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APPLICATION OF EYE-TRACKING TECHNOLOGY AS A DIAGNOSTIC TOOL FOR ASSESSING FLIGHT OPERATORS. PART 2: A STUDY OF QUALITIES IMPORTANT FOR OPERATORS IN THE AVIATION INDUSTRY

Summary. This paper is based on the results of an experiment aimed at studying attention distribution and switching among students using a stationary eye-tracking device. The hypothesis was that the operator's distraction tolerance should be influenced by his or her general mental strength; temperament, which is a derivative of the characteristics of the nervous system; and the level of intelligence, as a general indicator of the state of the nervous system. In addition, the paper discusses the results of psychological assessment, which are not directly related to the issue of distraction tolerance but indirectly affect it. These results are compared with characteristics that directly affect distraction tolerance.

1. INTRODUCTION

Professional psychological selection in aviation is one of the key factors ensuring flight safety in the future. However, dangerous trends can be witnessed all over the world when profit seeking leads to negative consequences. "Today's aviation shows a significant gap between the requirements for a pilot license – to safely fly the aircraft – and the actual real requirements and demands of the profession – to safely and efficiently operate an aircraft in an airline environment" [1]. "Regrettably, to many Approved Training Organisations (ATOs), a pilot candidate equals profit. Hence – to make a profit – the school needs a constant influx of cadets in training. Airlines, some of them happy to outsource their own training task, were also satisfied with a high volume of new trainee pilots, for a simple reason – an over-supply of pilots keeps new pilots cheap and labor costs down. The perception has changed when the results of this policy started to surface. Plenty of license holders who were initially able to secure the 100.000 € funding for the flight training with an ATO and to complete the training successfully were deemed 'not fit for the job' during the selection process at the airline company level" [2]. "Both today and in the future, it is essential that pilots have well-developed technical and managerial skills as well as skills in sustainability. This can only be achieved through a thorough selection of candidates as well as a better and more robust and diverse initial pilot training, than is the case today. Pilots' competencies must be trained in an integrated manner, with the goal of such training being the transfer of the knowledge in a way that makes sure the pilot trained is actually able to apply it. That means that competencies should not be trained in isolation, and it means the application in real-world environment and aircraft. At the end, the final objective for a professional pilot is a "safe, sustainable lifetime performance" – something that needs to be reflected already at the stage of initial pilot training and the selection process that precedes it" [1]. Unfortunately, of particular concern are cases, which are not uncommon, when pilots are not properly licensed. What this leads to can be seen in the many accidents that pilots were responsible for.

In Russia, there was an accident with a Boeing 737 operated by Tatarstan Airlines [3], one of whose pilots had a fake license. An audit that resulted from this accident revealed many violations, with similar licenses being withdrawn. However, this issue is not characteristic of Russia only. During the investigation of an Airbus A320 crash in Pakistan, the Aviation Secretary of Pakistan said that approximately 40% of pilots in Pakistan had fake licenses. At least nine pilots officially admitted that their licenses had been obtained illegally. At least four pilots working for Pakistan International Airlines had fake licenses [4]. Even where flight safety is at a quite high level, not everything goes well. An example is the Boeing 767 Atlas Air crash. On February 23, 2019, the plane took off from Miami International Airport and within 30 seconds started moving out of control. Panic and confusion filled the cockpit of doomed Atlas Air Flight 3591 in its final moments before crashing into the ground 40 miles outside of Houston, new government documents show. It is noted that co-pilot Conrad Jules Aska came to Atlas in 2017 after failing his test to become a captain at Mesa Air. He had previously dropped out of training programs at Air Wisconsin in 2012 and CommutAir in 2011 but did not list those employment stints on his application with Atlas. In 2015, captain Ricky Blakely failed his proficiency test on the Boeing 767 and was placed in a monitoring program "as a result of [his] repetitive need for additional training" [5]. This case shows that not only professional training can lack in quality but also professional psychological selection can be poorly performed, which led to the fact that the crew was psychologically unprepared to act in an emergency. In cases when pilots have fake licenses, professional psychological selection and screening is something that they have not gone through. "The financial solvency of the candidate must not be the primary factor in deciding whether s/he is accepted to a flight school or not. Other criteria like aptitude, skills, motivation, and professional standards should come first" [2]. This is where the issue of professional psychological selection is especially relevant. Therefore, further improvement of psychological selection and screening procedures in aviation is definitely an important and urgent issue.

2. EARLIER STUDIES AND REFERENCES TACKLING THE ISSUE OF MENTAL HEALTH AND PSYCHOLOGICAL SCREENING IN THE AVIATION INDUSTRY

"Mental health in aviation is a major concern among airlines, regulators, and passengers. This topic gained more attention after the 2015 Germanwings crash, which was deliberately caused by the plane's copilot. There are many different causes of mental illness in pilots, but as of now, there is almost no action taken to try and combat this issue. Little data exist on mental health in aviation, but steps to gather relevant information and provide better solutions are underway" [6]. However, managers in the aviation industry say that "Pilot screening and mental health measures aimed at preventing a recurrence of the Germanwings crash are rife with complications that will make them tough to implement" [7]. Nevertheless, this incident resulted in issuing a number of regulations, for instance [8]. "The industry and authorities in the United States and Europe are now debating doctor-patient confidentiality, pilot screenings, and medical check-ups, but it will be some time before progress is made" [7]. Carsten Spohr, Lufthansa's CEO, "has suggested random psychological tests but said there might never be a foolproof response" [7]. "There is a negative stigma around mental health in aviation. A study showed that fellow pilots assumed fellow pilots who were unsociable most likely to have a mental health illness. This identifies that even factors that are not signs of mental health can stigmatize others and the negative consequences of being identified as having mental health issues, even when this is not the case" [9]. This issue should also be addressed. Tony Tyler, IATA's CEO, said that "any measures must not stigmatize mental health problems and that pilots had to be helped in a supportive way. If you penalize people with these problems, they will not declare them and may go under the radar and that is the last thing you want" [7]. "Pilots and their employers must also be aware of recent life changes that may affect pilot performance and mental health characteristics. One such way is the Recent Life Change Questionnaire, which measures how susceptible someone is to change. This questionnaire identifies certain individuals who are more at risk of mental health issues and allows the airline to then provide support for them. It is crucial for airlines to develop

a program to remove individuals who are in a high-risk state and help them transition to a more suitable job" [10].

It is true that the screening of professionals already working in the aviation industry [11-13] with a view to ensuring flight safety is important, but it seems much more appropriate to pay attention to improving the professional and psychological screening of future pilots and air traffic controllers (ATCs) [14-17]. Professional psychological selection is a set of measures aimed at ensuring high-quality selection of the organization's staff based on assessing whether they are psychologically fit for particular positions. According to the opinion stated in some articles [15-18] and a number of other works, professional and psychological screening procedures used in Russia today for assessing pilots and ATCs [19] have a lot of significant drawbacks and need to be further improved. In particular, the articles by Gerasimenkova and co-authors [15, 16] examined the weaknesses of personality tests that are taken by aviation professionals in Russia, primarily the Russian version of the Minnesota Multiphasic Personality Inventory (MMPI) [20], which is recommended by "*Manual on the psychological support of selection, training, and professional activities of flight and dispatching personnel in Russian civil aviation*" [19] as a compulsory psychological test for pilots and ATCs used further in screening and selection.

It should be noted that personality tests are not very reliable in general. The main issues with their usage are associated with the fact that their results can be falsified and there is a decrease in the reliability of the data obtained owing to differences in the understanding of the questions among those taking the same test [21]. We will also cite here a competent opinion voiced by A.G. Shmelev (Doctor of Psychology, Distinguished Professor at Moscow State University, member of the Expert Council of the Russian Psychological Society, etc.), who is quite skeptical about the results obtained using procedures based on the American MMPI methodology: "This test was developed specifically for patients in mental health clinics and is widely used in private psychoanalysis. American companies have not been using this methodology for the past few years in assessing candidates who do not experience any psychological problems. The reason for this is simple: people who do not want to use psychological services or treatment and simply want to pass the MMPI test successfully give dishonest answers and deliberately hide the presence of any psychological problems and difficulties. Over the past few years, the MMPI has become virtually prohibited in use for selection purposes" [22]. When conducting surveys and tests (including those connected with professional psychological selection), it should be borne in mind that participants can give dishonest answers. However, it does not happen in every diagnostic situation. The issue of the mindset that the participant has when taking a test is quite complicated [21]. Apart from the mindset, the way how respondents understand questions in a test also influences the validity of their answers. It has been shown that if questions are ambiguous and difficult to understand, the participant gives different answers to the same questions when the test is repeated, which indicates low validity. At the same time, questions that are answered in the same way in repeated tests are not very helpful in classification [21]. This is why one of the ways to improve psychological screening methods in the aviation industry is using objective rather than subjective tools more extensively, among which are various devices and gadgets. An eye-tracking device, which we used in our experiment, is one of such devices. "Eye-tracking is a growing field of research with several applications such as eye-movements in the recognition of natural environments, in human-computer interaction, in speech and in reading" [23], and also in solving a number of other tasks.

Other countries also understand very well that it is essential to improve psychological screening methods in the aviation industry. "Throughout the hiring phase, pilots can be administered different personality tests to see if they are at risk of mental health issues" [6]. "Following the Germanwings Flight 9525, both the IATA and the Civil Aviation Medical Association are looking into solutions, one being random psychological tests. The issue with a reactive instead of proactive method is that rather than supporting pilots, it creates an even bigger stigma within the industry" [24]. "The European Aviation Safety Agency also issued a similar statement, stating all pilots need to undergo psychological evaluation" [25].

In general, everyone agrees that, as Hans Stapel and Rob Pijpers from Aviation Medical Center (an institute for psychological services in air traffic) put it, "psychological testing of pilots is not a hype, but a necessity. The safety, quality, and efficiency of the operations in air traffic have been

improved, probably partially or to a large extent by a decrease of the number of crew-related incidents. The air traffic area fortunately has given more and more attention to Human Factor topics. At the same time, new challenges arise from the environment of the company. Psychologists can help to face these new challenges, among others by a good selection" [26]. It is true that aviation psychologists have developed screening systems such as Global Pilot Selection System [27] and a few others [28-30] which are used throughout the world. However, as Michael Müller, the famous German aviation expert, said, Andreas Lubitz's story will certainly raise the question of how to select pilots in civil aviation in order to avoid such cases. The key factor is that today there is no single standard for selecting pilots, and each airline solves this issue independently [31].

Nevertheless, "Europe, taking Russian standards as an example, has introduced more stringent requirements regarding commercial aviation pilots" [32]. The European Commission has decided to put pilots and other crew members under special scrutiny. Airlines are now obliged to test their aircraft crews for mental strength and conduct unscheduled checks of pilots and flight attendants for the use of psychotropic agents, including prescribed drugs and alcohol. Many of the practices mentioned were borrowed from Russian civil aviation [32]. The article, which was published in 2018, state that European standards are expected to come into force by the summer of 2020. Airlines will have enough time to adapt to the new regulations. First, they will provide their pilots with access to programs for those with psychological issues. Second, they will develop tests for pilots. Third, they will develop a regulation for unscheduled checks for the use of psychotropic agents. Fourth, the European Commission has made it mandatory for all airlines in the EU countries to randomly test crew members for alcohol consumption before the flight. In Europe, psychological tests have not been conducted before, and the world does not have a unified system for training aviation psychologists [32]. However, the information cited from Shadrina, T [32] is somewhat ambiguous, given the existence of *Manual on Prevention of Problematic Use of Substances in the Aviation Workplace. 1st Edition* [33] and the data described in other articles [27-30] and a number of other sources.

3. MATERIALS AND METHODS

This paper is based on the results of an experiment that was conducted to study attention distribution and switching among students by using a stationary eye-tracking device (the Tobii REX eye tracker [34]). The experiment was conducted in two stages.

The first stage, which was conducted in November 2016, involved 48 third-year students at Saint Petersburg University in Civil Aviation majoring in air traffic control. Their ages ranged from 20 to 23 years. There were twenty-seven males and twenty-one females. The results of the first stage are discussed in detail in the articles by Gerasimenkova, A. and co-authors [15, 16] and other works. The second stage, which was conducted in November 2017, involved 43 fourth-year students studying to become civil aviation pilots. Their ages ranged from 20 to 25 years. All of them were males. As part of this experiment, all the participants also took a number of psychological tests.

The psychological tests used include the following:

- the Eysenck Personality Inventory (EPI) [35] adapted by A.G. Shmelev [21] for measuring two dimensions of personality – extraversion and neuroticism;
- the "Forecast" test [36] for assessing mental strength;
- Eysenck's IQ test aimed at measuring the intelligence quotient [37];
- the Thomas-Kilmann Instrument (TKI) [38] adapted by N.V. Grishina [21] for measuring an individual's response to conflict situations;
- the MMY-1 test [39] aimed at determining behavioral styles; and
- a questionnaire for determining the level of subjective control [21] to assess general and specific indicators of internality [40].

These instruments were used at both stages of the experiment. At the first stage of the experiment, other psychological assessment methods were also used, but as they were not used at the second stage, they are not discussed in this paper. The results obtained with their help are described in the articles by Gerasimenkova, A. and co-authors [15, 16] and a number of other papers.

To analyze the results, we used the R programming language [41] (available under the GNU GPL license [42]). Correlation analysis methods and Pearson's chi-squared test were used [43].

The experiment was conducted in accordance with the fundamental principles of bioethics [44] and on a voluntary basis.

4. PSYCHOLOGICAL TESTING: RESULTS AND DISCUSSION

In the study, the aim was not only to find correlations between the results of the experiment and the psychological characteristics of its participants but also to study the participants' psychological characteristics and compare them with the data obtained in some of our previous studies on the topic [14-18]. Based on logical reasoning and common sense, a hypothesis was put forward that the operator's reaction to distractions may be influenced by his or her mental strength, which can be estimated using the "Forecast" test [36]; temperament, which is influenced by the type of the nervous system connected to mental strength and can be estimated by the EPI test [21]; and the intelligence quotient, which, according to the scientists' opinion substantiated in Mainstream Science on Intelligence [45], is the main indicator of the state of the nervous system and is measured (in this study) using Eysenck's IQ [37]. In addition, the results of psychological tests were studied that are not directly related to the issue of distraction tolerance but have an indirect connection with it. They were compared with the characteristics that directly affect distraction tolerance.

The results are shown in Figs. 1-4, 6, and 7, and Tables 1-7.

Distribution by temperament (the EPI methodology) shows that by far the biggest group is the sanguine type (see Fig. 1). More than 70% of pilots have this type of personality. This is a much greater proportion than that previously obtained by the authors over the past few years (when studying a group of 391 people) and shown in Fig. 1. The data on the temperament of ATCs do not differ much from the data obtained previously on much larger samples. The proportion of sanguine people is quite high (54.2%), which is normal. There are also many choleric people (28.1%). This is quite a big share for the sample of ATCs, and it is also unusual for pilots. The phlegmatic type accounted for only 13.5% of the sample, and this share is usually slightly higher. There are even a number of melancholic people, who have the so-called weak type of nervous system. This type is rare among both pilots and ATCs; however, as can be seen from Fig. 1, the data that were previously collected by the authors demonstrated a bigger share.

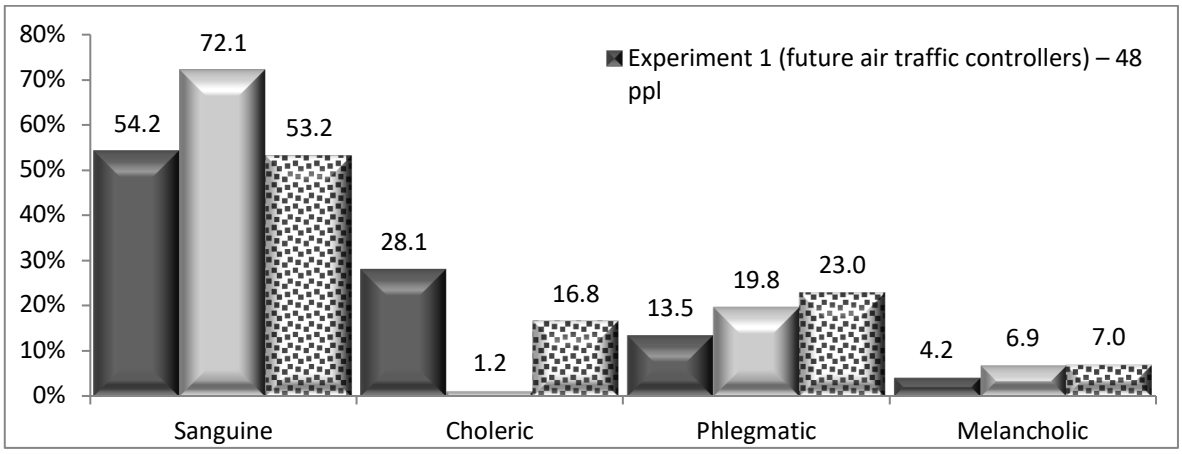

Fig. 1. Distribution of participants in the experiment by temperament (the EPI test) in comparison with the data collected previously by the authors when testing aviation professionals (391 people)

In terms of neuroticism (n), Pearson's chi-squared test revealed significant differences between the male sample and the female sample ($\chi^2_{cr.0.99} = 3.841 > \chi^2 = 4.0114 > \chi^2_{cr.0.95} = 6.635$ for $\nu = 1$; see Table 1). It should be noted that neuroticism is more pronounced in females (there is a higher percentage of melancholic and especially choleric individuals among the female participants), which

means their nervous system is less balanced. The average level of neuroticism (6.9) among pilots is lower than that among ATCs (9.3).

Table 1

Distribution of temperament and neuroticism (n) by sex among students majoring in air traffic control (based on the EPI methodology)

females	Sanguine	Phlegmatic	Choleric	Melancholic
	8	3	8.5	1.5
	n < 12		n > 12	
	11		10	
males	Sanguine	Phlegmatic	Choleric	Melancholic
	18	3.5	5	0.5
	n < 12		n > 12	
	21.5		5.5	
Note: for mixed temperament types, 0.5 was added for each of the corresponding types				

As the bar chart in Fig. 2 shows, the levels of mental strength among pilots and ATCs are almost identical. Nobody ranked lower than "satisfactory". However, even though females accounted for almost half of the ATCs in the experiment, Pearson's chi-squared test did not reveal any significant differences between the male sample and the female sample in terms of mental strength ($\chi^2 = 0.7385 < \chi^2_{cr.0.95} = 5.991$ for $\nu = 2$; see Table 2).

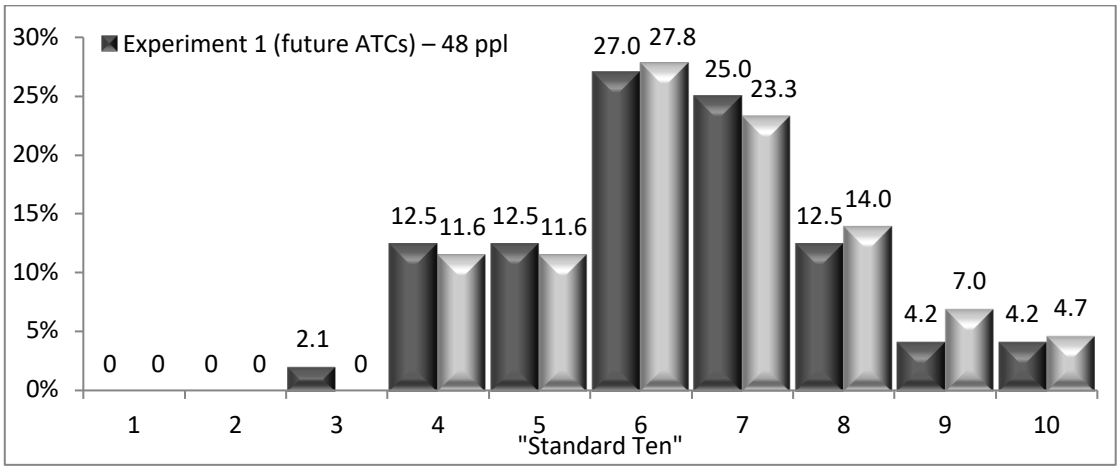

Fig. 2. Distribution of participants in the experiment by mental strength (MS_{sten}) based on the "Forecast" test

Table 2

Distribution of the participants by sex and mental strength determined using the "Forecast" test

Forecast	Unfavorable		Favorable							
MS_{sten} Mental strength (standard ten)	1	2	3	4	5	6	7	8	9	10
MS_{scores} Mental strength (scores)	Unsatisfactory		Satisfactory			Good		High		
	≥ 33	29-32	23-28	18-22	14-17	11-13	9-10	7-8	6	≤ 5
females	0	0	1	3	3	5	4	3	1	1
males	0	0	0	3	3	8	8	3	1	1

As for intelligence characteristics, the samples are quite similar (see Fig. 3). Average and high IQ values prevail. The average IQ among ATCs (119.14) is slightly higher than that among pilots

(114.65). Pearson's chi-squared test revealed significant differences between the male sample and the female sample in terms of IQ levels ($\chi^2_{cr.0.99} = 9.210 > \chi^2 = 7.8652 > \chi^2_{cr.0.95} = 5.991$ for $\nu = 2$). Female participants demonstrated higher IQ levels than male ones did (see Table 3). These data correlate with the data presented in other articles [14-16]. This can be seen by comparing the results presented in Fig. 3 and those shown in tables 3, 4, and 5, with the data from one of our previous papers [14].

Although both the pilots and the ATCs who participated in our experiment demonstrated slightly higher IQ results than those samples of students who were previously studied for a quite long period, the differences are not significant.

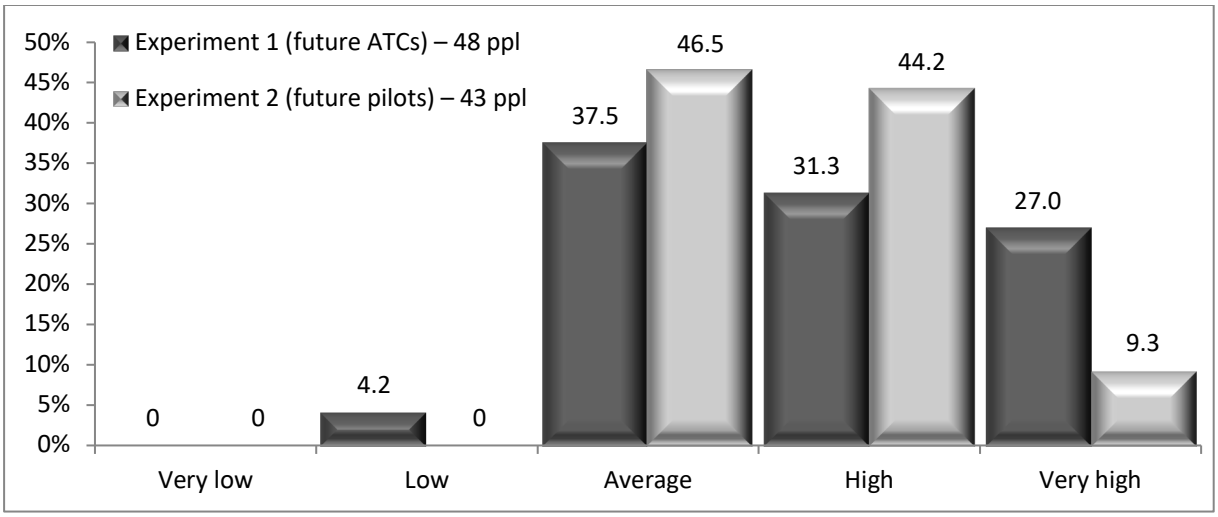

Fig. 3. Participants in both experiments distributed by IQ levels

Table 3

IQ distribution by sex among future ATCs

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

Table 4

The distribution of Eysenck's IQ test results in different samples [14]

IQ / Sample	< 70	71-90	91-110	111-130	> 130
Total sample (603 ppl)	0	38	232	246	87
Males (344 ppl)	0	26	152	127	39
Females (259 ppl)	0	12	79	117	51
Pilots (232 ppl)	0	17	110	92	13
Air traffic controllers (141 ppl)	0	11	52	50	28
Managers of air navigation services (36 ppl)	0	2	13	16	5
Humanities students (194 ppl)	0	8	57	88	41

A comparison of IQ distribution across the samples showed (see Table 6) that, according to Pearson's chi-squared test [43], the differences between the samples are highly significant ($p \leq 0.01$), excluding the differences ($p > 0.05$) between ATCs and humanities students (which is not very clear).

Table 5

The average values of IQ and conflict management strategies in different samples [14]

Sample	N	IQ	Average score				
			Competing	Collaborating	Compromising	Avoiding	Accom-modating
Total sample	603	114.7	5.05	6.76	7.21	5.87	5.11
Males	344	112.4	5.86	6.71	6.92	5.57	4.94
Females	259	117.8	3.97	6.84	7.60	6.25	5.34
Pilots	232	110.5	5.89	6.75	7.08	5.32	4.96
Pilots (males)	209	109.9	6.01	6.78	7.00	5.31	4.89
Pilots (females)	23	115.8	4.74	6.43	7.78	5.48	5.57
Air traffic controllers	141	115.9	5.38	6.81	6.99	5.89	4.93
Air traffic controllers (males)	78	114.7	6.08	6.77	6.62	5.94	4.59
Air traffic controllers (females)	63	117.3	4.52	6.86	7.44	5.83	5.35
Managers of air navigation services	36	114.8	4.69	7.03	7.33	6.33	4.61
Managers of air navigation services (males)	18	112.1	5.50	6.61	6.83	6.28	4.78
Managers of air navigation services (females)	18	117.6	3.89	7.44	7.83	6.39	4.44
Humanities students	194	118.9	3.87	6.70	7.51	6.41	5.55
Humanities students (males)	39	121.5	4.79	6.21	7.10	5.92	5.97
Humanities students (females)	155	118.3	3.64	6.82	7.61	6.53	5.40

Table 6

Pearson's chi-squared test results [14]

Sample 1	N	Sample 2	N	Parameter	ν	χ^2	Results	
Males	344	Females	259	IQ	3	18.6253	$p \leq 0.01$	SD
				Competing (β_1)	12	64.6156	$p \leq 0.01$	SD
				Collaborating (β_2)	7	4.0215	$p > 0.05$	NSD
				Compromising (β_3)	8	27.0218	$p \leq 0.01$	SD
				Avoiding (β_4)	8	21.8083	$p \leq 0.01$	SD
				Accommodating (β_5)	9	12.4440	$p > 0.05$	NSD
Pilots	232	Air traffic controllers	141	IQ	3	18.8844	$p \leq 0.01$	SD
				Competing (β_1)	11	6.6805	$p > 0.05$	NSD
				Collaborating (β_2)	7	3.8463	$p > 0.05$	NSD
				Compromising (β_3)	8	13.6399	$p > 0.05$	NSD
				Avoiding (β_4)	7	9.5073	$p > 0.05$	NSD
				Accommodating (β_5)	7	2.4680	$p > 0.05$	NSD
Pilots	232	Humanities students	194	IQ	3	31.5290	$p \leq 0.01$	SD
				Competing (β_1)	12	50.0101	$p \leq 0.01$	SD
				Collaborating (β_2)	7	6.3074	$p > 0.05$	NSD
				Compromising (β_3)	8	14.3643	$p > 0.05$	NSD
				Avoiding (β_4)	8	39.1902	$p \leq 0.01$	SD
				Accommodating (β_5)	9	12.7886	$p > 0.05$	NSD
Air traffic controllers	141	Humanities students	194	IQ	3	5.3653	$p > 0.05$	NSD
				Competing (β_1)	10	28.1265	$p \leq 0.01$	SD
				Collaborating (β_2)	7	3.7237	$p > 0.05$	NSD
				Compromising (β_3)	6	7.7161	$p > 0.05$	NSD
				Avoiding (β_4)	6	7.8557	$p > 0.05$	NSD
				Accommodating (β_5)	9	6.9581	$p > 0.05$	NSD

SD – significant differences; NSD – no significant differences; ν is the number of degrees of freedom.

Among the psychological characteristics that theoretically may indirectly affect distraction tolerance, we identified behavior styles in general and conflict management strategies in particular, the latter of which can be determined using the TKI test [21, 38]. It is obvious that the way a person behaves, especially in a conflict, is an integral indicator that reflects the person's general readiness to perceive stimuli that are relevant for work. The TKI test results for the participants in both stages of the experiment are shown in Fig. 4. When comparing the results obtained with the results of a previous study [14], which used a sample of 603 students at St. Petersburg State University of Civil Aviation and Irkutsk State University (see Table 5), it is clear that there are no significant differences between the samples. Collaborating and compromising also slightly prevail. In the article by Arinicheva eta l [14], it was emphasized that "The results of the TKI test showing preferences for particular conflict management strategies are presented in Table 5 and demonstrate that men are much more prone to competing than women, which is also true for future pilots in comparison with humanities students. At the same time (see Table 6), according to Pearson's chi-squared test, it is in terms of the proneness to competing that there are highly significant differences ($p \leq 0.01$), excluding differences between ATCs and pilots ($p > 0.05$), which is quite predictable. Significant differences ($p \leq 0.01$) can also be seen between future pilots and humanities students in terms of resorting to avoidance as well as between men and women in terms of almost all conflict management strategies". In general, the conclusions made for both pilots and ATCs are also true for the experiment discussed in this paper.

The MMY-1 test [17, 39] for assessing behavioral styles has three scales based on personality focus: α_1 – a person's focus on themselves (on their own interests); α_2 – a person's focus on the people around (interest in interacting with them); and α_3 – a person's focus on action (work). The results obtained on these three scales are used as coordinates on a special grid (μ_2). The point having these coordinates indicates a person's behavioral style and the ten sectors of the μ_2 grid indicate which of the ten behavioral styles this person has. In addition, using the α_1, α_2, and α_3 coordinates, the value of r is calculated, which is the distance from the point corresponding to the person's behavioral style to the point indicating the so-called optimal (in terms of managing aircraft crew resources) style. It is found using the following equation:

$$r = \sqrt{(\alpha_1{}^2 + (\alpha_2 - 50)^2 + (\alpha_3 - 50)^2)} \quad (1)$$

where α_1, α_2, and α_3 are the coordinates of the point reflecting the behavioral style on the μ_2 grid [17] (see Fig. 5).

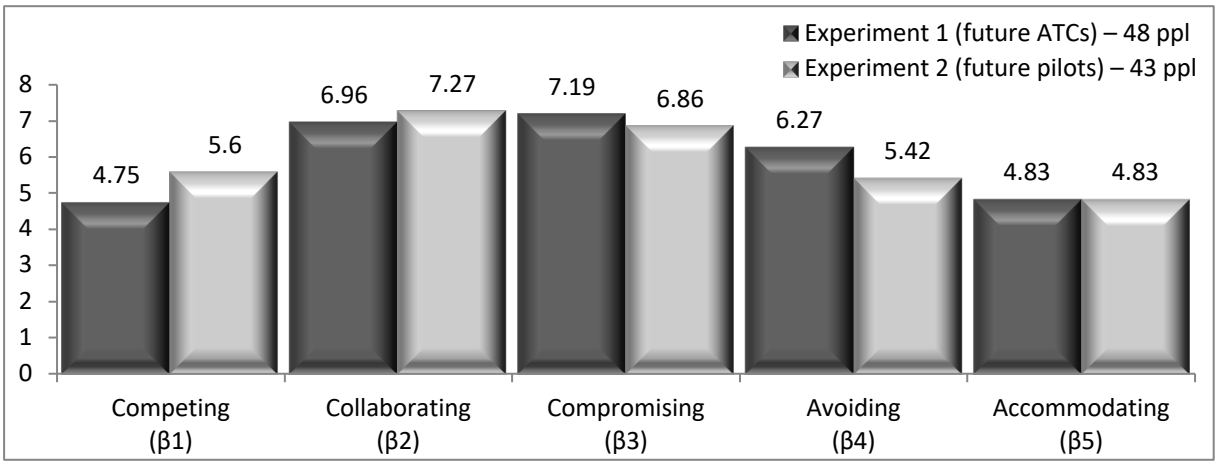

Fig. 4. Distribution of conflict management strategies among the participants

As the bar chart in Fig. 6 shows, there are no significant differences in the distribution of either individual coordinates or the value of r between the participants in the two experiments. The paper by Dzhapharadze, T.R., and Malishevsky, A.V. [17] contains information on 261 pilots aged 21 to 43 who worked for different airlines of the post-Soviet countries and took a course to learn how to fly a Boeing-737. Every participant was tested once before taking the Multi Crew Co-Operation program in the period from December 2008 to April 2013. As can be seen from the bar chart in Fig. 6, there are no

significant differences between professionals and students. The professionals have a slightly better behavioral style, but the difference is not big. In all the categories (and in a number of other studies that we conducted using quite big samples), the conforming style prevails (75.0% of future ATCs and 81.4% of future pilots who participated in the experiment; 80.5% of professional pilots who participated in the experiment discussed in [17]), which is close to behavioral style 5.5 described by Robert R. Blake and Jane S. Mouton [46]. This confirms the conclusions made in Askarov, A. B., and Emrulov, A. B., and Platonov, Yu. P. [47, 48] regarding the specific features of the Russian mentality.

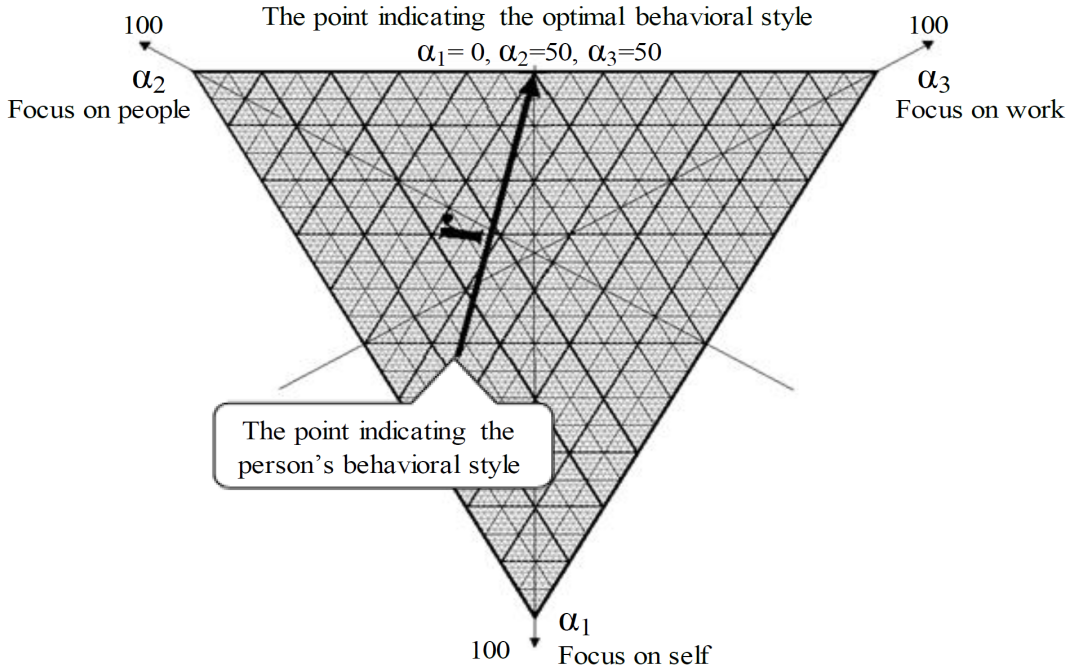

Fig. 5. Finding the distance from the point indicating the individual behavioral style to the point indicating the optimal behavioral style on the μ_2 grid [17, 39]

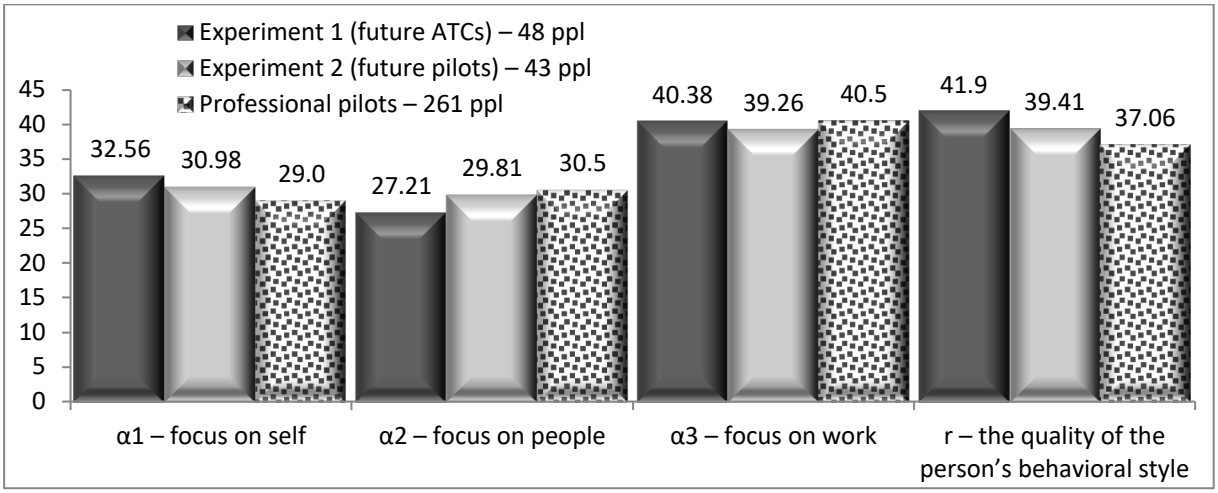

Fig. 6. Average values of α_1, α_2, and α_3 on the μ_2 grid and the distance from the point indicating the individual behavioral style to the point indicating the optimal behavioral style among the participants in comparison with professional pilots (261 people)

Responsibility affects all mental processes in the person, especially motivation and concentration on the task at hand. In the experiment, a questionnaire was used to determine the level of subjective control [21] which characterizes a person's social responsibility [40]. The questionnaire has seven scales: general internality (I_1), internality regarding achievement (I_2), failure (I_3), family (I_4), work (I_5), interpersonal relationships (I_6), and also health (I_7). The lowest levels of internality in the samples

studied in the experiment, as well as in the already mentioned group of pilots discussed in Dzhapharadze, T.R., and Malishevsky, A.V. [17], are observed (see Fig. 7) regarding work (I_5) and failure (I_3), which indicates that the participants are somewhat inclined to avoid taking responsibility for what is happening at work and attribute their failures to external circumstances. This is consistent with the results of surveys conducted among other groups of aviation professionals.

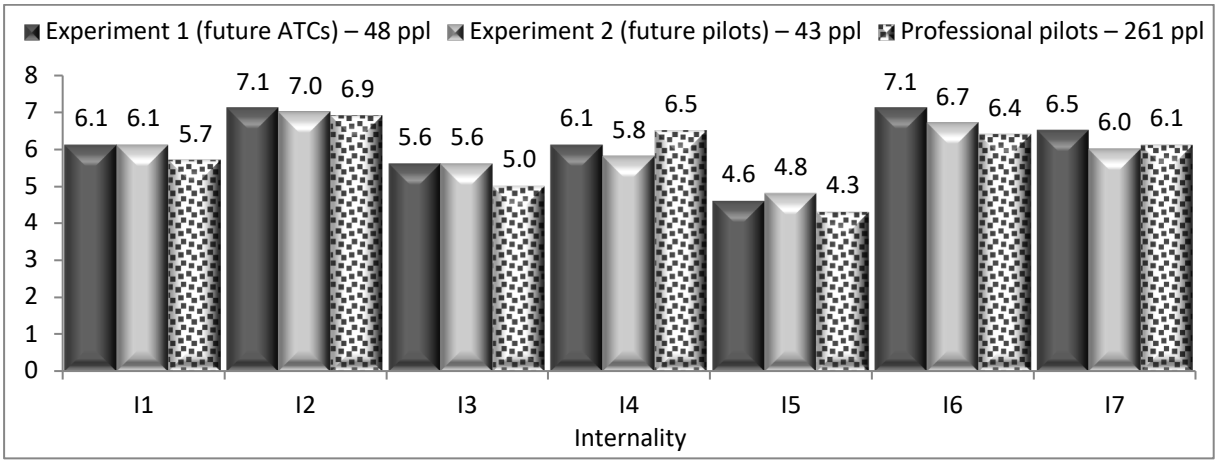

Fig. 7. Distribution of the average standard points by different types of internality among the participants and professional pilots

Based on all the results of assessing psychological characteristics that both directly and indirectly affect distraction tolerance, a correlation analysis was performed using Pearson's correlation coefficient [43]. A fragment of the results is given in Table 7, where the most significant correlations are shown. As can be seen, there were no strong correlations between the psychological characteristics being studied, and neither were their strong correlations between these characteristics and the results of the research using eye-tracking technology.

Table 7

Individual correlations obtained from the results of the experiment on the sample of 91 people

First value	Second value	$r_{corr.}$	Correlation strength	Correlation significance		First value	Second value	$r_{corr.}$	Correlation strength	Correlation significance
MS_{scores}	N	+0.5010	moderate	$p < 0.001$*		n	I_2	-0.2236	weak	$p < 0.05$***
MS_{scores}	I_1	-0.3649	moderate	$p < 0.001$*		r	I_7	+0.2521	weak	$p < 0.05$***
MS_{scores}	I_2	-0.3508	moderate	$p < 0.001$*		I_1	β_4	-0.2484	weak	$p < 0.05$***
MS_{scores}	I_3	-0.3545	moderate	$p < 0.001$*		I_2	β_1	+0.2246	weak	$p < 0.05$***
MS_{scores}	I_6	-0.4146	moderate	$p < 0.001$*		I_2	β_4	-0.2219	weak	$p < 0.05$***
MS_{scores}	β_4	+0.2291	weak	$p < 0.05$***		I_3	β_5	+0.2487	weak	$p < 0.05$***
α_2	β_1	-0.2300	weak	$p < 0.05$***		I_5	β_1	+0.2671	weak	$p < 0.05$***
α_3	I_2	+0.2224	weak	$p < 0.05$***		I_5	β_4	-0.2109	weak	$p < 0.05$***
α_3	β_1	+0.3020	moderate	$p < 0.01$**		I_6	β_4	-0.3052	moderate	$p < 0.01$**
α_3	β_2	-0.2247	weak	$p < 0.05$***		β_1	β_5	-0.4745	moderate	$p < 0.001$*
*Correlation significance: * – very highly significant; ** – highly significant; *** – significant*										

5. CONCLUSIONS

It is known that the influence of psychological factors on the performance of operators in the aviation industry affects such indicators as safety, timeliness, recoverability, readiness, and stress. As, firstly, safety is the operator's ability to remain functional for a certain period of time until an error is

made, and, secondly, his or her recoverability depends on the strength of the nervous system, that is, on such a characteristic as temperament, this experiment in one way or another touched upon all the factors influencing the reliability of the operator (in our case, the pilot or air traffic controller).

In the experiment, no strong correlations between psychological characteristics were revealed. Significant correlations are consistent with theoretical assumptions. Mental strength is highly significantly correlated with neuroticism. High levels of internality correspond with the most acceptable behavioral styles and conflict management strategies. The data presented give an idea of the participants' psychological characteristics, but the main conclusion is negative. The hypothesis about the correlation between the psychological characteristics discussed and distraction tolerance was not confirmed. No significant correlations between mental strength, IQ, temperament, and the results of the experiment were found at either the first or the second stage of the experiment.

Even though a negative result is still a result, it seems that the methodology of the experiment needs to be amended.

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