A STUDY OF HUMAN FACTORS IN NAVAL AVIATION ACCIDENTS

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CANADA

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BY
H.C. LANSDELL
R.N. FRIZELL

DRML REPORT NO. 83

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ABSTRACT

The accident rates of forty-four pilots attached to HMCS 'Magnificent' were compared with their scores on psychological tests, deck-landing performance, and ratings of ability by the batsmen. The main result of the study was a relationship found between the total flying accident rate, at sea and ashore, and four scales of the Minnesota Multiphasic Personality Inventory. Because of the small size of the sample and the moderate size of the correlation, further data are necessary before the Minnesota Multiphasic Personality Inventory can be used in pilot selection to estimate the probable accident rate of an individual.

Introduction

In December, 1950, Commodore C.N. Lentaigne, R.N., then Assistant Chief of Naval Staff (Air) of the Royal Canadian Navy, requested that the Time and Motion Study Unit of the Operational Research Group, DRB, conduct a study of aircraft accidents aboard HMCS 'Magnificent'. Since, in the analysis of causes of aircraft accidents, a major emphasis commonly is placed on a factor of 'pilot error', Commodore Lentaigne felt that a psychologically oriented study might be of use in attaining the goal of only one accident per hundred deck landings, which is occasionally achieved by a ship of the Royal Navy. On December 1, 1950 the personnel and project were transferred to the Human Resources Section of the Defence Research Medical Laboratories where the work was completed.

In February, 1951, the authors of this report were privileged to be aboard the carrier on its winter cruise for exercises in the Atlantic. The pilots were interviewed and were assessed by various means during this preliminary observation period, and this program was continued during the summer at HMCS 'Shearwater', the Naval Air Station at Dartmouth, N.S. The records of the Accident Investigation and Prevention Section (AIPS) of the RCN at Ottawa were perused.

The light fleet aircraft carrier HMCS 'Magnificent' was launched in 1944 and completed in 1948. She is equipped with a fighter squadron of Hawker Sea Furies and an anti-submarine squadron of Grumman Avengers. These two squadrons, of 11 and 14 pilots respectively, comprise the Carrier Air Group (CAG). A shore-based Support Air Group (SAG) of about 7 Sea Fury and 12 Avenger pilots has less opportunity for embarked flying; it serves as a reserve group from which pilots are drawn for the CAG. Apart from exercises at sea, both groups make considerable use of the airdrome at HMCS 'Shearwater'.

Every available naval pilot in active service was included in this study. However, the small size of the group was a serious handicap in the statistical analysis.

Of the published studies of naval aircraft accidents, none recommends itself as a model. An interesting study of naval aircraft accident records by Older and Webb (1) serves mainly as a guide for avoiding pitfalls in the compilation of records. Their report concludes that conventional USN records yield limited information on the nature and causes of airplane accidents. Implementation of their extensive recommendations on the nature of accident investigation records would make possible fertile research. Direct investigation of pilots, as attempted in the present research, might be very profitable if coordinated with such complete records.

A thorough survey of the recent general accident literature is found in R.L. Thorndike's 'The Human Factor in Accidents' (2). Some of his main points are noted here as they will be found to have implications for the present study.

The concept of an accident-prone individual has not proved to be useful. Thorndike states: '... the trend of evidence to date provides little support for the hypothesis that Air Force accidents are to be charged to a few 'accident-prone' individuals, and that conditions could be markedly improved by more rigorous selection procedures...' (p.147). However, he states that 'where there are many accidents, i.e., in a job in which accidents are frequent or where observations have covered an extended period, differences in proneness tend to play a relatively large role in accounting for differences in actual frequency, and the importance of chance factors becomes less' (p. 146).

Naval aviation, because of greater hazards, has a higher accident rate than normal military aviation; Thorndike's statements do not necessarily preclude some application of the 'accident-prone' approach to this field.

Thorndike notes that the Minnesota Multiphasic Personality Inventory has not been used in a satisfactory manner for the testing of pilot groups. He also suggests that the criterion of lower accident rate often may be impractical. To prove that a factor is related to efficiency of performance may be easier than to show whether or not it causes accidents. For example, the ingestion of alcohol has been shown to influence the performance of certain complex tasks, but it is difficult to show that the ingestion of alcohol increases an accident rate. When identification of the causes of accidents is the specific purpose of a study, Thorndike recommends extensive repeated interviews, with proper control studies of the normal occurrence of risks. He states: 'number of hours flown provides a very inadequate index of exposure to risk, either for individuals or for goups. An index which would provide a more adequate expression of risk would be desirable both for research and for administrative purposes' (p.160).

The approach adopted in this report was that, in naval aviation, the accident rate should be checked against personality test scores, and that some new concept of ability, other than accident rate, should be examined.

Procedure

Generally, the sole criterion for a study of accidents is an accident rate. In this study an additional criterion was explored. During the cruise, ratings of the pilots' deck-landing ability were obtained from their Deck Landing Control Officers or 'batsmen.'[1] Later, ashore, this procedure was duplicated with the SAG.

The accident histories of the pilots were obtained from the records of the AIPS at Ottawa. The accidents were analyzed in terms of three categories: (1) Total number of accidents; (2) embarked accidents; (3) embarked accidents in which the A-25 (the official accident report form) intimated or asserted that the pilot made one of three types of error preceding an accident. In the latter category, a pilot was deemed: (a) to have made an error in his checking routine before landing (e.g., a pilot may forget to put the flaps down); (b) to have made an improper response to the batsman's signals (e.g.,he may make a slow response to the signals); (c) to have handled the aircraft inefficiently after the 'cut', the mandatory signal to shut off power and land (e.g., he may re-apply power after the 'cut'). These errors were used to identify what this report has termed the 'psychological' embarked accident rate.

[1]Each batsman was asked to rate the pilots within a squadron, with whom he was familiar, from best to worst.

Age, marital status, number of children, type of commission, and flying experience at the time of the accidents were determined by interviews and examination of various records.

During the cruise and later at the shore station, the following tests were given: a rough questionnaire of attitudes; the RCAF Classification Test (a general intelligence test); and the Minnesota Multiphasic Personality Inventory (MMPI). An unsuccessful attempt was made to test the pilots' familiarity with standard emergency procedures by means of a quiz based on 'Pilot's Notes'.

The flight-deck logs from February to June, 1951, were used to determine for each pilot the percentage of 'wave-offs'; the reasons for 'wave-offs'; the arrester-wire numbers caught upon landing; and the variability in respect to wires caught. A 'wave-off' occurs when a pilot has been instructed to give up his attempt to land aboard, and to fly back into the landing circuit. Most wave-offs result from a faulty approach to the ship. When an aircraft lands aboard, its hook catches one of ten arrester wires, preferably the second or third wire.

Results

The 44 pilots had a total of 119 accidents during their naval service; 5 of these pilots had no accidents. Sixty-two accidents, involving 29 pilots, occurred while the squadrons were embarked. Thirty-eight of the embarked accidents, involving 26 of the 44 pilots, were classified as having a psychological factor according to the analysis of the A-25 form.

On July 1st, 1951, the flying experience of the pilots averaged 1121 hours; the range was from 398 to 2300 hours.

Accident rates were computed for each pilot on the basis of his total flying time. The total accident rate, the embarked accident rate, and the 'psychological' embarked accident rate were calculated for each pilot in terms of number of accidents per 1000 flying hours. Pilots with no accidents were generally taken as having a minimum accident rate for statistical purposes. This minimum value was one-sixth or less of the smallest actual rate in the various calculations. The small amount of data did not appear to justify further analysis of such factors as the number of deck landings, flying time aboard HMCS 'Magnificant', etc.

Most of the pilots had had flying experience prior to their naval careers. In calculating accident rates, pre-naval flying time was not deducted from the total flying time of each pilot. Corrections could not be made since some of the pilots did not have their old logs available. The accident rates used here, therefore, do not reflect the true number of accidents per 1000 hours of total flying experience. Accident rates computed on a basis of naval time only would have been subject to the criticism of not accounting for the pilots' previous flying experience. Of the six possible comparisons of flying experience of the pilots[2], only one was significant: the CAG Avenger pilots averaged more flying hours than the SAG Avenger pilots.

The correlation between the total accident rates and the total embarked accident rates was quite high ($r = .81$), as was the correlation between the total embarked accident rates and the rates for embarked accidents involving a psychological factor ($r = .88$). The correlation between the total accident rates and the rates for embarked accidents involving psychological factors was .72. These correlations indicate that the two embarked rates are similar, whereas the total accident rate may differ

[2]Four squadrons may be compared six ways: CAG, Avengers vs Sea Furies; Avengers, CAG vs SAG; CAG, Avengers vs SAG Sea Furies; Sea Furies, CAG vs SAG; SAG, Avengers vs Sea Furies; and CAG Sea Furies vs SAG Avengers.

essentially from the 'psychological' embarked rate. However, the size of these correlations suggests there is little that is unique about the so-called 'psychological' embarked accident rate. Compared to the total accident rate, the comparatively small range and number of embarked accidents suggest that these latter two accident rates are not as reliable.

The most interesting result was the multiple correlation obtained between the total accident rate and four scales of the personality test (L, ?, Ma & Pd scales, R = .55).

The batsmen's ratings were not related to either of the embarked accident rates. However, the total accident rate showed a negative relation: the pilots rated in the top third of their squadrons tended to have a higher total accident rate.

The accident rates were not related to the average wire number caught upon landing, or the variability in the wire number caught. The fighter aircraft landed farther up the deck and had a higher percentage of wave-offs. In the CAG the percentage of wave-offs tended to be related negatively to the 'psychological' embarked accident rate, while in the SAG the percentage tended to be related positively, i.e., the greater the accident rate the greater the percentage of wave-offs. In the period studied the SAG pilots tended to land farther up the deck. However, the observations for the two groups were taken on different exercises under different conditions. The SAG had operated in calmer seas (deck-foul wave-offs, which include the wave-offs caused by a pitching deck, had a ratio of 12% to the number of deck landings for the CAG and 4% for the SAG). The batsmen tended to rate as better, those pilots who had a lower percentage of wave-offs. There was no consistent relation between these ratings and the wire numbers caught or the variability in wire numbers caught by the pilots.

None of the accident rates distinguished between pilots of the CAG and the SAG, between Avenger and Sea Fury pilots, between pilots who were married and those who were single, between pilots who had children and those who had not. The intelligence test (CT) scores bore no relation to any of the other variables.

Too few of the pilots were able to supply the number of flying hours at the time of all their accidents to permit a satisfactory check on the predisposing nature of one accident to lead to another (2, p.120). The restricted amount of data did not allow for adequate comparisons between different types of error leading to wave-offs, and the criteria.

Short service pilots had significantly lower accident rates and number of accidents than permanent force pilots. This does not seem to agree with the batsmen's ratings which are slightly in favour of the permanent force pilots. Only one of the MMPI scores (L) distinguished between these two types of pilots.

The answers on the attitude questionnaire did not show any relationship to accident rates or batsmen's ratings. In our opinion, a more intensive study of such attitudes would be of no value.

The complete statistical analysis of the data is given in the Statistical Appendix.

Discussion

A relationship appears to have been discovered between an accident rate of pilots and their scores on a psychological test. The multiple correlation of .55 between the total accident rate and the Ma, Pd, L & ? scores on the MMPI is significant. This result shows that in this group of pilots one can estimate the accident rate of a pilot within certain wide limits from a knowledge of his score on 4 scales of the MMPI. The size of the correlation, however, leaves much to be desired. That these scales would predict the accident rate before the pilot enters the service is doubtful. The case could easily be that having a certain rate of accidents partly determined the pilots' answers on the test. This aspect would appear relevant as the two more important scales (L & ?) are normally used simply to judge the nature of a subject's 'attitude' to the test; scores beyond certain limits indicate that scores on the other main scales may be misleading. These scales are two of the 'validating' scales. The original purpose for which the test was designed – diagnosis of forms of psychological maladjustment – was of little concern here. Pilots with general psychological handicaps related to deck-landing ability are not likely to reach the operational stage.

Because the accident rate used here is not a true rate, and because of the limited number of cases, confirmatory evidence is required. Before assuming that the MMPI is useful for selection purposes, or that extensive statistical investigation into such test correlations will reveal a good deal about the psychological nature of aircraft accidents, data on pilots from the USN or RN should be studied.

The lower accident rate for the short service pilots may indicate a real difference in ability. This difference in accident rate might be a result of their having less total flying time in the RCN than the permanent force pilots.

That the batsmen's ratings should be related in some respects to the percentage of wave-offs was to be expected. An extended systematic study of all the various errors made by pilots in the landing circuit might shed some further light on the nature of the batsmen's opinions. The ratings obtained in this study are probably different from those that would have been obtained if ratings had been asked on the more nebulous concept of 'accident-proneness.'

Probably the peculiar differences between the CAG and SAG in the deck-landing variables are related specifically to the different types of conditions under which they were operating. Further study of such factors over longer periods might reveal more general conclusions which would be independent of specific exercises and could be useful measures of pilot performance for predicting accidents.

The average CT score, of 64 correct out of 80, was high in comparison with the Canadian norm of about 32. With regard to the Ma scale of the personality inventory, on which the pilots were above average, the authors of the test state that persons with high Hypomania scores are 'active and enthusiastic' (3, p.6). This characterization of the pilots would appear to be appropriate. Unfortunately, no data on MMPI scores could be found in the literature to allow comparisons between RCN and other naval pilots.

The authors of this report agree with Thorndike that the 'number of hours flown provides a very inadequate index of exposure to risk, either for individuals or for groups'. The flying time for the RCN pilots included experience with different types of planes, with different kinds of climatic conditions, with different types of flying exercises, and so on.

The failure to discern more important psychological aspects to the accidents may be due, in part, to the crudeness of our measuring instruments. However, many of the groupings used in this study were too small for satisfactory comparisons. Thorough sub-division of the groups for proper matching of factors would have been absurd. The number of pilots in the RCN is too small a population for the statistical requirements of an objective study of all the factors which may be involved in the causes of their accidents. Stated in other terms, almost every flying accident in the RCN appears to be an unique event.

A final problem may be raised. Are pilots who have fewer deck-landing accidents operationally more effective against hostile aircraft or submarines? The ideal criteria for 'good' naval pilots may not be closely related to their deck-landing ability or accident rate.

Summary

Forty-four pilots of the Royal Canadian Navy were observed during the first few months of 1951 for psychological factors related to their deck-landing accidents. A relationship was found between the total flying accident rate, at sea and ashore, and four scales of the Minnesota Multiphasic Personality Inventory. However, the implications of the result are not clear. Other tests, measures of deck-landing performance, and ratings of ability were investigated, but no significant relations were found with either the overall accident rate or with deck-landing accidents caused by 'pilot error.' The small size of the group suggests that the results should be interpreted with caution.

Recommendations

The results of this study cannot be construed as having immediate implications for reducing the accident rate aboard HMCS 'Magnificent'. At present too little is known about the factors which receive emphasis from the present results. Although American and British research with larger numbers of pilots may supply a better perspective on such factors, the following suggestions would appear to be worth consideration as Canadian Naval Aviation continues to develop:

1. In expanding facilities of the AIPS for statistical investigation of accidents, the recommendations of recent research reports should be considered (1,2,5).

2. By the time a hundred or more active pilots are available for study, a procedure should have been instituted for precise recording of all landing-circuit errors and other features of the deck-landing performance. Analysis of this data over a reasonable period of time should help define objectively the important characteristics of a good 'deck' pilot; and the data may help in predicting the occurrence of accidents.

3. Future studies should develop some objective measures of the pilots' operational efficiency in various types of exercises.

4. The administration of psychological tests (e.g., the MMPI) to incoming pilots could be handled routinely through Staff Officer Personnel Selection, RCN. Sufficient material should be accumulated within the next few years to permit an investigation of a most important problem — pilots who are killed in accidents.

5. For evaluating the comparison of accident rates of the two types of commissions in the present study, some estimate should be made of the relative lengths of their service with the RCN.

6. We would note that RCN policy with regard to facilities (e.g., briefing room layouts, air conditioning, cafeteria, etc.) for the pilots does not appear to compare favourably with American practice aboard the modern carriers. Although this is outside the scope of this report, we presume that modernization of our carrier's facilities would aid the pilots in performing their difficult job.

Acknowledgements

We wish to express our sincere appreciation of the cooperation and understanding of all the personnel in Canadian Naval Aviation with whom we have worked. Particular mention must be made of Commodore Lentaigne's adept handling of arrangements. Commodore Adams and his officers were especially kind in welcoming us aboard HMCS 'Magnificent'. Cdr. Gratton-Cooper, Lt/Cdr. Bradley, and the CO's of the groups have shown unlimited patience in helping us comprehend naval air operations. We are indebted to the AIPS staff for their enthusiastic cooperation.

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4. Cofer, C.N., J. Chance, and A.J. Judson, *J. Psychol.*, 1949, 27, 491–499.

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STATISTICAL APPENDIX

This appendix describes in detail the results used in the report. The following notation has been used: N = number of pilots, $\bar{X}$ = average value, r = Pearson product moment correlation coefficient, P = probability that no actual difference exists (P values equal to or less than .05 may be taken as indicating that a true difference exists).

I. Description of the Population

1. *Number of accidents (N = 44) as of July 1st, 1951 (see Table 1)*

		range
Embarked accidents	62,	0–6
'Psychological' embkd. accidents	38,	0–4
Total naval aircraft accidents	119,	0–8

Table 1

Flying hours and number of accidents for various groups of pilots as of July 1st, 1951

Group Squadron	No. pilots	Total flying hours	Total number of naval accidents	Total number of 'psychol.' embkd. accidents
CAG Avenger	13	17532	40	12
Sea Fury	10	11196	29	11
Total	23	28728	69	23
SAG Avenger	12	10159	28	8
Sea Fury	7	8202	20	7
Total	19	18361	48	15
Avenger Total	25	27691	68	20
Sea Fury Total	17	19398	49	18
Total	42	47089	117	38

Note: Avenger aircraft have been used by the RCN only since 1951; their data include a large amount of experience with the now obsolete Firefly aircraft. The number of accidents listed in this table is for pilots for whom flying experience was known. The range of flying hours for individual pilots was 398–2300 hours with a standard deviation of 443 hours. Accident rates calculated on the above data show no important differences among the groups.

2. *Deck-landing performance (see Table 2)*

	$\bar{X}$	range
Approaches to deck	36.1	3–69
Number of deck landings	26.3	2–51
Number of wave-offs	7.0	0–21
Per cent: wave-offs/approaches	18.5	0.0–42.2
Average wire number caught	2.79	(1052 landings)
Individual standard deviations of wire numbers caught (index of variability)	1.32	.83–1.94

3. *Other descriptive data*

a Marital status: 13 single, 29 married (2 undetermined)
b Married pilots: 7 with no children, to 3 with 3 children
c Type of commission: 25 permanent force, 19 short service
d Age (N = 38): $\bar{X}$ = 28.0, range = 24–30 years

4. *Scores on psychological tests*

a. CT score (N = 39): $\bar{X}$ = 64.1, range = 45–80

b. Minnesota Multiphasic Personality Inventory – Group form (N = 39):

Scale	raw $\bar{X}$	S.D.	$\bar{X}$ with K*	Test norm
?**	5.9	15.83		....
L	3.2	1.78		1–7
F	4.5	2.32		0–7
K	15.2	4.72		7–17.5
Hs	3.5	2.88	11.1	7.5–15.5
D	17.3	4.20	17.3	12.5–21
Hy	18.1	3.11	18.1	11–22
Pd	15.6	3.99	21.7	14.5–23
Mf	22.9	4.36	22.9	15.5–25.5
Pa	8.3	2.56	8.3	4.5–11.5
Pt	8.6	5.56	23.8	18–28
Sc	7.6	5.20	22.8	17–27.5
Ma	17.7	4.04	20.7	13–21
Mal***	13.3	3.87		....

*The K adjustment is derived from the group K.

**Omitting one extreme case, $\bar{X}$ = 3.4, S.D. = 4.23.

***Mal score calculated according to Cofer, C.N., *et.al.* (4).

Table 2

Deck-landing Performance, February 28th to June 6th, 1951

Group Squadron	No. pilots	No. DL's	Percentage of landings catching wire number 1	2	3	4	5	6	7	8	9	10	No. WO's	No. DF's	$\bar{X}$ % WO/DL	$\bar{X}$ % WO/app.	$\bar{X}$ of $\bar{X}$ wire nos.	$\bar{X}$ of SD of wire nos.
CAG Avenger	14	591	24.0	27.9	25.1	15.9	4.7	1.0	0.2	0.7	0.2	0.3	138	87	23.8	16.5	2.58	1.32
Sea Fury	11	275	16.4	23.3	26.6	20.0	6.5	2.9	3.6	0.7	0.0	0.0	109	19	39.5	25.7	3.02	1.37
Total	25	866	21.6	26.4	25.6	17.2	5.3	1.6	1.3	0.7	0.1	0.2	247	106	30.7	20.6	2.78	1.34
SAG Avenger	10	136	16.9	21.3	31.6	18.4	5.2	5.9	0.7	0.0	0.0	0.0	21	5	16.2	12.3	2.99	1.26
Sea Fury	5	50	20.0	20.0	22.0	14.0	10.0	6.0	8.0	0.0	0.0	0.0	12	2	28.4	20.8	3.67	1.33
Total	15	186	17.7	21.0	29.0	17.2	6.5	5.9	2.7	0.0	0.0	0.0	33	7	20.3	15.1	3.22	1.28
Avenger Total	24	727	22.7	26.7	26.3	16.4	4.8	1.9	0.3	0.6	0.1	0.2	159	92	20.6	14.8	2.75	1.30
Sea Fury Total	16	325	16.9	22.8	25.8	19.1	7.1	3.4	4.3	0.6	0.0	0.0	121	21	36.1	24.2	3.22	1.35
Total	40	1052	20.9	25.5	26.1	17.2	5.5	2.4	1.5	0.6	0.1	0.2	280	113	26.8	18.5	2.94	1.32

Legend: DL = deck landing. WO = wave-off recorded as faulty approach by pilot to ship. DF = wave-off recorded as caused by deck-foul (e.g., previous aircraft which landed obstructed deck), pitching deck, etc. % WO/DL = percentage of wave-offs to deck landings. % WO/app. = percentage of wave-offs to total number of approaches to deck (deck landings, WO's, and DF's). $\bar{X}$ wire no. = mean wire number caught upon landing. SD of wire nos. = standard deviation of wire numbers caught.

The last four measures were calculated for each pilot; the means shown are averages derived from individual pilot values and not the averages of the data shown in this table.

II Analysis of Results

1. *Comparison of flying experience of the 4 squadrons*

(a) Total flying hours:

	N	$\bar{X}$
CAG Avenger.............	13	1349
Sea Fury	10	1120
SAG Avenger	12	847
Sea Fury.............	7	1127

(b) Variance table for total flying hours:

Source	Sum of Squares	df	Variance Estimate
Between	1,595,191	3	531,730
Within	6,660,131	38	175,267
Total	8,255,322	41	F= 3.03, P = 01–.05

(c) t-test, X total flying hours Avenger pilots, CAG vs SAG:

t = 3.00, df = 38, P = .001–.01

2. *Accident rates (N = 43) (number of accidents per 1000 hours flying experience)*

(a) Total acc. rates and embarked accident rates, r = .83
(b) Total acc. rates and 'psychol.' embkd. acc. rates, r = .72
(c) Embkd. acc. rates and 'psychol.' embkd. acc. rates, r = .88
(d) Comparison of squadron mean total accident rates:

i.

	N	$\bar{X}$
CAG Avenger,	14	2.54
Sea Fury,	10	2.73
SAG Avenger	12	2.67
Sea Fury,	7	2.65

ii. Variance table for total accident rates (4 squadrons):

Source	Sum of Squares	df	Variance Estimate
Between	0.24	3	0.08
Within	160.34	39	4.11
Total	160.58	42	F = .02, no significant differences

3. *Deck-landing performance*

(a) Variance table for pilots' mean wire numbers (4 squadrons):

Source	Sum of Squares	df	Variance Estimate
Between	4.5351	3	1.5117
Within	19.4543	36	.5404
Total	23.9894	39	F = 2.80, P = .05–.10

(b) Variance table for pilots' % wave-off/approaches (4 squadrons):

Source	Sum of Squares	df	Variance Estimate
Between	1040.65	3	346.883
Within	2683.04	36	74.529
Total	3723.69	39	F = 4.65, P = .001–.01

(c) Variance table for pilots' % wave-off/deck-landings (4 squadrons):

Source	Sum of Squares	df	Variance Estimate
Between	3042.51	3	1014.17
Within	9375.12	36	260.42
Total	12417.63	39	F = 3.89, P = .01–.05

(d) Comparisons of wire numbers caught (n = no. of DL's):

i. CAG – Avenger vs Sea Fury:

n = 866, df = 6 (last 4 wires grouped), $X^2 = 21.31$, P = .01–.02

ii. CAG vs SAG:

n = 1052, df = 6, $X^2 = 15.96$, P = .01–.02

iii. Avengers – CAG vs SAG:

n = 727, df = 5, $X^2 = 12.85$, P = .02–.05

(e) The above results indicate the difference in performance of the two types of aircraft. They suggest also that the different conditions, during which the data on the two groups were recorded, resulted in different performance characteristics. Therefore, a constant was added or subtracted to the % wave-off values such as to make the squadron means identical; these 'corrected' values were used for certain calculations involving the total number of pilots. The SD's of the wire numbers are not significantly different for the different groups. See Table 3 for relations among the deck-landing variables and Table 4 for relations between some deck-landing variables and accident rates.

4. *Batsmen's ratings of the pilots' deck-landing ability*

The batsmen rated the pilots within each of the two squadrons with which they were familiar. Each group (of two squadrons) had three raters. Only the CAG ratings were checked for reliability: one day retests were high, but with a week intervening the rho's varied. This is not surprising in view of the fact that the batsmen expressed a desire to revise their previous opinions (this period included the first time the Avengers had landed aboard). Rho's between batsmen were not wholly satisfactory for either group. Statistical difficulties arose in three cases when the pilots had not been observed by one of the batsmen rating a particular squadron. The method adopted for assigning a single rating for any pilot was mainly one of averaging his ratings but making a few adjustments in the light of the opinions of the more experienced batsmen. See Table 5 for the relations between the ratings and deck-landing performance.

(a) Relations between ratings and total accident rates:

i. Ratings arbitrarily divided into three groups:

	high	medium	low
$\bar{X}$ total accident rates:	3.8	1.7	2.5

ii. Variance table for pilots' total accident rates (3 categories of ratings):

Source	Sum of Squares	df	Variance Estimate
Between	30.73	2	15.37
Within	122.53	38	3.22
Total	153.26	40	F = 4.77, P = .01–.05

(b) No relations between ratings and 'psychological' embarked accident rates or flying experience.

Table 3

Pearson product moment correlation coefficients between deck-landing variables

Group	No. Pilots	SD wire no. and corrected WO/app.	SD wire no. and corrected WO/DL	SD wire no. and corrected wire no.	WO/DL and wire no.- both corrected
CAG	25	-.10	-.16	.57	-.39
SAG	15	-.17	-.17	.05	.23
Avengers	24	-.03	-.05	.57	-.08
Sea Furies	16	-.25	-.27	.18	-.12
Total	40	-.13	-.16	.29	.10

Table 4

Pearson product moment correlation coefficients between some deck-landing variables and accident rates

Group Squadron	No. pilots	Total acc. rates and SD wires	'Psychol.' embkd. acc. rates and SD wires	Total acc. rates and corrected % WO/app.	'Psychol.' embkd. acc. rates and corrected % WO/app.	Total acc. rates and corrected $\bar{X}$ wire no.
CAG Avenger	14	.04	.22	-.08	-.19	.29
Sea Fury	10	-.05	.15	-.19	-.55	-.13
Total	24	.02	.20	-.11	-.34	.03
SAG Avenger	10	-.55	-.02	.11	.44	-.04
Sea Fury	5	.26	.31	.11	.36	-.36
Total	15	-.19	.10	.11	.42	-.19
Avengers	24	-.17	.10	.00	.14	.10
Sea Furies	15	.08	.22	-.08	-.24	-.23
Total	39	-.07	.15	-.03	-.01	-.08

Note: It was considered advisable that the accident rates be normalized, on a 9-point scale, to perform the above calculations.

5. *Psychological test scores*

a) CT. score:

i. Relation to accident rates, N= 40:

total rate........................ r = .04

normalized 'psychol.' embkd. rate..... r = .08

ii. Relations to deck-landing performance variables, N = 36;

with Sd wire nos.............. r = .12

with corrected wire nos...... r = .19

with corrected WO/app,...... r = -.02

iii. Similarly, no relation between scores and batsmen's ratings.

b) Minnesota Multiphasic Personality Inventory, N = 39:

i. The two scales of this test which appeared to bear some relation to the accident rates are shown in detail in Table 6.

ii. The normalized total accident rate correlated with the Ma scale -.19, the Pd scale -.22, and the Mal score -.23.

iii. The normalized total accident rate had a multiple correlation, R, with Ma, Pd, ? & L scales of .55.

Normalized total accident rate = 6.224 + .311 normalized ?-score -.383 L-score -.110 Pd-score -.003 Ma-score.

iv. Relations between test scores and deck-landing performance variables were negligible, the highest coefficient being between Mal score and corrected WO/app.: r = .31 (N=35).

v. The MMPI did not distinguish significantly between pilots who had and pilots who did not have 'psychological' embarked accidents.

6. *Comparison between the two types of commissions (Permanent Force and Short Service)*

a) Variables which differentiated between the two groups are shown in Table 7.

b) The two groups did not differ significantly with respect to:

i. Total hours flying experience:

$\bar{X}$ flying hours: SS, 1147 (N = 19); PF, 1100 (N = 23)

ii. Percentage of pilots with no 'psychological' embarked accidents:

SS, 53% (10/19); PF, 32% (8/25)

$X^2 = 1.90$, df = 1, not significant

iii. Batsmen's ratings:

above average ratings: SS, 42% (8/19); PF, 57% (13/23)

$X^2 = .54$, df = 1, not significant

iv. CT scores, MMPI scores (other than L scale), deck-landing performance variables.

7. *Miscellaneous*

a) Age of pilots was not related to accident rates.

b) Neither marital status, number of children, nor absence of offspring was related to accident rates.

Table 5

Relations between batsmen's ratings and deck-landing performance (rho)

Squadron	No. pilots	% WO/app.	% WO/DL	Wire no.	SD wire no.
CAG Avenger	14	.70	.62	-.25	.09
Sea Fury	10	.55	.48	-.56	-.24
SAG Avenger	10	.18	.13	.41	.55
Sea Fury	5	.50	.50	-.10	-.70

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