APPENDIX 3A

STATISTICAL ANALYSIS

- by -

J. T. Harris

For the purpose of statistical analysis it was found possible to combine tables 3.2 and 3.9, 3.3 and 3.10, and 3.4 and 3.11. Each combined table could then be subjected to a 3-factor analysis of variance procedure. Each of the tables 3.5, 3.6 and 3.7 were subjected to a 2-factor analysis of variance procedure. However the six tables analysed involved only eight main factors since one factor appeared in each of the six tables and another in each of the three combined tables.

Tables 3.1 and 3.6 were excluded from the statistical analysis since the factors involved would be covered by the above analyses.

Since the original data was in percentage form it was considered appropriate to subject them to an angular transformation before proceeding with the analysis. In addition a value of sixty was deducted from each value thus obtained so as to ease the subsequent numerical calculations without affecting the results. The figures so adjusted appear as the transformed values in the tables below.

The procedure of analysis of variance separates the total variance into that contributed by the separate factors. Using Snedecor's F test it is possible to determine whether the variation introduced by a given factor is significantly different from sampling fluctuation . Where an F value reaches the 5% level of significance it is denoted by one star, where it reaches the 1% level it is denoted by two stars, and where it reaches the 0.1% level it is denoted by three stars. The three situations are referred to as significant, highly significant, and very highly significant, respectively. Full details of the procedure can be obtained in an appropriate statistical handbook.

The definitions of the symbols and their subscripts appear in the tables where they are first employed. A brief summary is given with each analysis and an overall one is included at the end.

Tables 3.2 and 3.9

Percentage retrieval for indexers for searches by project and technical staff

Times (mins.)(T)		16	12	8	4	2
Method (M)	Staff (S)	T_1	T_2	T_3	T_4	T_5
U.D.C.	Project (S_1)	82	80	74	77	72
M_1	Technical (S_2)	84	86	78	78	76
ALPHA	S_1	89	85	77	85	73
M_2	S_2	81	78	74	76	63
FACET	S_1	76	79	71	71	71
M_3	S_2	62	73	66	55	70
UNITERM	S_1	89	85	83	88	75
M_4	S_2	85	83	73	87	85

Transformed Values

6.4	8.0	2.0	2.0	0.7
4.9	3.4	-0.7	1.3	-1.9
4.2	2.0	-0.7	0.7	-7.5
10.6	7.2	1.3	7.2	1.3
-8.1	-1.3	-5.7	-12.1	-3.2
0.7	2.7	-2.6	-2.6	-2.6
7.2	5.6	-1.3	8.9	7.2
10.6	7.2	5.6	9.7	0.0

Means of Times

	T_1	T_2	T_3	T_4	T_5
	4.56	4.35	-0.26	1.89	-0.75
Ex.Facet	7.32	5.57	1.03	4.97	-0.03

Means of Staff

	S_1	S_2
	0.75	3.16
Ex.Facet	3.03	4.51

Means of Methods

M_1	M_2	M_3	M_4
2.61	2.63	-3.48	6.07

Analysis of Variance (Full)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	473.57	3	157.86	
S	58.32	1	58.32	
T	198.19	4	49.55	**
Interactions				
M x S	110.46	3	36.82	*
M x T	149.40	12	12.45	
S x T	26.27	4	6.57	
Residual	73.70	12	6.14	
Total	1089.92	39	27.95	

Analysis of Variance (Ex. Facet)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	79.35	2	39.68	
S	16.58	1	16.58	
T	235.16	4	58.79	***
Interactions				
M x S	84.61	2	42.31	**
M x T	45.86	8	5.73	
S x T	9.55	4	2.39	
Residual	61.19	8	7.65	
Total	532.30	29	18.36	

The full analysis of variance table indicates that the M x T and the S x T variances do not differ significantly from the residual. A new residual variance of 8.91 was thus possible by combining the three. Against this the M x S variance and the T variance were significant and highly significant respectively. The M and S variances are not significant when tested against the value for M x S.

Since Facet appears to behave in a distinctly different way from the other Methods the analysis was undertaken with its exclusion. Once again a new residual combining the original and the M x T and the S x T variances was possible and a value of 5.83 obtained for it. The conclusions however remain unchanged except for significance at a higher level.

Tables 3.3 and 3.10

Percentage retrieval for indexers for searches by project and technical staff

Indexers (I)		Hadlow	Warburton	Sharp
Method (M)	Staff (S)	I_1	I_2	I_3
M_1	S_1	74	81	77
	S_2	81	77	83
M_2	S_1	80	85	83
	S_2	76	70	78
M_3	S_1	71	78	71
	S_2	63	69	64
M_4	S_1	84	83	86
	S_2	78	85	82

Transformed Values

-0.7	4.2	1.3
4.2	1.3	5.6
3.4	7.2	5.6
0.7	-3.2	2.0
-2.6	2.0	-2.6
-7.5	-3.8	-6.9
6.4	5.6	8.0
2.0	7.2	4.9

Means of Indexers

	I_1	I_2	I_3
	0.74	2.56	2.24
Ex.Facet	2.67	3.72	4.57

Means of Staff

	S_1	S_2
	3.15	0.54
Ex. Facet	4.56	2.74

Means of Methods

M_1	M_2	M_3	M_4
2.65	2.62	-3.57	5.68

Analysis of Variance (Full)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	271.57	3	90.52	
S	40.82	1	40.82	
I	15.16	2	7.58	
Interactions				
M x S	55.58	3	18.53	*
M x I	19.99	6	3.33	
S x I	9.37	2	4.69	
Residual	37.72	6	6.29	
Total	450.22	23	19.57	

Analysis of Variance (Ex.Facet)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	37.21	2	18.61	
S	14.76	1	14.76	
I	10.87	2	5.43	
Interactions				
M x S	44.14	2	22.07	*
M x I	2.86	4	0.71	
S x I	9.82	2	4.91	
Residual	36.70	4	9.18	
Total	156.36	17	9.20	

The full analysis of variance table indicates that a new residual combining the original and the M x I and the S x I variances is possible. Its value is 4.79. Against this the M x S variance is significant and the I variance not significant. The M and S variances are not significant in comparison with that of M x S.

An analysis excluding Facet reveals the same conclusions with in this case a new residual of 4.94.

Tables 3.4 and 3.11

Percentage retrieval according to subject for all searches by project and technical staff

Subject (J)		Aeronautical	General
Method (M)	Staff (S)	J_1	J_2
M_1	S_1	73	79
	S_2	77	82
M_2	S_1	79	84
	S_2	72	74
M_3	S_1	70	77
	S_2	62	72
M_4	S_1	82	82
	S_2	81	81
Transformed Values		-1.3	2.7
		1.3	4.9
		2.7	6.4
		-1.9	-0.7
		-3.2	1.3
		-8.1	-1.9
		4.9	4.9
		4.2	4.2

Means of Methods

M_1	M_2	M_3	M_4
1.9	1.62	-2.97	4.55

Means of Staff

	S_1	S_2
	2.30	0.25
Ex Facet	3.38	2.00

Means of Subjects

	J_1	J_2
	-0.17	2.72
Ex Facet	1.65	3.73

Analysis of Variance (Full)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	117.20	3	39.07	?
S	16.81	1	16.81	
J	33.64	1	33.64	
Interactions				
M x S	40.06	3	13.35	**
M x J	15.42	3	5.14	*
S x J	0.09	1	0.09	
Residual	2.23	3	00.74	
Total	225.47	15	15.03	

Analysis of Variance (Ex. Facet)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	20.87	2	10.44	
S	5.74	1	5.74	
J	13.02	1	13.02	*
Interactions				
M x S	34.73	2	17.37	*
M x J	7.42	2	3.71	
S x J	0.70	1	0.70	
Residual	0.90	2	0.45	
Total	83.39	11	7.58	

The full analysis of variance indicates that the S x J variance can be combined with that of the residual to yield a new value of 0.58. Against this the M x J and the M x S variances are significant and highly significant respectively. When the S variance is compared with the M x S variance it is not significant and similarly when the J value is compared with that of the M x J value. There is no way of telling whether the M value is significant.

Once again an analysis excluding Facet was undertaken. A new residual as above was possible with a value of 0.53. Against this however the M x J variance was not significant so that a further new residual of 1.80 was possible. The M x S and J variances were significant in comparison with this value but the M and S variances were not in comparison with the M x S value.

Table 3.5

Percentage retrieval according to indexing sub-programme for searches by College staff

Documents (D)	1 - 6000	6001 - 12000	12001 - 18000
Method (M)	D_1	D_2	D_3
M_1	64	74	77
M_2	75	80	82
M_3		74	74
M_4	70	77	86
Transformed Values			
	- 6.9	-0.7	1.3
	0.0	3.4	4.9
	(- 7.1)	-0.7	-0.7
	- 3.2	1.3	8.0

Means of Methods

M_1	M_2	M_3	M_4
-2.10	2.77	-2.83	2.03

Means of Documents

D_1	D_2	D_3
-4.30	0.82	3.37

Analysis of Variance (Full)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	72.67	3	24.2	*
D	122.23	2	61.12	**
Residual	17.77	6	2.96	
Total	212.67	11	19.33	

The analysis reveals that the D main effect is highly significant and that of M significant. These results are sufficiently strong to require no modification arising from the use of an estimated value in cell D_1, M_3. Facet itself does not appear to behave in such a way as to demand any further analysis.

Table 3.6

Percentage retrieval for searches by project staff in the three rounds of testing

Round (R)	1	2	3
Method (M)	R_1	R_2	R_3
M_1	78	74	76
M_2	83	78	84
M_3	73	69	79
M_4	78	81	87
Transformed Values			
	2.0	-0.7	0.7
	4.9	2.0	6.4
	-1.3	-3.8	2.7
	2.0	4.2	8.9

Means of Methods

M_1	M_2	M_3	M_4
0.67	4.43	-0.80	5.03

Means of Rounds

	R_1	R_2	R_3
	1.90	0.42	4.67
Ex. Facet	2.97	1.83	5.33

Analysis of Variance (Full)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	72.89	**3**	24.30	*
R	37.25	**2**	18.63	
Residual	22.76	**6**	3.79	
Total	132.90	11	12.08	

Analysis of Variance (Ex.Facet)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	33.61	**2**	16.81	
R	19.14	**2**	9.57	
Residual	19.37	4	4.84	
Total	72.12	**8**	9.01	

In the full analysis the main effect M is significant but the R effect falls just short of it. When Facet is excluded neither main effect reaches significance.

Table 3.7

Percentage retrieval by searching for project staff in first two rounds of testing

Persons (P)	Warburton	Hadlow	Cleverdon
Method (M)	P_1	P_2	P_3
M_1	77	75	76
M_2	80	84	77
M_3	74	71	70
M_4	83	78	82
Transformed Values			
	1.3	0	0.7
	3.4	6.4	1.3
	-0.7	-2.6	-3.2
	5.6	2.0	4.9
Means of Methods			
	M_1	M_2	M_3 M_4
	0.67	3.70	-2.10 4.17
Means of Persons			
	P_1	P_2	P_3
	2.40	1.45	0.92
Ex Facet	3.43	2.80	2.30

Analysis of Variance (Full)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	78.17	3	26.06	**
P	4.47	2	2.24	
Residual	20.21	6	3.37	
Total	102.85	11	9.35	

Analysis of Variance (Ex Facet)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	21.67	2	10.83	
P	1.94	2	0.97	
Residual	19.34	4	4.83	
Total	42.94	8	5.37	

In the full analysis the P variance can be combined with the residual to give a new residual of 3.08. Against this the main effect is highly significant. The exclusion of Facet gives rise to a situation where M is not significant.

Whilst different values for the residual terms are obtained in the different analyses close agreement is seen to exist between those of the full 2-factor analyses and between two of the full 3-factor analyses. The same applies, but with a higher value for the residual,in situations where Facet is excluded. The behaviour of the combined tables 3.4 and 3.11 appears in certain respects to be out of keeping with that of the others and so the conclusions of its analysis needs to be treated with a certain amount of reservation.

The values obtained generally for the residual are high and well above those that would arise from binomial variation alone. A large amount of extraneous variation is present and it is against this almost entirely that the contributions of the various factors have to be judged.

There are amongst the eight factors considered some whose contribution is not significantly different from that of the residual. These are Persons representing different searches, Indexers, and Rounds of testing. Documents introduces very significant variation with seemingly a strong correlation between success and document numbering. There also appears to be a significantly better response with General subjects as with Aeronautical ones.

Time itself is a significant factor but the mode of its behaviour is seen to be peculiar. The values for 4 minutes are higher generally than those for 8 minutes especially when Facet is excluded. This suggests the need for further investigation.

The contributions of Method and Staff are significant by way of interaction and in order to study the behaviour of these more closely the averages of Method and Staff for the three combined studies are recorded below. The ordering has been altered to rank favourably for Project.

		Uniterm	Alpha.	U.D.C.	Facet
Time	Project	6.62	5.52	1.40	-0.88
	Technical	5.52	-0.26	3.82	-6.08
Indexers	Project	6.67	5.40	1.60	-1.07
	Technical	4.70	-0.17	3.70	-6.07
Subject	Project	4.90	4.55	0.70	-0.95
	Technical	4.20	-1.30	3.10	-5.00

It will be observed that the results for Technical are more varied than those for Project. For both Uniterm is the most and Facet the least favourable. However the lead of Project for Uniterm is not so great as that for Facet. Next to Uniterm for Project comes Alphabetical. The difference is small and the actual values seem slightly higher than those of Uniterm for Technical. In the third place for Project comes U.D.C. but it is nearer to Facet than it is to Alphabetical. The second place for Technical is held by U.D.C. and this is fairly close to Uniterm. The reversal of the ranking of Alphabetical and U.D.C. is very interesting - the difference between them for Project and for Technical appears significantly the same. Whilst Facet holds fourth position for Technical the difference between it and Alphabetical is relatively great.