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# Developing a Diagnostic Tool for a Prognostic Assessment of Resistance to Professional Information Stress in Flight Personnel

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## Abstract

**Introduction**. Stress resistance is a professionally important quality for flight personnel. However, the methods for determining stress resistance (neuropsychic resistance) recommended by the regulatory documents for applicants to military flight schools are rather subjective. This paper presents a novel diagnostic tool as an objective instrument for assessing resistance to the effects of experimental information stress.

**Methods**. The authors developed the diagnostic tool for assessing resistance to the influence of informational experimental stress intended for use in occupational psychological selection of flight personnel. A stressor represented a complex of stressful stimuli, including a competitive exam, complicated arithmetic tasks, and interferences having both noise and distraction effects. The level of stress resistance was determined by the dynamics of mental activity during testing, the physiological ‘cost’ of activity (heart rate at different stages of the experimental stress examination), and external behavior manifestations (speech, movements, posture, and facial expressions). The standardization procedure for a representative sample (n = 3191) used the Descriptive Statistics statistical software package, Microsoft Excel 2007. The author’s script of the diagnostic tool was incorporated into the software of the Reacor multifunctional psychophysiological complex.

**Results and Discussion**. The study examined the applicability of the novel diagnostic tool for diagnosing applicants to military flight schools. The study sample comprised 1135 male candidates aged 18–27 years. The findings indicated the presence of a significant correlation between psychological, physiological, behavioral indicators of subjective stress resistance and the success of flight training (according to expert assessments of simulator training and flight practice). Therefore, the developed diagnostic tool for assessing resistance to experimental information stress is a sensitive test for diagnosing stress resistance and can be recommended for use in occupational psychological selection of flight personnel.

## Keywords
flight personnel, professional stress, information stress, experimental stress, stress resistance, stressor, occupational psychological selection, professionally important qualities, psychometric indicators, prognostic assessment

## Highlights

- Experimental information stress is created by a complex of stressful stimuli (complicated arithmetic tasks, unexpectedness when presenting stimuli, time deficit, and sound interferences with noise and distraction effects).
- Resistance to stress is determined by psychometric indicators of stress manifestations, including the dynamics of mental activity during testing, the physiological 'cost' of activity (heart rate at different stages of the examination), and external behavior manifestations (speech, movements, posture, and facial expressions).
- The indicators of stress manifestations in candidates for admission to the flight school had significant correlations with the indicators of the success of their flight training.

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## Introduction

The profession of aviation pilot is an extreme and dangerous profession; stressful situations are a constant factor in such a professional activity. As introduced by G. Selye in 1936 (Selye, 1936), the concept of stress as a nonspecific adaptive reaction of the body to various influences of excessive intensity continues to attract attention of researchers in various scientific fields (Berebin & Pashkov, 2017; Bitutskaya, Lebedeva, & Tsalikova, 2020; Karayani & Syromyatnikov, 2016; Kulikova, 2019; Ponomarenko, 2006; Rabenu, Yaniv, & Elizur, 2017). Studies have shown that both the qualitative uniqueness of stress factors and the individual characteristics of the organism contribute to stress reactions (Solov'eva, Nikolaev, Denisenko, & Denisenko, 2012; Carver, Sutton, & Scheier, 2000; Fink, 2016; Vine et al., 2015). According to the qualitative characteristics of stressful stimuli stresses are conventionally divided into physiological and psychological ones. Physiological stress represents a response to damage to the integrity of the body; it is characterized by impaired homeostasis. The stereotypical nature of reactions under physiological stress reflects the mechanisms of restoring homeostatic balance. Psychological stress is understood as a state of mental stress, combined with physiological symptoms of stress, which occurs under the influence of an intense socio-psychological stimulus and is characterized by a large variability in manifestations.

According to the qualitative characteristics of stress factors, researchers distinguish informational and emotional types of psychological stress (Bodrov, 2000, 2006; Yuzhakov, Avdeeva, & Nguyen, 2015). Information stress arises in situations when it is necessary to process large amounts of information within a short space of time. This entails information overloads, when subjects do not cope with solving emerging problems and do not have time to make right decisions under conditions of high responsibility for the consequences of their decisions (Gander, Vorona, Ponomarenko, & Alekseenko, 2016; Kovtunovich & Markachev, 2008; Samotrueva et al., 2015; Sobol'nikov & Irgit, 2018). Emotional stress arises when there is a threat of danger to the psychological, social or physical integrity of the human body and personality (Solov'eva et al., 2012; Stamova, Gulin, & Nazirova, 2017; Yuzhakov et al., 2015; Yumatov, 2020; Carver et al., 2000). However, such a differentiation of stresses, based on the distinction between stressful stimuli (informational or emotional), is rather relative because it is often difficult to determine which of the identified stressors is the leading one. In flying in a stressful situation, it is difficult to distinguish informational stressors from emotional ones, as emotions appear on the basis of previous cognitive processing of information; even a purely physical stimulus is addressed to the pilot's psyche and is subjected to information analysis. Previous studies (Bodrov, 2006; Gander et al., 2016; Ponomarenko, 2006) demonstrated that pilots often experience information overloads, because they need to process large amounts of information in a short space of time, which has varying degrees of uncertainty, and also great responsibility for the consequences of their decision. The described circumstances of information overload usually determine the development of professional stress of flight personnel, which is defined as information stress (Ponomarenko, 2006).

Therefore, any aviation stress (primarily informational) that pilots experience during flights is both emotional and physiological, since emotional stress causes the same changes in the body as physiological stress (Ponomarenko, 2006).

The importance of occupational selection of stress-resistant individuals in aviation is obvious. Few individuals can maintain full working capacity or even increase it in critical situations. In others the same conditions may arise a feeling of fear, cold perspiration, slowed thoughts, and inadequate chaotic activity (Kitaev-Smyk, 2013). In this case an individual's behavior turns out to be non-adaptive; it is not aimed at rational control of the situation, which is inadmissible in aviation (Krasilnikov, Krachko, & Malchinsky, 2014). It is difficult to predict human behavior under stressful conditions, because the individuals who had good performance indicators in normal conditions often turn out to be non-productive (Kitaev-Smyk, 2013). As recommended in regulatory documents, psychological tests should be used to examine stress resistance (neuropsychic resistance) during occupational psychological selection (OPS) in military aviation schools. However, such tests and questionnaires are based on self-assessment and are influenced by subjective factors (Nikiforov, Vorona, Bogomolov, & Kukushkin, 2015; Pokrovskii, Mingalev, Pukhnyak, & Abushkevich, 2011; Yuzhakov et al., 2015).

Prediction of the behavior of the subjects in stressful situations of real professional activity is argued by their resistance to the effects of experimental stress. Under normal conditions, it is difficult to form such a 'laboratory' situation, which may correspond to a real professional stressful environment. The difficulty lies in the creation of a subjective reality of the extremeness of acting

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factors. In addition to the objective importance of stressors, an individual attitude towards stimuli, their assessment and comparison with personal resources are of great importance in the process of the development of a stressful state. According to R. Lazarus (Lazarus, 1993), the development of stress depends on how an individual evaluates the relationship between external environmental requirements (intensity and quality of stimulus) and his/her own coping resources. Stress-triggering emotions appear only in the case of a negative balance of this relationship. According to the concept of stress by Selye (1982), stress is determined by a pluricausal (multi-causal) adaptation syndrome arising under the influence of a complex of factors that are necessary for its development. Consequently, either a single intense stimulus with extreme impact or a complex of acting factors represent an experimental stressor. Taking into account the purpose of the diagnostic tool for assessing professional suitability for flight training and work, its developers should focus on real technical and organizational capabilities of its application. The OPS specialists do not have such devices as a centrifuge that can be used as a dosed physiological stress stimulus. In the OPS process the assessment of stress resistance of each candidate for admission to the flight school takes no more than 20 minutes. However, the real number of candidates for admission is often up to 1000 or more.

This study presents the novel diagnostic tool developed by authors for a prognostic assessment of resistance to professional information stress in flight personnel. This diagnostic tool examines resistance to the effects of experimental information stress and can be used in the process of occupational psychological selection of applicants to flight schools. Since in today's fifth-generation military aircraft navigation devices have been converted to digital indicators of information display, the novel diagnostic tool is especially important. When developing the program of this diagnostic tool, the authors used the fundamental works of Selye (1982), Lomov (1984), Bodrov (2006), Kitaev-Smyk (2013), and Ponomarenko (2006).

This study *aims* to develop a diagnostic tool for an objective assessment of resistance to the effects of experimental information stress using psychometric indicators, which can predict the behavior of subjects in stressful situations of real professional activity.

## Methods

### *Development of a stress stimulus for the creation of experimental information stress*

Initially, a stressful stimulus was presented by a complex of emotionally saturated factors, including tragic video and audio stimuli (slide show of car and plane crashes, photographs of people with severe injuries and simultaneous exposure to negative sounds of a siren, machine gun fire, broken glass, dramatic screams of men, women, and children), the very situation of competitive testing, and intense emotiogenic instruction upon presentation of test items (Krasilnikov, Krachko, & Malchinsky, 2013). However, it turned out that this stress stimulus caused not a stressful, but an orienting response, because at the stage of stressful exposure the pulse rate did not increase but decreased in the majority of subjects; they entered the study room asking a question, "Are

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they showing a scary movie here?" This was explained by their acquaintance with horror images from thrillers. Therefore, after the analysis of the relevant literature (Bodrov, 2006; Gazieva, 2018; Gander et al., 2016; Kitaev-Smyk, 2013; Ponomarenko, 2006; Samotrueva et al., 2015; Yuzhakov et al., 2015; Yumatov, 2020; Bernardi et al., 2000) and empirical testing of various methods for experimental stressing (Krasilnikov et al., 2013, 2014; Krasilnikov, Krachko, & Malchinsky, 2015; Krachko, Krasilnikov, & Malchinsky, 2017; Krachko, Krasilnikov, Malchinsky, & Khvostova , 2018), the authors developed the following complex of effective stressful stimuli:

(a) Complicated mathematical tasks, which solution causes an activation of more substantial areas of the brain, compared with verbal tests (Aidarkin & Fomina, 2012; Pavlygina, Karamysheva, Tutushkina, Sakharov, & Davydov, 2012; Roik & Ivanitskii, 2011; Neubauer & Fink, 2009; Wagner, Sebastian, Lieb, Tüscher, & Tadić, 2014; Zago et al., 2008). The tasks consist of 100 examples, presented in the form of three modified arithmetic tests (Arithmetic Counting 1 (AC1), Arithmetic Counting 2 (AC2) and Addition of Numbers (AN)), where operations with integers are performed according to complicated rules.

(b) Screen presentation of test arithmetic tasks in random order, one at a time, at intervals of 3–4 s, which creates emotional stress from unpredictability of expectation, and also excludes the effect of memorization and 'habituation' (Alyushin, 2015).

(c) The impact of informational interference through headphones when performing tasks, which had both noise (the beat of the metronome) and distractor (a dramatic radio exchange of an air traffic controller with a pilot about an emergency in an airplane) effects (Utochkin, 2010).

(d) High motivation for competitive participation in competitive exams, which is obligatory, because without motivation to get a high score in this test, its stress-generating effect is minimized.

### *Psychometric indicators of stress manifestations*

The authors assessed resistance to experimental information stress according to the following criteria.

*The psychological criterion* included indicators of performance, dynamics, stability of mental performance. Mental performance is measured by the number of correctly solved arithmetic tasks when performing three tests (AC1, AC2, and AN) and their sum. The dynamics is determined by the ratio of correct answers in the AC1 and AC2 tests. Stability is assessed by the results of the Addition of Numbers test, divided into six equal parts (by the number of zero solutions in each part of the test).

*The physiological criterion* is determined by heart rate (HR) values at different stages of the examination. The choice of heart rate is determined by the fact that according to many studies (Baevskii, Kirillov, & Kletskin, 1984; Bakhchina, Demidovskii, & Aleksandrov, 2018; Kitaev-Smyk, 2013), the heart rate dynamics is an integrative indicator of changes in the physiological state of the body, characterized by a moderate interindividual variation. This provides the optimal standardization of indicators and their assessment; the reliability and simplicity of heart rate measurement facilitate its use in OPS. The authors refused to use galvanic skin response (GSR) as a pattern of physiological response accompanying mental activity, because of large interindividual differences in indicators, dependence on environmental conditions, which made it difficult to carry out standardization for the sample and criterial assessment of GSR values.

The physiological criterion includes heart rate values at the stages of performing arithmetic tests (AC1, AC2, and AN), heart rate values at the background stage and the final stage of rest, stress index (the ratio between heart rate values at the background stage and those at the stage of performing the AC1 test) and recovery index (the ratio between heart rate values at the background stage and those at the final stage of rest).

*The behavioral criterion* included changes in the behavior of the subjects that reflect the level of emotional stress during the study (speech and motor retardation or hyperactivity, stuttering, tremors, and changes in facial expressions and vegetation). Behavioral indicators were divided into the following ones: pronounced (impairing the performance of test tasks), moderate (impeding the performance of tasks), episodic moderate or mild forms of manifestation, absence of behavioral manifestations.

The psychological, physiological, and behavioral criteria (psychometric indicators of stress manifestations) are combined into an integral assessment of stress resistance (Bodrov, 2001; Krachko, Krasilnikov, & Malchinsky, 2019; Yuzhakov et al., 2015).

### *Development of the study program*

The authors developed a scenario with the specification of procedures and textual content of activities at each stage of the experimental stress study, and also a complex of psychometric indicators of stress manifestations and methods of their registration. The tool was implemented on the basis of the Reacor multifunctional psychophysiological complex which contained an original script for conducting the study according to the following stages: (a) the background stage, (b) the stages of performing arithmetic tasks (AC1, AC2, and AN), alternating with the stages of instructions for each task, and (c) the rest stage.

### *Standardization of the diagnostic tool indicators*

The authors examined psychometric indicators of stress manifestations for the samples of candidates who entered the flight school over a three-year period. Quantitative indicators (indicators of psychological and physiological criteria) were checked for compliance with the normal distribution. Therefore, the authors calculated the following: (a) characteristics of the sample position and (b) characteristics of the sample dispersion.

For the calculations, the authors used the Descriptive Statistics statistical software package, Microsoft Excel 2007, and obtained statistical characteristics of the indicators included into the integral value of stress resistance that were measured in quantitative indicators (for the general sample of applicants, n = 3191). The authors presented the results of these calculations in their previous publications (Krachko et al., 2018, 2019).

 

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The findings suggest that the quantitative indicators of the integral value of stress resistance correspond to the normal distribution according to the distribution of test scores on representative samples, which is confirmed by the representative data obtained from empirical tests (n = 3191) (Krachko et al., 2019).

## Results and Discussion

According to normative assessment scales the primary quantitative indicators of stress tolerance were converted into partial estimates (a five-point scale) as follows:

– a primary indicator that is in the $< \bar{x} - \sigma$ interval scored two points.
– a primary indicator that is in the interval between $\geq \bar{x} - \sigma$ и $< \bar{x}$ scored three points.
– a primary indicator that is in the interval between $\geq \bar{x}$ и $< \bar{x} + \sigma$ scored four points.
– a primary indicator that is in the interval between $\geq \bar{x} + \sigma$ scored five points.

Using the normative assessment scale of the distribution of quantitative indicators of stress resistance, the authors used partial estimates (a five-point scale) for each indicator. In terms of the level of manifestation the points distributed as follows: two points indicated a low level of manifestation, three points – a satisfactory level, four points – a good level, and five points – a high level.

Indicators of the dynamics of mental performance and qualitative indicators of behavioral manifestations were immediately converted into partial estimates using a five-point scale (Krachko et al., 2019).

Table 1 presents the standards for psychometric indicators of stress manifestations, that were developed in accordance with the normative assessment scales of the distribution of primary indicators using a five-point scale.

Table 1
*Standards for assessing psychometric indicators of stress manifestations*

| | Points (partial estimates) | | | |
|---|---|---|---|---|
| | 2 | 3 | 4 | 5 |
| Psychological criterion | | | | |
| Indicators of mental performance (MP) | | | | |
| AC1 | 2 and < | 3–6 | 7–10 | 11 and > |
| AN | 6 and < | 7–15 | 16–23 | 24 and > |
| AC2 | 5 and < | 6–10 | 11–13 | 14 and > |

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Table 1
*Standards for assessing psychometric indicators of stress manifestations*

| | Points (partial estimates) | | | |
|---|---|---|---|---|
| | 2 | 3 | 4 | 5 |
| Psychological criterion | | | | |
| Sum of tests (AC1 + AN + AC2) | 14 and < | 15–29 | 30–45 | 46 and > |
| Stability of MP | 2 and > zero solutions | 1 zero solution | Absence of zero solutions | Absence of zero solutions |
| Dynamics of MP | Stable low estimates for AC2 and AC1 | Stable satisfactory estimates for AC2 and AC1 | Stable good estimates for AC2 and AC1 | Stable high estimates for AC2 and AC1 |
| Physiological criterion | | | | |
| Heart rate at the background stage | 100 and > | 86–99 | 72–85 | 71 and < |
| Heart rate at the AC1 stage | 127 and > | 108–126 | 90–107 | 89 and < |
| Heart rate at the AN stage | 119 and > | 102–118 | 84–101 | 83 and < |
| Heart rate at the index AC2 stage | 113 and > | 97–112 | 81–96 | 80 and < |
| Tension index | 1.43 and > | 1.26–1.42 | 1.12–1.25 | 1.11 and < |
| Recovery index | 1.07 and > | 0.96–1.06 | 0.89–0.95 | 0.88 and < |
| Behavioral criterion | | | | |
| Indicators of behavioral manifestations | Severe manifestations | Moderate manifestations | Episodic manifestations | Absence of behavioral manifestations |

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The integral value of stress resistance was calculated using the expert analytical method of multidimensional scaling, which was developed in the field of aviation psychology as the most acceptable for the practical assessment of the professionally important qualities of a military pilot. In accordance with the method of multidimensional scaling, certain coefficients of significance were assigned to each measurement indicator (Krachko et al., 2019).

The psychological criterion indicators (AN, stability and dynamics of MP) are indicators of primary importance, the other three indicators (AC1, AC2, sum of tests) are of secondary importance.

The indicators of the physiological criterion (heart rate at the background stage, heart rate when performing the AN test, and the recovery index) are of primary importance. Heart rate values when performing AC1 and AC2 tests and the tension index are of secondary importance.

For the indicators of the behavioral criterion, the first coefficient of importance was assigned to pronounced manifestations; moderate and mild manifestations referred to the indicators of secondary importance.

The calculation of the integral value of stress resistance (SR) was carried out in an electronic database in the Excel format according to the formulas presented in previous publications (Krachko et al., 2018, 2019). According to the degree of stress resistance, the individuals are divided into four groups: (a) *individuals with a low integral value of SR*, who are characterized by a high probability of disorganization of activity in stressful situations; (b) *individuals with a satisfactory integral value of SR*, who are characterized by a high probability of a decrease in the reliability of activities in stressful situations; (c) *individuals with a good integral value of SR*, who are characterized by the preservation of the reliability of activities in stressful situations; and (d) *individuals with a high integral value of SR*, who are characterized by the preservation of high reliability of activities in stressful situations.

To assess the relationship between the psychometric indicators of stress manifestations, combined into an integral value of subjects' resistance to experimental information stress and the results of expert assessments for simulator training ($n = 562$), the authors carried out a correlation analysis, which showed good reliability coefficients of relationships among these variables ($p < 0.05$). The indices of the integral value of stress resistance, obtained during the examination of applicants in the process of occupational psychological selection, were compared to the estimates of emotional tension during flight simulator operation among the same subjects (who became cadets). When comparing, it turned out that cadets with high scores of the integral assessment of stress resistance had low scores of tension and better acted in special (emergency) situations during flight simulator operation. The presence of the relationships among the studied estimates indicates the criterial (prognostic) validity of the developed diagnostic tool, based on a significant coefficient ($p < 0.05$) of the correlation between the integral value of stress resistance and values of the external criterion (marks for simulator training).

Significant differences (at $p < 0.05$) were also observed when comparing the indicators of resistance to experimental information stress and the results of flight practice in the sample of cadets ($n = 562$), divided into polar groups of the 'best' and the 'worst' (according to rating assessments of experts). Cadets with excellent ratings for the performance of flight missions using training aircraft had high stress resistance values. Cadets from the group of the 'worst' (according to expert assessments for flying practice) had higher stress manifestations and a low integral value of stress resistance during the experimental stress study.

### *Conclusion*

The data on the existence of a significant correlation and significant differences (at $p < 0.05$) between the integral value of cadets' stress resistance and success of their flight training (according to expert assessments of simulator training and flight practice), give us a reason to believe in possible practical application of the developed diagnostic tool.

The criterion validity based on two approaches (prognostic and by dividing into polar groups according to the success of flight practice) provides grounds for using the novel diagnostic tool in order to predict resistance to professional information stress based on the resistance of subjects to experimental stress caused by a complex of information stress-generating stimuli.

Thus, this diagnostic tool is a sensitive test for identifying resistance to information stress in individuals undergoing examination, which makes it possible to recommend it for use in the procedures of occupational psychological selection of candidates for admission to flight schools.

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**Author Contributions**

**G. T. Krasilnikov** carried out an analytical review of literature related to the issues of occupational stress among aviation specialists and stress resistance, provided theoretical grounding and pilot testing of the Assessment of Stress Resistance diagnostic tool, and performed the analysis of the results.

**E. A. Krachko** carried out theoretical analysis of the current state of the issues of professional aviation information stress and stress resistance, contributed to the development and pilot testing the Assessment of Stress Resistance diagnostic tool, conducted statistical analyses, and drew generalizing final conclusions.
**F. V. Malchinsky** analyzed the current state of the issues of a prognostic assessment of stress resistance in the process of occupational psychological selection (OPS) of applicants to military flight schools, performed the adaptation of the Assessment of Stress Resistance diagnostic tool to the procedure of OPS, and tested the Assessment of Stress Resistance diagnostic tool.

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