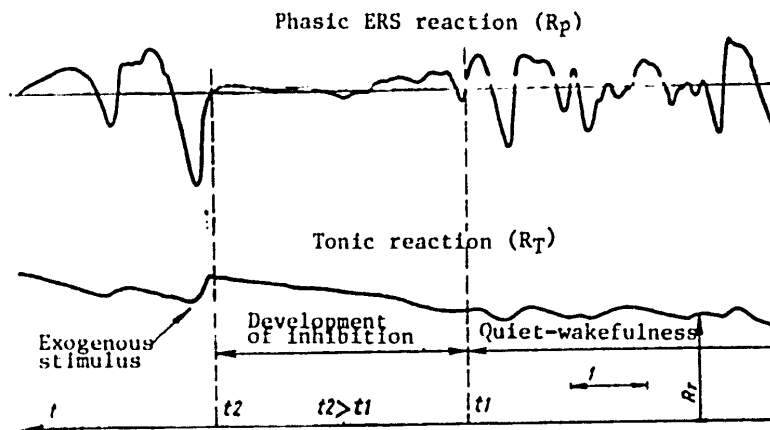


Figure 4. Phasic and tonic ERS reactions

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Figure 4 illustrates typical curves of tonic  $R_T$  and phasic  $R_p$  components recorded in the course of actual work performed by an operator, as an example of the ERS curves obtained with this recorder. The recording was made using two type N-390 automatic tracing devices. As can be seen in this figure, in the time interval of  $t_1, t_2$ , we observe the most vivid tonic reaction with concurrent extinction of the phasic reaction, which is typical of decline in wakefulness level.

On the basis of the data obtained from these studies, several variants were developed of an automatic device for monitoring wakefulness level of an operator, and they differ in set of monitored ERS parameters. In one variant, the relative increment of the tonic reaction is used and in the other, in addition to this relative increment there is also monitoring of the interval between adjacent phasic pulses; in the third variant, only the interval between phasic pulses is monitored. The latter variant, which is technically the simplest, is in the process of being adopted in the railroad transportation system to monitor alertness of locomotive engineers.

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PSYCHOLOGY

APPLIED RESEARCH AT THE UKRAINIAN SCIENTIFIC RESEARCH INSTITUTE OF PSYCHOLOGY

Moscow VOPROSY PSIKHOLOGII in Russian No 6, 1978 pp 178-182

[Article by V. I. Voytko, Kiev]

[Text] In the last few years, the Ukrainian Scientific Research Institute of Psychology has devoted much attention to expansion of the front of applied psychological investigations as it is refining the strategy of scientific research directed toward development of basic and exploratory investigations. The former deals with both the area of education and various areas of industrial and scientific endeavor.

Applied research is being pursued in the following directions: 1) upgrading the educational process in preschool institutions; 2) improving the effectiveness of teaching and educational work with lower, middle and higher grade school children; 3) upgrading the general education and occupational training of students at vocational and technical schools; 4) increasing the effectiveness of professional activity of pedagogues at schools and PTU [vocational and technical schools], as well as instructors of young workers; 5) screening and psychological training of operators of complex systems, computer users, as well as administrators of departments at scientific research institutes.

Specific problems referable to all of the above directions are developing on the basis of theoretical research pursued in the laboratory of methodology of psychological research (laboratory head: Prof V. I. Voytko). We are trying to implement the complex approach to analysis of pressing problems of development and function of the individual at different stages of his life and socialization. With such an approach, it is possible to take into consideration the system of objective and subjective factors that influence the effectiveness of educational and occupational activities of man. The personality and role-related approach to applied research makes it possible to investigate the individual both as an object and subject of cognition, labor and intercourse at the same time. Applied research is directed toward the search for and activation of psychological reserves of the individual (worker, engineer, operator, scientist, administrator, pupil, student, preschool child, etc.).

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As indicated by our experience, such work can develop successfully along two lines of paramount importance: 1) detection and utilization of reserves of the individual (especially young, growing) for optimum participation in the socially useful work process, in the world of modern occupations and specialties; 2) investigation and activation of the reserves for the speediest and best socialization of the individual among other people, developing in him psychological readiness and ability to find himself among those around him, aiding in development of both the individual and the entire group. When studying the individual, psychological profiles are prepared of different people; when studying a group, a sociopsychological portrait is created of work and creative groups.

Socialization of the individual begins already at a preschool age, as the child learns the demands of adults and his peers. Psychological preparation of children for school plays a substantial role in this process, and it includes the following elements: motivational (creating a desire to learn and readiness for a social role as a school child, which is based on proper conceptions of school and future life in school), intellectual (acquiring a certain level of knowledge and ideas about life around the child, forming certain thinking actions and operations), emotional-volitional (readiness to obey rules and ethical standards, capacity for controllable behavior, development of voluntary mental processes: perception, memory, imagination, thinking, etc.). All these elements together provide for the necessary level of active social adaptation of the child to school conditions, in which educational activity is the chief element.

The staff of the laboratory of preschool rearing psychology (laboratory head: V. K. Kotyrlo) have prepared two monographs, on the basis of studies pursued for 4-5 years, and they are intended as a practical aid to parents and teachers in preschool institutions to prepare children for school.\* The monograph by V. K. Kotyrlo, "Development of Will in Preschool Children," was also published in CSSR (1977).

Republic-level seminars convene regularly for instructors at preschool institutions, and they deal with questions of preparing children for school. Some methodological recommendations have been published on how to organize and implement such work in nursery schools.

The staff of the laboratory of psychodiagnostics and formation of the personality of lower-grade school children (laboratory head: Yu. Z. Gil'bukh) worked in 1976-1977 on the study of effectiveness of teaching nonachievers in the 2d grade in special "catch-up" classes. For this purpose, a set of diagnostic test methods was used, which was developed in the laboratory. The results confirmed the hypothesis that instruction in such classes is

\*"Home Preparation of Children for School," Kiev, 1974 (aid for parents);  
"School Starts Tomorrow," Kiev, 1977.

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beneficial and that it would be purposeful to institute individualized instruction classes at the time children are enrolled in school. In 1977, such classes were filled on the basis of data obtained in a psychodiagnostic examination of children. At the present time, the question of how long children should remain in such classes is being considered.

In addition to beneficial changes in mental development of children instructed in individualized teaching classes, there is also formation of a positive attitude toward studying in them, appearance of self-confidence and acquisition of a satisfactory sociopsychological status in the school group. The knowhow gained in conducting such classes merits praise. Studies warrant the statement that this is one of the tested means of increasing the effectiveness of the teaching and educational process in elementary school. In our opinion, the specifics of such classes consist of the fact that maximum use is made of the psychological reserves of young school children and that an individualized approach is practiced.

In the laboratory of teaching psychology (headed by S. D. Maksimenko), studies are directed toward refining control of the learning process. Psychologically substantiated methods have been developed for formulation of school assignments, distinctions of their acceptance and performance by school children; the optimum conditions have been defined for self-control, self-regulation and mutual control [checking]. A search is in progress for educational material that would contribute the most to the mental development of pupils, their practical activities; studies are in progress of the psychological aspects of designing textbooks, which are based on the experimental genetic method of investigation. Due consideration is given to sociopsychological determinants of the educational process in the "pupil-teacher" and "pupil-pupil" systems, which makes it possible to develop a positive attitude toward learning in school children, thereby solving not only educational but teaching problems, as well as permitting formation of psychological readiness for productive labor under socialism.

We include among the sociopsychological determinants of education in the "teacher-pupil" system the sociopsychological state of the pedagogic team, as the social environment that develops examples of intellectual, emotional, work-related, ethical and cultural behavior, and which exerts a constant influence on pupils on all levels of awareness. Accordingly, in the laboratory of social psychology (headed by L. A. Lepikhova), studies are conducted on sociopsychological mechanisms of functioning of pedagogic groups. The personality features of pedagogues, sociopsychological mechanisms of adjustment, interpersonal compatibility, public opinion in schools with different levels of organization are investigated.

Investigation of the effectiveness of the process of socialization of pupils revealed that it depends on the number and content of social roles performed by the individual at the stage of school education. Since the main form of pupil activity in school is educational activity, one must provide for roles in class self-rule that would not only aid in mental development

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of pupils, but would be helpful to the class supervisor with regard to organization of the teaching and educational process. For this purpose, studies have been in progress for several years on the effectiveness of class supervisor helper groups in the upper grades of one of the schools in Kiev. The members of such groups perform the following duties: they participate in regulating the study load (amount of homework), resolving conflict situations among pupils, collecting information about the occupational interests of the pupils, preparing educational and work-related descriptions of each pupil. All these functions are performed in accordance with the instructions of the class supervisor and under his immediate supervision. This work aids in developing organizational [management] skills in students and in developing interest in pedagogic work. It enables the pedagogue to gather information, both about the class group as a whole and individual pupils, which aids in practicing the personal-role-related approach to management of sociopsychological adjustment of students.

Organization of specialized sports classes in some of the general education schools of the Ukraine, in connection with Olympiad-80 [1980 Olympics], is of considerable interest, from the standpoint of increasing the effectiveness of management of the process of organizing pupils. The staff of the institute, which participate in these classes as consultant psychologists, work with the trainers in developing programs for psychophysical development of pupils. The classes in physical culture and sports have the objective not only of stimulating physical development of pupils, but using participation in sports for development of emotional-volitional traits, sociopsychological adjustment and regulation of behavior, preparing pupils in the middle grades for considerable intellectual and work loads, which are expected of them in the higher school grades and when they begin to work.

In the laboratory of psychophysiology (headed by A. M. Karpukhina), studies are pursued of the parameters of various psychophysiological states in man (different levels of mental tension, operator and emotional stress, fatigue, sleep, etc.). New approaches are being developed to solve the problem of monitoring and regulating psychophysiological states of operators. The studies are directed toward development of ergonomic requirements and recommendations referable to psychophysiological states of man in ergatic systems, as well as development of bioengineering systems and complexes directed toward increasing the efficiency of performance, including that of school children in the learning process.

The staff of the laboratory of vocational guidance (headed by B. A. Fedorishin) is holding experimental classes on vocational information in the upper grades of one of the schools in Kiev. A monograph, entitled "Classes on Vocational Information in Upper Grades of Secondary School," was published (1976) on the basis of the accumulated experience. It has been recommended by the Ukrainian Ministry of Education as a textbook in the vocational guidance class, "Fundamentals of Choosing a Profession," (17 hours) in the schools of the Ukraine.

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For several years there has been a vocational counseling center attached to this laboratory. Its purpose is to help students of higher grades in Kiev to choose their future occupation. A vocational counseling center was organized at one of the schools, where methods are being tested for demonstration of occupationally significant traits in the students. The objective of this work is to develop models of a school vocational counseling center for subsequent adoption in this republic's schools. A set of 15 simple and reliable methods has been tested, which are suitable for use by teachers.

A Luch-68 apparatus has been developed at the institute shops by scientists and engineers, and it is used to examine some of the mental qualities of young people for vocational guidance purposes.

By order of the Ukrainian Ministry of Education, the laboratory of vocational training psychology (headed by V. A. Molyako) prepared psychological recommendations for a "Statute on interschool educational and industrial combines." The laboratory staff participates in studying the knowhow of interschool educational and industrial combines and is working out recommendations for deployment thereof in the different oblasts of the Ukraine. Investigation of creative activity of designers, psychological readiness of secondary school students to choose occupations in industry and agriculture occupies a significant place in the work of this laboratory. Problems of scientific control of psychology of individuals through mechanisms of public opinion, consideration of public interests and formation of internal conviction in the individual are prominent in this work. Psychology of vocational teaching and education is closely linked with problems of social psychology. In essence, a new discipline is emerging: industrial social psychology.

The work of the staff of the laboratory of psychology of occupational and technical education (headed by R. A. Ponomareva) is directed toward developing the psychological bases for improving assimilation of technical professions by young people (electricians, all-purpose lathe hands, assembly plant mechanics). Analysis of the professional performance of such workers made it possible to define the main psychological requirements for development of a system of in-class tests, the use of which optimizes vocational training in secondary PTU. At the same time, an experimental study is in progress in several secondary PTU of Kiev to find problems directed toward determining the level of formation of the system of vocational knowledge and skills of students, as well as didactic procedures for introduction thereof. In collaboration with the Ukrainian State Commission for Vocational Screening, regular republic-level seminars are held for PTU workers, which deal with pressing problems of psychology of vocational and technical education.

A "Program of sex education for PTU students and premarital counseling [preparation for married life]" was prepared in the laboratory of educational psychology (headed by M. I. Borishevskiy), on the basis of

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experimental studies conducted in prior years on adolescent psychology (self-awareness, value orientation, ideals, self-regulation of behavior, relations between adolescents of opposite sex). Methodological instructions have been worked out on experimental adoption of this program. A republic-level seminar was held for instructors and teachers of PTU who are presently directly involved in introducing this program in 100 vocational and technical schools of Ukrainian SSR.

Studies of the personality distinctions of school children with behavioral problems are conducted in the laboratory of psychology of difficult adolescents (headed by E. I. Dranishcheva). Significant deviations in the personality structure of such pupils, distinctions of relationships at home and in the peer group at school are investigated on the basis of theoretical analysis and experimental research. Criteria and practical procedures are being developed for defining the type of difficulty, problem area in the structure of the personality and methods of forming positive traits. The monograph, "Theoretical Problems of Preventing Juvenile Crime," was published (1978) in collaboration with the Institute of Government and Law. There is a permanent psychological consultation office at one of the schools in Kiev for pedagogues and parents of difficult adolescents, while periodic consultations for school children and pedagogues are available at several other day and boarding schools. The laboratory staff participates in organizing republic-level seminars for educators who work with difficult children. In particularly difficult cases, forensic psychological expert evaluations are made in criminal cases, at the request of court and investigative agencies, where the suspects or victims are minors.

The laboratory of psychology of personality (headed by G. S. Kostyuk), which investigates the conditions and moving forces of personality development at a young age, devotes much attention to psychological aspects of improving education of higher grade pupils as a social form of controlling their instruction, increasing its role in their development, preparation for work and mastering the chosen profession. On the basis of investigations, recommendations are being prepared on problems of developing satisfactory motivation for learning in higher grade pupils, as well as cognitive interests, desire for independent supplementary learning, application thereof to work and public activities. Attention is given to the need to detect and consider the individual typological distinctions of pupils. These recommendations are described in articles published in pedagogic journals and collections. A monograph dealing with the psychology of early youth is being prepared for publication.

A new approach to construction of the "man-computer" system was developed in collaboration with the Institute of Cybernetics, Ukrainian Academy of Sciences, which is directed toward various categories of nonprofessional users of computer technology.

Development of this system is based on investigation of activity of computer users, planning standard activity, working out a psychologically natural

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programming language (YAOD) as a means of solving problems with computers, development of psychologically substantiated teaching devices (content and methods of teaching) using programmed aids, as well as the software system. As a result, it was possible to reduce drastically the time required to learn to solve problems with computers and, what is the most important factor, to obtain close to standard performance by most subjects. The system is used in automated control systems of several industrial enterprises and educational institutions. Studies are in progress in the laboratory of psychology of training computer users (headed by Ye. I. Mashbits).

In 1973-1977, studies were conducted on psychological problems of tutorship (V. I. Voytko, I. S. Gichan). The main concepts of these investigations served as the basis for the work of the tutor faculty based at the Ukrainian Republic Center for Economic and Scientific-Technological Propaganda, in Kiev.

In 1977, work began in the laboratory of psychology of scientific creativity (headed by V. G. Ivanchenko) on sociopsychological instruction of administrators of scientific departments at scientific research institutes. The psychological and pedagogic implementation of such instruction implies broad use of diagnostic and teaching films [situations], made on the basis of scripts written by psychologists. The method of designing such films and principles involved in working with training films have been worked on at the institute since 1972.

Since 1969, the Ukrainian Republic Medicopedagogic Commission has been based at the laboratory of psychology of mentally retarded children (headed by N. M. Stadnenko). It deals with diagnostically difficult and conflict situations submitted by oblast commissions; it offers consultant, management and methodological assistance to oblast commissions in the area of studying children and placing them in special schools; it organizes measures for advanced training of physicians and pedagogues (members of oblast medicopedagogic commissions); it participates in preparing proposals for development of a network of specialized general education boarding schools and special-purpose preschool institutions in this republic, as well as measures to improve education and teaching for children with mental and physical developmental defects. A set of methods for determination of the level of mental development of lower grade school children (for placement in specialized schools of Ukrainian SSR) was developed, tested and recommended to oblast commissions. The laboratory is involved in preparing the program for auxiliary schools, in particular, an original program for a diagnostic class; methodological letters were prepared for teachers, as well as textbooks for auxiliary schools.

Research dealing with socialization of preschool children with hearing problems is being conducted in the laboratory of psychology of children with impaired hearing (headed by L. S. Lebedeva). As a rule, the hearing-impaired child attends a special school, where instruction lasts 4 years longer than in the usual school. We undertook the task of forming, during

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the period of preschool development, of skill in auditory perception of speech using sound-amplifying equipment, as well as normal speech development in children. We found that it was possible not only to place the child in public school, but to organize intercourse with all of the main socialization agents (parents, peers, mass media, etc.).

The cycle of such classes is conducted on an individual basis with the active participation of the child's parents. It lasts for 1 to 3 years, depending on the extent of hearing and speech disturbances.

An experimental program has been prepared for workers in surdological laboratories and parents, which permits the use of an individualized approach to speech instruction when a child has partial impairment of hearing.

Methods of quantitative evaluation of psychological characteristics of operators of complex systems are being developed in the laboratory of occupational psychodiagnostics; there too, recommendations have been prepared on the design of consoles, information models and work places for operators who have to pick up multichannel, different-level information. An instrument test was developed for identifying and forming a number of psychological traits that are professionally important to operators: distinctions of interaction, short- and long-term memory, operational thinking, emotional equilibrium, etc.

There is a patent department at the institute, whose tasks include methodological assistance to inventors of devices that pertain to specific psychological principles. In 1975-1978, a number of author certificates was issued for inventions, including a driver-training simulator, flight control device, apparatus for psychophysiological research, etc.

In 1978, a specialized laboratory for introduction of psychological achievements in practice (headed by V. L. Muntyan) was created at the institute. It will make it possible to improve applications of psychological achievements in various branches of practice and make this work purposeful and well-organized.

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PUBLICATIONS

USE OF POLYMERS IN SURGERY

Kiev PRIMENENIYE POLIMEROV V KHIRURGII in Russian 1978 signed to press  
23 Dec 76 pp 2, 3-6, 130

[Annotation, introduction and table of contents from book by Tat'yana  
Esperovna Lipatova and Georgiy Aleksandrovich Pkhajadze, Bayjiva Dumka,  
1,500 copies, 130 pages]

[Text] The monograph describes the possible applications of synthetic poly-  
meric materials in medicine as endoprotheses and tissue ad-  
hesives. The polyurethane-based medical adhesive KL-3 used as an example,  
a complex of physicochemical and medicobiological research, which is essential  
for a characterization of alloplastic material, has been described. The  
monograph contains information on the biological destruction mechanism of  
polyurethanes in an animal body and its model media, the mechanism which de-  
termines the approach to the production of polymers applicable in medicine,  
with a predetermined length of stay in animal organisms.

The monograph is intended for specialists who work on the production of  
materials for alloplasty, and also for medical workers engaged in the usage  
of synthetic polymers in surgery.

The application of polymeric materials in surgery is now one of the most  
important trends in the science of polymers. Even though numerous polymeric  
products are used extensively in medicine (various surgical devices, equip-  
ment, vessels, films for the covering of an operative field, dressing mater-  
ials and others), their application in the surgical treatment of human in-  
ternal organs was started relatively recently. This new trend, which was  
called alloplasty, proved to be quite promising. Polymeric alloplastic  
material is frequently more acceptable, in terms of both its influence on  
an organism and its physicomachanical properties, than autoplasty, homo-  
plasty and heteroplasty by biological substances [1].

The development of alloplasty has posed many extremely important problems in  
the areas of: the biology of tissues which are in contact with a polymer, the  
perfection of surgical methods and the creation of biologically compatible

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polymers. Fulfillment of these goals must be achieved through the joint efforts of specialists in high-molecular compounds, in biology and in medicine.

Polymers used now in endoprosthesis belong to different classes of chemical compounds, namely, carbon-chain polymers containing various substitutes in the main (carbon) chain [2], heterochain [3] and heteroorganic polymers [4]. Their structural configuration (Fig. 1) can be linear, branched and cross-linked [5]. It becomes evident that in terms of chemical and macromolecular structure, polymer chemistry offers surgery an unlimited range of polymers which can serve as a base for the manufacture of synthetic materials and objects made of synthetic materials.

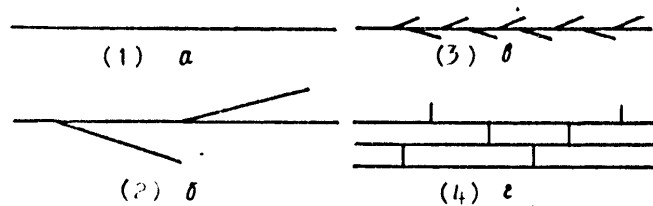


Рис. 1. Схема структуры макромолекул:  
 а — линейная структура; б, в — разветвленная с малым и большим числом ответвлений соответственно; г — сетчатая, пространственная, трехмерная.

Figure 1. Schematic of Macromolecular Structure

Key:

1. Linear structure
- 2,3. Branched structure with small and large number of branches, respectively
4. Cross-linked, spatial, three-dimensional structure

As far as their mechanical properties are concerned, polymers made to work at human body temperatures are categorized as flexible and rigid ones. Flexible polymers are characterized by a greater degree of reversible deformations, and most often they have a cross-linked structure or strong physical links between certain functional groups (for example, some linear polyurethanes, rubbers). Polyamides (kapron, nylon), some polyurethanes, carbon-chain polymers and others can be classified as rigid polymers.

In addition, polymeric material can be monolithic or porous. To a considerable extent, different types of fillers (mineral or organic) make it possible to determine the structure and to change the properties of both types of polymers in a desirable direction.

Polymers of almost all classes, except for those with a blastomogenic effect, have been tried experimentally in endoprosthesis. It is likely that many polymers, after being purified of low-molecular impurities, may turn out to be biologically compatible.

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This monograph does not present all types of polymers, which have been studied in animal experiments, for application in alloplasty, because they often did not provide the information sought. The failures were most often due to the fact that in the process of investigation, attention was paid only to the reaction of the organism or surrounding tissue to the introduced implant, while the chemical structure of the polymer was not taken into consideration. Such experiments do not enable specialists in high-molecular compounds to draw conclusions about the chemical structure of polymers suitable for use in medicine. In our opinion, along with medicobiological investigations, it is vital to conduct a thorough physicochemical study of changes which take place in a polymer when introduced into an animal organism; i.e., the solution to the problem of polymer use in surgery must be comprehensive. It is the only way to develop scientific bases for selecting polymeric materials for endoprostheses.

Considering the problems which are solved in surgery by means of alloplasty, it turned out that endoprostheses can be divided into two groups: those with a temporary effect (for example, prostheses of extrahepatic bile ducts, hollow organs, muscles and aponeuroses) and those with life-long effect (atrioventricular valves, substitutes of the lens and vitreous body of the eye). Endoprostheses must meet different requirements, depending on how long they "serve" in the organism. In the first case, as the biological destruction of the polymeric implant is taking place, it must be replaced by a regenerated tissue and removed from the organism, without causing any harm. In the second case, it is necessary for the alloimplant to preserve the complex of physicochemical and mechanical properties during the whole period of its stay in the organism. Therefore, it is natural that the requirements for the materials used in the manufacture of endoprostheses are different.

As a rule, it is required that the hermetic quality be preserved for an alloimplant of temporary action during its stay in the organism for a certain period of time. This means the destruction of polymeric material must parallel its replacement by connective tissue. Therefore, the time period of the polymer's destruction in the organism must be strictly specified; this necessitates a thorough morphological study. There exist literary data [7] to the effect that even polymers which are considered extremely stable undergo destruction when introduced into an organism. This monograph discusses a possible mechanism of such destruction under the influence of certain cellular systems in the organism. It is probable that almost all synthetic polymers undergo the process of destruction when introduced into the organism, but these processes evolve at different speeds.

In order to use polymeric material successfully in medicine and to specify the area of its application, it is essential to clarify a number of important properties which are discussed in the monograph. One of the important tasks is to investigate the reaction of the surrounding tissue to polymer and to determine the direction of the most important biochemical processes in them. In addition, it is necessary to study the antigenic properties of polymeric material, since it is extremely important if it is used repeatedly.

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The possibility of providing polymers with therapeutic effects represents a completely independent trend. There can be diverse ways of "inoculating" polymers with pharmacologically active substances, depending on the purpose for which the alloimplant is intended.

Along with biological analysis, the monograph demonstrates a need for physico-chemical studied of the polymeric implant itself. The results of such studies should, first and foremost, clarify the degree of stability of the chemical bonds in polymers and the degree of their destruction under the influence of various factors in the organism, and should also identify the products of biological destruction. Therefore, it seems expedient to investigate the influence exerted on a polymer by various media which model the media of the organisms; i.e., extracts of tissues and organs, solutions of enzymes and others.

The problem of studying migration and ways to remove the products of destruction from the organism is closely related to the question of the speed of biological destruction in polymeric materials. Use of polymers with a radioactive label allows for answering this question with a sufficient degree of precision.

The monograph contains data regarding the influence of mechanical loads on a polymer in a model medium. The necessity of conducting experiments of this kind is brought about by the fact that an alloimplant introduced into the organism is subjected to loads of various types which exert a certain influence on its structure.

The behavior of a polymer in the organism is influenced not only by its chemical structure, but by its permolecular structure as well. The latter, in our view, comprises formations consisting of a large number of macromolecules and their segments. The monograph shows that changes in the permolecular structure of amorphous cross-linked polyurethanes are parallel to chemical changes. In linear crystalline polymers, even insignificant variations in their chemical structure result in a change of degree of crystallization [5].

Numerous studies indicate that porous polymeric material is more suitable for implantation into an organism than monolithic material. Apparently, it is first of all stipulated by a larger contact surface of such alloimplants with media and tissues in the organism. Therefore, study of the moistening of polymers, which are intended for endoprosthesis, with model media acquires a particular significance. It is probable that augmentation of the polymer surface in contact with tissues and media of the organism can be achieved by introducing into them harmless (and, possibly, even therapeutic) fillers which eventually will be washed out, thus exposing a greater area of the alloimplant.

This monograph examines in detail two kinds of polymeric materials used in endoprosthesis; i.e., polyurethanes which are destroyed in the organism, and Polyglycol Methacrylates which are intended for life-long stay in the organism and are used as swollen Gels.

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Medical adhesives represent a special kind of alloimplants, because they polymerize (or harden) while in contact with the wound area. Polymerization of a medical adhesive must be fast enough, because the monomers which form it are, as a rule, toxic and therefore should not diffuse in the tissue. The adherent suture is normally formed under conditions of high humidity, therefore it is necessary that the adherent material either force out most of the moisture from the wound surface, or bind the moisture chemically while preserving a sufficient strength of bonding. In other respects, an adherent suture must meet the same requirements as the regular temporary endoprosthesis.

The monograph comprises a comprehensive literary survey which basically covers cyanoacrylate adhesives since they are most common; it examines the mechanism of their destruction in the organism. With the polyurethane adhesive KL-3 synthesized in the Institute of Chemistry of High-Molecular Compounds of UkSSr Academy of Sciences taken as an example, it is shown which particular investigations must be conducted prior to the delineation of the area in which the medical adhesive can be used in surgery. Such investigations will help formulate the criteria of biological compatibility of polymeric materials, recommend ways to regulate the periods of time during which endoprostheses can stay in the organism, and outline further studies in the area of alloplasty.

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PUBLICATIONS

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CURRENT PROBLEMS IN SPACE BIORHYTHMOLOGY

Moscow PROBLEMY KOSMICHESKOY BIOLOGII: AKTUAL'NYYE PROBLEMY KOSMICHESKOY BIORITHMOLOGII in Russian Vol 23, 1977 signed to press 5 May 77 pp 4, 5-6, 311

[Annotation, introduction and table of contents from book by S. I. Stepanova, "Nauka" Publishing House, 1350 copies, 311 pages]

[Annotation]

[Text] This monograph is devoted to the analysis of a number of current problems in space biorhythmology which are part of the general problem of the prophylaxis of desynchronism (disruption of the natural structure of the circadian rhythms) among the members of space flight crews. The author examines basic experimental data on the adaptation of the human organism to phase shifts in the sleepwakefulness cycle and to unusually long periods of daylight. Assuming the constancy of the "information-energy value" of the diurnal cycle, the author develops the problem of establishing the limit of human adaptability to unusually long periods of daylight.

Intended for the use of specialists in space medicine and the planning of work and rest periods during space flight, the monograph may also be useful to physiologists, hygienists and clinicians.

Introduction

Space biorhythmology is a new direction in science which arose at the same time as piloted space flights. It is part of the more general science of biological rhythms, known as biorhythmology or chronobiology\*. Space biorhythmology embraces the principles of the scientific organization of labor and rest in the conditions of space, as based on the principle of rhythm. This approach is determined by an understanding of rhythm as a basic property of living systems.

\*The term "chronobiology" refers, essentially, to the science of life when regarded in the aspect of time. This is a quite broad concept, since a whole series of the departments of biology are concerned with time, notably embryology and the physiology of aging and pathology. "Biorhythmology"

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is narrower in scope, emphasizing precisely the rhythmical side of a given process, or the phenomenon of rhythm. For that reason we prefer to use the term "biorhythmology" whenever the rhythm of vital activity is the subject of research.

The rhythmic alternation of sleep and wakefulness is a necessary condition for maintaining the stability of the human being's physical capability and health not only in space but in any situation whatever. The experience of transmeridional flights shows that disruption of the ordinary succession of sleep and wakefulness has an adverse effect on health and physical capability. The effects of episodic disruptions of this sort do not remain permanently; however, if the disruptions occur frequently, the negative consequences become chronic in the form of serious illnesses.

During space flight the usual succession of sleep and wakefulness is commonly somewhat altered. Most commonly the alterations take the form of shifting the individual's sleep to unaccustomed hours, and of curtailment (less often, increase) of the duration of the diurnal cycle (or migration of the sleep-wakefulness rhythm phase along a 24-hour scale). The negative effect of such regimes in space life is intensified by decay of the primary system of external periodic signals which on earth regulate the rhythmic activity of the organism--namely, systems of time sensors, or synchronizers. Under the conditions of orbital flight at the present time, the succession of light and darkness--one of the main time sensors--is accomplished within a period of 90 minutes (the duration of a single loop). In this situation the rhythm of succession of illumination obviously loses the synchronizing effect which it would have on the human sleep-wakefulness rhythm. Therefore, even simple maintenance of the sleep-wakefulness rhythm, to say nothing of its reformulation, represents a more difficult problem in space than it does on earth.

It is interesting that control of the sleep-wakefulness cycle in human subjects in space was of interest to K. E. Tsiolkovskiy. In his science-fiction tale "Outside the Earth," where he describes a piloted space flight for the very first time in human history (this author believed, by the way, that space flight would first be accomplished in a near-earth orbit), Tsiolkovskiy puts these words into the mouth of one of his heroes: "... our rocket makes a full revolution of the earth in 100 minutes... The solar day is 67 minutes in duration, the night 33 minutes... It is impossible to pay any attention to our night. We don't sleep for half an hour--that's not our custom. I propose 16 hours of activity and 8 hours of sleep--approximately, of course, Each one of us can arrange his own night just by closing the shutters, and similarly, arrange his own day by turning on the electricity" (Source 194, p 60).

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Unfortunately, maintenance of the accustomed order of sleep and wakefulness cannot always be observed in space. Not all specialists concerned with organizing space flights take full account of the negative influence of unaccustomed orders of living on the functional state of our astronauts. In connection with this it has become necessary, using special earthbound experiments simulating the conditions of space flight (simulating, first of all, the separation from terrestrial physical synchronizers), to study the possibility of adapting the human organism to such changes in the life rhythm as are characteristic of modern space flights--that is, adapting it to a rhythm phase shift of sleep-wakefulness and its migration. Close to this problem is the more extensive one of establishing a limit of human adaptability to diurnal periods of unusual length. Equally important is the selection, for space flight purposes, of persons least susceptible to the effects of primary alteration of the physical order of life (that is, persons capable of a quicker and easier adoption of a new sleep-wakefulness rhythm). Finally, the problem of the utilization of free time on space flights occupies an important position in organizing this activity.

Work on problems of space biorhythmology has been conducted at our laboratory for a period of 10 years. The theoretical bases of this work were formulated in 1975 by B. S. Alyakrinskiy in his monograph "Principles of the Scientific Organization of the Work and Rest of Cosmonauts." The present monograph is devoted largely to an analysis of experimental material accumulated by our own laboratory, and also material obtained by Soviet and American cosmonauts, including that from the Salyut and Skylab orbital stations. The results of the present analysis are being used in the preparation of a series of recommendations for the organization of human life in the conditions of space.

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THEORETICAL BASES OF THE PLANNING OF LIFE-SUPPORT SYSTEMS

Moscow PROBLEMY KOSMICHESKOY BIOLOGII: TEORETICHESKIYE OSNOVY PROYEKTIRO-VANIYA SISTEM ZHIZNEOBESPECHENIYA in Russian Vol 36, 1977 signed to press 2 Sep 77 pp 4, 5-10, 256

[Annotation, introduction and table of contents from book by G. I. Morozov, "Nauka" Publishing House, 1250 copies 256 pages]

[Annotation]

[Text] This book deals with the theoretical problems of planning life-support systems from the point of view of systems analysis. The author establishes the concept of a complex of life-support systems and proposes a classification for such complexes. Using the life-support systems of transport and interplanetary spaceships as examples, he examines the structure of these systems along with their interconnections and their ties with other on-board systems. He demonstrates the basic methods in use in the mathematical modeling of life-support systems.

Intended for the use of research workers in life-support system planning, the book may also prove helpful to specialists in space biology.

Tables, 22; illus., 59; biblio., 8 items.

Introduction

As a consequence of the rapid adoption of the achievements of science and technology in literally every sphere of human existence during our times, there will appear perceptible changes both in the conditions of human life and in our ideas of the optimality of those conditions. The development of technology enables man to exert so powerful an influence on the natural environment surrounding him, and even on the biosphere as a whole, that such development will inevitably exert a perceptible influence on the con-

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ditions of human life itself. In view of the present-day possibilities of technology and the ever-increasing tempo of technical progress, we may expect very soon to witness, side by side with the positive changes which are already evident, the appearance of certain other changes which are unfavorable for human society. Every year there is a more evident necessity for the speedy development, on a scientific basis, of measures aimed at the liquidation (or compensation) and prevention of unfavorable consequences of technical progress. The problem of developing such measures has two aspects. One of these consists in utilizing means for limiting the action of technology on nature. A very great deal of attention has recently been devoted to this aspect of the problem, especially in the USSR. In 1972 the USSR Supreme Soviet adopted the resolution "Measures for Future Improvement in the Preservation of Nature and Rational Utilization of Natural Resources."<sup>1</sup> That same year a second resolution was adopted by the CC CPSU and the USSR Council of Ministers: "Intensification of the Preservation of Nature and Improvement in the Utilization of National Resources."<sup>2</sup> These two resolutions prohibit industrial installations from discharging gases into the atmosphere which are harmful to human beings, and from releasing unpurified waters into natural reservoirs; they also prohibit a number of practices which disrupt the equilibrium of nature, and, in particular, alter the conditions of human life.

All these measures are very important; they will no doubt make possible a substantial reduction in the development of unfavorable changes in living conditions. However, not all of the possible consequences of technical progress can be allowed for by the application of legislative methods. No less important is the second aspect of the problem, a second way towards its solution--namely, the planning of technology with due allowance for its minimal effect on the human environment, and, in particular, for the development of technical means to assure environmental parameters comfortable for human beings.

Historically, this problem was first encountered by specialists working on high-altitude aircraft with pressurized cabins; later on it came to the attention of builders of underground installations, submarines and spaceships. At the present time the greatest progress in this area has been realized by piloted spacecraft designers. Extensive scientific-research and design efforts have gone into the creation, by Soviet industry, of special systems usually referred to as "life-support systems"<sup>1</sup>, the main function of which is the maintenance of conditions aboard spaceships which make medical services possible.

<sup>1</sup>"Party Worker's Handbook," No 13, Moscow, Political Literature Publ. House, 1973, p 88.

<sup>2</sup>Ibid., p 119

<sup>1</sup>G. I. Voronin (1973) notes that the published literature on the subject employs more than 15 different nomenclatures to cover these systems.

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Of course, those systems which guarantee the vital functions of astronauts are quite adaptable to the solution of many "terrestrial" problems connected with maintaining environmental conditions favorable for the human being. However, as a result of the complexity and high cost of these systems at the present time, their use is economically justified only for such unique problems as those encountered in human space flight. Moreover, there are no essential limitations on the possible area of application of life-support systems originally developed for use by astronauts. In the future, as these systems are perfected and acquire simpler and more economical designs, they may quite possibly find application in ground use. Therefore, problems in the planning of highly developed life-support systems may well be of interest to specialists outside the field of spacecraft design. Of particular value in this connection is the "closure" principle now being applied in space systems. This principle is simply that vitally necessary substances required by the human body can be manufactured from ordinary human wastes and excretions. The use of this principle in the construction of systems makes possible a sharp curtailment in the demand for oxygen, water, food and other substances needed for human life. As often happens in technological development, the principle was borrowed from nature itself, since both on the scale of individual biogeocoenoses and within the biosphere as a whole, there is continuous circulation of both organic and mineral substances. The presence of this analogy between life-support systems in space and ecological systems<sup>2</sup> offers a basis on which many specialists view the life-support system as a model of the natural ecological system (in the extreme case, a model of the terrestrial biosphere aboard a spacecraft). The earliest researchers studying problems in the conquest of space believed that life-support systems would have to be entirely "closed," and for that reason would have to be based on the use of photosynthesis by plants, the plant excretions playing the same role on piloted spacecraft as the one they play in the terrestrial biosphere. K. E. Tsiolkovski in 1895 wrote of a "space greenhouse" as the basis for a life-support system. However, with the creation of the first spaceships, due allowance for weight limitation, energy requirements and system volumes made it clear that for short-term space flights it would be more economical to use systems either entirely dependent on reserves or utilizing certain physicochemical processes to produce pure drinking water and oxygen from the products of metabolism of the crew. At the present time a majority of design developments in life-support systems are following these two lines.

Extensive research on various possible technological processes in the closure of life-support systems has led to several unexpected results. It appears that there are a great number of technological processes of physicochemical nature which are known to be implementable, but which nevertheless have been very little studied, so that any choice of the ones most adapt-

<sup>2</sup>As Yn. Konechchi maintains (1967), "...the terms 'pressurized cabin' and 'closed ecological system' have been used synonymously in bioastronautics," (p 83).

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able to practical use is difficult. In addition, although the creation of a fully closed life-support system is scarcely even considered any longer, individual biological objects may in principle be used for the partial closure of life-support systems as far as regards water and oxygen (single-cell algae, bacteria, higher plants), while higher plants in the near future may become the only possible producers of food aboard spacecraft.

In such circumstances the most practically acceptable routes for the development of life-support systems are two in number. The first consists in a comprehensive evaluation of the merits and weaknesses of the technological processes being compared, in order to determine the most promising ones and to implement them. The second consists in holding to a single life-support system, or at least to a small number of variants which are closest to practical realization, in order to speed up development. The most logical and justified route appears to be the first, which would enable designers to reject, with complete justification, any variants which were insufficiently promising, even though offering more utility in the near future. The second route would make possible an acceleration of immediate projects, but it would also admit the presence of "blind-alley" decisions offering no continuity with later projects.

The complication of space problems which is expected in the fairly near future will multiply by several times the present requirements on technical capabilities, and will impose more rigid conditions for meeting those requirements. This in turn will raise the probability of nonoptimal or erroneous solutions being adopted on an intuitive basis, with accompanying material and mental loss. It is therefore necessary to develop methods which will assure a selection of solutions not merely on the basis of experience and intuition but also on the basis of objective, quantitative criteria making possible a comparison of different variants of life-support systems and a selection of the optimal ones.

In planning a complex of life-support systems, allowance must be made for a large number of factors affecting the choice of life-support system type (purpose and type of spacecraft, functional life of ship and system, number of crew members, character of ship directory, weight and energy limitations, operational safety, reliability, economic indices, etc.) and for the specific features of life-support systems:

- 1) continuous performance of crew during the entire flight period;
- 2) close functional bond with design of the living quarters of the spaceship and with other on-board systems (heat regulation, power supply);
- 3) complex interconnection between individual elements and subsystems;
- 4) dependence of life-support system characteristics on work routines of the crew;

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- 5) great variety in possible variants of technological processes; and
- 6) presence of contradictory requirements (physiological-hygienic, volume-weight, energy, operational, and so forth).

All these features dictate the necessity of developing specific planning methods for use in creating long-range life-support system complexes-- methods based on the use of systems analysis, and, essentially, on the development of a theory of life-support systems planning.

The use of a systems approach in planning such complex entities as life-support systems makes it possible to embrace an aggregate of such systems as a whole, the interaction of systems, subsystems and more partial elements; and it offers the timely elimination of contradictions between elements, along with full utilization of the advantages arising from the combination of life-support systems into a single whole.

Current publications dealing with research in this area are virtually nonexistent. The majority of works dealing with the planning of life-support systems are devoted to problems in setting up individual system components, to the study of various technological processes supplying the vital requirements of the crew (oxygen, water, food), and to utilization of human wastes.

All of the foregoing impelled the author to write a book which would combine and generalize the basic principles and methods involved in planning life-support systems. Essentially, this book is an attempt to set forth the bases of a theory of life-support system planning, a theory which would facilitate the creation of plans for the most perfected combinations of such systems for every type of piloted spacecraft. The book consists of nine chapters.

In Chapter I are given basic definitions, along with a justification of the approach adopted by the author regarding the composition of life-support systems. The chapter also includes a classification of life-support systems by type of piloted spacecraft.

Chapter II is a summary of published data on the condition of vital activities among astronauts during space flight, both when inside and when outside their ships. The chapter also takes up the magnitude of astronauts' needs for vitally important substances, and their requirements in the elimination of bodily wastes, the latter being given in the form of figures on energy expenditure.

Chapter III is a statement of the bases of systems analysis as applied to the planning of life-support systems.

Chapter IV is a formulation of the main problems in planning theory, with indicated approaches to their solution.

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Chapter V includes an analysis of various criteria for the comparison of life-support systems. Here the author examines the possible forms assumed by weight-energy criteria, and analyzes the special features of a comprehensive evaluation of life-support systems with the help of dimensional and dimensionless coefficients. Two forms of dimensionless complex criteria are given which are capable of the combined reflection of several life-support system parameters at the same time.

Chapter VI is an analysis of various criteria for the comparison of life-support systems. Here it is shown that the solution of this problem, in application to systems of this sort, is impossible with use of a single method. A rational combination of all known methods for the guarantee of reliability, with obligatory allowance for organizational factors arising in the practical development of systems, is required.

Chapter VII is devoted to the problem of the mathematical modeling of life-support systems. It includes a classification of life-support system models, along with references to methods of model compilation and to various problems in the planning and testing of systems.

Chapter VIII contains a survey of the methods of mathematical optimization of the characteristics and content of life-support systems. Two methods are examined in detail: linear programming, which is the most widely used in resolving various planning problems; and dynamic programming, proposed by this author for the solution of problems in optimizing the composition of life-support systems during comparison of variants based on various different principles.

Finally, Chapter IX is a presentation of the principles of optimization of a test program.

In the present work the author takes up only life-support systems for space flight. However, those chapters in which the specific conditions of space flight (weightlessness, for example) are not implied may prove valuable in the planning of analogous systems for ground purposes.

In Chapters I, III and V use has been made of certain materials prepared by the author in collaboration with S. P. Andreyev, A. M. Kononenko, A. S. Mironov and A. B. Sushinskiy.

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