The effect of gender differences on the reliability of aptitude screening of aviation specialists

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Abstract. The Aim. *This paper examines the problem of reliability of aptitude screening currently in place in commercial aviation in terms of its indiscriminate applicability to males and females. The task consisted in evaluating some professionally important qualities in males and females, who have successfully completed aptitude screening while being admitted to the aviation school, and identify the presence or absence of differences between the obtained results. For that purpose, a research was conducted that involved 60 third-year traffic controller students of the Saint Petersburg State University of Civil Aviation (35 males and 25 females).* **Methods.** *The psychodiagnostic method included the Prognoz-1 and Prognoz-2 stress tolerance evaluation forms developed in the S.M. Kirov Military Medical Academy, H.J. Eysenck intellectual development test, A. Buss and A. Durkee hostility assessment forms. The authors' earlier findings were also used. Statistical processing was performed using correlation analysis and Pearson's chi-squared test.* **Results.** *The analysis of psychodiagnostic findings has shown the absence of positive differences in the intellectual development of males and females in the observed group. In general, the intelligence of the study participants was sufficiently high (121.17 average IQ for males and 123.04 for females). The assessment of the stress tolerance of the surveyed group using two different variants of the Prognoz forms also has not identified any significant differences between males and females (stress tolerance of females is somewhat lower, than that of males, but the identified difference is obviously not crucial). However, both among males (1 person) and females (1 person) participants were identified, for whom the prediction per both diagnostic method was "unfavourable". Positive differences between the examined males and females were identified in terms of tendency towards physical aggression (A. Buss and A. Durkee test).* **Conclusions.** *The psychodiagnostic method used as part of this work have not identified fundamental gender differences. An exception is the tendency towards physical aggression. In females this indicator is clearly lower, though there are girls who display high aggressiveness. Most experimental subjects demonstrated high stress tolerance and sufficiently high level of intellectual development. And while the examined group does not display clear differences in IQ (there are reasons to believe that the larger is the surveyed group the less significant are the positive differences between males and females in terms of intellectual development), however, the trend of female aviation specialists having overall higher IQ can be observed. The research must continue, extending the range of assessment methods, including alternative approaches that do not involve personality inventories, while simultaneously evaluating the extent of professionally important psychological qualities of aviation specialists, yet not with respect to gender, but in accordance with a candidate's identified gender type.*

Keywords: *aptitude screening, gender differences, intelligent, stress tolerance, aggressiveness.*

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Introduction. One of the ways of reducing the destabilizing effect of the human factor (HF) on flight safety [1, 2] is competent organization of the aptitude screening (AS) of aviation specialists [3], which, as early as at the first stage, will allow identifying those who for some reason are unsuitable for work in aviation. That is especially true for operators, i.e. pilots and air traffic (AT) controllers.

Indeed, in emergency situations pilots display various behaviours. In one case [4] we can observe accurate, competent actions in a truly dire situation, in others [5-8] we can see panic and actions that cause catastrophic consequences.

N.V. Yakimovich, a well-known aviation psychologist, on the RRJ-95B RA-89098 crash: "After a destructive landing and onset of a massive fire that any second could cause an explosion onboard the aircraft, the pilots inevitably reached the final stage of stress and panicked. That is evidenced by the fact that upon landing the pilots stopped acting professionally and did not turn the engines off. Driven by the instinct of self-preservation, they rushed to save the passengers and their own lives. Human psyche is built upon natural laws and it is not always possible to overcome them. Therefore we cannot expect people to do the impossible, i.e. something they are unable to do while being in adverse mental states" [9]. We can of course agree with N.V. Yakimovich that we cannot ask people to do the impossible, but the fact remains. What is impossible for some people others can do. Damir Yusupov landed an airplane with failed engines on a corn field [4]. Certainly, some luck was at play, but the high professionalism and stress tolerance of the aircraft commander (ACC) are key. The report of the Interstate Aviation Committee (IAC) regarding the results of the An-148-100V RA-61704 crash [7] clearly states the following among the causes of the disaster: "individual psychological features of the pilots (for the ACC, reduced intellectual and behavioural agility, fixation on own point of view and inability (impossibility) to "hear" the hints of the second pilot; for the second pilot, disrupted rationality and sequence of actions), who in a stressful situation with inferior cockpit resource management came to the fore; loss of ACC operating capability in psychological terms (psychological incapacitation), which caused a complete loss of dimensional orientation and prevented due reaction to the hints and actions of the second pilot, namely after a PULL UP warning of EGPWS [7].

During the Boeing 737 disasters in Kazan [6] and Rostov-on-Don [8] the crews could not execute a go-around, even though the aircraft were in good working order. In both cases there was panic onboard. By contrast, while Tammie Jo Shults was piloting a similar Boeing 737 with a failed engine and decompressed cabin her voice did not even quiver. She successfully landed the damaged airplane [10]. In other words, all people are different in terms of their psychological resistance and other important psychological qualities. The AS aims to develop reliable selection criteria. If flight safety is indeed our primary goal, increasing AS reliability is certainly important and relevant.

Problem definition. The current Guidelines [3] that specified the procedure for aviation specialists AS is in fact an inferior version of the Soviet Guidelines [11]. The Report [12] explicitly states that some aspects specified in the Guidelines [11] were left out in the Guidelines [3]. The authors elaborated upon that issue in [2].

Another important aspect is that both the Guidelines [11] and, consequently the Guidelines [3], due to the industry situation of that time, were exclusively geared towards males. The authors analyzed a number of problems that has caused in [1].

The authors have absolutely no intention to question the fact that females can make great pilots. Not all of course, but not all males are able to be pilots either. As to the females who became outstanding pilots, beside the aforementioned Tammie Jo Shults, we can mention Amelia Mary Earhart and many prominent Soviet and Russian female pilots: L.V. Zvereva, V.S. Grizodubova, P.D. Osipenko, M.M. Raskova, M.L. Popovich, L.M. Ulanova, M.V. Popovich, S.E. Savitskaya, S.V. Kapanina and many others.

Another matter is whether AS for males is to differ from that for females. Common sense suggests that it should. At least for the reasons examined in [1]. But it is not all that simple. This paper aimed to examine some professionally important qualities in males and females and identify the differences (if any) in the obtained results.

Inputs and methods. A research of the effect of gender differences on the reliability of aptitude screening of aviation specialists involved 60 third-year students of the Faculty of Flight Operation of the Saint Petersburg State University of Civil Aviation (SPBGU GA) majoring in airspace management (ASM), i.e. future air traffic controllers. The group included 35 males and 25 females.

The used psychodiagnostic methods included:

- Prognoz-1 form for stress tolerance (ST) evaluation (N_1, ST in points) [13];
- Prognoz-2 form, also for ST evaluation (N_2, ST in points) [14];
- H.J. Eysenck test for intellectual development evaluation [15] (IQ, intelligence quotient);
- Buss-Durkee hostility inventory (for evaluation of A_P, physical aggression, A_{IA}, indirect aggression, A_{Ir}, irritation, A_N, negativism, A_R, resentment, A_S, suspicion, A_{VA}, verbal aggression and A_{SA}, self-aggression) [16];
- Thomas-Kilmann instrument (for identification of the mode of behaviour in a conflict: T_{CMPT}, competing, T_{CLBR}, collaborating, T_{CNPR}, compromising, T_{AVDN}, avoiding, T_{ACMD}, accommodating) [16];
- A. Assinger's test (for identifying levels of aggression, ε_{AA}) [16];
- V.I. Andreev's test (for identifying the proneness to conflict, $\sigma_{Andr.}$) [17];
- Cook-Medley scale (for identifying the levels of hostility γ_H, cynicism γ_C, aggression γ_A) [18].

Additionally, the analysis covered previously obtained data that were published by the authors in [19-22].

Table 1. Distribution of research participants in terms of intellectual development

Level of intellectual development		In general		Males		Females	
		ppl.	%	ppl.	%	ppl.	%
very low	70 > IQ	0	0	0	0	0	0
low	90 ≥ IQ ≥ 70	1	1.7	0	0	1	4.0
average	110 ≥ IQ > 90	13	21.7	8	22.9	5	20.0
high	130 ≥ IQ > 110	26	43.3	16	45.7	10	40.0
very high	IQ > 130	20	33.3	11	31.4	9	36.0

Table 2. Gender-based distribution of the intelligence quotient (IQ) in air traffic controller students (based on experimental data given in [27])

Air traffic controller students	IQ				
	very low	low	average	high	very high
	< 70	70-100	101-110	111-130	> 130
females	0	1	3	9	8
males	0	5	11	6	5

The findings were analyzed with the R programming language that is widely used as statistical software for data analysis and became a de-facto standard statistical program [23] (licensed under GNU GPL [24]). This work used correlation analysis methods [25] and Pearson's chi-squared test (χ^2) [25].

The research was conducted in accordance with primary bioethical rules [26] on a voluntary basis.

Results and discussion. The findings were not quite what was expected. Figure 1 and Table 1 show the distribution of research participants in terms of intellectual development. As it can be seen, the participants' intelligent is about the same.

The intellectual development of the examined participants is sufficiently high with the group's average IQ of 121.95. A the same time, the average IQ of males is 121.17, and that of females is 123.04. Positive differences were not identified (for the number of degrees of freedom $\nu = 2$ the empirical value χ^2_{emp} of Pearson's criterion [25] is lower than its critical value for level $p < 0.05$ $\chi^2_{emp} = 0.2095 < \chi^2_{0.05} = 5.991$).

If we compare the results of this study with those obtained by the authors earlier [22, 27, 28], we can observe a similar pattern, although some differences are present. Thus, another group of third-year SPBGU GA students majoring in ASM that took part in the experiment described in [27] showed similar results in the same test [15] (see Table 2): group's average IQ = 119.15, 115.00 and 124.48 for males and females respectively. Here, the differences between males and females proved to be significant ($\chi^2_{0.01} = 9.210 > \chi^2_{emp} = 7.8652 > \chi^2_{0.05} = 5.991$ for $\nu = 2$), but that is an exception rather than the norm.

Thus, [28] that cites data on 1294 SPBGU GA students in various majors who were surveyed using the Rudolf Amthauer test [29] examines the existence of differences in intellectual development of males and females. A the same time, the Pearson criterion helped identify clear differences

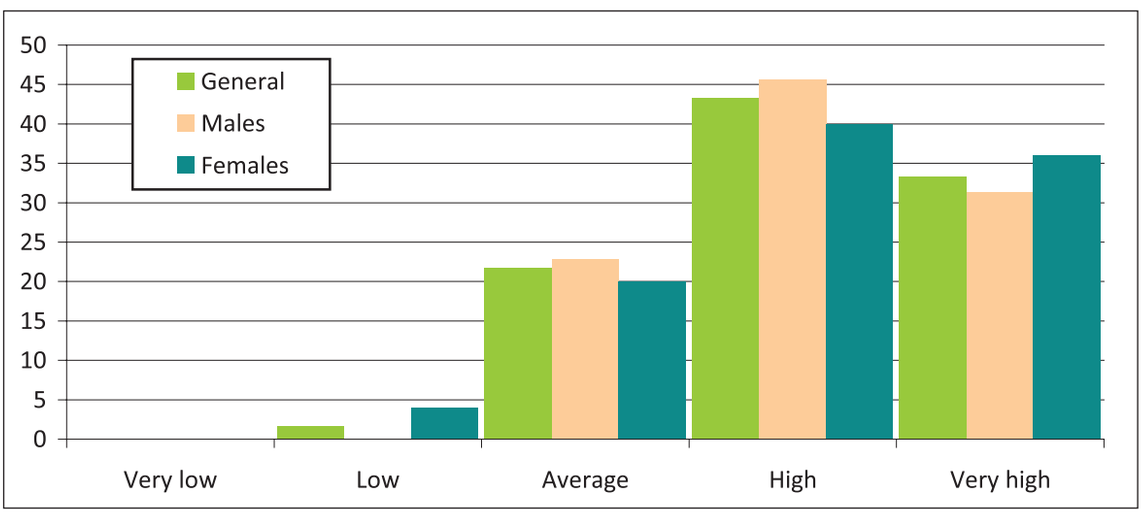

Figure 1. Distribution (%) of examined participants in terms of intellectual development (according to the Eysenck test)

Table 3. R. Amthauer test results of 1697 SPBGU GA students (for clarity, the distribution of intellectual development groups is shown in percentages) [22]

Students	IQ								Average score
	< 100	100-105	106-110	111-115	116-120	121-125	126-130	130 <	
Pilot students									
Males (245 ppl.)	4.49	7.36	11.02	21.63	26.12	16.73	11.02	1.63	114.74
Females (0 ppl.)	-	-	-	-	-	-	-	-	-
Air traffic control students									
Males (60 ppl.)	1.67	10.00	10.00	30.00	25.00	16.66	5.00	1.67	114.10
Females (25 ppl.)	-	-	8	16	24	40	12	-	118.08
Student technicians									
Males (371 ppl.)	2.43	2.96	6.47	28.84	29.38	21.56	6.74	1.62	115.73
Females (43 ppl.)	2.33	4.65	6.97	23.26	30.23	11.63	18.6	2.33	116.54
Transportation organization students									
Males (130 ppl.)	7.69	3.85	16.15	24.62	19.23	18.46	6.92	3.08	113.69
Females (125 ppl.)	4.00	4.80	8.80	21.60	30.40	21.60	8.00	0.80	115.17
Economics students									
Males (102 ppl.)	1.96	2.94	11.77	33.33	28.43	13.73	6.86	0.98	114.59
Females (330 ppl.)	1.52	3.03	11.21	28.78	32.12	17.58	4.55	1.21	114.97
Humanities students									
Males (44 ppl.)	-	-	6.82	45.45	22.73	22.73	2.27	-	115.41
Females (156 ppl.)	1.28	0.64	0.64	34.62	38.46	14.10	9.62	0.64	116.44
Law students									
Males (28 ppl.)	7.14	7.14	32.14	21.43	14.29	17.86	-	-	110.96
Females (38 ppl.)	13.16	13.16	13.16	39.47	13.16	5.26	2.63	-	109.08

in the case of air traffic controllers and air transportation organizers, while for engineering, humanities (Public Relations and Human Resources) and law students clear gender differences were not observed. It should be noted that the presence of positive differences in the sample of air traffic controllers appears to be more of a variance, as there were only 18 females in the sample with 50 males. As it follows from Table 3 that contains more complete data for this test from [22], for all categories except law students the IQ of females is somewhat higher.

Another important psychological quality of an operator is the stress tolerance.

In the experiment described in [27] all the participants had the ST not lower than acceptable (see Table 4), although the scatter is quite significant, i.e. from 3 to 10. (Normally, in the data obtained in SPBGU GA this indicator is within 4 to 8; greater deviations are rare. Estimate 3 is sufficiently low. That is the limit, when the prediction is still favourable for operator activities.) No reliable differences between the samples of males and females in terms of ST estimates (E_{ST}) were identified based on the Pearson criterion ($\chi^2_{ST} = 0.7385 < \chi^2_{0.05} = 5.991$ for $\nu = 2$).

In this study (see Table 5 and Figures 2 and 3) both the male and female samples included one participant with $E_{ST} = 1$,

Table 4. Gender-based distribution of ST estimates (E_{ST}) in experiment participants described in [27]

E_{ST}	1	2	3	4	5	6	7	8	9	10
females	0	0	1	3	3	5	4	3	1	1
males	0	0	0	3	3	8	8	3	1	1

Table 5. Gender-based distribution of ST estimates (E_{ST}) for this study's participants

E_{ST}	1	2	3	4	5	6	7	8	9	10
Prognoz-1										
females	1	0	2	2	10	3	3	1	2	1
males	1	0	1	1	6	8	10	4	2	2
Prognoz-2										
females	1	0	1	0	3	5	4	5	0	6
males	1	1	0	0	0	5	7	11	4	6

i.e. with unfavourable forecast. It is difficult to say whether that is the case or the result of incorrect test performance (the issues of testing with the use of personality inventories were identified by the authors in a number of papers, e.g. [1,

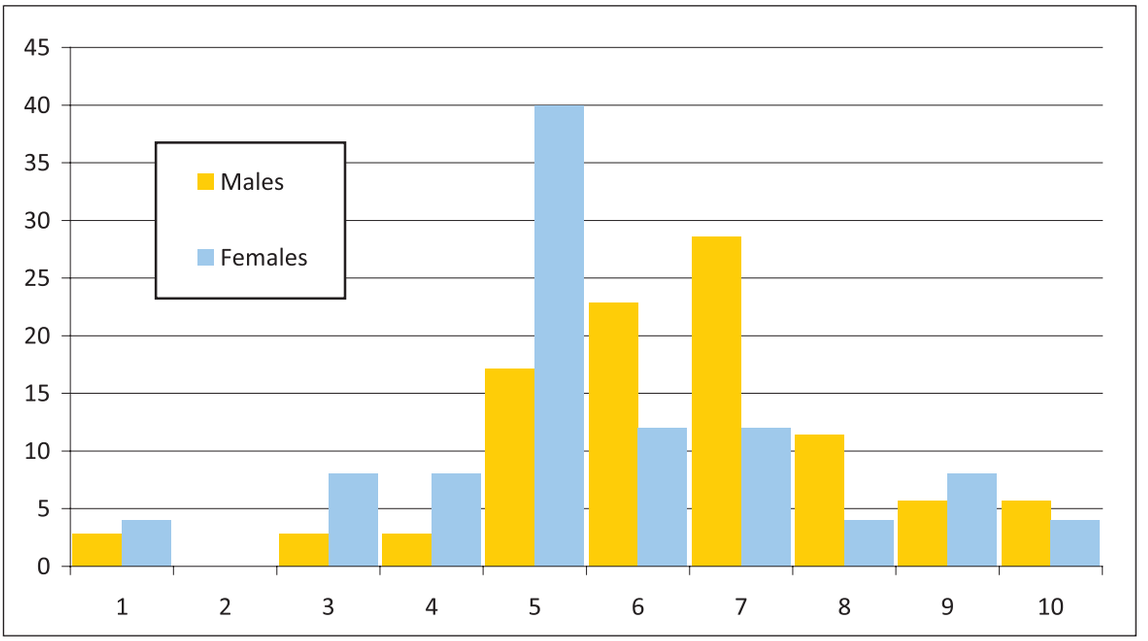

Figure 2. Distribution (%) of study participants by stress tolerance (E_{ST}, subject to the results of the Prognoz-1 form)

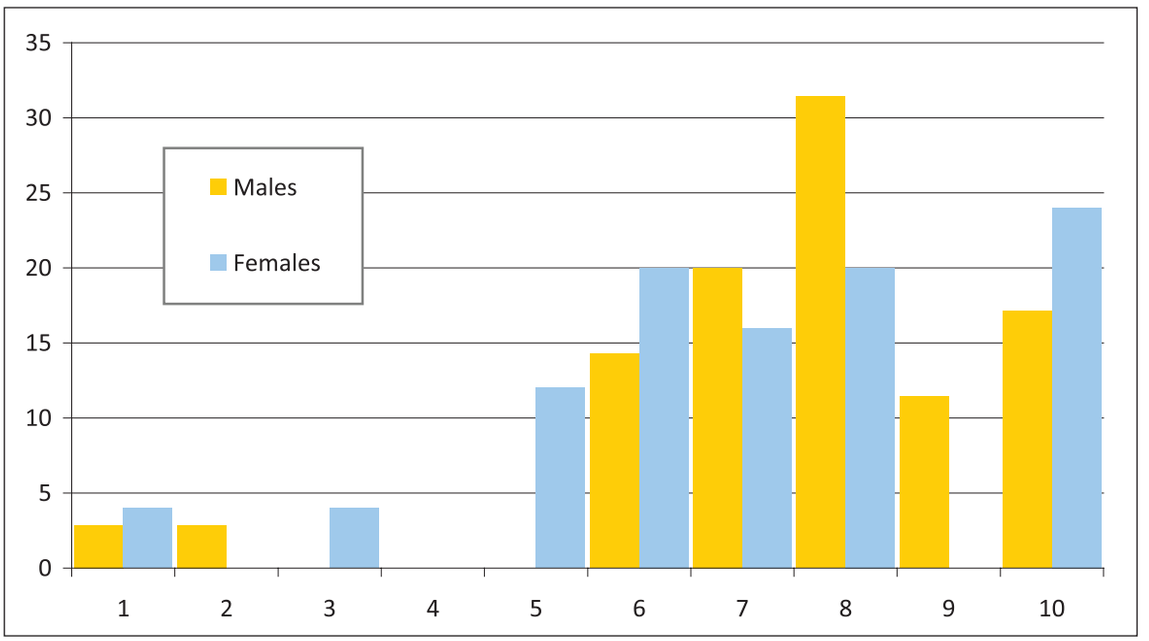

Figure 3. Distribution (%) of study participants by stress tolerance (E_{ST}, subject to the results of the Prognoz-2 form)

2, 20]), but the result is troubling. However, if we look at the big picture, the Prognoz-1 questionnaire produced the group-average result of $N_1 = 12.97$ ($N_1 = 11.89$ for males, $N_1 = 14.48$ for females), which corresponds to good ST ($E_{ST} = 6$). The Prognoz-2 questionnaire produced the group-average result of $N_2 = 15.08$ ($N_2 = 14.37$ for males, $N_2 = 16.08$ for females), which corresponds to high ST ($E_{ST} = 7$).

This study has also not identified positive differences by Pearson's criterion. The Prognoz-1 form produced the empirical Pearson's criterion of $\chi^2_{EMP} = 5.6327 < \chi^2_{0.05} = 5.991$ for $\nu = 2$. The Prognoz-2 form produced the empirical Pearson's criterion of $\chi^2_{EMP} = 1.7763 < \chi^2_{0.05} = 7.815$ for $\nu = 3$. In general, females have slightly lower stress tolerance than males, but the difference is clearly of little consequence.

Conclusions. The analysis of research findings showed that the psychodiagnostic methods used by the authors have not identified fundamental gender differences. An exception is the tendency towards physical aggression that was identified using the Arnold H. Buss and Ann Durkee test [16], where we have found positive differences using Pearson's chi-squared test ($\chi^2_{0.01} = 11.345 > \chi^2_{emp} = 11.1289 > \chi^2_{0.05} = 7.815$ for $\nu = 3$). In females this indicator is clearly lower (see Fig. 4), though there are girls who display high aggressiveness.

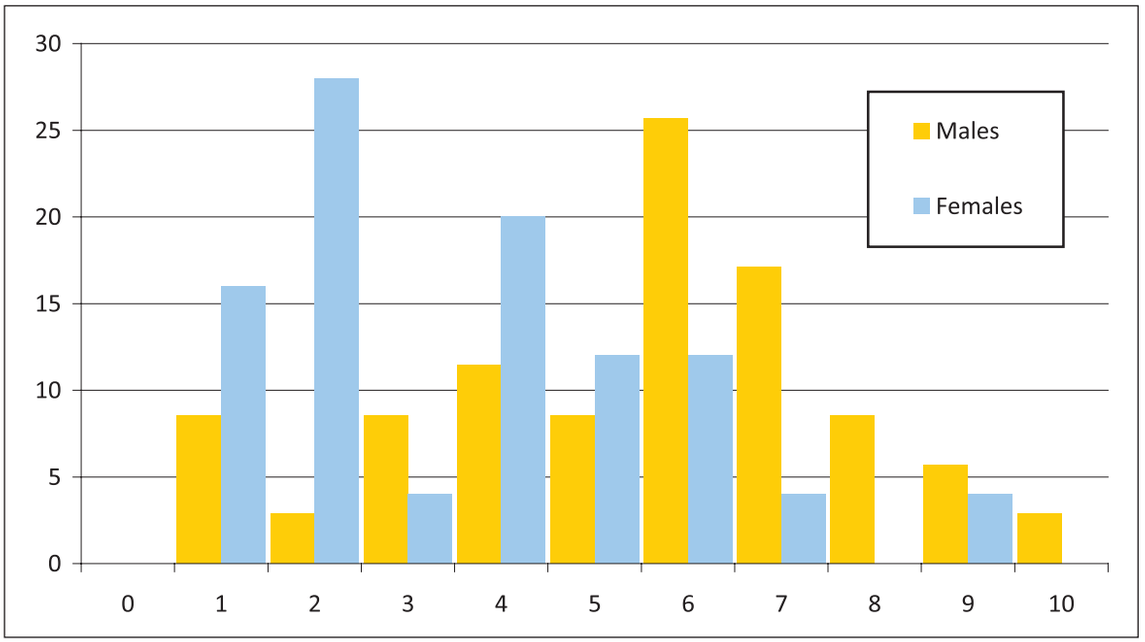

Figure 4. Distribution (%) of the test results of study participants on the Physical aggression (A_P) scale of the Arnold H. Buss and Ann Durkee test

Almost all students who took part in this research have sufficiently good stress tolerance, however, the presence of three persons with unfavourable predictions requires attention at the AS stage.

Most study participants displayed sufficiently high intellectual development. In general, it proved to be somewhat higher than average for the SPBGU GA students. (We are not referring to the results shown in Table 3, as the results of the Rudolf Amthauer and Hans Jürgen Eysenck tests slightly differ from each other. A sufficiently large body of data per the H.J. Eysenck test collected as part of the research, that was described in detail in [21], is shown in Table 6.)

This group does not display clear differences in IQ (there are reasons to believe that the larger is the surveyed group the less significant are the positive differences between males and females in terms of intellectual development), however, the trend of female aviation specialist having overall higher IQ can be observed. Possibly, females only engage in the competition in the aviation industry only if they feel they have a competitive advantage. But that remains only an assumption.

Conclusion. The scope of this paper does not allow discussing all the aspects of the problem, that were identified during the research. Although, in reason, we believe that AS for males and females who aim to become pilots and air traffic controllers should after all differ by a number of criteria, despite the fact that the analysis of the obtained results of a psychodiagnostic survey of students selected for training indicates that the existing AS procedure that is geared towards males, in most cases (except for some results, e.g. tendency towards physical aggression, as shown in this paper, or temperament, as it was shown in [27]) successfully select females based on "male" criteria, as in terms of the magnitude of surveyed personality characteristics, regardless of the candidates' gender, no differences were identified. The obtained results (as well as an analysis of global scientific research in this subject matter [30-34]) suggest that improving the reliability of AS requires researching

Table 6. Distribution of H.J. Eysenck IQ test results [21]

Sample \ IQ		70 and less points	71-90 points	91-110 points	111-130 points	over 130 points
Sample as a whole	603 ppl.	0	38	232	246	87
Males	344 ppl.	0	26	152	127	39
Females	259 ppl.	0	12	79	117	51
Pilot students	232 ppl.	0	17	110	92	13
Air traffic control students	141 ppl.	0	11	52	50	28
Transportation organization students	36 ppl.	0	2	13	16	5
Humanities students	194 ppl.	0	8	57	88	41

the differences in the expression of the necessary psychological and personality-specific professionally important qualities of aviation specialists not by criterion of gender, but rather in accordance with the identified gender-related personality type.

This research must be continued and as much as possible reoriented towards the search for methods that do not use personality inventory tests, e.g. as it was done in [27].

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The authors' contribution

Arinicheva O.V. Review and analysis of the state of the art of the problem under consideration, collection of psychodiagnostic data on flying and air traffic control personnel for statistical processing. The theoretical component of the work.

Ziuba T.V. Review and analysis of the state of the art of the problem under consideration, collection of psychodiagnostic data for statistical processing per aviation specialists not involved in operations.

Malishevsky A.V. Review and analysis of the state of the art of the problem under consideration, collection of psychodiagnostic data on flying and air traffic control personnel for statistical processing. Processing of the obtained results.