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COMPARING FIGHTER LEAD-IN TRAINING PERFORMANCES (U)

by

DR B.U. NGUYEN

SEPTEMBER 1997

OTTAWA, CANADA

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Recommended by: _____ DASOR

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ABSTRACT

Pilot candidates undergoing training to qualify to fly fighter aircraft in the Canadian Forces first proceed through Fighter Lead-In Training (FLIT) at Moose Jaw, SK. After successful completion of the FLIT course, candidates enroll in a Basic Fighter Pilot (BFP) course. Due to time and training constraints, the students of BFP course, serial 9602, came from three distinct FLIT courses. This study assesses the conjecture that pilot candidate performance on the BFP course could be related to the type of FLIT training the candidates received.

RÉSUMÉ

Les candidats inscrits au programme de formation des pilotes de chasse des Forces armées canadiennes doivent d'abord réussir la formation de chef de patrouille à Moose Jaw (SK), après quoi ils doivent suivre le cours élémentaire de pilote de chasse. En raison du manque de temps et de ressources, les étudiants du BFP - 9602 - viennent de trois groupes distints de FLIT. Cette étude examine si les résultats des étudiants du cours BFP étaient reliés à l'origine de leur cours précédents.

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COMPARING FIGHTER LEAD-IN TRAINING PERFORMANCES

1. INTRODUCTION

1. This study assesses the conjecture that pilot candidate performance on the Basic Fighter Pilot course (BFP), serial 9602, could be related to the type of Fighter Lead-In Training (FLIT) the candidates received. It was found in [1], that from the mid-term results of the BFP course, there was evidence to support the hypothesis of a performance related differential. This repeats the analysis performed in [1], but does so on the overall performance of the pilot candidates in the BFP course.

Background

2. CF-18 pilots are trained and tested through a number of preparatory courses such as the BFP and the FLIT courses. Before attending the BFP course at 4 Wing, Cold Lake, AB, the candidates must pass FLIT training.

3. Under normal circumstances, pilot candidates will have taken the FLIT course at the Flying Instructors School (FIS), at 15 Wing, in Moose Jaw, SK. Successful candidates from the FLIT course proceed to the BFP course as part of their training program. Due to time and training constraints, a group of 20 pilot candidates, preparing to take the July 1996 BFP course were separated into three sub-groups. Each sub-group was sent to a different FLIT course prior to attending the BFP course.

4. The first sub-group (eight candidates) took the full FLIT at FIS utilizing Tutor (CT-114) aircraft. The second sub-group (seven candidates) were trained in a modified FIS FLIT course, also in Moose Jaw. This modified FLIT course was identical to the full course, with the air-to-surface tactics and air combat manoeuvre training removed. The third and last sub-group (five candidates) was sent to a United States Air Force T-38 Conversion/IFF (Introduction to Fighter Fundamentals) course run at Randolph Air Force Base, Texas.

5. The candidates of these three FLIT sub-groups were united to undertake the BFP course, starting July 1996 (Serial 9602), conducted by 410 Squadron (Operational Training Unit) in Cold Lake. Before commencement of the BFP course, several concerns were raised regarding the possible performance of the sub-groups as a result of their different FLIT training backgrounds [2]. Included in their concerns [3] were the following issues:

i) candidate performance on the BFP course could be related to the FLIT training background;

ii) some sub-group candidates would require extra training missions/flying hours to graduate;

iii) some sub-group candidates might perform better or poorer in specific phases of the BFP training as a result of their FLIT training; and

iv) the impact of FLIT equipment differences on candidate performance at 410 Squadron.

6. Limitation. This study is the first step in an overall evaluation of Fighter Lead-In Training. It is restricted to evaluating the hypothesis that a performance differential exists due to different FLIT trainings between sub-groups.

2. MATHEMATICAL MODELS

7. Two statistical tests, Kruskal-Wallis and One-Way ANOVA, described in detail in the Annex A, were used to analyze the hypothesis.

8. Kruskal-Wallis Test. The Kruskal-Wallis test is a non-parametric rank sum method. This model can be used to test the null hypothesis that k samples come from identical distributions. It is very robust as it makes no assumptions about the nature of the sample data. However, it is less sensitive to small differences in sample distributions compared with other statistical tests.

9. The Kruskal-Wallis test produces an **H** test value which can be approximated by a Chi-Square distribution with k - 1 degrees of freedom where k is equal to 3 (the number of FLIT groups) for our purpose. For a given level of confidence, if the **H** value exceeds the Chi-Square distribution value, the null hypothesis would be rejected. Otherwise, the null hypothesis is accepted and the performance of the sample groups would be assumed to be the same.

10. One-Way ANOVA Test. One-way analysis of variance is a statistical method for comparing the means of several data sample groups. Whereas the Kruskal-Wallis test does not make any assumptions about the data, One-Way ANOVA assumes that the standard deviations of the sample groups are all equal. References [4,5] suggest that a simple general rule can be used to test the validity of the ANOVA assumption. The rule proposes that the ratio of the largest standard deviation of the sample groups to the smallest standard deviation must be less than two for the assumption to be taken as valid.

11. The One-Way ANOVA test was run using the Statistical Analysis Software (SAS) system. SAS General Linear Model [6] procedure produces two main outputs: the **F** statistic and the probability that an **F** value greater than or equal to the **F** statistic could be produced by chance. This probability value can be interpreted as the likelihood that the data sample groups are the same.

3. ANALYSIS AND RESULTS

12. There are twenty students in the BFP course. However, there are two students whose performances are under investigation and there are three students who have ceased training. We do not incorporate these questionable students' performances into the analysis since the recorded data might not reflect their true performances.

13. The two statistical tests were applied to the course averages. The course average of a student is the ratio of the total points he obtained to the sum of the number of simulator flights and the number of actual flights. Table 1 ranks these averages in decreasing order. Due to confidentiality, the students' names are replaced by letters, i.e., A, B, C, ... FLIT 1 labels the sub-group of eight students of the full FLIT course; FLIT 2 labels the students of the sub-group taken the modified FLIT course; and TEXAS labels the students of the sub-group trained in Texas.

14. Kruskal-Wallis Test. Table 2 contains the results of the application of the Kruskal-Wallis test to BFP course averages. The resulting parameter **H** test value is 0.491 while the Chi Square values for the 90 percent and 95 percent confidence levels (10 and 5 percent probability of error) are 4.61 and 5.99, respectively. The Kruskal-Wallis test for these levels of confidence would indicate that the null hypothesis should be accepted. Thus, the three sub-groups come from identical distributions.

Student	Group	Course Average	Rank	Special
A	FLIT 1	4.12	1	
B	TEXAS	4.0303	2	pending
C	TEXAS	3.9109	3	
D	FLIT 1	3.8039	4	
E	TEXAS	3.68	5	
F	FLIT 2	3.6733	6	
G	FLIT 2	3.6465	7	
H	FLIT 1	3.5644	8	
I	TEXAS	3.4412	9	
J	FLIT 1	3.4356	10	
K	FLIT 2	3.4216	11	
L	FLIT 2	3.3465	12	
M	FLIT 1	3.31	13	
N	TEXAS	3.3	14	
O	FLIT 1	3.2415	15	
P	FLIT 1	3.1919	16	
Q	FLIT 1	2.8901	17	pending
R	FLIT 2	2.8704	18	ceased training
S	FLIT 2	2.8333	19	ceased training
T	FLIT 2	2.8116	20	ceased training

TABLE 1. FLIT Student Performances

FLIT 1	Rank
Pilot A	1
Pilot D	3
Pilot H	7
Pilot J	9
Pilot M	12
Pilot O	14
Pilot P	15
FLIT 2	Rank
Pilot F	5
Pilot G	6
Pilot K	10
Pilot L	11
TEXAS	Rank
Pilot C	2
Pilot E	4
Pilot I	8
Pilot N	13
H Value =	0.49
Chi Square(.10,2) =	4.61
Chi Square(.05,2) =	5.99

TABLE 2. Kruskal-Wallis Test Results

15. Note that in Table 2, the student name labels (A, B, C ...) are kept the same as in Table I. However, the students are grouped into their original sub-groups - FLIT 1, FLIT 2 or TEXAS. Also, the ranks in Table 2 are from 1 to 15 instead of 1 to 20 as in Table 1, as we have removed the students who have ceased training or whose cases are pending.

General Linear Model Procedure			
Group	Observations	Scores	
		Mean	Std Dev
FLIT 1	7	3.524	0.336
FLIT 2	4	3.522	0.163
TEXAS	4	3.583	0.270
F Value =	0.06		
Probability(>F) =	0.939		

TABLE 3. One-Way ANOVA Test Results

16. ANOVA Test. The results of the ANOVA analysis of the performance scores of the candidates on the BFP course are shown in Table 3. From Table 3, the ratio of the largest standard deviation (0.336) to the smallest (0.163) is roughly 2. The data passed the test for common standard deviation. Therefore, the assumption required for the ANOVA test is considered valid and the ANOVA procedure can be applied.

17. From Table 3, the F statistic of 0.06 and an associated probability of 0.939 (93.9 percent) were calculated. This implies that the probability that the distributions of group scores are the same and that the differences observed in the performance means are due to chance is 93.9 percent. Therefore, the ANOVA test also indicates that the null hypothesis should be accepted.

18. The same statistical tests were applied to the set of data where the three students (R, S, and T) who had ceased training were included. Again, it is found that the null hypothesis is accepted in both tests - the Kruskal-Wallis and the One-Way ANOVA.

4. CONCLUSIONS AND RECOMMENDATIONS

19. With the present data, no statistically significant evidence exists that students' performances from the three groups - FLIT 1, FLIT 2 and TEXAS - are different. However, this conclusion is based on a small sample size, as data is available for a single year only. For a more definitive study, it is recommended that data be gathered over several years, and the statistical analysis repeated.

20. It was shown in [7] that, in general, students' future performances are related to their past performances with regards to flight training. It is recommended that a study based on selection criteria, students' performances, psychological tests, etc be performed to determine the profile of a successful pilot student.

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ANNEX A: MATHEMATICAL MODELS

1. Two methods were used in [1] to test the hypothesis that there was no difference between the BFP course performances using the mid-term results of the students in the BFP course. The first method is the Kruskal - Wallis (K-W) test. It is a non-parametric model, that is it makes no assumption about the nature of the sample data [4]. The K-W test can be used to test the null hypothesis that k samples come from identical distributions. While the K-W test is very robust, it is less sensitive to small differences in sample distributions compared to other statistical tests. The second method is called the One-Way ANOVA test. The One-Way ANOVA assumes that the standard deviations of the sample groups are all equal [4-5]. Because of its assumption, the One-Way ANOVA test is more sensitive to sample differences than the K-W test. However, we must have some confidence that the equal standard deviation assumption applies to run the One-Way ANOVA test.

Kruskal-Wallis (K-W) test

2. Data are ranked jointly in the K-W test as if they were from one sample. The test statistic is calculated from the rank of each data element as follows:

$$H = \frac{12}{n(n+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(n+1)$$

where: $n = n_1 + n_2 + ... + n_k$,

n_i is the number of data elements in the *ith* data group,

k is the number of data groups, and

R_i is the sum of the ranks for the *ith* data sample group.

3. When there are several data elements with the same value, the rank assigned to these elements is the average of the ranks they jointly occupy. For instance, if the third, fourth and fifth ranked data elements have the same value, these three data elements would be assigned the rank of four. The next data element in rank order would be given the rank of six, and the ranking would continue.

4. The sampling distribution of **H** can be approximated by a Chi-Square distribution [4]. For a given level of confidence, if the **H** value exceeds the Chi-Square distribution value, the null hypothesis would be rejected. Otherwise, the performance of the sample groups would be assumed to be the same.

5. The **H** value is found to be equal to 0.491 for the set of 15 students excluding the students under investigation and the ones who had ceased training. The **H** value is equal to 2.5776 when the three students who had ceased training were included. When the **H** value is greater than 6 then there is evidence that the performances of the three groups are different.

<u>One-Way ANOVA Test</u>

6. One-Way ANOVA test assumes that the standard deviations of the sample groups are all equal. When data support such assumption, the One-Way ANOVA test is useful to detect small sample differences.

7. When samples are collected from k data groups, n_i would be the sample size for the *ith* group. Denote the *jth* observation from the *ith* group by x_{ij}. The general linear model for One-Way ANOVA can be described by:

$$x_{ij} = \mu_i + \varepsilon_{ij}$$

where: μ_i is the mean of the distribution for sample group i, and

ε_{ij} is a random variation for observation x_{ij}.

8. The ε_{ij} are assumed to be simple random samples from a normal distribution with mean zero and standard deviation σ. The sample sizes n_i may differ, but the standard deviation σ is assumed to be the same for all sample groups.

9. To test the validity of the equal standard deviation assumption, [5] proposes a general rule. This rule suggests that when the ratio of the largest standard deviation of the sample groups to the smallest standard deviation is less than two for the assumption to be taken as valid.

10. The Statistical Analysis Software, SAS [6], is used to run the One-Way ANOVA test. The SAS output contains the **F** statistic and the probability P that an **F** value is greater than the **F** statistic could be produced by chance. **F** is the distribution of One-Way ANOVA test. The probability value P could be interpreted as the likelihood that there is no performance difference. This means that, if that probability value, P value, was less than 5 percent then the ANOVA test would indicate that the performance levels are different.

11. It is found that the P value is equal to 0.9392 for the set of 15 students excluding the ones under investigation and the ones who had ceased training. The P value is equal to 0.1912 for the set of 18 students excluding the ones under investigation and including the ones who had ceased training. Note that the equal standard deviation assumption for the ANOVA test is satisfied for both the set of 15 students and for the set of 18 students. The standard deviations for the set of 18 students are the same as the ones for the set of 15 students in Table 3 of the main text except for FLIT 2 where the standard deviation is now 0.383. Also, an analysis of the residuals were done. It does not indicate any correlation.

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