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Risk profiling of airline pilots: Experience, temperamental traits and aggression

Ryszard Makarowski [a, *], Piotr Makarowski [b], Tomasz Smolicz [c], Mieczysław Plopa [d]

[a] Institute of Psychology, University of Gdansk, Gdańsk, Poland
[b] Gdansk University of Physical Education and Sport, Gdańsk, Poland
[c] Polish Airlines LOT, Poland
[d] University of Finances and Management in Warsaw, Warsaw, Poland

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ABSTRACT

It has been assumed that the greater the number of flying hours, the better the pilot is at solving problems. The studies suggest, however, that this issue is more complex. What is important is not only a pilot's experience but also their personality traits such as temperament, aggression, and risk-taking tendencies, which all influence how the pilot reacts under stress. After examining 112 pilots of passenger planes, we found that individuals characterized by a high need for stimulation seek situations, consciously or not, of excessive or unnecessary risk to achieve the right level of stimulation. In terms of their psychological characteristics, the study also revealed that some pilots are less predisposed to be airline pilots.

The connection between effectiveness of action and the personality and temperament of pilots was first identified in the 1940s (Humm, 1948; Mitchell, 1942). Subsequent research studies, which proliferated in the 1990s, produced several beneficial results, e.g., the number of mistakes made by pilots decreased. Among other things, the investigators used the Temperature Structure Scales to explore personal traits such as extraversion, domination, achievement motivation, and aggressive behavior (Hörmann and Maschke, 1996). In 2004, Schutte used the NEO-PI-R[1] to examine 93 pilots flying commercial planes and concluded that the pilots were emotionally stable and manifested low levels of anxiety, impulsiveness, and aggression. In this study, 95% of the participants were male and the mean age was 42 (ranging from 23 to 65 years). These pilots were employed by 14 different commercial airlines, ranging from small to very large (Schutte, 2004).

On the Neuroticism scale, over 60% of the pilots scored low or very low. Only 13% reported a high level of neuroticism. This indicates that as a group, pilots tended to report being emotionally stable. For the Extraversion scale, 42% of the pilots had high scores, whereas 23% had low scores. There was a trend towards higher scores, but it was not as strong the trend for the Neuroticism scale. For the Openness scale, the distribution was near normal, with 29% of the pilots scoring high and 37% scoring low on this dimension. The Agreeableness scale mimicked the Openness scale, with 27% of the pilots scoring high and 32% scoring low. Finally, on the Conscientiousness dimension, there was an overwhelming trend towards high scores, with 58% of the pilots scoring high or very high and only 7.5% of the pilots scoring low on this dimension.

Boyd et al. (2004) aimed to determine whether there were any significant psychological differences that would allow them to predict what type of planes a given pilot should fly (a fighter plane: $N = 870$, a bomber $N = 159$, or an airlift/tanker: $N = 1076$). For this

* Corresponding author. Institute of Psychology, University of Gdansk, Bażyńskiego 4, 80-309, Gdańsk, Poland.
E-mail address: makarowski@wp.pl (R. Makarowski).

[1] The NEO-PI-R questionnaire consists of 240 statements, and a respondent indicates if these describe him/her on a 5-point scale ranging from "I fully agree" to "I completely disagree". The items are classified as 5 major factors (scales), and each of those can be further divided into 6 smaller components (subscales) as follows: Neuroticism (Anxiety, Hostility, Depression, Self-Consciousness, Impulsiveness, and Vulnerability to Stress), Extraversion (Warmth, Gregariousness, Assertiveness, Activity, Excitement Seeking, and Positive Emotion), Openness to Experience (Fantasy, Aesthetics, Feelings, Actions, Ideas, and Values), Agreeableness (Trust, Straightforwardness, Altruism, Compliance, Modesty, and Tendermindedness), and Conscientiousness (Competence, Order, Dutifulness, Achievement Striving, Self-Discipline, and Deliberation). Although the NEO-PI-R questionnaire is a very precise tool, it takes a long time to complete due to the large number of items. This is why in 1989, its authors designed a shorted version consisting of 60 items (12 per scale). It is known as the NEO-FFI (NEO-Five Factor Inventory) and is based on the Five Factor Personality Model by Costa and McCrae (1985). This tool explores 5 personality factors: Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness.

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purpose, they used the NEO-PI-R questionnaire. The results showed that, when compared with the other groups, jet fighter pilots scored, on average, lower on the Agreeableness scale and higher on the Conscientiousness scale.

Currently, particular attention is paid to effective teamwork of the plane crew. After studying 292 pilots that fly for European airlines, a moderate correlation was found between some personality traits (communication skills, cooperation, and leadership). Based on these findings, it was suggested that personality questionnaires should be used as a pre-selection tool to screen candidates for piloting roles (Hörmann and Goerke, 2014). It was argued that this strategy would contribute to the long-term success of the pilots in their professional careers (Martinussen and Hunter, 2010).

Few studies have investigated how personality and experienced stress may influence task performance in civil aviation. These studies suggest that some aspects of personality can contribute to safety issues (aviation incidents; Dillinger et al., 2003; Ganesh and Catherine, 2005; Martinussen and Hunter, 2010; King, 2014; Wilson, 2013; Yamamoto et al., 2015). Most often, the five-factor personality model developed by P. Costa and R. McCrae is used to test pilots' personality (Campbell et al., 2010a, 2010b; Chappelle et al., 2010; Khorramdel et al., 2014).

The strongest relationships between temperamental traits and choosing an occupation or practicing sports have been observed in areas where a substantial physical threat was present (e.g., piloting, mountain climbing, race car driving, or parachute jumping; Studenski, 2004; Terelak and Jońca, 2008). Many studies have found that low reactive individuals engage in high-risk sports and jobs because they function better when the level of stimulation is higher (Eliasz, 1982; Gracz, and Sankowski, 2000; Klonowicz, 1984; Studenski, 2004). The study by Glenc (2006) supports these findings; pilots scored lower on the Emotional Reactivity scale than the control group. Other studies show that, when in danger, low reactive pilots make decisions faster and are more stress-resistant. Conversely, highly reactive pilots obtain higher results on the Neuroticism and Anxiety scales (Maciejczyk, 1974).

Analyses of temperament conducted by Makarowski (2013) confirmed that professional pilots and parachute jumpers had high levels of strength of excitation, which suggests that they prefer risk taking to risk avoiding. High strength of excitation corresponds to low emotional reactivity and low trait anxiety. Even a short review of existing studies justifies further examinations of pilots of passenger planes and supports the view that these examinations should be based on a temperament theory. One temperament theory, widely known in Europe and beyond, is J. Strelau's Regulative Theory of Temperament, which was derived from Pavlov's temperament typology. This theory defines one's temperament as a set of basic, relatively stable personality traits that, above all, describe formal (energetic and temporal) characteristics of one's reactions and behaviors. These features become apparent even in early childhood, and their equivalents are found in the animal world. Temperament, although naturally conditioned by inborn neurobiochemical mechanisms, slowly changes during maturation (and aging) and is also influenced by some specific interactions between one's genotype and the environment (Strelau, 2008, 2015).

Human temperament largely determines one's need for stimulation in different situations. This need can be satisfied in various ways such as risky or aggressive behaviors. Temperamental traits influence one's inner aggression motivation by modulating one's need for stimulation. Temperamental traits act as moderators, which suggests they precede acts of aggression or risky behaviors. Therefore, it seems justified (and is our goal for this paper) that studies of pilots should take into account selected temperamental traits and their connections to aggressiveness and risk-taking.

Referring to the dual-process models widely used in social and personality psychology, Slovic et al. (2004) proposed to distinguish between two types of risk: risk as analysis and risk as feelings. The terms proposed by P. Slovic are somewhat simplified since the risk itself is not an emotion but can trigger intense emotional excitement.

Apter (1984) assumed that instead of only one level of arousal there are two and that these two levels are optimal for one's functioning to be effective. The first level, the telic state, is connected to a situation in which an individual's main focus is on attaining a particular goal. The second level, the paratelic state, involves orientation towards the activity itself, not towards its instrumental character that serves the goal (Apter and Batler, 1996; Kerr, 1991; Kerr and Svebak, 1989).

Similarly, Zaleśkiewicz (2005a, 2005b) proposed to distinguish between the stimulating and instrumental motivations behind risk taking. When an individual undertakes risky behaviors to experience pleasant physiological arousal, it is called stimulating risk and involves pleasures such as sex, taking drugs, or engaging in extreme sports. Whether someone takes these risks depends mainly on how great one's need for stimulation is, and decision making is not preceded by an analysis of possible losses. Taking stimulating risks is impulsive and characterized by a low level of self-control. In this case, emotional information processing prevails. It is the desire to experience positive emotions that leads to risk taking. The second type of motivation for risk taking is needed to fulfill an intentional goal. Any risk involved is considered to be merely a tool—a means to an end. Here, there is no place for emotions or pleasure; the risks are reasonable and calculated. For this to be the case, the risk-taking individual needs a high level of self-control. With instrumental risk, a person's focus in on possible losses and the main goal is to achieve positive results (Zaleśkiewicz and Piskor, 2007).

There are many areas where we can observe differences between pilots and engineers. Examples include coping with stress and risk assessment. Makarowski (2013) compared the anti-health risk levels in engineers (air mechanics), helicopter pilots (soldiers), and pilots of tourist planes. He found significant differences between these groups. The lowest risk level was reported by engineers (air mechanics) and the highest was reported by the army helicopter pilots.

According to the Federal Aviation Administration (FAA, 2008), there are five attitudes that—when manifested by pilots—may result in making dangerous decisions:

1. Anti-authority (relying on your own assessment of the situation).
2. Impulsivity (excessive need for activity).
3. Invulnerability (excessive faith in one's strengths and skills).
4. Resignation (avoiding difficulties and lacking self-confidence).

The French IFSA (Institute Francais de Sécurité de Aeriene) reports that according to its observations, attitude no. 1 was found in approximately 15% of cases, attitude no. 2 in approximately 20%, no. 3 in approximately 43%, no. 4 in approximately 14%, and attitude no. 5 in approximately 8% of cases where pilots made a dangerous decision (Makarowski and Smolicz, 2012).

1. Objectives

The presented theories and selected findings justify the research project presented in this paper. We wish to single out distinct groups of pilots on the grounds of different constellations of the following three variables: temperament, aggression, and risk.

2. Methods

2.1. Participants

We examined 112 men that were pilots of passenger planes (Boeing 737, Airbus 320, and Embraer 170) whose mean age was 36.33 years ($SD = 4.12$) and mean number of flying hours was 5224.60 ($SD = 757{,}30$). The examined pilots had either a higher education degree or an engineer's degree and were all airline pilots.

The control group was made up of 127 randomly selected men (mean age = 34.43, $SD = 9.97$), who were all engineers that graduated from various technical colleges in Poland and were not connected with aviation. In terms of age, education, and gender, the control group was similar to the examined group. There was no significant difference between the age of the pilots and the age of the engineers (the Cochran-Cox test = 2.50, $p = 0.72$).

2.2. Measures

The following research tools were used to measure temperament, aggression, and risk.

1. **The Pavlovian Temperament Survey** (PTS; Strelau and Angleitner, 1994; Strelau et al., 1999; Strelau and Zawadzki, 1998). Described below are Pavlovian dimensions of temperament measured by the PTS. The questionnaire consists of 57 questions.
   - **Mobility of nervous processes** is the speed of transition with which neurons go from the state of inhibition to the state of excitation (from the state of excitation to the state of inhibition). A measure of this characteristic is how quickly a cell moves from one activity to the next or how quickly it changes from the active to passive (or passive to active) state. This is an ability to respond to environmental changes in a rapid but adequate manner. With high levels of this trait, an individual's mood easily changes from positive to negative. These individuals prefer multitasking, quickly adapt to new surroundings, and adequately react to unexpected environmental changes.
   - **Strength of excitation** describes how resistant the neurons are to strong stimuli. This ability allows nerve cells to withstand intense stimulation (both long-term and short-term) without triggering protective inhibition (going into relaxation). Individuals with a high level of this trait prefer acting under highly stimulating conditions. They are typically risk takers, resistant to tiredness, and perform well in physically or socially demanding situations (whether they are short- or long-term). These individuals work well under stress.
   - **Strength of inhibition** is a property of neurons that aims to safeguard the nervous system against overload. It is the ability of the nervous system to form inhibitory conditioned responses. In addition, it is the ability to interrupt an ongoing action, if necessary. Individuals with a high level of this trait easily refrain from behaviors that are incompatible with the law or moral standards. These individuals can conceal their emotions when the situation requires them to. This trait is not dissimilar to behavioral self-control.

A detailed description of how this tool was constructed can be found in the international manual, which covers 16 languages spanning 4 continents (Europe, America, Australia, and Asia). Language-specific responses have also been published (Strelau et al., 1999).

What follows is only a selection of the research findings based on a meta-analysis of these 16 language versions completed by a total of 13,393 respondents (7042 of whom were female) aged 10 to 85.

The scales' reliability measured with Cronbach's *alpha* ranges from 0.79 (for strength of excitation) to 0.86 (for mobility of nervous processes). The correlations between the individual subscales are as follows: between strength of excitation and strength of inhibition = 0.25, between strength of excitation and mobility of nervous processes = 0.52, and between Strength of inhibition and mobility of nervous processes = 0.21. No correlation exists between the questionnaire's subscales and the participants' age (Fajkowska et al., 2012; Strelau, 2008, 2015).

2. **Aggression Questionnaire** (Buss and Perry, 1992; Tucholska, 1998; Valdivia-Peralta et al., 2014). The questionnaire consists of 29 questions.

The Aggression Questionnaire, which was developed by A. Buss and M. Perry, measures the levels of physical and verbal aggression, hostility, and anger. The questionnaire's authors indicate that both physical and verbal aggression constitute the behavioral component of human behavior. In their opinion, anger is combined with physiological excitement and constitutes the emotional component of human behavior, whereas hostility—feelings of acrimony, dislike and injustice—represents the cognitive component of behavior.

A five-point scale was used: (1) Never or hardly applies to me, (2) Usually does not apply to me, (3) Sometimes applies to me, (4) Often applies to me and (5) Very often applies to me. The Cronbach's *alpha* values were: physical (0.82), verbal (0.75), hostility (0.80) and anger (0.85), which are similar values to those in the original study (Buss and Perry, 1992).

3. **SIRI (The Stimulating-Instrumental Risk Inventory**; Zaleskiewicz, 2001; 2005a)

The SIRI 2001 is used to measure one's perception style and how risky behaviors are interpreted. The questionnaire was created by T. Zaleśkiewicz and differentiates between two styles of risky behavior: stimulating and instrumental behavior.

- Stimulating risk— risk is perceived as a way to provide one's self with stimuli, arousal, and excitation. The focus is on being active and seeking sensations (strongly stimulating situations) regardless of the possible results or potential for loss.

  Stimulating risk taking is defined as follows:

1. Uncontrollable.
2. Magnitude of possible losses is not important.
3. Emotional processes are more important.
4. Positive arousal is dominant.
5. One concentrates mainly on the possible gains.
6. Impulsive decision making (short time perspective).
7. Unconscious processing is more important.

- Instrumental risk— in this case, risk is perceived as a chance to achieve a positive outcome. An individual engages in risky situations only when there is a chance of profit. The stimulating aspect of risk taking is insignificant because the objective is what really matters. This type of risk requires rational thinking and focus on the goal.

  Instrumental risk taking is defined as follows:

1. Controllable.
2. Magnitude of possible losses is very important.

3. Cognitive processes are more important.
4. Negative arousal is dominant.
5. One concentrates mainly on the possible losses.
6. Reflective decision making (long time perspective).
7. Conscious processing is more important.

The questionnaire consists of 17 questions. Stimulating risk taking: Cronbach's *alpha* = 0.696; average correlation $r = 0.370$. Instrumental risk taking: Cronbach's *alpha* = 0.725; average correlation $r = 0.470$.

We used STATISTICA 12.5 and SPSS AMOS 23 to analyze the data.

2.3. Procedure

The study was performed in the Main Testing Center for Air and Medical Examinations in Wrocław and in the Aeroclub of Grudziądz.

The three questionnaires were administered on the same day and the participants answered a total of 102 questions. The tests were given in a fixed order. The study took place over three summer months.

The protocol of this study was approved by the Ethics Board for Research Projects at the Institute of Psychology at the University of Gdansk (decision no. 12/2012). Prior to the study, a written consent was obtained from all participants.

3. Results

Together, the questionnaires measured 9 variables: three temperamental variables, two risk-related variables, and four aggression-related variables.

First, a comparison was made between the results obtained by two comparative groups: pilots and engineers. We suspected that the values of the measured variables (temperament, aggression, risk) would be different for pilots, which would justify treating them separately when predicting one's optimum performance in a task situation. We used Student's t-test (two-tailed, unpaired, homogenous variance) to determine the differences between the temperament, levels of aggression, and risk of the pilots and engineers. Table 1 shows the results.

Pilots obtained higher scores in the examined temperamental variables, risk, and aggression (with the exception of verbal aggression and anger). All differences were statistically significant. We found that the pilots had a greater need for stimulation (stimulating risk). Conversely, engineers were characterized by lower levels of physical aggression and hostility. The analysis of the differences between pilots and engineers revealed that the former had higher levels of all types of risk and temperamental variables. Among the engineers, we found high levels of verbal aggression, i.e., a tendency to verbally attack other people and manifest anger. The lowest levels of verbal aggression and anger were found among pilots of passenger planes. One could assume that this is highly desirable, particularly when the crew is in a cooperative situation (i.e., Cockpit Resource Management) (Wiener et al., 1993).

The obtained data confirmed that it was justifiable to treat pilots separately; therefore, all further analyses concern only the pilots of passenger planes.

Next, we calculated the correlations between the pairs of variables. The results are given in Table 2.

A high correlation was found between strength of inhibition and excitation, and between strength of inhibition and mobility of nervous processes. Similarly, high correlations were found between the different measures of aggression (physical aggression and anger $r = 0.60$; physical aggression and hostility $r = 0.66$; and hostility and anger $r = 0.71$). We found moderate correlations between the different measures of risk, between the mobility of nervous processes and instrumental risk, and between the mobility of nervous processes and hostility. Already at this stage a clear pattern in the matrix was visible that later influenced the clusters.

A cluster analysis is most often used when there are no *a priori* hypotheses and a study is still in its exploratory phase. We used STATISTICA's Generalized EM & k-Means Cluster Analysis module, which included cross-validation to determine the number of clusters. This method appears to be the best (Guidici, 2003). The data were standardized prior to performing the analyses. We grouped the cases using the k-means method and provided the STATISTICA 12.5 package with 3 initial cluster centers; the cases were selected to maximize the distance between the clusters.

A *k*-means clustering by cases procedure was used to identify groups homogeneous in terms of the examined temperamental traits, risk, and aggression within the entire population of pilots of passenger planes. A total of 35 pilots (34%) were categorized as the first cluster, 49 pilots (49%) as the second cluster, and 18 pilots (18%) as the third cluster.

As given in Table 2, the correlation value between strength of excitation and strength of inhibition is 0.11 and is statistically insignificant. The theory predicts that strength of excitation and strength of inhibition should correlate negatively and that this relationship should be statistically significant. Correlations between these two variables calculated for individual clusters show that the results are consistent with the theory. For Cluster #1, $r = -0.36$, $p = 0.03$; for Cluster #2, $r = -0.27$, $p = 0.04$; for Cluster #3 the correlation value is positive: $r = 0.48$, $p < 0.01$.

We confirmed the accuracy of this division into three groups by performing an analysis of variance (Kruskal-Wallis test) (Table 3). We found statistically significant differences in the levels of the examined variables. The number of cases was different in the individual subgroups—the design was unbalanced (non-orthogonal).

Table 1
Comparison of temperament, risk, and aggression among engineers and pilots (Cochran-Cox test).

	Pilots		Engineers		Test	p
	M	*SD*	*M*	*SD*	Cochrana-Coxa	
Mobility of nervous processes	44.23	3.82	35.48	11.44	8.002	***
Strength of excitation	54.31	3.86	48.40	5.86	6.872	***
Strength of inhibition	58.54	5.65	53.16	6.06	4.538	***
Stimulating risk	26.74	5.73	23.94	6.84	3.341	**
Instrumental risk	26.37	4.17	25.03	4.31	2.297	**
Physical aggression	22.00	6.54	18.99	5.15	−9.004	***
Verbal aggression	14.76	5.21	18.74	3.60	8.952	***
Anger	16.84	5.36	20.41	7.19	−5.796	***
Hostility	16.96	3.11	14.56	5.28	2.630	**

*$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

Table 2
Intercorrelations among the variables.

Measures	1	2	3	4	5	6	7	8
1. Stimulating risk								
2. Instrumental risk	0.47**							
3. Physical aggression	−0.01	−0.17						
4. Verbal aggression	−0.01	0.30*	0.33*					
5. Anger	0.24*	−0.24*	0.60***	0.29**				
6. Hostility	0.16	−0.26**	0.66***	0.38*	0.71***			
7. Mobility of nervous processes	−0.11	0.39*	−0.13	0.06	−0.15	−0.23**		
8. Strength of excitation	0.30**	0.54***	−0.13	−0.01	−0.23	−0.38*	0.51**	
9. Strength of inhibition	−0.26***	−0.06	0.10**	−0.27*	−0.22	−0.05	0.46**	0.11

*$p \leq 0.05$; **$p \leq 0.01$; and ***$p \leq 0.001$.

Table 3
Analysis of variance (Kruskal-Wallis test) of the variables within the individual clusters.

	Cluster #1		Cluster #2		Cluster #3		Kruskal-Wallis test			Difference
	M	*SD*	*M*	*SD*	*M*	*SD*	*Chi-square*	*H*	*p*	*Cluster #1:#2: #3*
Stimulating risk	22.78	4.14	29.55	4.48	28.07	4.12	13.19	26.09	***	1:2***. 1:3***
Instrumental risk	24.62	3.31	28.39	3.83	22.50	3.04	20.17	25.16	***	1:2***. 1:3**
Physical aggression	17.61	2.40	24.33	5.51	34.01	3.17	37.46	37.91	***	1:2***. 2:3***
Verbal aggression	13.62	2.68	15.11	2.77	16.50	2.39	26.60	35.26	***	1:2***. 2:3***
Anger	10.50	3.47	16.90	2.48	22.72	3.76	47.97	58.20	***	1:2***. 2:3***
Hostility	14.81	2.58	17.34	2.74	28.13	3.43	29.16	46.05	***	1:2***. 2:3***. 1:3**
Mobility of nervous processes	42.13	4.15	44.17	3.13	37.24	3.51	28.02	30.43	***	1:3***. 2:3***
Strength of excitation	51.03	5.25	55.31	2.16	47.30	2.44	45.56	49.99	***	1:3***. 2:3***
Strength of inhibition	59.38	5.37	52.14	5.28	56.33	4.12	35.47	52.57	***	1:3***. 2:3***

*$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

Table 4
Model fit indices.

Model fit indices	Chi-square	df	CMIN/df	p	RMSEA	LO	HI	PCLOSE	GFI
Pilots	60.27	26	1.22	0.071	0.035	0.21	0.67	0.354	0.919

Nonetheless, we used Sheffe's method in our ANOVA since it uses the F distributions and can be applied to samples of both equal and unequal sizes.

A cluster analysis is a classic exploratory approach; therefore, we also conducted a confirmatory analysis that involved grouping the data by variables, not by cases. We assumed that the factors would be comprised of the variables that had the highest or lowest trait values within a given cluster. The analysis was performed using an asymptotic distribution-free method. Table 4 presents the model fit indices for the examined population of pilots.

Steiger and Lind's RMSEA (Root Mean Square Error of Approximation) value was 0.035, which is acceptable if ≤ 0.08. Browne and Cudeck (1993) and Hu and Bentler (1999) claim that when the RMSEA value is less than 0.005, a model fits the data well. According to Steiger (1990, 2007) and Browne and Cudeck (1993), a model fits the data acceptably well if the RMSEA value is between 0.006 and 0.008. If the value is greater than 0.008, a model poorly fits the data. The PCLOSE test value was 0.354, which also indicates the model fits the data well. The PCLOSE test assesses the closeness of fit of the empirical data matrix to the theoretical model. Additionally, the PCLOSE tests the null hypothesis that the RMSEA is no greater than 0.05. If the PCLOSE is less than 0.05, we reject the null hypothesis and conclude that the computed RMSEA is greater than 0.05, which indicated a lack of a close fit. The GFI (goodness-of-fit index) should exceed 0.90, and the value we obtained was 0.919 (McDonald and Marsk, 1990, p.249). This measure is not directly linked to how large a sample is, but it provides information as to whether a model tested fits the data significantly better than no model at all (Jöreskog and Sörbom, 1993, p. 123). Therefore, we can consider that our model has been verified against the results distribution from the data matrix.

The values of the path coefficients, coefficients of determination, and correlations between factors are shown in Fig. 1. There is a high correlation ($r = 0.37$) between the first and the second factor, a moderate negative correlation ($r = -0.28$) between the second and the third factor, and a weak correlation ($r = 0.22$) between the first and the third factor.

Considering the above, pilots of passenger planes can be divided into three groups:

1. **Risk-avoiders** (34 percent). The first cluster is made up of individuals characterized by a low need for stimulation. They demonstrated the lowest mean level of stimulating risk and the greatest strength of inhibition.
2. **Reasonable risk-takers** (48 percent). In this cluster, individuals have a high need for a stimulating and instrumental risk. They are characterized by high levels of mobility of nervous processes and strength of excitation. They reported the lowest level of strength of inhibition and the highest level of stimulating risk.
3. **Individuals who protect their resources through aggression** (18 percent). This cluster includes participants who had the highest levels of physical aggression, verbal aggression, anger, and hostility, but at the same time the lowest levels of mobility, strength of excitation, and instrumental risk.

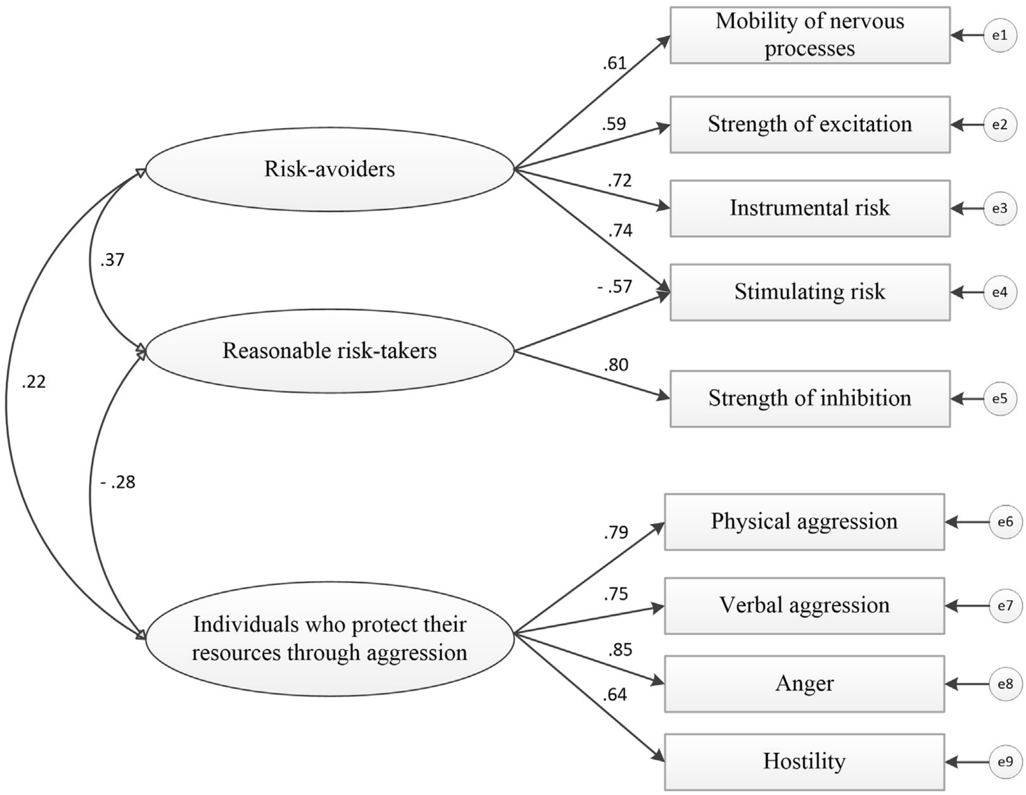

Fig. 1. A path diagram for the three isolated factors.

4. Discussion

Our research findings show that professional pilots of passenger planes do not form a homogeneous group. The cluster analysis allowed us to identify three subgroups of different constellations of the examined variables (temperament, aggression, and risk).

The first group, called ***risk-avoiders***, includes persons who report low levels of stimulating risk and high levels of strength of inhibition. The first attribute is typical of individuals who avoid situations that trigger high arousal. These persons are not interested in risky behaviors associated with pleasant feelings. They appreciate peace and security. They do not function well in highly stimulating conditions; in fact, they regard them as a source of fear or anxiety. Their high-level strength of inhibition is connected with their ability to conceal their emotions when desirable and to refrain from behaviors that are incompatible with social expectations. This trait is not dissimilar to behavioral self-control. Individuals included in this group are agreeable, conventional, conformist, and conscientious. They are not disposed to compete with others. Here we observed the lowest levels of all examined types of aggression. These individuals function well in low-stimulation situations. Their life experience suggests that any aviation-associated decisions should be made in peace and with no excessive haste. Coupled with conscientiousness and behavioral self-control, we argue that this provides an individual with optimal control over the situation, whether pre-flight preparations or the flight itself. We can say that these pilots are emotionally stable. Research studies on military pilots conducted by Biernacki et al. (2013) suggest that thanks to the impact of high self-control, high levels of inhibition, and high levels of excitation, pilots are able to maintain constant situational awareness during a flight.

The second group, the so-called ***reasonable risk-takers***, is composed of individuals who demonstrate the highest levels of stimulating risk, instrumental risk, mobility, and strength of nervous processes, and the lowest level of inhibition. This set of characteristics indicates that these individuals are action-oriented, which provides them with excitation and requires rapid actions. Members of this subgroup tend to engage in impulsive, risk-related behaviors. When an individual undertakes risky behaviors to experience pleasant arousal, this is called stimulating risk and involves pleasures such as sex, taking drugs, or engaging in extreme sports. Whether someone takes these risks or not depends mainly on how great one's need for stimulation is, and the decision is not preceded by an analysis of possible losses.

These individuals also report a high level of instrumental risk, suggesting that in some situations they focus on potential profits, e.g., financial profit, winning a competition, or solving a navigation task related to planning a flight. It is possible for one person to have a high level of instrumental risk when performing one's professional duties and a high level of stimulating risk after the working hours or when spending time on one's hobby. For high-level stimulating risk, emotional processes play a greater role and the focus is mainly on the profits. With instrumental risk, an individual concentrates more on possible losses and cognitive processes are of greater importance. A literature review suggests that aviation attracts not only sensation-seekers but also those who wish to learn to cope with challenging tasks that occur during a flight. Individuals who want to become pilots are levelheaded, skilled at managing risk, and capable of deep and analytical reflection (Campbell et al., 2010a; Carretta, 2011, 2013). In contrast, not only may a pilot seek high-stimulation situations but also be an outstanding specialist in analytical assessment of risk management.

In contrast with the second group, the third group—***individuals who protect their resources through aggression***—displayed the lowest levels of mobility and strength of excitation. These individuals function poorly under conditions of stress and high excitation and have a low resistance to tiredness when a situation involves lengthy activities. We can say that they manifest high reactivity and low emotional resistance. They avoid any risk that could increase their excitation levels. This group also manifested the lowest mean level of instrumental risk, which means that its members, if they decide to engage in risky activities at all, will focus on possible losses. Above all, pilots from this group do not want to lose any resources they have (i.e., health, aircraft pilot qualifications, and a well-paying job). Examinations revealed that individuals with smaller resources tend to use a defensive attitude to protect them (Hobfoll, 2006).

As it turned out, this group is characterized by the highest levels of physical aggression, verbal aggression, anger, and hostility. Therefore, we can cautiously suspect that for these pilots, aggression is a way to maintain and defend resources they possess. When we then consider that this group is characterized by a low-level of instrumental risk, we can say that these individuals' behaviors are uncontrolled and spontaneous. They lose their temper easily, are ready to inflict pain, offend others, and hold grudges for a long time.

The examinations we present here prove that a population of pilots is internally diverse, and support the view that for some pilots, seeking risky situations—thereby increasing their stimulation levels—is associated with their optimum functioning (Germain, 2010; Makarowski, 2013). This implies that some professional pilots may need to maintain intense excitation. It should be noted that the second group was characterized by high levels of both stimulating and instrumental risk. This, in turn, implies that in some situations, these pilots act as reasonable risk-takers who above all objectively calculate possible losses, whereas in other situations, they actively seek extreme experiences to gain some benefits (Zaleśkiewicz, 2005a, 2005b).

4.1. Practical implications

Members of the second group we distinguished as **reasonable risk-takers** appear to be the most predisposed to be professional pilots. They manifest high levels of strength of nervous processes and strength of excitation. Their actions are optimal when they act under stressful conditions. They function well when the level of excitation is high, and risky situations fulfill this criterion. We should not forget, however, that high need for risk and thrills may entail certain threats. To reach the right level of stimulation, these individuals may consciously or unconsciously seek situations of excessive or unnecessary risks. Going beyond the threshold of optimum excitement results in deterioration of one's functioning. Consequently, errors may occur, and—as a result—aviation incidents, accidents, or plane crashes.

Hunter (2002) noticed that high levels of experience and qualifications are associated with a dangerous tendency to assess and perceive risks as lower than they actually are. Pilots who have had many experience can accept flying in very difficult and perilous weather conditions. With great experience comes greater risk tolerance. This is why intervention programs are needed, and should involve identifying the personality factors that should later be worked upon. Reason's model (1990) of accident causation seeks to categorize the causes of aviation accidents by filtering them into one of three areas, one of which is latent factors. A pilot who is self-righteous and overconfident about his abilities may fit into this category.

It is worth considering if those individuals could benefit from simulator trainings with as few external distractions as possible—if this can be achieved under conditions of maximum deprivation. This would reflect situations that occur naturally during long-distance flights, flying at night or over an ocean. In these situations, pilots are often drowsy and sometimes fall asleep.

Individuals from the third group are characterized by lower psychological resilience. When we consider this, it becomes clear that some people are less predisposed to be professional pilots. If these individuals pursue this occupation, they do so despite the fact that they would have to function at a suboptimal level of stimulation. Their temperament structure does not guarantee they will be able to handle stress and tension effectively. Because of this, their reactions are more often ones of anxiety or fear.

Błoszczyński (1997) examined individual differences in arousal levels among pilots. There were three indicators of arousal: heart rate (in beats per minute), breathing frequency, and the stick force (the force exerted by the pilot on the control column). The examinations were carried out on a flight simulator, on which the pilots performed flights in the aerodrome traffic circuit. The results revealed that pilots had the fastest heart rate (approximately 150 beats per minute) when they were taking the fourth turn, and when they were later descending in the direction of landing. During a takeoff and initial climb, pilots' heartbeats ranged from 60 to 80 beats per minute. The arousal is more intense during the parts of the pattern that place an additional burden on the pilot. If emotional stress is too high, a pilot can repeat simulated flights that resemble a given difficult situation until the tension subsides. An idea worth considering is that—from time to time—experienced pilots and novices alike could wear a pulsometer during compulsory simulator trainings to assess their heart rate. This is particularly important when practicing standard difficult situations such as an in-flight death of a crew member (a flight lieutenant), a fire in two engines, or lack of fuel. This could provide insightful feedback for both the pilot and the instructor, and the training could be adjusted accordingly. This issue is of fundamental importance because for years, people have believed that a pilot's problem-solving skills increase with his flying time (the number of hours spent piloting aircrafts)—that is, with his experience. As it turns out, the number of flying hours is not a good indicator of how well one solves problems. Relevant research findings led the Federal Aviation Administration to recommend adopting new training methods that would allow pilots to develop skills needed in critical in-flight situations, irrespective of their experience (Federal Aviation Administration [FAA], 2013).

The results we presented in this article demonstrate that training pilots how to behave in risky situations should include issues concerning coping with stress when one's level of arousal is too high or too low. This may prove significant for recruitment processes in aviation and could help modify existing safety programs.

Our findings partially support the statements found in the Aviation Instructor's Handbook 2008, as far as one's predisposition to make risky decisions is concerned. The group of “risk-avoiding pilots” we singled out in the study is similar to pilots characterized by resignation. The so-called reasonable risk-takers are an equivalent of someone adopting the “invulnerability” attitude. The last group, pilots who protect their resources, is similar to pilots who demonstrate an impulsive attitude.

Presented examinations and their review can prompt deeper scientific and practical reflection on how to build a psychological profile of a pilot who is optimally suited to various task situations. It is highly useful to take into account temperamental traits, aggression levels, and risk-taking tendencies. We also argue that it is reasonable to extend the examinations to include a wider model of psychosocial variables, take into account a pilot's interpersonal skills, and explore how much support they generate in family structures.

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