

CONTENTS

PREFACE	ix
NOTATION	x
CHAPTER I. INTRODUCTION	1
1. Some general remarks on multifactor multiresponse experiments	1
2. The restricted scope of this monograph	3
3. One continuous response and one relevant unstructured factor: fixed-effects model and random-effects model of ANOVA	4
4. One continuous response and two or more unstructured factors in cross classification: the two models of ANOVA	5
5. One continuous response and one or more structured factors	6
6. Multiresponse experiments and the need for a multivariate development	7
7. Formal versus informal approach	9
8. A brief chapter-wise description of the scope of the present monograph	11
Literature	13
CHAPTER II. LINEAR MODELS	14
1. Some further remarks on structured-unstructured categorization for factors and responses	14
2. Linear models	15
2.a. Some general remarks	15
2.b. Some special models	16
3. Remarks on the multivariate extension	17
Literature	18
CHAPTER III. POINT ESTIMATION OF LOCATION PARAMETERS	19
1. Introduction	19
2.a. Single linear estimation for the uniresponse case	19
2.b. Formulae for estimation of treatment effects under block designs—some examples	21
2.c. Comparison between two different designs in terms of single linear estimation	23
3.a. Simultaneous linear estimation for the uniresponse case	23
3.b. Interpretations of the criteria and their use in comparison of designs	24
4.a. Single linear estimation for the multiresponse case	27
4.b. The same problem under a somewhat more general model	28
5. Some examples of single linear estimation for the multiresponse case	29
6. Simultaneous linear estimation for the multiresponse case	30
7. Summary	31
Literature	31
CHAPTER IV. TESTING OF LINEAR HYPOTHESES	32
1. The fixed-effects model of MANOVA	32
2. Linear hypotheses under the fixed-effects model of MANOVA	33
3. Three current test procedures	34

4. The union–intersection principle and its impact on MANOVA and design of experiments	36
4.a. Bilinear decomposition of the H_0 of MANOVA and some general considerations	36
4.b. Some examples of response-wise infinite and contrast-wise finite decomposition	39
4.c. An example of response-wise finite and contrast-wise infinite decomposition: the step-down procedure	41
4.d. Some examples of response-wise finite and contrast-wise finite decomposition	43
4.e. The main motivation behind the decomposition and the union–intersection procedures	45
5. Some supplementary mathematical and statistical remarks	46
5.a. On availability of tables for the use of the various test procedures	46
5.b. A remark on the distribution of the F_i 's of the step-down procedure	47
6. Applications of the model (4.2) to some growth curve problems	48
7. Some numerical examples	50
7.a. The doubly infinite decomposition	50
7.b. Response-wise infinite and contrast-wise finite decomposition	61
7.c. Response-wise finite and contrast-wise infinite decomposition	63
Literature	65
CHAPTER V. PROPERTIES OF THE TEST PROCEDURES	67
1. Introductory remarks	67
2. Intrinsic properties of group I procedures	68
2.a. Monotonicity property for the Λ -criterion	70
2.b. Monotonicity property for the trace criterion	70
2.c. Monotonicity property for the largest-root test	71
3. Some remarks on the admissibility of the different procedures	71
4. Some results from a Monte Carlo study	72
4.a. Specifics of the Monte Carlo study	72
4.b. Summary of findings	75
Literature	77
CHAPTER VI. CONFIDENCE BOUNDS	78
1. General principles	78
1.a. Distinction between general confidence regions and simultaneous confidence intervals	78
1.b. Intervals based on (H_0, H)	78
1.c. Bounds on the “partials”	79
1.d. The nature of the interval estimation in terms of the percentage points of the distribution function used	80
1.e. An additional requirement beyond what is suggested by the pair (H_0, H)	80
1.f. Intervals not <i>prima facie</i> based on any (H_0, H)	80
2. Bounds connected with a linear hypothesis against a linear alternative under the normal multivariate linear model I	81
2.a. General features	81
2.b. Nature of bounds associated with a bilinear decomposition	81
3.a. Exact expressions for bounds associated with the doubly infinite bilinear decomposition	82
3.a.1. The case $u = 1$	84
3.a.2. The problem of two mean vectors: two-sample case	85
3.a.3. The problem of two mean vectors: single-sample case	86
3.b. Three examples of bounds associated with the response-wise infinite and contrast-wise finite decomposition	86
3.c. Bounds associated with the response-wise finite and contrast-wise infinite decomposition	87
3.d. Bounds associated with the doubly finite bilinear decomposition	87

4. Supplementary mathematical and statistical remarks	88
4.a. On the derivation of the bounds	88
4.b. On the lengths of the confidence intervals	88
5. Some examples of the total and partial distance functions: block-treatment designs	89
6. Numerical examples	91
Literature	95
CHAPTER VII. GRAPHICAL METHODS AND INTERNAL COMPARISONS	97
1. Internal comparisons: general philosophy	97
2. A multiresponse graphical internal comparisons procedure	98
3. Outline of the procedure	102
4. Discussion of certain features of the method	103
5. Extensions based on an analogue of the ANOVA identity	104
6. Numerical examples	106
Literature	112
CHAPTER VIII. HIERARCHICAL AND p -BLOCK MULTIRESPONSE DESIGNS AND THEIR ANALYSIS	113
1. Introductory remarks on multiresponse designs in general	113
2. General description of hierarchical designs and some formal problems under that class	114
3. A sketch of the mathematical justification of the procedure proposed in Section 2	118
4. Multiresponse designs with p -block systems	120
5. Testability conditions of hierarchical designs with p -block systems	120
6. Nature of the multivariate designs for an important special case	125
Literature	125
CHAPTER IX. INCOMPLETE MULTIRESPONSE DESIGNS	127
1. Introduction	127
2. A simple example of an IM design	127
3. Procedure for analysis of general multiresponse design	136
4. Concluding remarks	138
Literature	138
CHAPTER X. CONSTRUCTION OF MULTIRESPONSE DESIGNS	139
1. Introduction	139
2. Multiresponse designs arising in factorial experiments	139
2.a. Not each response is sensitive to every factor	139
2.b. Different sets of effects are important for different factors	143
3. Multiresponse designs of the block-treatment type	144
3.a. Hierarchical designs	144
3.b. Regular incomplete multiresponse designs	145
Literature	145
BIBLIOGRAPHY	146
APPENDIX A. SOME SPECIFIC MATRIX RESULTS	151
1. Conditional or generalized inverses of certain patterned matrices	151
2. Some transformations and representations of matrices	154
3. Some properties of direct products of matrices	156
Literature	156
APPENDIX B. TABLES AND/OR CHARTS ASSOCIATED WITH THE PROCEDURES	157
APPENDIX C. by E. B. FOWLKES and MRS. E. T. LEE	216

I. Computer programs for multivariate analysis of variance	216
A. The eight operators	216
B. The main program	226
C. The second program	227
D. FORTRAN IV routines for the MANOVA operators	228
E. Example	232
F. FORTRAN listings for the MANOVA operators	237
G. Programs to be supplied by the user	279
H. Composing FORTRAN IV programs to use the MANOVA operators	279
II. Computer program for internal comparisons	279
Literature	299
AUTHOR INDEX	301
SUBJECT INDEX	303