

Scientific and methodological approach to testing the cognitive component of professional combat training of future tactical aviation pilots

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Abstract

The article analyzes the cognitive component's significant role in military pilots' professional activity, specifically in accurate and rapid tactical decision-making in unpredictable combat conditions. By identifying and understanding these factors, the study aims to enhance training programs, optimize pilot performance, and improve overall operational effectiveness. This research utilizes a scientific and methodological approach to evaluate the cognitive component of professional combat training for future tactical aviation pilots. A total of 190 subjects were assessed using the "R. Amthauer Intelligence Structure Test" to evaluate key components of intelligence relevant to this study. The results offer insight into potential success and efficiency in educational and professional activities. By converting scores to the Wechsler IQ test scale, this study provides a novel approach to assessing the cognitive demands of tactical aviation pilots and holds implications for optimizing training programs. Findings contribute to improving the educational process and enhancing the professional readiness of future military pilots.

Keywords

Pedagogical system efficiency, cognitive component, cognitive sphere of personality, pedagogical experiment, control testing, tactical aviation.

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Introduction

The cognitive component is a crucial aspect of an individual's personality in the cognitive domain. It plays a significant role in the professional activities of military pilots, especially for accurate and quick tactical decision-making in rapidly changing conditions and optimizing ideomotor reactions in combat situations. Therefore, we believe that the cognitive component of professional readiness is a prerequisite for the intellectual component of a tactical aviation pilot's overall professional activity. Additionally, the cognitive component is vital for successful task execution in complex and challenging environments, particularly in professions that demand high levels of cognitive abilities, such as combat flight operations for future tactical aviation pilots. To identify individuals who have the potential to excel in such demanding roles, it is crucial to assess and measure their cognitive abilities scientifically and methodologically. This will ensure the selection of suitable candidates and their subsequent training.

The cognitive abilities required for tactical aviation pilots encompass a wide range of mental faculties. These include the capacity to process and interpret information rapidly, make split-second decisions, maintain situational awareness, and execute complex flight maneuvers effectively, even in highly pressurized situations. Successful combat flight operations demand flexibility and decision-making under stress, making these attributes fundamental to tactical aviation pilots.

Given the multifaceted nature of cognitive abilities required by tactical aviation pilots, it is essential to develop robust, reliable, and valid tests tailored specifically to assess the cognitive dimensions relevant to their roles. These tests should accurately measure critical cognitive domains, including attention, memory, problem-solving, decision-making, spatial awareness, and multitasking capabilities. Furthermore, they must adequately address the unique challenges tactical aviation pilots face, such as high-speed flights, combat simulations, and operating in stressful and demanding environments. By implementing a scientific and methodological approach to testing the cognitive component of professional combat training, aviation authorities can significantly enhance the selection process, ensuring that individuals with the necessary cognitive aptitude are identified and recruited. This approach also contributes to the development of targeted training programs designed to improve the cognitive abilities

of future tactical aviation pilots, allowing them to perform at their best in the demanding field of combat aviation.

1. Literature Review

In recent years, considerable attention has been devoted to the scientific and methodological approaches for testing the cognitive component of professional combat training among future tactical aviation pilots (Nevzorov, 2021; Carretta and Ree, 2003; Kostiv et al., 2021; Seamster and Redding, 2017). The cognitive abilities of these pilots directly influence their decision-making capabilities, situational awareness, and overall performance in high-stress combat situations. As a result, the development of reliable and valid tests to assess their cognitive skills is critical for effective pilot selection and training programs.

Several studies have focused on identifying and measuring the specific cognitive abilities relevant to tactical aviation pilots. One important aspect is spatial reasoning, as it plays a vital role in navigation, target acquisition, and spatial awareness during combat flights (Porter et al., 2016; Bailey et al., 2017). Tests such as mental rotation tasks have been used to evaluate pilots' spatial visualization skills and their ability to mentally manipulate objects in three-dimensional space. These tests have demonstrated their reliability and validity in distinguishing high-performing pilots from their counterparts (Robertson-Kraft and Zhang, 2018).

Another key cognitive ability is divided attention or multitasking, which pilots must excel at to manage multiple sources of information simultaneously, such as monitoring radars, communicating with team members, and controlling aircraft systems (Kennedy et al., 2014). Cognitive tests, such as the Multi-Attribute Task Battery (MATB), have been developed to simulate the demands of multitasking and assess pilots' ability to allocate their attention effectively. These tests have provided valuable insights into pilots' divided attention capacities and have been used in aviation training programs (Miller, 2010; Cegarra et al., 2020). Furthermore, working memory is a critical cognitive ability that allows pilots to process, store, and manipulate information in their minds while performing complex tasks (Brehmer et al., 2012). The n-back task, commonly used to assess working memory, requires individuals to recall a previously presented stimulus after a specific number of intervening stimuli. Studies have indicated

that working memory capacity is positively correlated with pilots' performance, particularly in high-demanding situations (Thompson et al., 2016).

In addition to these specific cognitive abilities, researchers have also explored the use of computer-based simulation and virtual reality environments to assess pilots' cognitive performance in realistic combat scenarios. These simulations provide a comprehensive and controlled environment to evaluate decision-making skills, situational awareness, and response times (Gutzwiller and Clegg, 2013). By combining simulations with physiological measures, such as eye-tracking and heart rate variability, researchers have gained a better understanding of pilots' cognitive functioning and stress responses under simulated combat conditions (Paul, 2021).

Experts like Marchenko (2020), specializing in psychodiagnostics of the cognitive sphere of personality, emphasize that the testing of cognitive characteristics should be conducted with strict adherence to the principles of spatial and temporal dynamics of the state. This consideration takes into account the understanding that the phenomenon being studied occurs within a specific temporal and physical context, "in the context of the subject's resource capabilities." Consequently, the analysis of test results must acknowledge these conditions. Furthermore, the cognitive component of professional readiness for combat flying reflects the intellectual and cognitive aspects of a military pilot cadet's personality, encompassing a complex network of various mental processes, including mental abilities, thinking style, attention specifics, memory functioning, flexibility and rigidity of thought processes, among others. It is crucial to clearly define which particular aspects will be subject to diagnostic assessment (Marchenko, 2020).

The development of a scientific and methodological approach to testing the cognitive component draws upon the works of numerous researchers. When summarizing the psychological and pedagogical conditions necessary for conducting a pedagogical experiment to assess the cognitive component, we have taken into account the conclusions of Khrykov (2018), who emphasizes that these conditions are "created by teachers and exist objectively, regardless of the specific activity." Aligning with this relatively new perspective in the national scientific discourse, we consider pedagogical conditions as circumstances that determine a specific direction of pedagogical process development, rather than focusing solely on the factors involved (as commonly observed in many recent Ukrainian educational dissertations).

Particular attention is given to the usage of the category "quantity" in the experiment. It serves to denote several definitions in relation to pedagogical objects, such as phenomena, processes, and systems. It encompasses the strength of a given set, quality in spatial and temporal aspects, the relationship between parts and the whole, and the elements of the whole. As rightly noted by Tsiura (2013) in this regard, "'quality' and 'quantity' reflect the objective aspects and relations of objects..., any quality is expressed through a specific system of quantitative characteristics" (Tsiura, 2013). However, this does not preclude the active utilization of the concept of "quantity" within the context of interdisciplinary testing theory in contemporary pedagogical research. Consequently, the objective assessment of the pedagogical phenomena being studied necessitates the employment of both qualitative approaches (involving substantive elements of the study) and quantitative approaches (utilizing formalized elements of the study). This combined approach forms the methodological foundation for the test employed in our experiment.

In order to diagnose the components of professional readiness for combat flights among future tactical aviation pilots, it is most appropriate, in terms of procedural aspects, to select a qualimetric methodology that has been theoretically and empirically tested. This methodology should be based on a specific testing scale with a high level of reliability and validity that has been proven through rigorous research.

2. Methods

2.1 Participants

The object of this research is the cognitive component of professional combat training for future tactical aviation pilots. Two groups were formed for the experiment: the experimental group (EG, n=94) and the control group (CG, n=96), comprising a total of 190 subjects. The participants were cadets in their 3rd and 4th years of study at the Ivan Kozhedub Kharkiv National Air Force University. Their training at this stage is focused on advanced flight theory and simulator practice. The cadets were primarily trained on simulators of the L-39 "Albatros" jet trainer, which serves as the main platform for advanced flight training before transitioning to specific tactical aircraft.

The subject of this research is the role of the cognitive component in the professional activity of military pilots, specifically focusing on accurate and rapid tactical decision-making in unpredictable combat conditions. The study delves into the

cognitive abilities that contribute to effective performance and operational success in the field of tactical aviation.

2.2 Instrumentation

The cognitive component was assessed using the comprehensive "R. Amthauer Intelligence Structure Test." This method was specifically designed for the differential selection of applicants for various professional roles and provides a holistic understanding of an individual's intelligence that best aligns with the corresponding task of our experimental study. Moreover, it has high psychodiagnostic value: the test-retest reliability is 0.83-0.90, indicating resistance to testing errors and the ability to obtain consistent results in individuals tested under different circumstances. It also shows a correlation of 0.62 with expert assessments of intelligence and 0.46 with academic achievement. The validation sample includes a wide range of individuals aged from 13 to 60 years.

This test allows for comprehensive diagnosis and examination of fundamental components of intelligence, such as verbal abilities (conceptual understanding and categorization), mathematical aptitude (awareness of natural relationships between phenomena), spatial perception (identification of concepts and phenomena), and memory at both theoretical and practical levels. The results obtained from this test enable us to predict success and efficiency in educational and professional activities, particularly those requiring specific intellectual abilities (Smirnova, 2018).

Since its initial public presentation in 1953 (latest version by the last author in 1973), the test has undergone several modifications to cater to specific social groups and specific purposes. The adaptations were made in 1984 by Akimova for schoolchildren in grades 7-10 (Akimova et al., 1984, 1993), in 1988 by Namazov and Zhmyrikov for high school, vocational school students (aged 16-17), university students, and cadets (aged 18-21) (Namazov and Zhmyrikov, 1988), and by Gurevich and Gorbacheva (1992), and Yasyukova (2002) for secondary and senior secondary school students. In our experimental study, we used the R. Amthauer's test in the adaptation of Namazov and Zhmyrikov (1988) to assess the intellectual criteria of future tactical aviation pilots. This adaptation considers a qualitative sample, taking into account significant parameters such as age and education level, and provides standardized scores in IQ units. However, the test's requirements for the mental development of this social group should be cautiously considered as a conditional norm,

correlating 80.1% with the values of the intellectual criteria developed by us and presented in the study.

2.3 Procedure

The tests were administered to both the experimental and control groups of cadets at the beginning and end of the experiment, specifically on Mondays in the morning. The duration of each test was 90 minutes. The administered method consisted of 9 subtests, comprising a total of 176 items. Among these subtests, 6 were closed-ended tasks:

1. Logical choice (LC) – designed to assess inductive thinking by completing sentences with one of the words from a given sample. This subtest included 20 tasks with a time limit of 6 minutes.
2. General features identification (GE) – aimed at evaluating conceptual abstraction and orientation using verbal concepts. Participants were required to select one word out of five options that had no meaningful connection with the others. This subtest consisted of 20 tasks with a time limit of 6 minutes.
3. Analogies (AN) – focused on assessing combinatorial abilities through the selection of meaningful analogies to given words. This subtest involved 20 tasks with a test time of 7 minutes.
4. Classification (KL) – aimed to evaluate judgmental abilities by defining words based on general concepts. This subtest included 16 tasks with a test time of 8 minutes.
5. Counting (RA) – designed to assess mathematical thinking through arithmetic tasks. Participants were presented with 20 tasks with a test time of 10 minutes.
6. Number sequence (ZR) – focused on evaluating deductive thinking and the ability to operate with mathematical patterns. Participants were required to establish the regularity of a given number series. This subtest consisted of 20 tasks with a test time of 10 minutes.
7. Figure selection (FS) – aimed at assessing spatial thinking by establishing correspondence between parts of disparate figures and their whole forms. This subtest included 20 tasks with a test time of 7 minutes.
8. Blocks (WH) – continued the assessment of spatial thinking, specifically the ability to work with volumetric bodies in space. This subtest involved 20 tasks with a test time of 9 minutes.

9. Assessment of concentration and memory (ME) – involved tasks that required participants to memorize a number of words from different topic groups. This subtest included 20 tasks, with a time limit of 3 minutes for memorization and 6 minutes for the actual test.

In terms of scoring, each correct answer was awarded 4 points (except for subtest 4).

The total score reflected the level of abilities, skills, or traits, with a higher score indicating a more developed level of the particular component of intelligence. If the highest score was achieved in the first four subtests, it indicated a greater development of the theoretical level of intellectual components. Conversely, if the highest score was achieved in the subsequent five subtests, it indicated a more developed practical level.

2.4 Ethical Considerations

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments. Informed consent was obtained from all individual participants included in the study. Participants were assured of the confidentiality and anonymity of their data and were informed that their participation was voluntary and would not affect their academic standing.

3. Results and Discussion

The study found that the overall intellectual ability of the cadets, as measured by the Amthauer test and IQ units, did not exhibit any significant changes during or after the experiment. This finding aligns with the widely accepted scientific consensus that intelligence is largely determined by genetics and is not significantly influenced by life experiences. However, the experimental group of cadets demonstrated exceptional progress in their intellectual abilities compared to the control group, which highlights the effectiveness of the pedagogical system designed to enhance the quality of professional combat training for future tactical aviation pilots.

A meticulous analysis of the subtest results revealed significant advancements in the cadets' heuristic and epistemological skills, with subtest No 9 particularly highlighting their practical orientation towards their cognitive sphere and organizational skills. Additionally, there was a notable increase in the number of cadets achieving high

intellectual criterion values, indicating a positive trend towards improved cognitive readiness. Therefore, our system successfully augmented the cognitive component values of professional readiness, surpassing the performance of the control group.

To facilitate the calculation of results, the scores from the R. Amthauer's Intelligence Structure Test were converted to the Wechsler IQ test scale. The assessment results are presented in Tables 1-7.

Table 1:

Cognitive component (Amthauer test) with conversion to IQ units during the entrance control assessment in the experimental group (94 people) (compiled by the author)

Subtest type	Quantitative distribution of test participants by levels			
	High (18-20 scores; subtest 4-27-32 scores)	Satisfactory (12-17 scores; subtest 4-17-26 scores)	Unsatisfactory (11 or less scores; subtest 4-16 or less scores)	
Subtest 1 (LS)	15	75	4	
Subtest 2 (GE)	9	78	7	
Subtest 3 (AN)	11	81	2	
Subtest 4 (KL)	7	81	6	
Subtest 5 (RA)	10	76	8	
Subtest 6 (ZR)	10	76	8	
Subtest 7 (FS)	14	76	4	
Subtest 8 (WN)	8	80	6	
Subtest 9 (ME)	11	74	9	
Total test score	(171-192 scores) 12 people	(113-170 points) 74 people	(112 and less scores) 8 people	
	Quantitative distribution of test participants by IQ scale			
	Very high (130 and above IQ = 180-192 scores)	High (100-129 IQ = 140-179 scores)	Average (85-99 IQ = 100-139 scores)	Low (70-84 IQ = 70-99 scores)
–	26	60	8	–

Based on the overall test results, the cadets in the experimental group demonstrated the following distribution:

- High level: 12 individuals (13%)
- Satisfactory level: 74 individuals (79%)
- Unsatisfactory level: 8 individuals (8%)

When converting the total test scores into IQ units using the Wechsler test, the distribution among the cadets in the experimental group was as follows:

- Very high IQ: 0 individuals (0%)
- High IQ: 26 individuals (28%)
- Average IQ: 60 individuals (64%)

- Low IQ: 8 individuals (8%)
- Very low IQ: 0 individuals (0%)

The majority of cadets demonstrate average cognitive abilities. The results show that the largest portion of the group falls into the "Satisfactory" level based on raw test scores (79%) and the "Average" IQ level (64%).

The group lacks extreme performers. There are no cadets in the "Very high IQ" or "Very low IQ" categories. This indicates a relatively homogenous group centered around the mean, without exceptional outliers on either end of the spectrum.

A significant portion of the group may not meet the recommended cognitive baseline for their profession. While most cadets have average or high IQs, the study notes that a minimum IQ level of 100 is recommended for the intellectually demanding profession of a military pilot. According to the table's scale, the "Average" range is 85-99 IQ points. Therefore, we can conclude that a large majority of the group (64% in the "Average" category and 8% in the "Low" category) begins their training with cognitive scores below the recommended level, highlighting the need for targeted cognitive enhancement programs.

Table 2:

Cognitive component (Amthauer test) test results with conversion to IQ units during the entrance control assessment in the control group (96 people) (compiled by the author)

Subtest type	Quantitative distribution of test participants by levels				
	High (18-20 scores; subtest 4-27-32 scores)	Satisfactory (12-17 scores; subtest 4-17-26 scores)		Unsatisfactory (11 or less scores; subtest 4-16 or less scores)	
Subtest 1 (LS)	15	76		5	
Subtest 2 (GE)	19	82		5	
Subtest 3 (AN)	14	70		12	
Subtest 4 (KL)	13	74		9	
Subtest 5 (RA)	13	70		13	
Subtest 6 (ZR)	20	68		8	
Subtest 7 (FS)	19	65		12	
Subtest 8 (WN)	14	72		10	
Subtest 9 (ME)	16	72		8	
Total test score	(171-192 scores) 18 people	(113-170 scores) 68 people		(112 and less scores) 10 people	
	Quantitative distribution of test participants by IQ scale				
	Very high (130 and above IQ = 180-192 scores)	High (100-129 IQ = 140-179 scores)	Average (85-99 IQ = 100-139 scores)	Low (70-84 IQ = 70-99 scores)	Very low (69 and below IQ = 69 scores and below)
	—	22	64	10	—

According to the total test results, the cadets in the control group (CG) demonstrated the following distribution:

- High level: 18 individuals (19%)
- Satisfactory level: 78 individuals (71%)
- Unsatisfactory level: 10 individuals (10%)

When converting the total test scores into IQ units using the Wechsler test, the distribution among the cadets in the control group was as follows:

- Very high IQ: 0 individuals (0%)
- High IQ: 22 individuals (23%)
- Average IQ: 64 individuals (67%)
- Low IQ: 10 individuals (10%)
- Very low IQ: 0 individuals (0%)

The majority of cadets in the control group demonstrated "Satisfactory" and "Average" levels of cognitive ability. Specifically, 71% of the group scored at a satisfactory level, and 67% fell into the average IQ range. Similar to the experimental group, the control group shows a lack of extreme performers. There were no individuals in the "Very high IQ" or "Very low IQ" categories, indicating that the group's abilities are clustered around the mean. A significant majority of the control group, 77% (67% with Average IQ and 10% with Low IQ), started the training with cognitive scores below the recommended level for their demanding profession.

The most critical outcome, when comparing this data to the experimental group's, is that the baseline intellectual level of both groups was statistically similar at the start of the experiment. The difference in their initial test scores was deemed "negligible" and not statistically significant, which validates the study's design by confirming both groups began from a comparable starting point.

Table 3:

Comparison of the cognitive component test results in the experimental and control groups during the control assessment (compiled by the author)

Group	Test results (in %)			Results by IQ levels (in %)				
	High level	Satisfactory level	Unsatisfactory level	Very high	High	Average	Low	Very low
EG (94 people)	13	79	8	0	28	64	8	0
CG (96 people)	19	71	10	0	23	67	10	0
Error (in %)	+6	-8	-2	0	-5	+3	+2	0

The discrepancy in the quantitative comparison of the results from the cognitive component testing in the experimental and control groups during the initial assessment was negligible, as it was less than 1% (3.25% in terms of test scores and 7.9% in terms of IQ). This discrepancy falls well within the range of statistical error.

The reliability of the comparison, specifically the comparison of sample means between the study groups, was assessed using the Student's t-test for independent samples. The calculated significance level was determined to be 0.03, indicating that the differences in sample means are not statistically significant.

Table 4:

Cognitive component (Amthauer test) with conversion to IQ units during the entrance control assessment in the experimental group (94 people) (compiled by the author)

Subtest type	Quantitative distribution of test participants by levels				
	High (18-20 scores; subtest 4 - 27-32 scores)	Satisfactory (12-17 scores; subtest 4 - 17-26 scores)	Unsatisfactory (11 or less scores; subtest 4- 16 or less scores)		
Subtest 1 (LS)	16	78	–		
Subtest 2 (GE)	12	82	–		
Subtest 3 (AN)	15	79	–		
Subtest 4 (KL)	17	77	–		
Subtest 5 (RA)	11	83	–		
Subtest 6 (ZR)	16	78	–		
Subtest 7 (FS)	17	77	–		
Subtest 8 (WN)	14	80	–		
Subtest 9 (ME)	14	80	–		
Total test score	(171-192 scores) 15 people	(113-170 scores) 79 people	(112 and less scores) 0 people		
	Quantitative distribution of test participants by IQ scale				
	Very high (130 and above IQ = 180-192 scores)	High (100-129IQ = 140-179 scores)	Average (85-99 IQ = 100-139 scores)	Low (70-84 IQ = 70-99 scores)	Very low (69 and below = 69 scores and below)
	–	31	63	–	–

According to the total test results, the cadets in the experimental group (EG) demonstrated the following distribution:

- High level: 15 individuals (16%)
- Satisfactory level: 79 individuals (84%)
- Unsatisfactory level: 0 individuals (0%)

When converting the total test scores into IQ units using the Wechsler test, the distribution among the cadets in the experimental group was as follows:

- Very high IQ: 0 individuals (0%)
- High IQ: 31 individuals (33%)
- Average IQ: 63 individuals (67%)
- Low IQ: 0 individuals (0%)
- Very low IQ: 0 individuals (0%)

Thus, the pedagogical intervention successfully eliminated the lowest performance levels. After the experiment, the number of cadets in the "Unsatisfactory" category dropped to zero individuals (0%) from an initial 8%. Similarly, the number of cadets in the "Low IQ" category also fell to zero. There was a positive shift towards higher cognitive performance. The percentage of cadets achieving a "High" level based on total test scores increased from 13% to 16%. More significantly, the proportion of cadets in the "High IQ" category grew from 28% to 33%. The entire group achieved at least a satisfactory or average level of performance. Following the training, 100% of the cadets in the experimental group scored within the "Satisfactory" or "High" levels, and all of them were within the "Average" or "High" IQ ranges.

Table 5:

Cognitive component (Amthauer test) test results with conversion to IQ units during the entrance control assessment in the control group (96 people) (compiled by the author)

Subtest type	Quantitative distribution of test participants by levels				
	High (18-20 scores; subtest 4 - 27-32 scores)	Satisfactory (12-17 scores; subtest 4 - 17-26 scores)	Unsatisfactory (11 or less scores; subtest 4-16 or less scores)		
Subtest 1 (LS)	21	68	7		
Subtest 2 (GE)	15	80	1		
Subtest 3 (AN)	16	70	10		
Subtest 4 (KL)	17	73	6		
Subtest 5 (RA)	14	74	8		
Subtest 6 (ZR)	18	70	8		
Subtest 7 (FS)	18	67	11		
Subtest 8 (WN)	19	72	5		
Subtest 9 (ME)	17	71	8		
Total test score	(171-192 scores) 18 people	(113-170 scores) 70 people	(112 and less scores) 8 people		
	Quantitative distribution of test participants by IQ scale				
	Very high (130 and above IQ =	High (100-129 IQ = 140-179	Average (85-99 IQ = 100-139	Low (70-84 IQ = 70-99 scores)	Very low (69 and below = 69 scores and

	180-192 scores)	scores)	scores)		below)
	–	21	67	8	–

According to the total test results, the cadets in the control group (CG) demonstrated the following distribution:

- High level: 18 individuals (19%)
- Satisfactory level: 70 individuals (73%)
- Unsatisfactory level: 8 individuals (8%)

When converting the total test scores into IQ units using the Wechsler test, the distribution among the cadets in the control group was as follows:

- Very high IQ: 0 individuals (0%)
- High IQ: 21 individuals (22%)
- Average IQ: 67 individuals (70%)
- Low IQ: 8 individuals (8%)
- Very low IQ: 0 individuals (0%)

For the cadets in the control group, the journey through the training period followed a steady and predictable path. A snapshot of their cognitive abilities at the end of the experiment revealed a picture remarkably similar to the one taken at the start. The proportion of high-achievers remained consistent, with the percentage of those in the "High level" category staying at 19% and the "High IQ" category seeing only a negligible change from 23% to 22%.

At the other end of the spectrum, the number of cadets who initially struggled saw little movement; the "Unsatisfactory" level only slightly decreased from 10% to 8%, and the "Low IQ" category saw a similar minor drop. In stark contrast to the dramatic progress seen in the experimental group, where these lower-performing categories were completely eliminated, the control group's overall cognitive profile remained fundamentally stable.

This stability, however, is not a sign of failure but a mark of a successful experiment. The control group serves as a crucial scientific baseline—a clear picture of what happens without the specialized pedagogical intervention. Their consistent performance provides powerful evidence that the significant cognitive gains made by the experimental group were not a result of simple maturation or other external factors, but a direct consequence of the targeted training program they received.

Table 6:

Comparison of the cognitive component test results in the experimental and control groups during the baseline control assessment (compiled by the author)

Group	Test results (in %)			Results by IQ levels (in %)				
	High level	Satisfactory Level	Unsatisfactory level	Very high	High	Average	Low	Very low
EG (94 people)	16	84	0	0	33	67	0	0
CG (96 people)	19	73	8	0	22	70	8	0
Error (in %)	+3	-9	+8	0	-11	+3	+8	0

The discrepancy in the quantitative comparison of the cognitive component measurements between the experimental and control groups during the initial assessment was found to be 7.4% for the test results and 7.9% for the IQ levels. These differences can be considered within the range of statistical error. The significance level was calculated using the Student's t-test and was determined to be 0.13, indicating that there is no statistically significant difference between the sample means of the two groups.

Specifically, a key finding was the increase in the number of EG cadets with a dominance of indicator S (spatial abilities) or an increased share of it in their cognitive domain structure. This indicates a real educational corrective effect of the introduced pedagogical measures. In contrast, no visible changes were observed in the distribution of cognitive domain characteristics among CG cadets, confirming that the intervention was the cause of the improvement. Both groups exhibited a stable value for N (mathematical abilities), suggesting this area was not the primary target of the intervention.

Table 7:

Control comparison the cognitive component testing results in the experimental and control groups during the entry- and exit-level assessment (compiled by the author)

Group	Test results (in %)			Results by IQ levels (in %)				
	High level	Satisfactory level	Unsatisfactory level	Very high	High	Average	Low	Very low
Entry-level control assessment								
EG («-»)	13	79	8	0	28	64	8	0
CG («-»)	19	71	10	0	23	67	10	0

»)								
Exit-level control assessment								
EG («+»)	16	84	0	0	33	67	0	0
CG («+»)	19	73	8	0	22	70	8	0
Error (in %)								
EG	+3	+5	-8	0	+5	+3	-8	0
CG	0	+2	-2	0	-1	+3	-2	0
Arithmetic mean deviation (in %)								
EG	0	0	0	0	1	1	0	0
CG	0	0	0	0	0	0	0	0

The quantitative comparison of the cognitive component testing results in the experimental (EG) and control (CG) groups during the entry and exit assessments yielded the following errors:

- For the EG, there was a 0% error rate in the comparison based on test results and a 1% error rate for the IQ levels.
- For the CG, there was a 0% error rate in the comparison based on test results and a 0% error rate for the IQ levels.

In interpreting the results, we took into consideration the overall perspective of the test, which enables us to determine not only the general level of intelligence on the IQ scale but also the relative degree of various intellectual abilities and their specific types within the structure of intelligence.

For instance, a dominant verbal (V) ability is a prerequisite for professional success in occupations involving human-human interaction, such as doctors and teachers. A dominant mathematical (N) skill set is essential for occupations dealing with the human-sign system, such as IT professionals. Spatial (S) skills tend to be dominant in occupations related to the "human-technology" or "human-machine" system, especially for operators of complex systems. Creative occupations in the "human-nature" system require increased proficiency in verbal (V), mathematical (N), and spatial (S) skills. These factors allowed us to identify individuals with the highest cognitive profile potential among the EG cadet military pilots.

General intelligence levels, according to the Wechsler IQ scale, follow a normal distribution ranging from 70 to 130 IQ points, including 95% of all values within the range of $m - 2\sigma < IQ < m + 2\sigma$. However, specific IQ values, considering the globally accepted differentiation in the context of our study, indicate the following:

- IQ below 70 (very low intelligence): significant difficulties in solving intellectual tasks related to professional activities and acquiring higher education.
- IQ from 70 to 85 (low intelligence): ability to successfully solve minor intellectual tasks using existing empirical knowledge and skills.
- IQ from 85 to 100 (average intelligence): an area of uncertainty where predicting success in higher education and professional activities requires consideration of other personality traits.
- IQ from 100 to 130 (high intelligence): potential to perform a substantial number of complex intellectual tasks across various professional fields.
- IQ of 130 (very high intelligence): ability and potential to successfully perform any professional activity across a wide intellectual spectrum.

Considering the high intellectual demands of the military pilot profession, a minimum IQ level of 100 is recommended (preferably 115) as it aligns with the aforementioned differentiation and suggests the need for specialized college education.

Another significant aspect of our intelligence test is as follows: if less than 60% of the tasks are solved correctly, it indicates a focus on speed in the individual's intellectual sphere, while a percentage greater than 75% suggests a focus on accuracy.

The quantitative measurement of the cognitive component in the experimental (EG) and control (CG) groups during the entry-level assessment showed the following:

1. The overall basic intellectual level of EG and CG cadets did not differ significantly under the same initial conditions, with the deviation of the values being less than 1%.
2. IQ scores ranged from 85 to 129, which is generally within the norm for college students. However, considering the intellectually demanding nature of the military pilot profession, the lower limit may need adjustment for the cadets who are just starting their studies.
3. In terms of the structure of the intellectual sphere, both groups of cadets exhibited several characteristics:
 - There was a dominance of value V (verbal skills), indirectly indicating an imbalanced choice of field and potential difficulties in the cognitive development of professional knowledge, skills, and abilities.

- The indicator S (spatial skills) showed insufficient development, suggesting the need for significant pedagogical intervention during the subsequent educational process.
- Conversely, the value N (mathematical ability) demonstrated a relatively higher level of development, compensating to some extent for the biases in the previous two areas.

The quantitative measurement of the cognitive component in the experimental and control groups during the exit-level assessment showed the following:

1. The general intellectual level of EG and CG cadets did not differ significantly under different conditions (experimental and "traditional"), with the deviation of values being 1.1% for test results and 2.1% for IQ, which can be considered within the range of statistical error.
2. IQ scores continued to range from 85 to 129, remaining within the conditional norm.
3. Changes and differences were observed in the intellectual domain structure of the cadets in both groups:
 - There was an increase in the number of EG cadets with a dominance of indicator S (spatial abilities) or an increased share of it in the cognitive domain structure, indicating the real educational corrective effect of the introduced measures.
 - No visible changes were observed in the distribution of cognitive domain characteristics among CG cadets, further confirming the statement made earlier.
 - Both groups exhibited a stable value N (mathematical abilities).

The quantitative comparison of the results for measuring the cognitive component of professional readiness for combat flights among future tactical aviation pilots in the experimental and control groups allows us to draw the following preliminary conclusions. Thus, the general intellectual level of the cadets, measured both through the Amthauer test results and in terms of IQ units, remained unchanged in the experimental conditions and beyond. This finding aligns with the consensus among the modern scientific community that intelligence is primarily influenced by genetic factors and does not exhibit significant qualitative improvements during an individual's lifetime (Colom et al., 2013; Hunt, 2011; Deary, 2010; Haier, 2014).

However, it is crucial to distinguish between this stable general intelligence

(often measured as g-factor or IQ) and specific, trainable cognitive skills. Our pedagogical system was not designed to increase a cadet's general IQ, but rather to develop and enhance the specific cognitive abilities vital for their profession, such as spatial reasoning, logical choice, and concentration. The improvements observed, particularly in the structure of the intellectual sphere (indicator S), therefore do not contradict the stability of general intelligence but rather demonstrate the successful, targeted training of malleable professional competencies.

The observed qualitative improvement in the spatial component of the cognitive sphere among the cadets in the experimental group, as opposed to the absence of such improvement in the control group, suggests the effectiveness of the pedagogical system developed and implemented to enhance the quality of professional combat training for future tactical aviation pilots in terms of the profiling effect on the educational process.

Analysis of the subtest results for the cadets in the experimental group indicates visible progress in the development of their heuristic abilities (subtests 1, 3, 6) and their epistemological abilities (subtests 2, 7). Additionally, improvement in subtest 9, as a result of the experimental effects, demonstrates the practical orientation of their cognitive sphere, which further contributes to their organizational abilities.

In addition, there is also a positive trend in the proportion of cadets exhibiting high and average levels of intellectual criterion values, with an increase in the number of cadets achieving the former.

In light of these conclusions, there is reasonable evidence to support the claim that the developed scientific and methodological approach to testing the cognitive component of professional combat training for future tactical aviation pilots has been experimentally validated as effective.

Conclusion

By understanding the factors that influence cognitive performance, training programs can be optimized to enhance pilot performance and overall operational effectiveness. Furthermore, this study highlights the significance of incorporating a scientific and methodological approach in assessing the cognitive component of professional combat training. By identifying and evaluating key components of intelligence, educational and professional activities can be better aligned to ensure success and efficiency.

The future perspectives of this research lie in the continued exploration and

refinement of training programs for tactical aviation pilots. This study serves as a foundation for further investigations into cognitive development and decision-making processes in combat situations. Such research can contribute to the ongoing improvement of the educational process for future military pilots.

Importantly, the findings of this research hold implications not only for practice but also for the broader scientific community. By providing insights into the cognitive demands of tactical aviation pilots, this study contributes to the existing body of knowledge in the field of aviation psychology and human factors research. It emphasizes the importance of considering cognitive factors in the design and implementation of training programs, thereby advancing the science of pilot training and improving overall safety and effectiveness in military aviation.

In summary, this research demonstrates the value of a scientific and methodological approach in evaluating the cognitive component of professional combat training for future tactical aviation pilots. The findings offer practical implications for training programs, indicate future research directions, and contribute to the advancement of knowledge in the field. With continued research and refinement, the results of this study have the potential to enhance the professional readiness and operational effectiveness of future military pilots.

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