Rationale and Application of Express Algorithms for Mental Health Assessment in Professional Selection and Screening Examinations

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ABSTRACT

The aim of this study was the physiological substantiation of express algorithms for assessing cognitive functions according to the data of clinical, psychological and neurophysiological studies in conditions of time deficit. The integrative indicator SCL-90-R - "general index of severity" has a high statistical significance ($p < 0.05$) in both healthy subjects and neuropsychiatric patients. The effectiveness of the "Mini-Mult" method in conditions of time deficit is determined by the results of the scales of hypochondria, depression, hysteria, paranoia, psychasthenia, schizoid and hypomania ($p < 0.05$). We also used a block of logical techniques. A similar survey for 15–25 min can be used as a standard for assessing neurocognitive status in screening studies of large groups. EEG power indices and spectra in theta, delta and alpha frequency ranges are an effective reflection of mental status.

Keywords: Stressors, Time deficit, Cognitive functions, Activation factors, EEG, Psychological testing

INTRODUCTION

The physiological consequences of psychological stress, as a form of interaction between a person and the environment, depend on a person's perception of their ability to cope with a stressor. Human perception of stress includes the activation of three interconnected biological systems (R-Suradijono, 2017). First, stress is perceived by sensory systems that assess and compare the stressful situation with the current state and previous stressful experience of the body. Second, the brain activates the autonomic nervous system through the sympathetic-adreno-medullary system and triggers the rapid release of catecholamines, norepinephrine and adrenaline. Third, there is a simultaneous activation of the hypothalamus-pituitary-adrenal system, which leads to the release of adrenal glucocorticoids and cortisol in humans (Ushakov et al., 2014; Bogomolov, 2021; Lytaev, 2021a).

Stressors can be divided into the following six types: 1) crises / catastrophes (for example, environmental disaster, terrorist attack), 2) important life events / acute stressors (for example, a broken leg, death in the family), 3) daily troubles / micro-stressors (eg, flat tire), 4) chronic stressors (eg,

ongoing financial stress, ongoing toxic work environment, family problems, divorce, academic pressure, leaving), 5) external stressors (eg air conditioning noise) and 6) organizational stressors (eg toxic leadership) (Jacob et al., 2017).

The curve of human functions shows how increased stress arousal – from eustress to distress – affects performance (Jacob et al., 2017; Pascalis et al., 2017; Masakowski, 2020). When the level of stress during arousal reaches a certain point (fatigue), performance decreases dramatically. It is important to note that the point of fatigue can differ from person to person. As the arousal builds up, no one notices that performance begins to decline and certain symptoms appear, such as exhaustion, health problems (such as headaches and migraines) and, finally, a complete breakdown. Therefore, any definition of stress should include eustress (good stress) as well as distress (bad stress) (Lytaev, 2015, 2021a).

Comparing the information obtained from direct and indirect measures to estimate fluctuations in working capacity represents the greatest methodological challenge (Dietrich et al., 2010; Corr et al., 2012; Ren et al., 2019; Lytaev, 2021b). A person who performs the work perfectly according to the direct indices output might display appreciable fluctuations in the indirect indices. The cost of such behavioral reactions is excessively high and the pattern of information obtained from the measurements may misleadingly suggest a high level of working capacity (Modi et al., 2012; Lytaev et al., 2021).

Taking into account the listed activation factors under stress, the purpose of this study was the physiological substantiation of express algorithms for assessing cognitive functions according to the data of clinical-psychological and neurophysiological studies in conditions of time deficit.

METHODS

For the assessment of cognitive functions, two methodological approaches were applied. The first of them was a complex of psychological testing; the second – EEG with subsequent computer processing of the results. The full range of examination took up to 40 min with the subsequent reduction to 15–25 min. The complex of psychological testing included 6 tests – the questionnaire of the severity of psychopathological symptoms SCL-90-R, the method of clinical and psychological research of the personality structure "Mini-Mult", as well as a block of logical methods: "Isolation of essential features", "Exclusion of unnecessary", "Simple analogies" and "Understanding the figurative meaning of proverbs and metaphors".

Using the described methodological techniques a study for three groups of subjects was performed. Study group I consisted of 102 healthy volunteers (18–35 years old) who underwent psychological testing. For neurophysiological research, study group II was formed, which consisted of 102 healthy subjects (18–60 years old) who underwent a planned psychiatric examination. To compare the data of healthy subjects, group III was formed, which consisted of 20 outpatients of a neuropsychiatric clinic.

Table 1. Test results according to the "Mini-Mult" method.

Scales	Mean ± error of the mean	
	Study group I	Study group III
Lie	41±0.9	45.9±2.4
Hypochondria	55±0.87	58.1±2.3
Depression	46±1.1	65.9±3.0
Hysteria	41±1.0	61.3±2.3
Paranoia	34±1.35	52.0±3.1
Psychasthenia	55±0.90	59.9±2.7
Schizoid	52±1.00	60.9±3.3
Hypomania	43±1.06	51.7±2.7

OUTCOMES

When analyzing the results of clinical and psychological testing of SCL-90-R, scales and indicators were revealed that statistically significantly differed in subjects in the study groups I (conditionally healthy) and III (outpatients). These are the second-order scales SCL-90-R – the general index of severity (mean value in group I – 0.73 ± 0.04; in group III – 1.08 ± 0.12) and the total number of affirmative answers (mean value in group I – 1.46 ± 0.03; in group III – 1.9 ± 0.17).

Statistically reliable results for most scales of the "Mini-Mult" method were obtained (see Table 1).

High results (the level of statistical significance $p < 0.01$ according to the Mann-Whitney and Wold-Walfowitz criteria) were obtained when analyzing the test data using the methods "Excluding unnecessary", "Simple analogies", "Isolation of essential features", "Interpretation figurative meaning of proverbs and metaphors".

Test results "Excluding unnecessary" in the study group III – 5 points in 4 people, 3 or less points in 5 (average value 4.97 ± 0.02); in the study group I – the prevailing mark is 5 points (mean value 3.8 ± 0.02).

According to the "Simple analogies" method in the study group III, the highest score of 23 points is absent, 11 patients scored less than 20 points (mean value 20.7 ± 1.8), in the study group I 23 points prevail (mean value 22.7 ± 0, 06).

Testing "Isolation of essential features" showed the following results. Study group III: more than 15 points 4 people, 13 and less than 7 people (mean value 13.55 ± 0.3); in the study group I – scores of 15-16 points prevail (mean value 15.87 ± 0.04).

According to the methodology "Understanding the figurative meaning of proverbs and metaphors", the following data were obtained: in the study group III – 9 patients scored 7 or less points (mean value 7.55 ± 0.3), in the study group I – the score in 9 points (average value 8.99 ± 0.01).

For the results of psychological testing, a multivariate regression analysis was carried out, which made it possible to clarify the picture of the relationship between the studied methods and scales. It was found that the integrative indicator "general index of severity" of the SCL-90-R test shows a stable
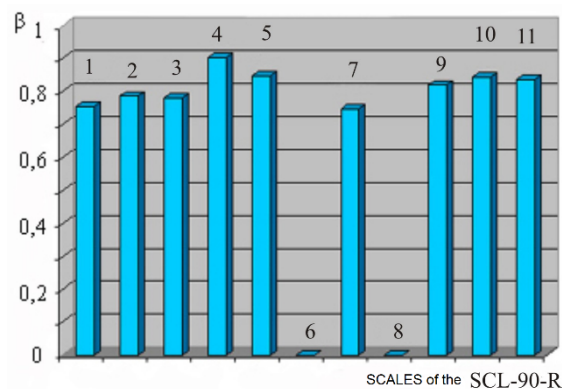
Figure 1: Standard regression coefficients for the SCL-90-R "General Severity Index Scale". Notes: The ordinate is the standard regression coefficients (ß). On the abscissa axis of the scale 1 – somatization, 2 – obsessiveness-compulsiveness, 3 – interpersonal anxiety, 4 – depression, 5 – anxiety, 6 – hostility, 7 – phobias, 8 – paranoia, 9 – psychoticism, 10 – the total number of affirmative answers, 11 – index of present symptomatic distress.

correlation with all thematic scales of this technique. Figure 1 shows a graph of standard regression coefficients (ß) in relation to the dependent feature "general index of severity".

It can be assumed that the integrating role of this indicator in the aggregate analysis of all thematic scales is quite high. The combination of this conclusion with the statistical reliability of the indicator proved above makes it sufficiently representative for judging within the framework of "norm" or "pathology" in conditions of lack of time. A similar correlation between the symptom severity index has been described in a number of other studies.

It has been shown that many scales of the "Mini-Mult" method have a regression dependence on the second-order scale "Index of present symptomatic distress" SCL-90-R, for example, the scale of psychopathy (see Figure 2). The correlation between different scales has been proved, not only within the framework of the same methods, but also between individual indicators of all the tests we used. In particular, the results of the scale of hypochondria "Mini-Mult" correlate with the indicators on the scale of somatization SCL-90-R. The results of the scale of psychasthenia "Mini-Mult" correlate with indicators on the scale of interpersonal anxiety SCL-90-R.

A scatter diagram with regression lines showing a linear regression relationship for the test results using the "Simple analogies" and "Interpretation of the figurative meaning of proverbs and metaphors" (standard regression coefficient is 0.355).

EEG registration and processing. In a neurophysiological study, resting EEG was recorded for a minute in 8 bipolar leads: Fp1 - C3, Fp2 - C4, C3 - O1, C4 - O2, O1 - T3, O2 - T4, T3 - Fp1, T4 - Fp2. Subsequent computer processing of the signal was carried out using the WinEEG software package
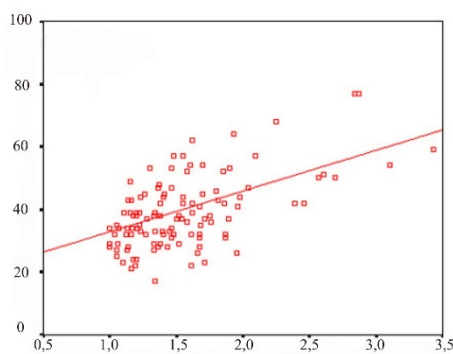
Figure 2: Scatter plot. The ordinate is the psychopathy scale (points); the abscissa is the SCL-90-R symptomatic distress index (points).

Table 2. EEG power spectra in delta and theta ranges.

Sites, 10/20	Delta		Theta	
	Group II	Group III	Group II	Group III
$Fp_1 - C_3$	14.72±0.9	13.45±2.4	10.38±0.5	16.32±2.2
$Fp_2 - C_4$	13.18±0.8	13.80±2.8	10.28±0.6	16.93±2.4
$C_3 - O_1$	7.30±0.6	11.40±2.0	6.16±0.4	17.49±2.9
$C_4 - O_2$	6.60±0.5	11.95±2.1	6.31±0.4	17.63±2.9
$O_1 - T_3$	9.60±1.3	12.60±2.3	6.02±0.4	16.74±2.5
$O_2 - T_4$	7.52±0.5	12.83±1.7	6.12±0.4	17.79±2.8
$T_3 - Fp_1$	14.25±0.9	12.70±2.2	10.46±0.5	18.63±2.7
$T_4 - Fp_2$	13.66±0.8	13.22±1.7	11.17±0.6	18.72±2.3

Note. The mean ± error of the mean.

by calculating the EEG power indices and spectra in 5 frequency ranges (theta, delta, alpha, beta1, beta2).

Attention is drawn to the significant difference in the average results in the theta range, for example, for the C4 - O2 derivation, the average values in the study group II are 6.31 ± 0.4, in the study group III - 17.63 ± 2.9, for the delta range in that In the same assignment, the mean values in the study group II - 6.60 ± 0.5, in the study group III - 11.95 ± 2.1 (see Table 2).

DISCUSSION

The results of this research indicate that the indices and power spectra at the same registration points for the same EEG range, as a rule, are related. In percentage terms (so that the sum of 100% is obtained by adding up the indicators in all ranges), the indices and power spectra reflect the "degree of presence" in the total oscillations of waves of a particular range. Most of the recorded EEG parameters are characterized by a relationship between the indicators in the "adjacent leads", since in a bipolar study the recorded curve reflects the algebraic sum of fluctuations in the electric potential under two electrodes. Thus, one of the two components of the algebraic sum for

each of the pair of "adjacent leads" turns out to be common. In addition, in some cases (this is shown for the delta, beta-1 and beta-2 ranges) there is a regression relationship between "paired electrodes" for identical leads in different hemispheres. We can assume that the delta and beta components of the oscillations are symmetric in the left and right hemisphere.

Among the psychological characteristics of express testing in conditions of shortage of time, the integrative indicator SCL-90-R is important – the general index of severity, as well as the scales of hypochondria, depression, hysteria, paranoia, psychasthenia, schizoid and hypomania of the Mini-Mult test.

The "psychological situation" perceived by the individual is considered critical for determining the level of stress. On this basis, "cognitive assessment", including primary and secondary assessment, is important for an individual under time pressure. At the initial assessment, a person forms a judgment about the meaning of an event as stressful, positive, controlled, provocative or inappropriate, followed by an assessment of his resources and possibilities of survival. Secondary assessment is a process of recalling a potential response to a threat and overcoming it as a process of performing this response (Wagner et al., 2004; Jacob et al., 2017; Lytaev, 2021a).

These approaches may be used to develop new efficient systems for the automatic classification of EEG (Khil'ko et al., 1993; Shostak et al., 1995). For example, developing a technology to distinguish normal from pathological EEG as well as to classify different types of pathology and different types of human functional states triggered by stressors and sensory stimulations is possible. Data from a 30–sec EEG assessment paired with a small amount of other data can be sent easily to remote computers for quick analyses and results. This may be critically important when the timely receipt of such results is important (Qiu et al., 2008; Lytaev et al., 2017, 2019).

CONCLUSION

Integrative index SCL-90-R - the general index of severity of symptoms has a high statistical significance ($p < 0.05$). In the group of healthy subjects the average value of the indicator was 0.73 ± 0.04, in the group of neuropsychiatric patients the average value was 1.08 ± 0.12.

The effectiveness of using the "Mini-Mult" method in conditions of time shortage is determined by the results on the scales of hypochondria, depression, hysteria, paranoia, psychasthenia, schizoid and hypomania, where the differences in the studied groups have a reliability of $p < 0.05$. High values (> 70) in any of the "Mini-Mult" scales require more in-depth examination. Such a survey, which takes 15–25 min, can be used as a standard for assessing neuro-cognitive status in screening studies of large groups.

Indices and spectra of EEG power in theta, delta and alpha frequency ranges are an effective reflection of mental status. EEG power indices and spectra consistently correlate with each other in bipolar derivations in all frequency ranges, with regression coefficients for the correlation dependence in the range of 0.6–0.8. Data on indices and power spectra in the theta range are highly reliable ($p < 0.01$) in assessing neurophysiological status.

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