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ORIGINAL ARTICLE

# GENETIC ASPECTS OF PILOTS' SPATIAL ORIENTATION

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**Introduction:** The paper presents the results from a study of pilots' spatial orientation in the civil aviation from genetic point of view. The study addresses the question of whether geocentrics are better suited to become pilots than egocentrics.

**Methods:** The research was conducted among two groups: group of pilots and group of representatives of other professions. The study was performed in the real flight conditions and laboratory conditions. 300 civil aviation pilots and test-pilots (each with over 5000 flight hours) and 150 non-professionals.

**Results:** The results show that the leading type of spatial orientation depends on the conditions in which the persons must make a decision.

**Conclusions:** There is no evidence supporting the idea that humans genetically fall into two types: egocentrics and geocentrics, according to their dominant type of spatial orientation.

**Keywords:** genetic aspects, spatial orientation in flight, egocentrics, geocentrics

**Figures:** 1 • **References:** 7 • **Full-text PDF:** http://www.pjamp.com • **Copyright** © 2014 Polish Aviation Medicine Society, ul. Krasińskiego 54/56, 01-755 Warsaw, license WIML • **Indexation:** Index Copernicus, Polish Ministry of Science and Higher Education

## INTRODUCTION

Human orientation in space is expressed by the ability to perceive one's position in the physical world, including the distance at which objects are situated with respect to one another, and with regards to oneself, the direction in which they are located and in which they move, as well as the size and shape of objects. The ability for spatial orientation is determined by a large number of constant and temporary relationships between the sensory modalities, as well as the channel and content of the perceptions, experience, knowledge, interests and psychological state at the moment of perception.

The basis for spatial orientation is orientation with reference to the vertical, coinciding with the effect of gravity. The gravitational vertical axis is the principal one in the system for detecting the characteristics of the surrounding space.

Spatial orientation during flight differs considerably from orientation on the ground. In the two-dimensional conditions on the surface of the earth the leading signals are the ones produced by the vestibular analyzer, and supplemented by the other sensory modalities whereas in the three-dimensional space during flight the leading sensory analyzer is that of vision; information provided by it often contradicts that coming from the vestibular system. The reasons for this phenomenon are objective. During flight a pilot is subjected to linear and angular accelerations along the three axes of the aircraft. The emergence of sensory perceptions when accelerations are present, is determined by the duration of the acceleration, as well as the strength and gradient of their increase. If the angular accelerations, or the gradients of their increase are small, significant changes in the spatial position of the aircraft can occur without the emergence of adequate perceptions, which causes doubts in the readings of navigational instruments in the cockpit – which becomes the basis for a cognitive conflict between "I feel", and "I know". This conflict often results in the loss of spatial orientation.

Alan Benson defines the concept of "spatial disorientation in flight" as the loss of the pilot's correct sense of his own, and his aircraft's correct position, movement and altitude, with regards to the fixed coordinate system of the Earth's surface and the gravitational vertical. In a broader sense, the term includes the loss of the correct sense of the position, movement and altitude of the pilot's own aircraft with reference to the position, movement and altitude of other aircraft [1].

It was spatial disorientation which was explicitly singled out by the investigation committee, as being the main factor that led to the crash of a Boeing 737 on 14.09.2008 near the city of Perm, resulting in death of the 88 persons on board the aircraft.

Pavel Kovalenko conducted a series of experiments on pilots in a leading airline company, which uses Boeing aircraft [3,6]. The stimuli was an attitude indicator (AI) with "direct" indication for roll and pitch ("inside-out" – moving sky and earth and an unmoving aircraft), used to model the situation, which led to the crash of the Boeing-737. The results show that 29 (78.4%) of the 37 tested pilots made mistakes in determining the direction of the roll and pitch; on more than 100 occasions they became disoriented by the direct indication displayed on AI.

It was also established, that during the last 20 years in the Russian civil aviation, spatial disorientation had been the cause of 10 aircraft crashes; more than 1000 lives had been lost, with material losses exceeding 1.5 billion USD. The situation in the western countries, including the US, have been similar.

At the same time, there have been no reported aircraft crashes caused by spatial disorientation, involving aircraft utilizing "reverse" indication ("outside-in" – unmoving sky and earth, and moving aircraft silhouette, displaying roll).

During the discussion of the results from previously conducted research [7], at a conference of the independent investigators of air incidents to the International Aviation Committee (IAC), the opinion was expressed that the main reason for erroneous actions, when using a "direct" indication, is the natural, genetically determined, inherited human orientation; according to this view humans are divided into two groups: egocentrics and geocentrics.

Egocentrics perceive themselves as the unmoving spatial orientation center, and the Earth and space as moving; geocentrics perceive the Earth as a center, i.e. perceive it as unmoving and themselves as moving. As a result, it was suggested, that pilots should be selected among people having natural geocentric orientation, since they would not make spatial orientation mistakes, regardless of the type of indication, unlike people with egocentric orientation.

In search of an answer to the question raised, Pavel Kovalenko conducted research among two groups of people – professionals (pilots), and nonprofessionals (representatives of other professions).

## METHODS

### Research hypothesis

As in experimental conditions the respondents show a tendency to change their spatial orientation method, it can be accepted that the spatial orientation of humans is not genetically predetermined.

Genetic factors represent the evolutionary inheritance of the individual. They are of key importance with regards to characteristics such as intelligence, temperament, emotions. The specifics of temperament, for example, are exhibited very early in life, and are difficult to change through training (experience plays a role, but their development takes place according to the inherited genetic code). The role of genes is to ensure a range of abilities, which then develop under the influence of the environment, but only within the limitations of the genetic code.

The hypothesis is based on the results from preliminary research, which proved the existence of three methods of spatial orientation, both during visual, and instrumental flight, when using a "direct" indication AI. The three methods differ mainly with regards to the choice of the unmoving image (aircraft, the earth and the horizon, the pilot himself), which become the center of the system for registering the movement in space. The second element, which distinguishes the three methods, is the choice of the moving component, which is perceived as controllable (the aircraft, the earth and the horizon, the pilot himself).

The first spatial orientation method (1 SOM) perceives the Earth, and the line of the horizon as static, while moving the controllable objects during visual flight are the cockpit of the aircraft (the contour on the windshield); during instrument flight, the moving object is the silhouette of the aircraft displayed by the AI. The operator perceives himself as being inside the controlled object and moving together with it.

The second spatial orientation method (2 SOM) represents both the Earth (the line of the natural horizon), and the cockpit (the contour on the windshield) during visual flight, as well as the Earth and the silhouette of the aircraft during instrument flight, as moving with regards to one another. For example, during a left roll, the silhouette rotates to the left, and the Earth rotates to the right. The operator is static.

With the third spatial orientation method (3 SOM) the cockpit and the operator's own body are perceived as static, while the Earth is perceived as moving, i.e. the line of the horizon becomes a controllable object.

Preliminary research [2,5], conducted by Pavel Kovalenko showed that during visual flight, 61% of the tested pilots used 1 SOM, 34% used 3 SOM, 3% used 2 SOM, and 2% used a combination of 1 SOM and 2 SOM. The results seem to support the claim that there exist two basic groups of people: geocentrics (1 SOM), and egocentrics (3 SOM).

### Research Method and Procedure

For the purposes of the research and in order to check the hypothesis, a graphical reconstructive method was applied, based on the analysis of drawings and verbal answers [4].

The stimulus material allowed to reconstruct the objective content of the pilots' activity, thus highlighting those images of objects, which were used by the respondents during information processing, preceding and guiding the motor response (Fig. 1.).

The respondents received a general instruction: "Draw what you see through the windshield of the aircraft's cockpit, or on the indicator of the AI in the process of using it."

They drew pictures of the silhouette on the windshield and the lines of the natural horizon and the AI during visual and instrumental flight, while performing right and left rolls, ranging from 10° to 130°. Drawings were produced on a "blank" background.

The instructions for this part of the test required to draw whatever could be seen through the cockpit windshield, using the symbols depicting the windshield of the aircraft cockpit and the horizon, superimposed on one another, during a 10° left roll and 30° right roll, etc. as well as to mark with the numbers 1 and 2 the symbols, according to the sequence of their depiction.

During the second part of the test, the rolls are depicted on the background of the symbols representing the windshield, the interior of the cockpit, or the line of the natural horizon. Such an approach provides an initial point for the spatial orientation system. Comparing the drawings with a "clear" background to those with a defined starting point provided the opportunity to determine the stability of the spatial orientation methods. After drawing each picture, the respondents numbered the sequence of the drawings. The graphical answers (drawings) were complemented by the answers to the questions of the inquiry.

The study was conducted under the conditions of real flight, onboard a An-28 laboratory-airplane, in the flight simulator of the Ka-32 helicopter, as well as in laboratory conditions. 300 civil aviation

*Please, provide some information about you:*

Name , or nickname .................................   Total number of flight hours ...................

Birthdate ..................

Position ...............................   Age ........................

*Draw what you see through the windshield of the cockpit of the aircraft, or on the indicator display when working with it.*

1. By using the symbols on the windshield of the aircraft cockpit and the depiction of the line of the natural horizon, by superimposing them, one on top the other, and by numbering them 1 and 2, according their sequence, draw what you can see through the cockpit ‘s windshield during:

*Symbols on the windshield of the cockpit and the line of the natural horizon*

1.1. Left roll 10°

1.2. Right roll 35°

1.3. Left roll 70°

1.4. Right roll 105°

1.5. Left roll 130°

2. Using the symbol on the windshield of the cockpit, draw what you can see during a 30° right bank.

Fig. 1. An excerpt from the “Direct Indication” test, by Pavel Kovalenko. (In the Russian original, the author’s title of the test is “View from the Windshield of the Cockpit).

pilots and test-pilots (each with over 5000 flight hours), as well as 150 non-professionals were subjected to the test. Over 20 000 drawings were analyzed.

## RESULTS

The analysis of the results of the test show that of the pilots using the 1 SOM during the first part of the test (on a "clean" background), only 15.4% kept using the same method during the second part, when there was a symbolic depiction on the windshield of the cockpit, provided as an starting point. During the second part of the test, the remaining 84.6% of the pilots used the 3 SOM. As regards the non-professional group, 18.2% of participants kept using 1 SOM; the remaining 81.8% switched to using 3 SOM.

Analyzing the test times of pilots by using the 1 SOM initially, and then switching to the 3 SOM shows, that they needed approximately the same amount of time to adapt to the new spatial orientation system, as did the pilots using only 3 SOM, however, the former ones made more mistakes.

If during the second part of the test the imposed starting point was the depiction of the frontal part of the cockpit, 98.2% of the pilots switched from using 1 SOM to using 3 SOM. The difficulties in this case were expressed in the longer times needed for completing the test and the increased number of mistakes.

When the starting point was the depiction of the line of the horizon, both the pilots, and the non-professionals taking part in the test, who used the 3 SOM during the first part of the test, chose the 1 SOM during the second part, 75.8% of the pilots and 86.2% of the non-professionals, respectively.

Geocentrics, who were not willing to change their 1 SOM, irrespective of the changing conditions of the test, represented an insignificant percentage of the total number of participants. The rest of the respondents demonstrated flexibility, as regards the choice of the method of spatial orientation, which confirmed the research hypothesis: there are no reasons to assume that either the egocentric, or geocentric spatial orientation methods are genetically predetermined.

Judging by the results from the study, there is also no reason to strictly separate people into egocentrics and geocentrics. The research data from those using only 1 SOM shows that this is a skill developed by suppressing the effects of the moving space, when the individual himself is moving and is related to the professionally important (personal) qualities, in particular, will and motivation. However, even such people, are not able to mentally stop the "moving wall of the subway tunnel" and to perceive themselves as moving bodies in a moving carriage, with reference to the static wall.

In order to establish with certainty whether the two abovementioned methods of spatial orientation are indeed inherited, it is necessary to conduct numerous, lengthy, and expensive studies. That is why our research was limited within the validity framework. Undoubtedly, there are a lot of things in humans which are inherited, but in order for us to justifiably emphasize them, instead of others, which are the result of socialization and personal experience, would require further research.

Since the Copernican scientific revolution it has been well-known to humanity that the Earth rotates around the Sun, however even astronauts often say that the Sun sets down under the horizon. In other words, if aviation has to rely on "natural geocentrics" it will be forced to become entirely unmanned.

It is necessary to point out, that the pilot training of people, who naturally use 1 SOM requires less effort, because of their more efficient method of spatial orientation. The rest of the people need specialized training, aimed mainly at the forming and development of the ability to stabilize the perception of the surrounding space during flight.

Spatial orientation during flight requires complex mental activity of the operators, in order to constantly maintain mental picture of the position of the aircraft with reference to the surface of the Earth and other objects, whether they are in air or on the ground. This activity takes place simultaneously with the processes of piloting, navigation, communication, and controlling various systems. Orientation in space and time at any moment of the flight is a major component of flying skills and is in itself an intellectual challenge for the pilots.

## CONCLUSION

It is unacceptable that flying, which is in itself a complex activity should be additionally complicated, since this might become the cause of accidents. Approximately one third of fatal air crashes are caused by spatial disorientation. Forecasts are not optimistic, since the advent of next generation of super-maneuverable aircraft, the existing problems will become even more acute. It is impossible to find people who are insured against spatial disorientation. Therefore, efforts should be focused, on one hand, on developing skills, and on the other, on the technology of indication, as represented by the symbols of the navigational aids, which should conform to the ways the pilots process the incoming information. Any attempt to disregard this requirement leads to a general, repeated error and represents a direct threat to flight safety.

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