Significance of chronometric indicators of mental functioning in pilot selection

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Introduction

Wide application of psychological tests, military selection purposes included, dates from the Alpha Army and Beta Army tests in the World War I. A number of tests, mostly the paper-and-pencil type, were used in later years for various jobs and military duties too. That period was characterized by efforts to develop new and improve the existing tests, whereas there were only a few initiatives for different type of tests and test equipment.

Technological advancements seen over the last few decades, especially those in the fields of electronic engineering and computers, have reflected on psychological instruments development too. Increasing sophistication of weapons and equipment also put increased demands before the operators. Along with increased complexity and pace of events grew demands for quick and precise responding, maintaining the satisfactory (relatively high) efficiency level, and errors implied more adverse effects.

From the military psychology perspective this period was characterized by development of new and different approaches and diagnostic tools, used as a complement to the tests known or replacing them. Thus today used are different computerized test batteries and complex simulators usually employed in selection and training effectiveness survey related to a complex duty. In addition to the overall efficiency, the equipment is used to register other data available during an activity for a better insight into the aspect/phenomenon examined and, consenquently, better implementation of the findings.

A similar approach, the chronometric one, is also focused on obtaining information of different aspects of the process examined. This paper aims to illustrate the validity of the information by the instance of selection of pilots, a duty exceeding many others in complexity and demands.

Problem and Methodology

Pilot (psychological) selection programs are continuosly developed and ameliorated by means of new diagnostic techniques and methods. What most of them have in common, along with various other contents, is collecting data on mental abilities, personality characteristics and motivation needed for the duty.

Connative indicators are beyond the scope of the paper, which will focus primarily on some mental abilities, with the goal to determine the following:

1. identify the indicators of mental abilities level and the indicators of dynamic and functional characteristics contributing significantly to prediction of flight training successfulness

2. determine overall discriminative power of different indicators of mental abilities to differentiate successful, unsuccessful and drop-out pilot candidates respectively.

The main criterion variable in this study was flight training successfulness, by which the candidates were categorized into three groups (G1, G2 and G3). Out of 149 flight trainees included in the study:

- 75 completed the training successfully (G1)
- 36 dropped out from the training (G2), and
- 38 failed the flying test (G3).

Of 18 cognitive tests used in the study there were 7 standard paper-and-pencil tests and 11 chronometric cognitive tests of the CRD series.

Three paper-and-pencil tests covered general intellectual abilities:

- D-48, Domino intelligence test (G.Anstey)
- TN-10, intelligence test (V.Pogacnik)
- M-series of intellectual abilities tests (Z.Bujas, B.Petz)

whereas the remaining four tests were used to test specific intellectual abilities:

- TP 3T, attention test (Pieron, Toulouse)
- BTI Pr, spatial relations test
- BTI Ob, figure comparing perceptive test
- BTI AII, numbers comparing perceptive test

Of 11 chronometric tests, 6 were used to examine perception abilities:

- CRD 13, spatial visualization test
- CRD 21, simple visual orientation test
- CRD 23, complex convergent visual orientation test
- CRD 241, visual identification test (numeric square)
- CRD 311, test of visual discrimination of signal location
- CRD 431, test of perception of (light) signal occurence

3 tests covered complex mental processing:

- CRD 11, convergent thinking test
- CRD 411, operative thinking test (with light signals)
- CRD 422, operative thinking test (with sound signals)

and the remaining 2 examined memory:

- CRD 324, test of actualization of short-term memory
- CRD 341, maze learning test.

Along with overall test solving time, each chronometric test yielded 8 data on test solving aspects. Thus the analysis included 88 indicators of functional characteristics of mental processing: speed (TMIN) and stability (TB-total ballast) served as mental processing dynamics, whereas time wasted on running-in (IB-initial ballast), time spent on mental blocks (TMB), error reactions (NE-number of errors, TE-time spent on errors, TAE-time after errors) and decreased processing speed due to monotony or fatigue (FB-final ballast) were indicators of functional disturbances.

Results

Data processing was conducted by means of the following analyses: one-way ANOVA and multivariate canonical discriminant analysis.

One-way ANOVA was used to test significance of differences in average indicators of overall efficiency on both mental abilities tests (overall outcome on paper-and pencil test and on chronometric tests respectively), and the significance of differences in average indicators of functional characteristics of performance in chronometric tests among the three groups examined.

Table 1. contains data on significance of differences in characteristics displayed among the group G1 (successful candidates) and G3 (fails). Out of 106 performance indicators the two groups differ significantly on 31 characteristics, with G1 (successful candidates) always performing better.

Only 2 paper-and-pencil tests were found to differentiate significantly the successful candidates from the fails: M-series (general intellectual abilities) and BTI-Pr (spatial relations test).

On the other hand, chronometric tests from all categories were found to differentiate the two groups – the spatial visualisation test (CRD 13) and visual orientation tests (CRD 21 and 23) from the perceptive test category, operational thinking tests (CRD 411 and 422) from the complex mental processing test category, and the short-term memory actualisation (CRD 324) from the memory test category. Significantly poorer performance by fails was found on all three mental processing aspects examined – the level of the ability examined (overall score) on all the tests administered, the dynamics (speed and stability) on most of the tests, and different indicators of functional disturbances; thus fails displayed extended time lost on running-in on most of the tests, early decrease of efficiency (tiredness) on the visual orientation test, operational thinking and short-term operational memory, as well as errors and mental blocks mostly on perceptive tests.

An important aspect of pilot candidates are notions on quitting motives. The decision may partly be induced by inappropiate training program or ill-precise selection criteria. Therefore, for the purpose of this paper the significance of difference in test solving efficiency between the drop-out group (G2) and the successful trainees group (G1) was analysed. The significant differences found are presented in Table 2., and suggest that the decision to leave the training might at least to an extent be motivated by candidate's own appraisal of insufficient mental abilities for the demanding pilot job (unlike the failing candidates (G3), who in addition to poorer cognitive functioning also lacked this self-critical dimension).

Table 2. reveals drops'-out significantly lower score on the standard general intellectual ability test (M-series) compared to the successful candidates, whereas by the overall performance on chronometric tests they performed poorer on the visual orientation test (CRD 241) and the operational memory test (CRD 324). The remaining significant differences indicate poorer dynamics and more pronounced functional disturbances in drop-outs while performing these mental activities.

Discriminant analysis was conducted to determine overall discriminant values of the significant predictors obtained, the results are presented in the Table 3.

Table 1. COGNITIVE FEATURES OF FLIGHT TRAINING FAILURE

TEST (CHARACTERISTICS)	TOTAL SCORE	SPEED (TMIN)	STABILITY (TB)	INIT.BLST (IB)	FIN.BLST (FB)	MENT.BLOCK (TMB)	NUM. OF ERR. (NE)	TIME SPENT ON ERR.(TE)	TIME AFTER ERROR (TAE)
D-48 (INTELLIGENCE)									
TN-10 (INTELLIGENCE)									
M-SERIES (INTELLECTUAL ABILITIES)	F = 5,135 p = 0,025								
TP-3 (ATTENTION)									
BTI-PR (SPATIAL RELATIONS)	F = 8,616 p = 0,003								
BTI-OB (FIGURE COMPARING)									
BTI-All (NUMBERS COMPARING)									
CRD 13 (SPATIAL VISUALIZATION)	F = 8,930 p = 0,003	F = 4,386 p = 0,037	F = 7,052 p = 0,008	F = 9,542 p = 0,002			F = 8,910 p = 0,003	F = 8,517 p = 0,004	
CRD 21 (SIMPLE VISUAL ORIENTATION)	F = 7,871 p = 0,005	F = 4,815 p = 0,030	F = 5,287 p = 0,023		F = 6,117 p = 0,014	F = 5,252 p = 0,023			
CRD 23 (COMPLEX VISUAL ORIENTATION)	F = 7,701 p = 0,006	F = 7,567 p = 0,006	F = 4,971 p = 0,027	F = 8,188 p = 0,005			F = 5,496 p = 0,020		F = 6,192 p = 0,014
CRD 241 (VISUAL IDENTIFICATION)							F = 8,785 p = 0,003		
CRD 311 (VISUAL DISCRIMINATION OF SIGNAL LOCATION)									
CRD 431 (PERCEPTION OF (LIGHT) SIGNAL OCCURENCE)									
CRD 11 (CONVERGENT THINKING)									
CRD 411 (OPERATIVE THINKING WITH LIGHT SIGNALS)	F = 7,425 p = 0,007	F = 4,611 p = 0,034			F = 4,414 p = 0,038				
CRD 422 (OPERATIVE THINKING WITH SOUND SIGNALS)	F = 6,959 p = 0,011		F = 5,608 p = 0.022	F = 6,098 p = 0,017				F = 4,305 p = 0,043	
CRD 324 (OPERATIVE SHORT-TERM MEMORY)	F = 5,262 p = 0,023		F = 5,904 p = 0,016	F = 3,913 p = 0,050	F = 7,218 p = 0,008				
CRD 341 (MAZE LEARNING)									

Table 2. COGNITIVE FEATURES OF FLIGHT TRAINING DROP-OUTS

TEST (CHARACTERISTICS)	TOTAL SCORE	SPEED (TMIN)	STABILITY (TB)	INIT.BLST (IB)	FIN.BLST (FB)	MENT.BLOCK (TMB)	NUM. OF ERR. (NE)	TIME SPENT ON ERR.(TE)	TIME AFTER ERROR (TAE)
D-48 (INTELLIGENCE)									
TN-10 (INTELLIGENCE)									
M-SERIES (INTELLECTUAL ABILITIES)	F = 5,094 p = 0,025								
TP-3 (ATTENTION)									
BTI-PR (SPATIAL RELATIONS)									
BTI-OB (FIGURE COMPARING)									
BTI-All (NUMBERS COMPARING)									
CRD 13 (SPATIAL VISUALIZATION)									
CRD 21 (SIMPLE VISUAL ORIENTATION)									
CRD 23 (COMPLEX VISUAL ORIENTATION)									
CRD 241 (VISUAL IDENTIFICATION)	F = 5,958 p = 0,016	F = 4,857 p = 0,029	F = 11,07 p = 0,001		F = 13,40 p = 0,000	F = 10,74 p = 0,001	F = 7,436 p = 0,007	F = 7,191 p = 0,017	
CRD 311 (VISUAL DISCRIMINATION OF SIGNAL LOCATION)									
CRD 431 (PERCEPTION OF (LIGHT) SIGNAL OCCURENCE)									F = 6,552 p = 0,018
CRD 11 (CONVERGENT THINKING)					F = 5,914 p = 0,016				
CRD 411 (OPERATIVE THINKING WITH LIGHT SIGNALS)									
CRD 422 (OPERATIVE THINKING WITH SOUND SIGNALS)				F = 5,382 p = 0,025					
CRD 324 (OPERATIVE SHORT-TERM MEMORY)	F = 4,613 p = 0,034			F = 6,834 p = 0,010	F = 4,535 p = 0,035	F = 6,486 p = 0,012		F = 7,559 p = 0,009	
CRD 341 (MAZE LEARNING)									

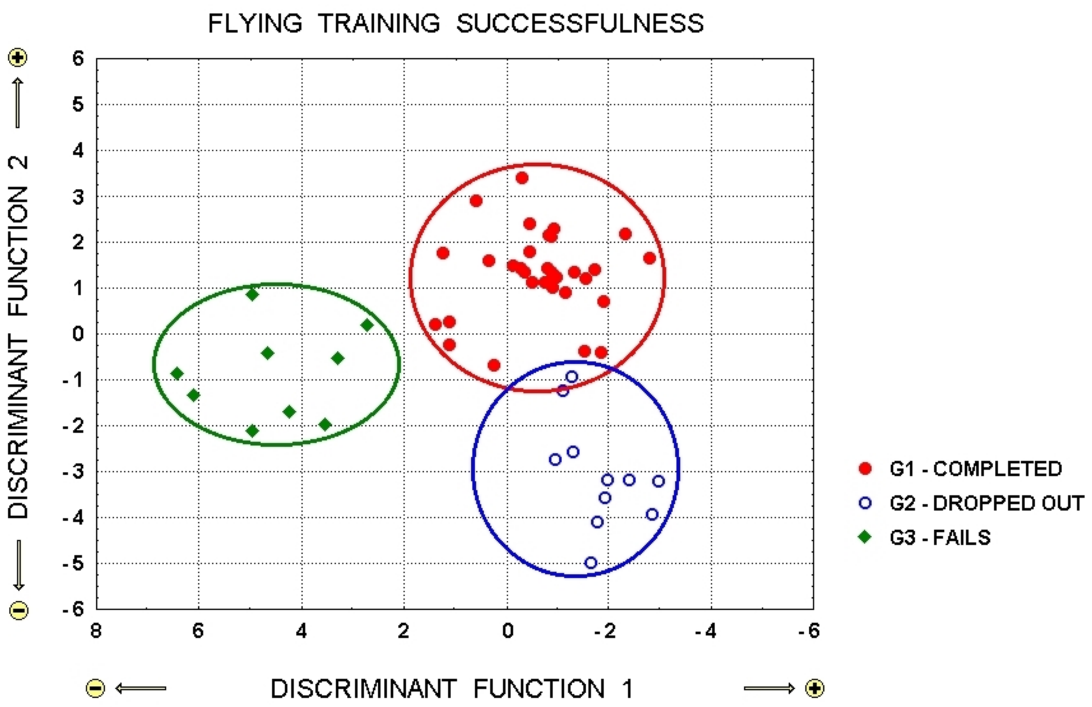
Table 3. Results of discriminant analysis

Discriminant Functions	DF 1	DF 2
Eigen value	4.827758	3.313058
Canonical R	0.910169	0.876439
Wilks' Lambda	0.039784	0.231854
Chi – Square	114.461900	51.888500
p-level	0.000007	0.002751

Both discriminant functions revealed statistically significant, with considerable power of discriminating the three groups examined. The first discriminant function (DF 1) is determined by indicators of operational thinking (CRD 411), and the other one (DF 2) by indicators of stability and functional disturbances manifested while doing the spatial visualisation test (CRD 13), visual identification test (CRD 241) and the operational memory test (CRD 324).

The position of the groups of respondents in the discriminative space defined by the two discriminant functions is shown in Figure 1.

Figure 1. The position of the groups in the discriminative space



The Figure 1. reveals high classification precision in the discriminative space. Classification accuracy for the successful candidates (G1) was 100%, for the drops-out (G2) 90,9%, and for the fails (G3) 100% respectively.

Conclusion

With regard to variety of the instruments used (standard paper-and-pencil tests versus chronometric tests), the study underlines both the value of chronometric (dynamic and functional) indicators and the fact that standard indicators of mental abilities alone are not sufficient in selection, at least in selection for complex and demanding duties such as the pilot duty.

The results obtained point to relation between the prediction of success in flight training and three cognitive functions: perceptive manipulation (spatial visualisation, visual orientation and visual identification), operational thinking and operational memory. Combination of indicators of these abilities in this case ensured high discrimination of successful from unsuccessful (fails) and drop-out pilot candidates, as well as high accuracy in posterior classification. On the other hand, some of the findings obtained indicate specific cognitive deficits in pilot training drop-outs (mostly consisting in functional disturbances in visual identification and short-term operational memory) that could be partly responsible for their outcome.

As the study involved a relatively small number of subjects, the results obtained should not be generalised, and also call for a follow-up verification.

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