Monitoring of Human Psychophysiological Condition as a Method of Increasing of Activity's Efficiency

Karpoukhina, Aza M.

Academy of Pedagogical Sciences, Kiev, Ukraine. 7220 N. 27th Ave#217, Phoenix, AZ 85051

akarpoukhina@hotmail.com

Kokun, Oleg M.

Academy of Pedagogical Sciences, Kiev, Ukraine

Zeltser, Mark L.

Consultant
117-01 Park Lane South, Apt D3F, Richmond Hill, NY 11418
mark_zeltser@excite.com

Abstract

The accelerating speed of the scientific and technological progress, globalization, and other factors of our age are responsible for permanently growing demands that people encounter in their activities. Therefore, one of the most important applied tasks of the ergonomics is to facilitate the effectiveness of various types of professional activity , while keeping up physical and mental conditions of a person. One of the effective means of doing it is to monitor psycho-physiological conditions in the process of performing normal, long-termed professional activities. The article discusses methodology of the monitoring of the psycho-physiological state (PPS) and its application in studies of PPS of schoolteachers and college students during a school year.

Keywords: Psycho-physiological state, monitoring, system approach, effectiveness of activity.

Introduction

The accelerating rate of the scientific and technological progress, globalization, and other aspects of the modern time exert more and more pressure and demands on human being in different spheres of his activity. In particular, professional learning and training are taking place now under essentially different conditions; new types of activities are emerging ; the flow of information is getting bigger and bigger. Psycho-emotional ,cognitive, and physical loads more and more exceed psycho-physiological capabilities of individuals, leading to stresses and psychosomatic illnesses. Therefore, one of the important tasks of the modern organizational psychology and ergonomics is to deal with the increasing levels of professional activity, while keeping in focus the need to protect physical and psychological health of an individual.

One of the most effective ways to resolve the above problem is by monitoring psycho-physiological state of a person performing certain activity. In this article

we will take a look at theoretical and applied issues of the psycho-physiological monitoring (PPM) of the psycho-physiological state (PPS)

Current view of the PPS

Today it is generally accepted that PPS of man's activities determines to a great extent the effectiveness, quality, and safety of his work, it is also considered as a premise for his professional improvement. Very often, when the psycho-physiological characteristics of an individual do not match with the demands of a performing task, it might become the cause of accidents, breaks of equipment , work-related illnesses , lowered job satisfaction. In such cases PPM can be considered as a good problem identification tool.
Contrary to some previous approaches that had looked at a person's state as a simple set of factors, the concept of PPS , from the inception, have been considered as a systemic approach, based on the functional systems theory [1].
From a system approach, a man's PPS is seen as a dynamic functional system , organized as a multi-level hierarchical structure; all the elements of this structure operate and interact to achieve a necessary results by providing psycho- physiological support of the current motivated activity of a person. The functional system acts as a self-regulatory system with feed-forward and feedback interconnections. From the psychological perspective it includes two levels of regulation - unconscious part and conscious /logical one. It includes also such mechanisms as afferent synthesis, goal-setting, program formation, decision-making, dynamic model of situations and feedback influences [4]. These mechanisms play important role not only in the development of adequate strategies but also in the regulation of operator's functional state.
From psychological perspective PPS can be defined as a complex hierarchical self-regulatory system, that includes dynamic internal components (bio-energetic, physiological, psychological, behavioral, personal, social [5; 6; 9]. The components act and attempt to achieve the set up goals. These goals have been forming under the influence of external social and physical-chemical factors of the environment, that were internalized by an individual.
It can be asserted that the whole formation and functioning of PPS is driven by the pursuit to reach the given goals. This definition of PPS encompasses all the relevant essentials. It adequately reflects the state of an individual as a "system" entity , that is shaping and changing during the activities and under specifics of the conditions of the activity; on the other side, it determines the effectiveness of this activity. This statement is in accordance with the self-regulatory psychological model of activity [2; 3] that allows to look at PPS as a source of force to perform necessary auto-regulatory actions.

The essence and methods of PPS monitoring

PPM is a permanent, long-termed measuring of some PPS parameters to record and project the moments of critical deviations from the optimal zone, with the purpose of an immediate correction [11; 12].
Such monitoring could become one of the key elements in the psycho-physiological regulation of activity. It combines two mutually linked processes - diagnostic and correction - that ought to be tightly coupled. The decision to make a correction and the extent of it is based on the

outcomes of diagnostics, and the methods of diagnostics determine the effectiveness of the correction.

In the process of monitoring it is necessary to take into attention psycho-physiological portrait of an individual and the intensity of various factors, that have an impact of changing PPS.

Here we want to emphasize one more time, that the PPS is a very complex multilevel system, that selectively includes components of various sub-systems that determine individual characteristics of a person; such selection is taking place under the influence of a certain goal of activity.

The monitoring opens additional opportunities to increase the effectiveness of activity, as a continuous tracking allows to individualize activities of a given person, and , on the other side, opens an option to determine with good accuracy the time, type, and extent of a necessary correction. This will create an optimization effect both on the level of criteria describing PPS , as well as on the level that determines the "psycho-physiological cost of activity" criteria. The latter one describes the PPS from the view of the intensity with which we are using available psycho-physiological resources and preserving person's mental and physical health [7; 8].

Often the purpose of monitoring is to estimate PPS conditions of a group of people during a rather long period of their activity. In such cases it doesn't make sense to use complex diagnostic procedures, that need significant expenses for equipment, highly skilled technicians ; the participants also wouldn't like such complex procedures. Practical implementations of PPS monitoring need to create fast track PPS estimation methods (express analysis).

These methods should be simple enough to use not only by professional psychologists, but also by professionals in adjacent fields, i.e. medicine, who can be trained to diagnose and interpret the results.

Such methods should satisfy a number of conditions :

-- they should be of a fast track type, need minimum time to prepare and perform the diagnostic procedure;

-- provide integrated , quantitative PPS data of individuals;

-- provide an acceptable level of accuracy and allow to do projections.

It is assumed that all other requirements of psycho-physiological procedures have to be satisfied as well; that includes following :

-- procedures have to be built on a sound scientific base and measure only parameters relevant to a given type of activity;

-- procedures must be objective and standardized (it does not exclude to use so called subjective procedures);

-- procedures should be specific and oriented to obtain estimates of one or a few factors , that determine success of the professional activity;

--- the results should not be significantly biased by the knowledge acquired by the subjects during the monitoring process [13].

We take a position that the development of such methods of express diagnostics warrant to replace an integrated diagnostic PPS indicator by some other indicators, of a different level, that would carry on indirectly information about PPS and allow to obtain it's estimate quick and easy.

One of the authors [10] had developed two express methods :

-- self-estimates of PPS based on scales;

-- bio-galvanometric control of PPS [11; 12].

Kokun and Karpoukhina developed also procedures to quickly obtain integrated PPS indicators:

-- an express method to estimate an adaptation of teenagers in extreme conditions [7];
-- an express method to diagnose psycho-physiological adaptation of athletes [10].
-- an express method to analyze adaptability of schoolchildren [11].
Optimization procedures (corrections) , based on the results and analysis of the monitoring, can be divided into several groups :
-- psychologically based recommendations (planning of an optimal workload, working schedules, nutrition , time of rest);
-- physiologic-hygienic and physical therapy methods (workouts, massages, self-massages, sauna, endurance exercises , sun baths, water physiotherapy)
-- psychological training (hypnotherapy, suggestive psychotherapy, lectures, seminars, meditation, relaxation technique, psychological auto-training);
-- pharmacological and phyto-therapeutic methods (anti depressants, tranquillizers, psycho stimulators, nootropic memory-stimulating agents , adaptogenic agents, immuno-stimulators, phyto and homeopathic agents);
-- using various health-oriented device methods (ultraviolet radiation, air ionizers, audio-visual effects, relaxing music , special video programs , electrical acupuncture, bio-activational therapy, "laser showers")

Monitoring PPS of schoolteachers

Twenty high school teachers , aged between 22 and 65, from the city of Kiev, had been selected to take part in our studies of the PPM procedures. The study had been taking place for half-a-year. The express PPS diagnostics had been performed once a week over this period. Altogether , we had done 16 sets of studies; some teachers participated in all 16 sets, others in 8 or more sets.
We developed and used two methods of PPS express-diagnostics :
1. self-estimated method based on using a number of scales ,offered to teachers (estimates of well-being, level of vitality, mood, ability to do the regular work demands, health, satisfaction with life, interest in the current job, job satisfaction).
2. bio – galvanometric control of PPS by recording the electrical potential of the skin on the pads of thumbs of both fingers (in millivolts, mV, and microamperes, mcA).
Employing both a "subjective" ,self-evaluation method, and an "objective", hardware method has allowed to get aggregated and reliable PPS estimates during the monitoring . The results of the studies, discussed later, showed correlations between some indicators used in both approaches.
In the first diagnostic procedure , the subjects of the study had been asked to evaluate different work and life-related factors (see table 1). By using non-calibrated scales (with a range from 1 to 100), where 1 means the worst possible estimate and 100 means the best possible value.
In the second procedure we registered the voltage and current that occurs when the pads of thumbs of both fingers came into contact with copper and zinc electrodes [11].
Using the PPS express diagnostics and the preceding dynamics of the PPS , we attempted to optimize the PPS of teachers by identifying the trend and deviations from the optimal PPS values of the individuals. Then we offered recommendations about the worktime and out-of-work activity load, the relationship with co-workers and family members, preventive measures to stay healthy, ways to increase productivity and motivation.

With the goal to correct their PPS, we also used such methods as a bio-activation of the PPS [11]. and self-psycho - correction approach, based on a neuro-linguistic programming technique.
In the Table 1 we summarized the results, collected during the whole period of the monitoring.

Table 1. The results of the express- diagnostic of the PPS of the schoolteachers (number of teachers, n = 20, total number of measures - 233)

SELF-ESTIMATED FACTORS / INDICATORS	MEAN VALUE	STD DEV
Well-being	61.3	17.1
Vitality/ Vigorousness	62.9	19.0
Positive disposition / good mood	70.0	17.7
Stamina / strength in performing the duties of the job	63.6	19.9
Health	60.0	21.4
Satisfaction with life (in general)	59.9	22.7
Interest in work	63.9	21.7
Satisfaction from work	60.8	22.8
Finger skin potential | microamperes |---------- | millivolts	4.9 628.0	1.9 46.3

It was found that some factors have been age-dependent. A valid negative correlation (r = -0.22 ; p <= 0.001) has been found between the age and "satisfaction with life", and positive one (r = 0.16, p <= 0.05) between age and "satisfaction from work".
Significantly greater dependence takes place between the age and the skin potentials in mV (r = - 0.43; p <= 0.001) and mkA (r = - 0.41; p <= 0.01). This coincides with data from Makash [14] about skin potentials decreasing with age.
The most important trade-related factors - interest in work and work satisfaction -- showed a strong coupling with satisfaction with life in general (r = 0.71 and 0.8, P<= 0.001), with strength/stamina to do the job (r = 0.77 and 0.70), with the feeling of well-being (r = 0.67 and r = 0.63), with vitality (r = 0.68 and 0.64), and with health (r = 0.58 and 056), all with the same p <= 0.01.).
Comparatively less link was found with disposition/ mood (r = 0.27 and 0.21).

We also established a valid link between skin potentials and feeling of a well-being (r = 0.15), mood (r = 0.15), and health (r = 0.18) (all with p <= 0.01).
We found an obvious time trend in the PPS dynamics, as from the mid-January all factors began to go down till the spring break. During the spring break and right after it the factors started to rise, then , in April, they were going down again. Some improvement happened after another nine days break. The same dynamics have been recorded with skin potentials; the only difference was that the increase has occurred not during the break, but some time later, on the first week when teachers returned to schools. These fluctuations in the PPS definitely have to be taken into account during the individual corrective actions, as well as in the recommendations provided to the groups.
In the course of analysis we identified two types of adaptive behavior - a labile type and a stable type. Each of them can b TABLE 2.e also divided into three categories - high, medium, and low (see Table 2).

TABLE 2. ADAPTIVE BEHAVIOR OF TEACHERS (n = 20)

Adaptive type	Subtype	n	%
STABLE	High Medium Low	3 4 1	15 20 5
Total of stable type		8	40
LABILE TYPE	High Medium Low	4 5 3	20 25 15
Total of labile type		12	60

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The adaptation type of 'stable' is characterized by relatively stable PPS dynamics along a long period of time. The 'high' subtype of this category shows rather high values of PPS diagnostic factors, with lower values for two other subtypes. The same is true for the labile (unstable) group.
The most beneficial categories are high-stable and medium stable groups. Other categories ,with less favorable kinds of adaptive responses, need more individualized approach in planning work and off-work schedules, and measures to improve PPS with physical exercises to increase endurance. In order to use adequate corrective measures, it is very important to determine the adaptation type of individual teachers, based on their PPS dynamics. In each specific case we need to take into consideration how PPS factors of a person are different from the averaged factors of his age group. It is also necessary to look at their deviations from the values, optimal for this person. As a rule of thumb, the red flag is risen when the PPS factors go down by 20 - 30 % in the self- evaluation studies,

or by 5 – 10 % in the skin potentials measurements. When these data reduces even lower, it becomes critical and signals a significant degradation of PPS ; such situations increase chances of different physical disorders and mental breakdowns. Before it happens, it is imperative to offer certain recommendations and procedures.
A significant reduction of PPS numbers might be caused by some objective causes (i.e. health problems) , as well as by other reasons (due to arguments with a co-workers, superiors, family problems), etc) .
The decline of skin potentials points to problems with a bio-energetic support of PPS, that might reduce the resistence of the body to infections, and the ability to perform professional and other duties.
The character of recommendations depends on a specific case, but the most common advice is to reduce the workload. Our studies showed that among other ways to correct PPS , rather effective were methods of bio-activated PPS correction (Kokun, 2004) and self-psychological correction (Grimak, 1999). The first method has been tested on 14 teachers , who were doing it 30 – 60 min, once or twice a day, during one or two weeks. After one week 10 teachers have increased their skin potential by 20 - 45 mV (M = 28.2 ; std dev = 12.3; $p <= 0.05$) and by 0.5 - 4.5 mcA (M =2.3, std dev = 0.55; $p <= 0.05$). Other four people showed the same improvement after two weeks. The new level stayed at least one or two weeks. Sixteen teachers agreed to use the second method, developed on the ideas of psychological neuro-linguistic programming . Twelve of them said that they had been using it regularly or periodically; they said that it had been helping them to relieve the negative stressful effects.

Monitoring PPS of students

We also tested our procedure on a sample of students from The National Academy of Art and Architecture (city of Kiev), Forty four young men and women , aged 19 – 25, have taken part. The studies were taking place during the whole college year, from October to May . The express diagnostic of PPS were made once a week, altogether 24 sets of measurements; some students participated in 12 - 22 sets. This college differs from other colleges by a much greater number of lectures and other academic activities (from 9 am to 5.30 pm five times a week) , which determines a higher workload.
In our studies we used the same methods of express diagnostic : self-evaluation of PPS-related factors and recording of bio-potentials. The same methods of correction (optimization) have also been applied.
As we have discussed before, the trends in the PPS dynamics for a specific group of subjects are very important when we need to decide what corrective actions to choose. This group dynamics allow to determine the variations among individual members of the group.
We found that male students showed in average more higher numbers in the both types of studies than female members. This difference was consistent in 9 out of 10 factors (except satisfaction with life).

TABLE 3. COMPARISON BETWEEN EXPRESS DIAGNOSTIC OF PPS FACTORS BETWEEN MALE AND FEMALE STUDENTS.

Number of female participants - 29, total number of measurements - 462.
Number of male participants - 15, total number of measurements - 220

FACTOR		Sex	n1	n2	Mean	Std. dev.	p ≤
Feeling of well-being		female	29	462	59,3	22,7	0,001
		male	15	220	72,3	22,3	
Vitality/Vigorousness		female	29	462	61,9	22,4	0,001
		male	15	220	69,5	26,2	
Positive disposition/good mood		female	29	462	65,9	21,6	0,001
		male	15	220	72,8	26,6	
Stamina/Strength		female	29	462	60,7	23,2	0,001
		male	15	220	72,2	28,0	
Desire to do something creative		female	29	462	62,8	25,5	0,001
		male	15	220	73,9	25,8	
Satisfaction with life		female	29	462	64,8	24,9	–
		male	15	220	67,6	28,7	
Interest in college studies		female	29	462	63,9	23,5	0,001
		male	15	220	79,3	23,7	
Satisfaction in college studies		female	29	462	57,2	24,2	0,001
		male	15	220	71,6	27,5	
Biopotentials	µA	female	29	462	6,3	3,2	0,001
		male	15	220	9,7	6,4	
	mV	female	29	462	639,4	53,2	0,001
		male	15	220	660,4	48,1	

Relatively higher numbers for male students practically for all factors are in agreement with other data , received from surveys and psychodiagnostics. In particular, females showed more signs of tiredness and fatigue caused by academic studies, they also indicated a higher level of social frustration and personal anxiety ($p <= 0.01 – 0.001$). We assume that a greater interest in education and getting satisfaction from it, found in male students, can be explained by a better adaptation mechanisms of their social-psychological and energy-activity components. On the other side, males more inclined to look at the future profession as a way to earn a bigger income and provide a better support for a family.

Such differences between sexes have been exposed in a bigger number of convincing correlations between classroom achievements and almost all data received from self-evaluations of the male students ($r = 0.17 - 0.28$; $p <= 0.05 - 0.001$) ; it included also a connection between bio-potentials and a number of self-evaluated factors, such as activity level, a sense of feeling well, interest in college studies, aspiration to be creative, having energy and motivation to work hard ($r = 0.17 - 0.28$; $p <= 0.05 – 0.001$).

In case of female students, college academic grades have some, lower correlation only with three factors : activity , motivation to be creative, and a motivation to work hard . (r = 0.12 - 0.22; p <= 0.05 - 0.001).
We can conclude that the male students self-evaluation PPS data reflects in a greater degree their real mental and physical status, and it has a direct link with their academic achievements. These links have a positive influence on each other.
Now we are going to discuss the common trends in the PPS dynamics during the school year. The senses of feeling well, being in a good mood, vitality, motivation to be creative have been showing some increase during the first few weeks of the academic year. Then, for a month or month-and-a-half, they have stabilized, and then showed a decline. The lowest data were recorded two weeks before the winter exams, followed by a rise to the initial level. About the same trend has been observed in the second half of the school year. Male students showed a greater change in factors before the exams period than the females.
The life satisfaction factor has been steadily going down during the first semester (r = - 0.18; p <= 0.001); in the second semester it fluctuated , but , in general, showed some increase (r = 0.16; p <= 0.001).
The interest in college studies and satisfaction from them have been showing a downward trend until two weeks before the exams, then it restored, but did not reach the initial level.
Both bio-potential factors showed a steady decline during the first semester (mcA: r= -0.16, mV: r = - 0.31; p<= 0.001), in the second semester it slowly recovered (mcA : r= 0.29; mV: r = 0.44; p <= 0.001). This trend characterizes seasonal fluctuations of bio-energetical component of PPS, which we considered quite normal. Despite it, this reduction has to be taken into consideration, as it warrants some additional measures to prevent degradation of PPS during winter time.
The analysis of data allowed us to divide all students into two categories based on the character of adaptation - stable and labile types. The distribution by types and subtypes is summarized in Table 4.

Table 4. ADAPTATION TYPES OF STUDENTS

Type of adaptation	Adaptation subtype	females		males		All	
		n	%	n	%	n	%
Stable	Stable-high	4	14	6	40	10	23
	Stable-medium	7	24	3	20	10	23
	Stable-low	3	10	1	7	4	9
Total of a stable type		14	48	10	67	24	55
Labile	Labile-high	6	21	2	13	8	18
	Labile-medium	5	17	3	20	8	18
	Labile-low	4	14	–	–	4	9
Total of labile type		15	52	5	33	20	45

Table 4 shows that male students have more favorable adaptation subtypes than women. As we have not found differences in academic achievements between men and women, the results can be explained by a fact, that

male students achieve the same academic performances by paying relatively less psycho-physiological "price" in the process of education than females.
As we indicated before, people with an unfavorable adaptation responses need individual approach and help in organizing their schedules of studies and rest, and also to improve and stabilize their PPS with physical endurance training.
As in the case of schoolteachers, the method of PPS bio-activation displayed quite good results. All 21 students, who used it (30 – 60 min daily, 1 – 2 times a day during 1 – 2 weeks) , showed an improvement of bio-potential factors by 10 – 80 mV (M = 35.6 ; std dev = 19.6, p <= 0.001) and by 0.9 - 8 mcA (M = 2.54, std dev = 0.74, p <= 0.001).
Majority of the students (17 out of 21) stated that they experienced better ability to work, more energy, and greater well-being feelings (M = 8.7 - 12.1; std dev = 19.4; p<= 0.05 - 0.0.01) . The method of self- psychocorrection also showed positive effects. Out of 36 students, who used it, 31 were using it on a regular basis or periodically. Nineteen students (61 %) reported that it was helping them, and other 12 (39 %) stated that it was very helpful.

Conclusion

The discussed theoretical and methodological principles and examples of PPS monitoring of professional and academic activities show its effectiveness in various ergonomic problems, particularly to increase the effectiveness of activity. These well-tested methods of diagnostic and correction can be successfully applied in different fields of human activity. The authors have information that during last 20 years PPS monitoring have been successfully used in a variety of professions and activities: equipment operators, athletes, college and high school pupils, etc.
We want to stress one more time , that the methodology of the system approach is the most adequate way to interpret the monitoring data and make decisions about necessary corrective measures. As various components of the PPS are interdependent, the formation and dynamics of the PPS of a person is determined both by general factors and peculiarities of this individual. The system approach helps to select for optimization a key element(s) of the PPS system and predict how one or another action would effect other elements and lead to a successful functioning of the whole system.

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