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SELECTION, TRAINING and CAREER DEVELOPMENT of NAVAL OFFICERS

A LONG-TERM FOLLOW-UP USING MULTIVARIATE TECHNIQUES

by

Commander K E GARDNER, MA, FSS, CEng, MIEE, Royal Navy

Thesis submitted for the degree of Ph.D., Graduate Business Centre,
City University

VOLUME 1

THE PRIMARY INVESTIGATIONS

City University December 1971

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FOREWARD

On 7 November 1945, the Board of Admiralty approved recommendations for extensive changes to Admiralty Interview Board procedure. The first 300 officers selected under the new procedure have now passed through the zone of promotion to Commander and it is possible to identify the abilities associated with success and to assess the effectiveness of the selection procedure and the relevance of training for determination of these abilities.

The accompanying thesis is the result of a comprehensive follow-up study of this group and comparative analyses of two more recent groups undertaken in the course of research at the City University. The paper is written in the form of a thesis for the Ph.D. degree but is intended to serve also as a report to my sponsoring authority, the Ministry of Defence.

Opportunities for such long-term follow-up are rare partly because of mobility of personnel and partly because adequate records of performance are seldom preserved for such a long period. I have been particularly conscious in this study of the foresight of those responsible for originating and keeping the records which have proved remarkably comprehensive and complete.

I gratefully record my thanks to the following:-

a. Ministry of Defence for the approval to undertake the study, and the Second Sea Lord's departments for provision of all training and career data.

b. Ministry of Defence, Senior Psychologist (Navy), for provision of all Admiralty Interview Board data and for helpful discussion.

c. The Dean and staff of the City University Graduate Business Centre, particularly Mr D E Manning and Dr P H Grinyer for their wise counsel and my supervisors Mr A H Russell and Dr A P O Williams for their enthusiastic support.

d. Professor A Rodger, Birkbeck College, and first Senior Psychologist (Navy) for valuable advice.

City University
December 1971

K E GARDNER
Commander, Royal Navy

ABSTRACT

1. Twenty five years ago the Admiralty Board approved recommendations for a radically new procedure for selection of officer cadets for the Royal Navy.

2. Under the new procedure candidates were ranked using a judgmental measure of personality and their performance in educational examinations. The former was an interpretation of candidates' behaviour in individual and group tasks and interview, performance in psychological tests, and headmasters' reports, and has remained essentially unchanged to the present day.

3. Selected candidates were given extensive training, initially in general naval matters, later in specialist subjects, to prepare them for service in Seaman, Supply and Secretariat, Engineer and Electrical branches.

4. The first 300 officers selected have now passed through the zone of promotion to Commander. Records of their performance in selection, training and subsequent career have been analysed to identify the abilities associated with success and the effectiveness of selection and training criteria for determination of these abilities.

5. Investigations of data structure using Principal Component Analysis and Factor Analysis have revealed the inter-relationships of examination and test scores, interview board marks, biographical items, training course results, superiors' assessments, and a synthetic variable denoting career success. Vectors representing these variables have been located in a three-dimensional framework with axes defined as personality, verbal-educational ability and spatial-mechanical ability. Comparative analyses of more recent samples show that the basic structure of this framework is stable.

6. The relationships depicted in the three-dimensional model, together with results of predictive studies using Discriminatory Analysis and Multiple Regression Analysis, show that success up to Commander's rank is associated with markedly different abilities in the various branches of the service and that short-term and long-term success are also distinct.

7. The conclusion is reached that discriminatory techniques could make a powerful contribution to present-day selection by facilitating optimum selection and placement of candidates in terms of relevant abilities.

SELECTION, TRAINING and CAREER DEVELOPMENT of NAVAL OFFICERS

A LONG-TERM FOLLOW-UP USING MULTIVARIATE TECHNIQUES

C O N T E N T S

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PART 1

INTRODUCTION

Chapter 1 Synopsis

2 The Historical Setting

3 Objective, Opportunity and Scope

4 Procedure and Report Structure

CHAPTER 1

SYNOPSIS

1. The selection of naval officers is concerned with the identification of individuals who can benefit from a long and intensive training and eventually become effective managers in a service environment.

2. Prediction of success in these two distinct roles, student and manager, requires more than guesswork and hunch. Twenty five years ago a procedure was introduced which was designed to reduce the gamble of selection. This procedure relied partly on an educational examination and partly on judgmental interpretation of candidates' performances in individual and group tasks, interviews and psychological tests. The educational examinations, which were conducted by the Civil Service Commissioners, have been replaced by "A" level requirements, but the judgmental procedure has remained essentially unchanged to the present day.

3. It is axiomatic that a planned selection procedure should be evaluated to determine the degree of confidence which can be placed in predictions based upon it. Limited short-term follow-up studies have been undertaken from time to time by Ministry of Defence staff, though results have not hitherto been published. These studies have been concerned with validation of the selection procedure in terms of student success. There has, until now, been no attempt at long-term follow-up to determine the effectiveness in terms of prediction of managerial potential.

4. The investigations reported in Volume 1 of this thesis seek to identify the abilities associated with short-term and long-term success; to assess the effectiveness of the "new-type" selection procedure and of training for determination of these abilities; and to determine the usefulness of various classes of data for predictive purposes.

5. The samples used in these primary investigations include some 300 officers who joined the Royal Navy via Special Entry Cadetships between February 1947 and August 1949, and in the analyses of data structure a further 250 candidates rejected during the same period are considered.

6. A wide range of data has been used including biographical items, selection scores (CSC examinations, psychological test scores and interview board marks), training results and career data in the form of "annual" reports. The structure of "interests" data has also been analysed but the information was found to be unsuitable for predictive purposes.

7. To facilitate comparison of short-term and long-term prediction several criteria of effectiveness have been used. These include the actual scores used for assessment of training course results and a composite synthetic variable constructed to denote long-term success.

8. The report of analyses begins with an account of univariate studies of means and variances of some 110 variables in the various samples. This is followed by bivariate analyses of predictive associations and correlations. A series of investigations of data structure, and of data condensation, using the multivariate techniques of principal component and factor analysis, is then described, providing a foundation for the final stages of the analyses, the predictive studies. For the purposes of deriving predictor functions the techniques of both discriminatory and multiple regression analysis have been used.

9. Because the sample sizes are very limited it has been necessary in some of the analyses to rely on statistical inference rather than the more pragmatic, and usually preferred, cross-validation of predictor functions. Statistical inference relies in its turn on assumptions of distribution the validity of which is not uniform throughout the data. It cannot be stressed too strongly that results derived by statistical methods have an associated probability of occurrence by pure chance. In the case of complex predictive functions there are often many different functions which would give equally good statistical results. Any given function must be treated as only one possible solution whose validity may be partly dependant on chance relationships in the parent sample.

10. The derivation of functions which could be used directly for predictive purposes in other samples was not, however, the main purpose of this study. Rather was it desired to approach the assessment of effectiveness of selection and training procedures through an understanding of the ability structures. The results of structural and predictive analyses are consistent and have been brought together in the form of models of the relationship between student and occupational success and basic abilities. These models illustrate the marked differences in

abilities associated with success in the student and manager roles and in different branches of the service. They show too the relative inefficiency of composite scores used for selection of candidates destined for different types of training and employment and the value of early training results as a guide to long-term success.

11. In Volume 2 of the thesis comparative studies of more recent samples are reported. The essential similarity of data structure deduced for these samples, which were widely separated in time, suggests that, although full cross-validation of the primary investigations is not possible, the situation being examined is a stable one.

12. A method of relating the models obtained by Factor Analysis of each of the samples has also been investigated and is reported together with examples in which the use of such related models for predictive purposes is explored.

13. The opportunity has also been taken in Volume 2 to report some further studies of biographical, interests and annual report data.

14. There have been discussions recently about the alleged need to lower selection standards to improve recruiting. The research reported in this thesis has shown that what is required is not a lowering but a choice of more relevant standards to ensure optimum placement of candidates as distinct from simple selection/rejection. Examples of the use of discriminatory analysis show that such a technique would be particularly suitable for providing the categorical predictions required in this multivariate classification situation.

15. The identification of abilities associated with career success in the various branches and the investigation of a suitable methodology for relating results to more recent samples provides a starting point for comprehensive study with a view to such a redesigning of the selection procedure.

CHAPTER 2

THE HISTORICAL SETTING

1. The processes of selection and training of officer candidates for the British armed forces have undergone profound change in the past century. From a time when all that was demanded was a suitable background and the ability to learn from experience the services have progressed to an era, dominated by technical innovation, when candidates are required to undergo extensive selection procedures and prolonged training to ensure their ability to cope with the task of management amidst the intricate paraphernalia of modern warfare.

The need for new methods

2. Evolution was powerfully stimulated as a result of the demands of the second world war. Shortly after the outbreak of war in 1939 rapid expansion of the Army made it necessary to find a large number of new officers. It was quickly realised that the traditional method of selection by means of a brief interview was quite inadequate. The greatly increased demand brought candidates from all sections of the community instead of the socially and educationally homogeneous stratum of pre-war days. The failure rate at Officer Cadet Training Units went up and the morale of both the unsuccessful trainees and potential candidates suffered. A more reliable method of selection became an urgent necessity.

3. Towards the end of the first world war the Americans had developed the use of intelligence tests for the selection and placement of army recruits and as a result some two million men were tested during 1917 and 1918. Between the wars the use of intelligence tests spread to schools and universities in the UK and growing interest in personnel problems in industry led to the foundation of the Industrial Health Research Board and the National Institute of Industrial Psychology. Although military psychology virtually lapsed in both America and UK during this period the Germans continued its development in the reconstitution of their armed forces after 1927. Vernon and Parry (1949) have outlined how the British services came to realise the importance of these developments in applied psychology when faced with the vast war-time expansion of the task of selection, allocation and training, and how scientific methods came to be applied on a scale unprecendented in Britain.

The first new-type Selection Board

4. The introduction of the new-type War Office Selection Boards in 1942 was a milestone in British Military psychology. The work of the WOSBs, as they were called, has been described by Morris (1949). Briefly the basic principles were:-

a. that the selectors should see the candidates not only as individuals but also as members of a group;

b. that the candidates should be observed performing tasks as well as talking;

c. that the several members of the board should bring different but complementary approaches to the judgment of candidates' suitability.

The selection procedure was spread over three days, allowing observation of the candidates in a variety of activities.

New type selection in the Royal Navy

5. In the Royal Navy, which in peacetime had been a relatively small regular force, the problems of selection and allocation of wartime personnel were severe. The Admiralty sought the help of the National Institute of Industrial Psychology and A Rodger (1945) has described how he and seven other psychologists were seconded to help with the selection and allocation of "hostilities only" ratings in July 1941.

6. The group was successful, not only in its allotted task, but also in convincing naval officers of its worth and by March 1943 the Senior Psychologist, now responsible direct to the Second Sea Lord, was involved in the selection and training of RNVR officers. Methods similar to those used by the WOSBs were introduced, though selection and training were integrated and extended over several weeks.

7. These activities attracted a good deal of attention and shortly afterwards the Engineer-in-Chief, already concerned about the quality of permanent Engineer officers, invited the Senior Psychologist to carry out tests on officers under instruction at the Royal Naval Engineering College. The results of the tests, which were carried out in November 1943, and his experiences with selection of RNVR officers, led the Senior Psychologist to recommend a review of the officer cadet selection procedure.

8. As the war progressed thoughts began to turn to the future, to the time when old deficiencies might be overcome, when the lessons of war could be applied to the problems of peace, when new methods would be needed to cope with the sophisticated systems now being conceived under the stimulus of war. There was growing concern over the quality of the cadet entry and the suitability of the methods of both selection and training for post-war conditions was questioned.

9. Since 1913 there had been two main methods of entry to officer cadetships in the Royal Navy: one at age 13½ to the Navy's own public school, the Royal Naval College, Dartmouth; the other, known as Special Entry, for boys of 17-18 years, which had in recent years provided the majority of Engineer officers.

10. The selection of Special Entry candidates under the "old-type" procedure was based on the results of an examination divided into two parts. Part 1 consisted of educational subjects, for which a maximum of 1200 marks could be awarded. Candidates who passed Part 1 appeared before an Interview Board for Part 2. The Board allowed 20 minutes per candidate, the time being used to read a report from the candidates headmaster, to interview the candidate, and to discuss his merits and award an "Interview and Record" mark out of 400. The candidates were then placed in order of merit according to their total marks in the two parts.

11. This simple form of selection was generally considered adequate in the conditions prevailing between the two world wars. The proportion of candidates to vacancies was high, and most of the candidates come from similar social and educational backgrounds, many from service families. The selectors' task of deciding which of the candidates most nearly came up to their ideal of good officer potential was relatively easy.

12. By the autumn of 1944 it was clear that the conditions to be faced in officer selection after the war would be very different. The methods introduced for RNVR officers had gained the confidence of the Admiralty and the time was ripe for a full enquiry into selection of Special Entry officers. An experimental selection board was convened on 15 September to ascertain whether a technique similar to that used by the War Office Selection Board could usefully be adapted for the selection of naval officers.

The result was an unequivocal recommendation that the new procedure should be adopted and on 19 December 1944 a committee was constituted with the following terms of reference:-

"a. To consider the present system of selection of candidates in the Special Entry group of examinations (Executive, Engineering, Supply and Royal Marines) and to consider whether any grounds exist for believing that improvements are desirable.

b. If so, to consider and make recommendations on the steps to be taken to effect any necessary improvements. The committee will consider what relevant experiments and investigations in connection with the entry of officer personnel have already been made, and whether these form a useful pointer to the direction in which any changes should be made."

13. The committee, whose membership was:-

Admiral Sir Percy Noble, GBE, KCB, CVO	Chairman
Captain C P Clarke, DSO, RN	
Canon Spencer Leeson, MA, Headmaster of Winchester College	
Professor Cyril Burt, MA, DSc, Professor of Psychology, London University	
Sir Sidney Barnes, KBE, CB, Director of Greenwich Hospital	
Mr K W Matthews, CW II Branch, Admiralty	Secretary

submitted its report on 27 June 1945, with recommendations for extensive changes. The proposals included the adoption of a new selection procedure, based on the WOSB methods, but requiring a total of only one and a half days, and the attachment of a psychologist to the selection board.

14. Appendix 2 of the report contained the results of a follow-up study conducted by Professor Burt to investigate the relationship between career success and selection performance amongst a group of officers who joined the service between 1925 and 1929 (see Chapter 6). Sir Sidney Barnes, in a note of reservation, expressed doubts about the weight to be attached to the interview in the new procedure and quoted the low correlation found by Professor Burt between interview marks in the old-type board and subsequent performance.

15. The Board of Admiralty recorded their approval of the proposed improvements to the interview procedure in Board Minute No 4045 on 7 November 1945 but it was some time before the question of relative weighting of examination and interview marks was finally settled. Caution prevailed and when the first new-type board for Special Entry cadetships was held in February 1947 the allocation for interview had been increased from 25% to 27%.

The birth of a branch

16. At the same time as the Noble Committee was reviewing selection procedures attention was being given to the problem of the new generation of electrical equipments. The Phillips' Report and the deliberations of the Middleton Steering Committee led to the setting up of the Electrical Branch in 1946 and the first selection board for cadetships in the new branch was held in August 1947. The procedure adopted was similar to that evolved for the other branches but some modifications were made to cater for an entry of candidates who had already taken their Higher School Certificate examinations and who would be required to spend three years of their training reading for degrees, mostly at Cambridge University.

Summary

17. During the twenty five years since the first "new-type" board was held there have been numerous changes in recruiting and training requirements and in branch structure but the essential features of the Admiralty Interview Board procedure and of the career pattern have remained unaltered. Studies of the short-term validity of the new-type board assessments were undertaken at an early stage. It is now appropriate to examine in depth the long-term relationship between career success and data recorded at selection and during training.

CHAPTER 3

OBJECTIVE, OPPORTUNITY AND SCOPE

1. The introduction of the new-type one-and-a-half day selection procedure in February 1947, replacing the brief interview of pre-war days, was a landmark in naval officer selection procedure. For the first time the board was able to consider the candidate's performance, not only in interview but also in individual and group tasks and tests of ability and aptitude, and to take into account the advice of a professional psychologist.

2. An important coincident change in training policy, effecting both the mechanical engineers and the newly formed electrical branch, was the separation of engineering education and specialist training on naval equipments into two distinct phases. The essential features of both the Admiralty Interview Board and the partitioned training have remained unchanged to the present time although numerous changes of detail have been made.

3. Follow-up on officers selected and trained under the new procedures has been scanty and so far as is known has not been published. In 1961 Dr Vernon undertook a short-term career study on Seaman officers but apart from this investigations have been confined to the training phase. No attempt has hitherto been made at long-term career validation, either of the selection procedure or of the subsequent training. It is the fundamental aim of this study to consider the question "What are the abilities associated with training and career success, and is the selection procedure relevant to the determination of these abilities?"

4. The feasibility of such a study depends on a number of factors. First, a comprehensive investigation is a lengthy operation requiring a knowledge of both the details and the underlying principles of selection, training and career structure and of the statistical techniques involved in analysis. Second, it demands not only the existence of records covering a long period of time but also access to them. Third, the processing of data covering some twenty years involves a great deal of computation which cannot be undertaken economically by purely human effort.

5. The appointment of a serving naval officer to post-graduate study, with access to a sizeable computer, provided the necessary effort and facilities. The existence of comprehensive records and the willingness of the authorities to make them available in anonymous form provided the material.

6. Preliminary study suggested that the first reliable criterion of long-term career success would be a measure related to promotion to the rank of Commander, the earliest selective promotion. To ensure that all officers still serving had passed through the zone, and hence had had an equal chance of promotion, it was necessary to constrain the sample to officers who joined no later than summer 1949.

7. It was found that a total of some 300 officers had joined via Special Entry cadetships between February 1947 and August 1949. Though the sample was not large, particularly when partitioned into the specialist branches, the advantages to be gained from simplicity of problem structure appeared to outweigh possible disadvantages of small sample size.

8. Although the main objective was to investigate the relationship between career success and the measures of abilities and performance used at selection and during training, early research revealed that a considerable amount of biographical data was available and there was thus a rare and valuable opportunity of studying the long-term significance of such data. The provision of information extracted from annual reports further extended the area of research and enabled relationships with career development also to be studied.

9. A broadening of objective became highly desirable and it was therefore decided to adopt the following aims:-

a. To identify the abilities associated with training and career success.

b. To assess the effectiveness of the "new-type" selection procedure for determination of these abilities.

c. To determine the usefulness of various classes of data for predictive purposes.

d. To draw conclusions about the relevance of the findings of the study to the current problems of selection and training.

10. Volume 1 of the thesis is concerned with the first three aims and Volume 2 chiefly with the last two. Assessment of the validity of the results recorded in Volume 1 and of their relevance to more recently selected candidates is inevitably indirect since the size of the main sample was dictated by the requirement that all officers should have had equal opportunity of promotion to Commander. The problem has therefore been approached in Volume 2 by means of comparative analyses of selection data structure of three groups; the first (as described above), comprising candidates of the first six "new-type" Special Entry selection boards, the second comprising candidates of boards seven to ten, and the third comprising candidates interviewed in 1969/70. The methodology adopted for this comparison illustrates how models derived from different samples may be related for predictive purposes.

11. Summing up, this is a long-term follow-up of officers who joined the Royal Navy via Special Entry cadetships between February 1947 and August 1949. A comparison of selection data structure for two other more recent groups provides a basis for assessment of relevance and validity and a method of relating models for predictive purposes is examined.

CHAPTER 4

PROCEDURE AND REPORT STRUCTURE

1. Evidence of quickening interest in the application of mathematical techniques of modelling to the problems of manpower planning has been apparent in the publication of the proceedings of two recent NATO conferences. The use of renewal theory, dynamic programming and Markovian constructs has been demonstrated by Bartholomew, Leese and Kossack respectively, all in papers edited by Wilson (1969). Application of quadratic programming to the promotion system of German Air Force officers has been described by Stolley in papers edited by Beale (1970).

2. The value of statistical models has long been recognised but techniques which once bore an alchemic stamp have commanded new respect since the advent of computers has made mathematically elegant solutions practicable. The power of data condensation techniques such as Factor Analysis and Discriminatory Analysis in bridging explanatory and predictive models of human systems is, however, still relatively unexplored.

3. There is always a risk that, in the pursuit of elegance in some multivariate abstraction, or in the use of the calculating power of the modern computer, one may lose sight of the vital fact that the observations are people and the variables are human characteristics. Dr Anstey, in opening the discussion on the papers mentioned in paragraph 1 pointed out that usefulness may depend critically on the extent to which the resources can be described in objective terms and that in manpower systems, many imponderable human factors may need to be taken into account.

4. A more fundamental danger is that of ascribing the status of ultimate truth to the outcome of any particular experiment, however convincing it may be. In any scientific field the observed phenomena can be described in a great variety of ways which are mutually consistent. The choice of a particular interpretation must depend on its utility. F R Moulton (1939) aptly said, "If scientists would remember that various equally consistent interpretations of every set of observational data can be made, they would be much less dogmatic than they are, and their beliefs in a possible ultimate finality of scientific theories would vanish."

5. The Royal Navy has always treated its officers as individuals and is rightly suspicious of attempts to treat them as mere quantities in a mathematical model. Insofar as a model is an abstraction from, and therefore an approximation to, reality there is no field of study where such suspicion is more appropriate than that of human endeavour, demanding, as it may, quantification of the immense variety of man's characteristics. Nevertheless, a model which expresses career relationships in numerical form may be of considerable value in policy-making, provided the limitations are understood.

6. In this research multivariate analysis techniques have been extensively used for the derivation of success/ability models. Principal Component Analysis, Cluster Analysis and Lawley's method of Factor Analysis are used in the study of data structure and for data condensation. Predictive functions have been derived, using both Multiple Regression and Discriminatory Analyses. Further details of the methodology and the techniques used in the various investigations are given in Chapter 12.

7. The structure of the report is to some extent dictated by the diversity of the study. Volume 1 is divided into five parts, the first part providing historical background and a general introduction to the research. Part 2 is devoted to a review of relevant literature and contains two main sections, the first dealing with theoretical material and the second with related studies. It is inevitable that a study which ranges so freely between psychological and statistical territory should demand a corresponding spread of reference. The review is by no means exhaustive and serves only to "set the scene" for the subsequent investigation.

8. The remainder of Volume 1 is concerned with the primary investigations, i.e. those involving candidates of the first six new-type selection boards. Description of the career patterns which form the basis of the study, definitions of the variables used, and delineation of the primary samples comprise Part 3. Separate chapters are devoted to each of the main career phases, viz pre-entry, training and post-training, and in each case details of the derivation of synthetic variables are included.

9. The investigations relating to the primary groups are described in Part 4, which begins with an outline of the analytical research and of the techniques and computational facilities used. Separate chapters are devoted to the univariate analysis and to each phase of the multivariate studies. In Part 5 the results of the primary investigations are summarised and an attempt is made to assess the possible relevance both of the findings and of the techniques to current policy-making.

10. In Volume 2 an account is given of secondary investigations which fall into two main parts:-

a. Further studies of the primary groups (candidates of boards 1-6).
b. Comparative studies of the primary and two later groups.

A more detailed account of the structure of Volume 2 is given in Chapter 22.

PART 2

L I T E R A T U R E S U R V E Y

Chapter 5 The Conceptual Background

6 Related Studies

CHAPTER 5

THE CONCEPTUAL BACKGROUND

The Criterion

1. What is occupational success? The definition of a criterion is central to the study of related abilities and of selection validity. The difficulty of definition has been stressed again and again in the last two decades. Thorndike (1949) devoted a chapter to the choice of an objective measure compounded of progress and satisfaction. Vernon and Parry (1949) considered four alternative categories of criteria in common use applicable to various circumstances. Davies (1950) reviewed the objective methods of definition based on performance and considered the significance of social factors such as human relations which may affect the "cost of work" as distinct from "output". He concludes that a comprehensive measure of success may need to take into account the assessments not only of superiors but also of equals, subordinates, and domestic contacts and that conventional yardsticks, such as earnings or status, must be tempered by measures of the individual's own feeling of satisfaction.

2. The range of possible definition was again apparent in a series of papers published in 1965. A Rodger recognised the importance of both satisfaction and satisfactoriness in a full-employment situation and drew attention to the dynamic nature of criteria. A S Thompson listed the essentials of a good criterion as "reliable, differentiating, practical, and relevant", with emphasis on the latter. He commented "- most of the criteria used in prediction studies leave much to be desired when matched against the overall objective of the situation -" and underlined the distinction between the vocational goal of the individual and the usual criteria of salary, superior' ratings, etc. He recognised the basic weakness of most criteria as their essentially static nature, and noted that in real life we are dealing with a changing individual in a changing environment. He saw career as a "pattern of movement" through a "world of work" and the criterion problem as one of measuring this pattern of movement. M H Brolly was less sanguine about the quantification of success, seeing each individual as a unique and continually developing conglomerate of characteristics operating in a dynamic environment, and the possible combinations, or interactions, capable of producing a success situation as almost infinite. P E Vernon, on the other hand, regarded this as a rare

situation. He recognised the usefulness of multiple criteria and distinguished between immediate, intermediate and long-term definitions.

3. There is evidence that the "systems concept", in which the individual is viewed in a state of dynamic interaction with his environment, is gaining ground. March and Simon (1958) see the individual pursuing success as defined by the organisation. Jacques (1961) regards "capacity" as innate, but developing in some more than others and at rates varying from one to another. Beresford (1969) finds that "ability" as judged by the Army is partly innate and partly the capacity to adapt to experience and to acquire the preferred behaviour pattern. Rundquist (1969), exploring why validity coefficients present such a stubborn ceiling, found that similar criterion performance, in this case industrial output, could be achieved by many combinations of selection, training, supervision and production techniques, and that a change in any one of these might produce a marked effect on the criterion.

4. This diversity of approach to the problem of criterion definition does not necessarily imply any fundamental incompatibilities with the traditional concepts of the structure of ability, the development of which is reviewed by Vernon (1950). Vernon's reluctance to accept the pessimism of Brolly may be viewed against the prodigious volume of statistical study completed by Vernon, a great deal of it while he was consultant on psychological research to the Civil Service Commission, the Admiralty and the War Office during and after the second world war. Their differences seem to be chiefly in the importance attached to environmental factors, not as an influence on ability but as a contribution to the overall success function. Brolly expressed his point of view in graphic terms. He likened the problem of measuring the difference between two managers' performances to that of finding the difference in weight of a £1 note and a 10/- note by weighing two trucks, each carrying one of the notes. He doubts the wisdom of developing a weighing machine accurate enough to distinguish between the two when so little is known about the differences inherent in the trucks.

5. In the present study an attempt has been made to steer a path between the extremes. Criteria have been formulated in terms of both career developments and promotion and it is likely that these measures reflect both satisfactoriness and satisfaction to some degree. A full account of the definitions is given in Part 3.

The Selection Objective

6. If definitions of criteria of success are so elusive what then is the objective of selection? Should the procedure be aimed at identifying those who will achieve an acceptable standard in the various stages of training? Should the selectors attempt to identify those who, with the aid of training, will give satisfactory service in their early careers? Should they look for management potential and the ability to benefit from all experience and acquire the necessary (and changing) behaviour patterns? In the context of the Admiralty Interview Board these objectives are to some extent inter-related, since a minimum standard of achievement in training is a pre-requisite for a longer career. In a full-employment situation they cannot be entirely divorced from considerations of suitability of the career to the candidate, since the best recruiter, and the one who is likely to give the longest service, is a satisfied officer. Hence satisfaction and satisfactoriness are both relevant.

7. A review of the problems of student selection is given by Himmelweit (1950). The author attempted to answer the question "What are we selecting for?" in the context of university entrance. There are close similarities with the problem of selection of officers for the services, though a greater proportion of candidates for the latter may have a clear idea of their own objectives. Himmelweit also considered the usefulness of cognitive and conative tests and of biographical data in student selection.

8. A recent study of the value of educational, psychometric and biographical data is reported by Freeman (1970), examining the performance of students at the University of Reading. He deduced that several personality factors are involved in students' early performance. Morea (1969) describes a study of the relationship between students' interests and their examination performance in the first year of a business studies degree course. Here the conclusion is reached that drop-out or failure may result as often from a student's lack of interest as from serious lack of ability.

9. The prediction of managerial performance was reviewed at length by Korman (1968). More than fifty studies are listed under the headings of psychometric and judgmental prediction. Psychometric studies are classified according to their use of cognitive ability tests, objective

personality and interest inventories, leadership ability tests, and personal history data. Judgmental prediction is classified under executive assessments, peer ratings, and superior and faculty ratings. Here the main conclusion reached is that judgmental prediction is relatively superior to psychometric prediction, though the evidence is not strong. The reason postulated is that judgmental predictors are essentially forecasting the general level of adequacy with which the person will be able to function in a complex, demanding environment, and the extent to which he will be able to handle the various stresses which exist in the managerial role. "In other words ... the 'judgmental predictors' are predicting a psychological dimension known to them and about which they have some conceptual understanding. Hence they adjust their cognitive activity and weight the predictors toward this end. On the other hand the psychometricians use the complex changing, unknown criterion as a point of departure and are thus operating more in the dark".

10. Other conclusions drawn from this survey are:-

"a. Intelligence, as measured typically by verbal ability tests, is a fair predictor of first-line supervisory performance but not of higher-level managerial performance. Restriction of range is probably the explanation for this finding.

b. Objective personality inventories and "leadership ability" tests have generally not shown predictive validity, with the exception of the projective measure of managerial motivation developed by Miner.

c. Personal history data as predictors are fair for first-line supervisors, but less so for the higher-level individual."

11. A report, not included in Korman's survey, in which Porter (1965) examines the validity of socioeconomic origin as a predictor of executive success, concludes that no support is found in the sample concerned for the "widespread belief in family effect".

12. An attempt to identify the underlying dimensions of personal background data is described by Baehr and Williams (1967). Factor analysis is used to study a wide spectrum of data and to derive a framework for investigation of the dynamic relationship between biographical variables and occupational success. Second-order factors were identified as representing five broad behaviour patterns.

13. Growing concern over the indiscriminate and often ill-informed use of psychological tests in industry in the USA is expressed in a paper by Sparks (1970). He observes that test scores may need to be tempered with interview results, biographical data, etc, but demands that all these variables should be validated as rigorously as the tests.

14. Study of the procedure evolved in 1946 for selection of naval officers reveals a recognition by its designers of many of the problems since encountered in other fields. The procedure leans heavily on judgmental prediction by experienced, but not too senior, serving officers. It incorporates a minimum educational requirement and cognitive tests are used, together with interviews stimulated by biographical and interest data, and with observation of group and individual tasks, in arriving at a balanced assessment of each candidate. In their predictions the board members seem likely to be operating in a way akin to that envisaged by Korman, arriving at a composite judgment in terms of immediate, intermediate and long-term potential along a psychological dimension of which they have a conceptual understanding based on direct experience.

The Cost

15. In the past three decades a great deal of attention has been given to design of personnel selection procedures and to the assessment of their success. Recently there has been growing interest in the cost.

16. Dunnette (1966) considers the "utility" or overall usefulness of a selection procedure under two headings, viz actual costs and potential costs. The former he associated with recruiting, assessment, induction and training, whereas the latter is defined as that cost which might be incurred if a wrong selection decision is made, viz:-

a. costs associated with engaging a person who subsequently fails;

b. costs associated with rejecting a person who would have been successful.

A simple illustration is given of a curve relating cost and selection standard on one predictor.

17. Dunnette is careful to stress the importance of humanitarian factors and adds that "utility" should be viewed more as a way of thinking about selection procedures than as a formal set of rules or prescriptions for attaching numbers or cost figures to evaluations of different outcomes.

18. No attempt has been made in this study to consider the cost factors in the evaluation of the naval selection procedure. It may well be that such considerations are worthy of special study.

Analysis

19. Extensive use is made in this study of statistical method and techniques, a comprehensive treatment of which is given by Kendall and Stuart (1962). References to relevant specific sources are given in Part 4 but a review of the literature would not be complete without brief mention of the developments in statistical methods, techniques and applications in the last three decades. Nowhere has this development been more apparent than in the realm of multivariate analysis, an outline of which is given by Kendall (1965).

20. Perhaps the most striking progress is in Factor Analysis, the early development of which, together with Principal Component Analysis, was so closely associated with the evolution of psychological theory. The classic works of Spearman (1927), Thomson (1939), Burt (1940), Thurstone (1947) and Cattell (1952) are all concerned with such applications and are representative of an era when Factor Analysis was essentially an empirical technique, inhibited by lack of computational facilities.

21. Factor Analysis is a way of getting an overview of a large number of correlation coefficients, to see if the common variance which they express, which has been measured only in pairs of variables, taken two-by-two, can be described in broader terms. A successful Factor Analysis is like the contour map of a whole countryside, which is based on many separate measurements of relative altitudes of hilltops and hollows. It gives new perspectives over the domain, and it brings into prominence features which had previously escaped attention. A fundamental consideration in Factor Analysis is to express the observed variables in terms of a smaller number of factors which adequately account for the correlations.

22. The development of the method of maximum likelihood, described by Lawley (1940), made a fundamental contribution to Factor Analysis by providing a statistical basis for judging the adequacy of the model, with a specified number of factors, to explain an observed correlation matrix. After half-a-century of association almost solely with the investigation of the structure of ability Factor Analysis took on a new

significance. Many possible applications became apparent in the rapidly developing use of mathematical method by operational research groups in business and industry, where it is often desirable to simplify and reduce to a few primary factors a large number of variables. Indeed Lawley and Maxwell (1963) claimed that, although the practical psychological controversy about the structure of ability had damped for a time the development of Factor Analysis, it was by then the most widely used of the multivariate techniques, particularly since the use of computers had facilitated the massive calculations involved. A comprehensive treatment of modern Factor Analysis is given by Harman (1967) and an alternative approach by Horst (1965).

23. Another method of dimension reduction, which has also been used in this study, is afforded by Discriminatory Analysis. The method is particularly relevant to the problems of selection where the objective is to allocate a new individual to one of a number of categories, on the basis of a set of measurements, so that the probability of incorrect assignment is minimised. The derivation of discriminatory models is described by Anderson (1958). Although the method has been applied to many scientific classification problems such as in biological and anthropometric research, little evidence has been found in published work of use in personnel selection investigations. The potential of the method is undoubtedly considerable and many possible applications are likely to be found in the problems of selection and placement.

24. The third method of analysis which has been extensively used in this study, and which is probably the most conventional in selection research, is Multiple Regression. A problem frequently encountered with the method is whether any of the many variables available for prediction can be discarded as adding little to the accuracy with which the regression equation estimates the dependant variable. Advantage has been taken of an important contribution to the method, presented by Beale, Kendall and Mann (1967), in some of the analyses undertaken.

25. In the final stages of the primary investigation a combination of Factor Analysis and Multiple Regression Analysis is used to

facilitate the computation of regression statistics for data including the large number of variables associated with annual reports. This powerful combination of techniques, described by Harman (1967), results, not only in a more elegant structuring of the data, but also in considerable computational savings, since the task of inverting the correlation matrix is reduced by the difference between the number of variables and the number of corresponding factors. In the secondary investigations, reported in Volume 2, the use of a combination of Discriminatory Analysis and Factor Analysis illustrates a further development of data condensation techniques.

26. A more comprehensive review of the conceptual relationship of multivariate analysis to the problems of selection, training and career development is given in the addendum to Volume 2.

CHAPTER 6

RELATED STUDIES

1. No record has been found of the publication of any follow-up study on officers selected by the Admiralty Interview Boards, but brief details of five studies, of which records are held in the Ministry of Defence, are given below.

a. Vernon (1945)

This is a study of 170 Royal Marine officers selected on the basis of nine consecutive Civil Service Commissioners' examinations in the period 1938 to 1942. The correlations shown in Table 6.1 were reported:-

	1	2	3	4	5	6	7	
Entrance examination order of merit								1
Entrance examination mark for interview plus record	.34							2
Passing-out order of merit	.55	.05						3
General assessment by GOCRM	.07	.20	.35					4
Character assessment based on S206, first 2 years	-.01	.38	.25	.64				5
Ability assessment based on S206, first 2 years	-.11	.32	.28	.53	.63			6
As (5), but second 2 years	-.02	.04	.11	.63	.43	.38		7
As (6), but second 2 years	.15	.15	.19	.67	.54	.48	.80	8

(Note: Variables (5) and (6) - 98 observations; variables (7) and (8) - 32 observations.)

TABLE 6.1

Thus, in this group of officers selected by boards operating under the "old-type" or pre-war procedure, there was quite good agreement between entrance-examination order of merit and passing-out order of merit, but virtually none with later assessments. Interview-plus-record showed some agreement with early annual reports but less with later ones.

b. Rodger (1945)

This fragmentary follow-up of 16 cadets who, in their first term at Osborne in 1919 were given an intelligence test by Professor Spearman, gave the correlations shown in Table 6.2.

	1	2	3	
Intelligence test				1
First term examination	.78			2
First term assessment	.66	.90		3
Present rank, 1944	.68	.68	.68	4

(Note: Correlations with variable 4 are tetrachoric, remainder are rank.)

TABLE 6.2

On this very small sample the intelligence test, first term examination and first term assessment all appeared to have some predictive value for rank 25 years later.

c. Burt (1945)

In a follow-up undertaken for the Noble Committee, Professor Burt took samples of 63 Executive and 91 Engineer officers who were selected in the Special Entry competitions between 1925 and 1929 and found product-moment correlations between entry examinations and passing-out marks as shown in Table 6.3

	Executive	Engineer
English (1)	.182	.225
General Knowledge (2)	.024	.319
Lower Mathematics (3)	.262	.598
(1) + (2)	.123	.328
(1) + (2) + (3) + Physics	.468	.735

TABLE 6.3

Professor Burt concluded that written entrance examinations had little predictive value for passing-out results of Executive officers but high value for Engineer officers. He also deduced that the interview had low predictive value for both groups but the figures are not recorded. He found that, of those promoted to Commander, Executive officers were "slightly above average for Interview but little for written work", Engineer officers were "somewhat higher than average for written work and slightly higher than average for Interview".

d. Vernon (1961)

In this study Professor Vernon followed up 60 Seaman officers selected by five Special Entry boards between 1946 and 1948. These were the first five boards after the procedure was changed as a result of the Noble Committee recommendations. This study is the only one on record in which an attempt has been made to follow up officers selected by the new-type boards beyond the end of their training. By the time of the study the officers concerned were either senior Lieutenants or junior Lieutenant Commanders.

Professor Vernon explored the use of superior officers' assessments on "annual" reports as criteria. He had hoped to use the last pair of reports rather than the whole series as a basis for evaluating the predictions of earlier tests and assessments but found the data very unreliable. He attempted a subjective grading of written comments on the reports (variables 13, 15, 17, 19) but with no greater success.

The complete correlation matrix is given in Table 6.4.

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TABLE 6.4

Tetrachoric correlations among selection, training and annual report variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Verbal tests SP35 + 96																		
Non-verbal tests SP97 + 117 + 160	.34																	
President + Dep Pres mark	.13	-.19																
Psychologist mark	.27	.15	.54															
Testing Officer mark	.02	.10	.67	.81														
Board Mark	.11	-.08	.90	.74	.70													
Examination total mark	.22	.33	-.16	-.34	-.27	-.31												
Dartmouth examinations total	.18	.30	.34	.36	.26	.38	.08											
OLQ grading	-.09	.31	.33	.12	.39	.25	-.11	.38										
HMS DEVONSHIRE total mark	.34	.71	-.04	-.02	.08	-.20	.33	.63	.37									
Midshipman report total score	.07	.15	.12	.09	.05	.06	.14	.24	.31	.34								
Act S Lt S202's score	.02	.20	.10	-.22	-.06	.01	.08	.20	.18	.30	.41							
" " " " grading	-.23	.30	-.03	-.27	-.08	-.10	.35	.13	.07	.32	.40	.50						
First S206's score	.20	.08	.14	-.11	-.17	.18	.13	.31	.18	.20	.62	.48	.57					
" " grading	-.16	.11	.33	.16	.05	.37	.04	.05	.24	.14	.50	.43	.48	.76				
Middle S206's score	-.11	.06	.09	-.15	.01	.01	.04	.08	.20	.20	.16	.44	.52	.49	.48			
" " grading	.17	.15	.09	-.08	-.07	.07	-.04	.17	.03	.14	.15	.25	.42	.52	.41	.78		
Last S206's score	.05	.12	.16	.34	.07	.20	.03	.03	.24	.13	.20	.26	.38	.37	.36	.33	.16	
" " grading	-.07	.25	.14	.18	.18	.31	-.06	.30	.05	.12	-.09	.24	.56	.36	.40	.52	.52	.68

Note: Variables 1 to 7 refer to the selection board

" 8 to 10 refer to basic naval training

" 11 to 19 refer to superiors' assessments on "annual" reports

The conclusions drawn were:-

(1) The non-verbal tests are more useful than the verbal for prediction of later performance.

(2) The board-members marks predicted Dartmouth performance moderately but the next training phase, HMS DEVONSHIRE, and later performance only patchily.

(3) Training performance shows patchy correlation with later assessments.

(4) The predictive validities should not be taken at their face value as the selection ratio is very high, about 1 in 4 candidates being accepted.

e. Cashen (1968)

Increasing shortages of candidates for commissions led to a further study of a more recent sample of entrants. Dr Cashen used multiple regression analysis to derive predictor formulae. This was a "short-term" follow-up, to the end of the third year of training. The formulae are now used when marginal candidates are being assessed by the AIB.

The highest multiple correlations were obtained for third year academic prediction, being .60 for Seaman/Supply and .50 for Engineer officers and were based on "A" levels and Dartmouth first year academic scores.

Multiple correlations for Dartmouth first year academic prediction ranged from .54 to .30; the lower value was derived for a group of 97 scholars (Engineers), for whom prediction is weakened by the lapse of time between tests/interviews, and entering BRNC. First year academic prediction was based on a variety of cognitive tests and on Board marks. Each element in the successful formulae was significant at the 5% level, and usually lower.

Board mark was found to correlate significantly with Dartmouth first year non-academic criterion. In a group of 493 officers of all three specialisations the correlation between the two scores was .34 which is significant at P .001.

Dr Cashen's study was the first to apply multiple regression techniques to the assessment of RN officer selection, and demonstrated not only their applicability but also the contribution they can make to an understanding of the process and its practical improvement.

2. Other papers particularly relevant to the present study include:-

a. Morris (1949)

This evaluation of the work of the War Office Selection Boards in the period 1942-1945 is of particular interest because, when the "new-type" Admiralty Interview Board procedure was being designed, careful attention was paid to the lessons learnt in the application of WOSB procedure.

b. Vernon (1950a)

This was a comprehensive short-term validation of the Civil Service Selection Board procedures introduced in 1945 and described by Wilson (1948). Professor Vernon made extensive use of factor analysis to study the structure of CISSB gradings and this paper contains one of few published attempts to correct for the effects of selection. He concluded that the investigations provided indubitable evidence of the value of psychologically planned procedures in the selection of high-grade personnel.

c. Anstey (1966)

In this follow-up of the Civil Service Administrative Class and the Diplomatic Service Dr Anstey identified the primary objective as "to identify candidates likely to do well eventually in the main career grade". He went on, "If the new entrant fails to reach this main career grade or does badly in it, he must be regarded ultimately as a failure. Both short and long term criteria are therefore essential."

This philosophy has been applied to the present study.

d. Fulton (1968)

The report of the committee under the chairmanship of Lord Fulton contains in Volume 3 the results of extensive surveys and follow-ups in the Civil Service. The method used by Dr Anstey for defining a "Combined Criterion Score" in his follow-up of the Administrative Class is of particular interest.

3. Numerous papers have been presented in the USA, many of which are of indirect interest. A valuable summary of some 50 of these is given by Korman (1968). The use of psychological and educational tests in the US armed forces is discussed at length by Wool (1968).

PART 3

D A T A

Chapter 7 The Career Structure

8 Pre-entry Data

9 Training Data

10 Post-training Data

11 Delineation of Samples

CHAPTER 7

THE CAREER STRUCTURE

1. The subject matter of the investigations reported in this volume is the career data of RN Special Entry officers who were selected between February 1947 and August 1949. These officers fall into two main groups.

2. The first group comprises three branches of the service viz Seaman (X), Supply and Secretariat (S), and Engineer (mechanical)(E), selections for each of which were made by a single interview board from candidates who had first qualified in an educational examination conducted by the Civil Service Commissioners. There were three entries each year, in January, May and September.

3. The second group, identified as group (L), consists solely of officers of the Electrical branch. Selections were made once a year in August and the educational qualification was a higher school certificate with passes in mathematics and physics.

4. A third group, which has been considered only for the purposes of comparison, since available selection data is limited, consists of officers of the Dartmouth 13½ year old entry. These are identified as Group D in this report.

5. The career pattern for both main groups may be considered in three broad phases, viz pre-entry, training, and post-training, as shown in Figure 7.1. Detailed descriptions of the derivation of data relevant to these three phases are given in Chapters 8, 9 and 10. Definitions of the samples and summaries of data available for each are provided in Chapter 11.

6. Important career milestones are also shown on Figure 7.1 and in each case the mean age and the age range for the 269 officers of the first group (ie X, S and E) are given. Thus the average age of attaining relevant school certificate passes was 15.8 years, the earliest was 14.1 and the latest 17.5 years. The average age of joining the RN was 17.8, and the range was from 17.0 to 18.5.

7. Immediately after joining the service the officers underwent a period of training, the length and composition varying from one branch to another and in some cases as a result of back-classing because of sickness or failure in examinations. At the end of training officers were promoted to the rank of Lieutenant and an award of seniority was made, the amount depending on performance in the various stages of training.

The average age corresponding to the basic date of promotion was 22.4 and the range was from 20.9 to 23.8.

8. In the "post-training" phase officers are employed in a series of appointments, each lasting about two to three years, planned to give the widest possible experience in preparation for higher management duties.

9. All officers are promoted to the rank of Lieutenant Commander on attaining eight years seniority as Lieutenants, and in consequence the length of experience in active appointments as a Lieutenant is limited by the amount of seniority gained on completion of training. An officer gaining no seniority has the full eight years experience but the "average" officer in this group had 6.6 years and those with the best all-round training performance had only 5.1 years. The varying total duration of training and experience as a Lieutenant is shown separately by the "wedge" in Figure 7.1. The average total duration was 12.6 years but the durations for individuals varied from 11.0 to 13.8 years.

10. Officers continue to gain experience as Lieutenant Commanders and are considered for promotion as they pass through a zone of seniority, the precise limits of which vary from one branch to another. The average age of promotion of this X, E and S group was 37.7 years and the limits were 33.7 and 40.5. The length of time spent in the rank of Lieutenant Commander is shown by the separate "wedge" at the bottom of the diagram. The average time (for those who were promoted) in this group was 7.3 years but individuals varied from 4.0 to 9.5 years. The total duration of service from time of joining to time of promotion varied from 16.2 to 22.3 years, the average being 19.9.

11. The ages for the 56 officers of the second group, the Electrical branch, are not shown on the diagram. Because of the requirement for Higher School Certificate the entry age was rather older, the average being 18.2 and the range 17.2 to 19.0. The duration of training, which included an engineering degree course, was also slightly longer. The duration of training and experience as a Lieutenant varied from 12.2 to 14.1 years, with a mean of 12.8. There was, however, no difference in the average age of promotion to Commander, 37.7, though the range was rather less, from 34.7 to 39.8.

12. The number of officers available for study in each group diminishes

progressively throughout the follow-up period. A hypothetical career structure, illustrating the combined effects of promotion and wastage, is shown in Figure 7.2. In the whole training period a total of about 15% of the original entry may be lost due to failure, resignation or death. By the time the group has passed through the zone of promotion to Commander about one third of the original number may have been lost by wastage and about one third may have been promoted. An account of the principles underlying the structure is given by Jones (1969).

13. Curves showing the actual wastage and promotion factors for the X, E and S group are given in Figure 7.3 and for the L group in Figure 7.4. In neither case should the curves be considered necessarily typical of a long-term situation. In the X, E and S group the redundancy cuts in 1957 may have significantly affected wastage in the "Lieutenant" period. In the L group there is evidence, discussed later, of unusual influences on both wastage and promotion.

14. The curves are drawn to show wastage and promotion ratios in relation to original entry numbers. Promotion factors are more usually considered in terms of numbers remaining in the service. The present ratio for each of the groups studied is as follows:-

Group	X	E	S	Total X,E S	L	D
No promoted/No still serving	.57	.68	.60	.63	.85	.52

These ratios are however liable to change significantly as a result of retirement at age 40 (see Figure 7.2).

15. No attempt has been made to continue the analysis beyond promotion to Commander because some officers in the groups considered have only just reached the top of the zone of selection to Commander. Thus the study may be described in broad terms as a follow-up to age 40.

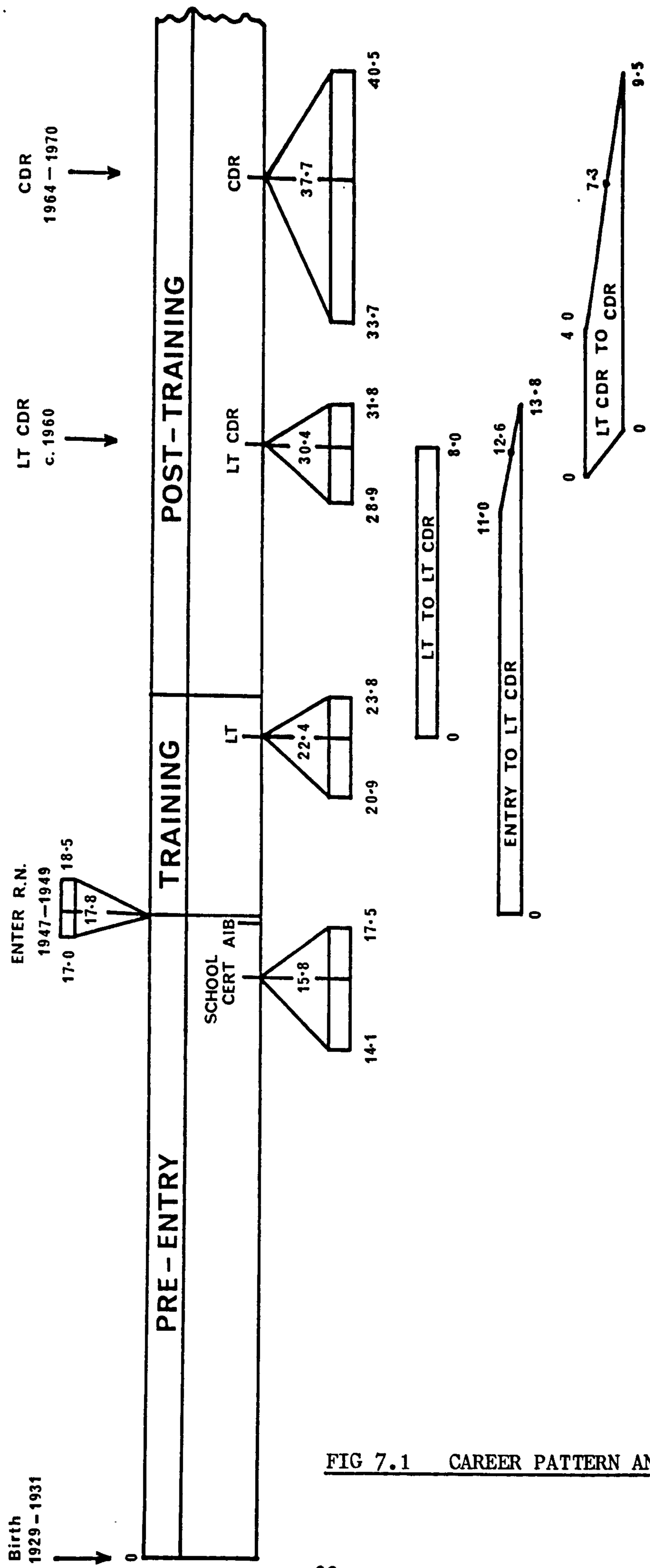


FIG 7.1 CAREER PATTERN AND TIMING

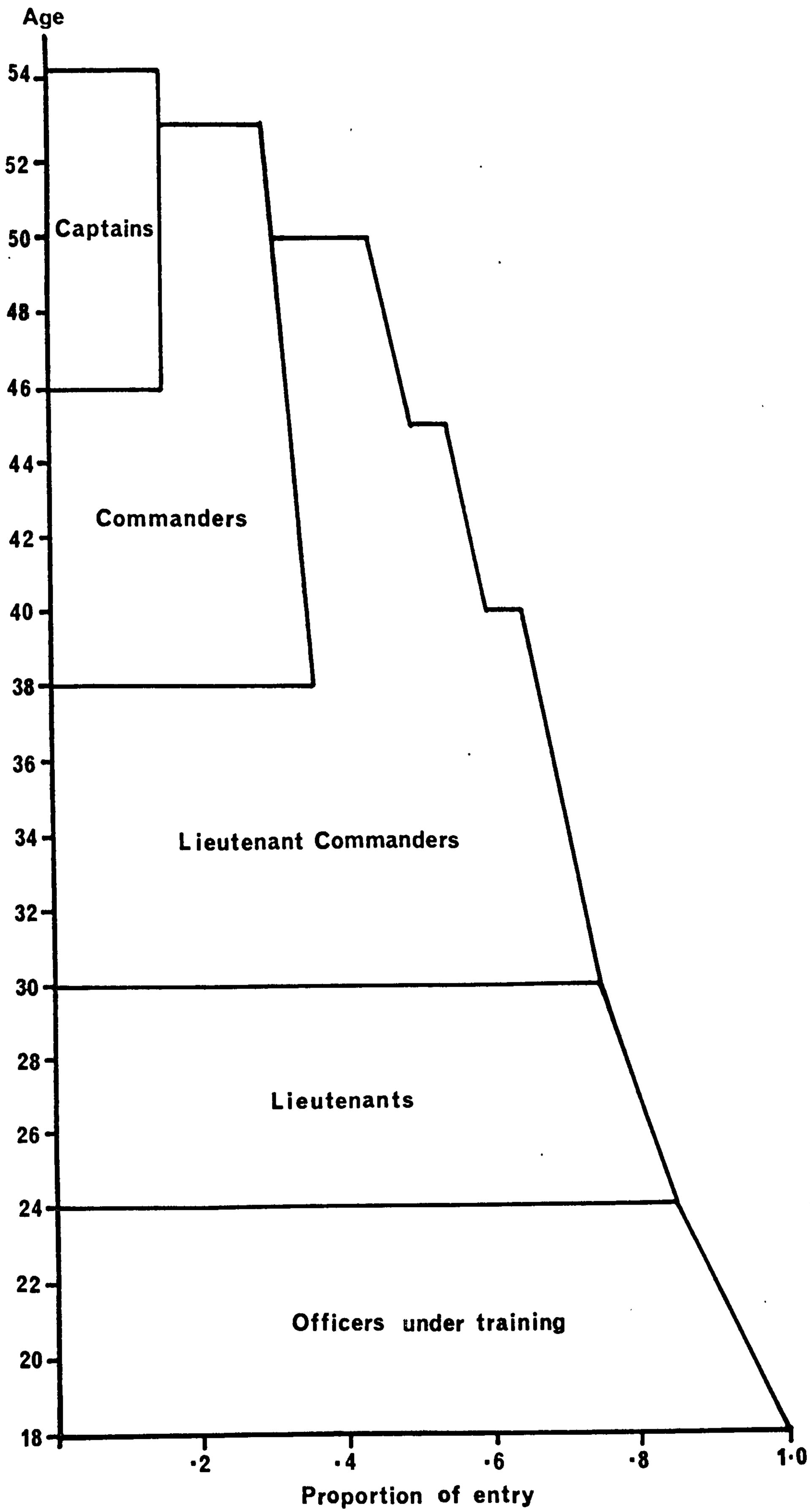


FIG 7.2 HYPOTHETICAL CAREER STRUCTURE

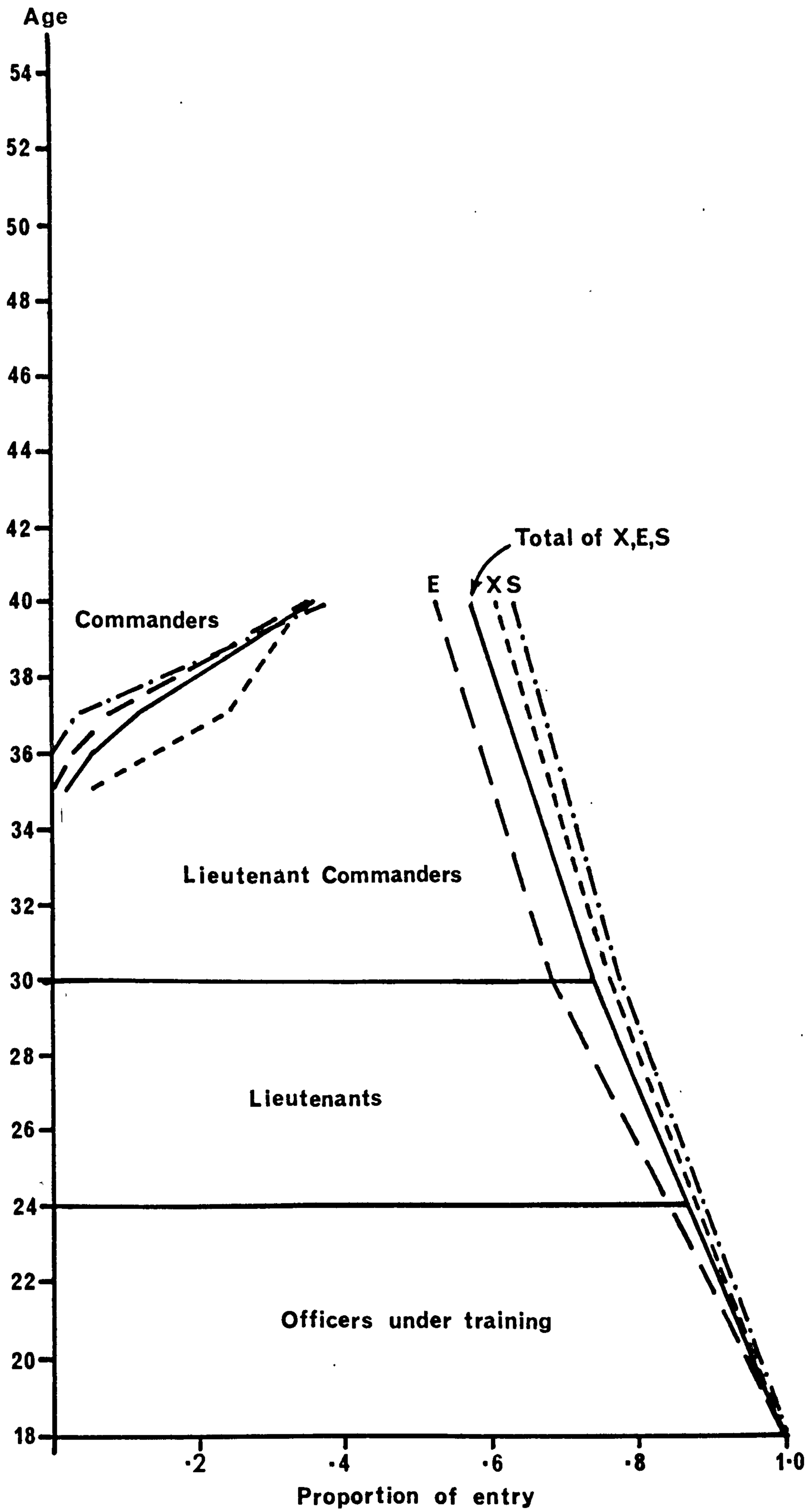


FIG 7.3 CAREER STRUCTURE X, E AND S OFFICERS

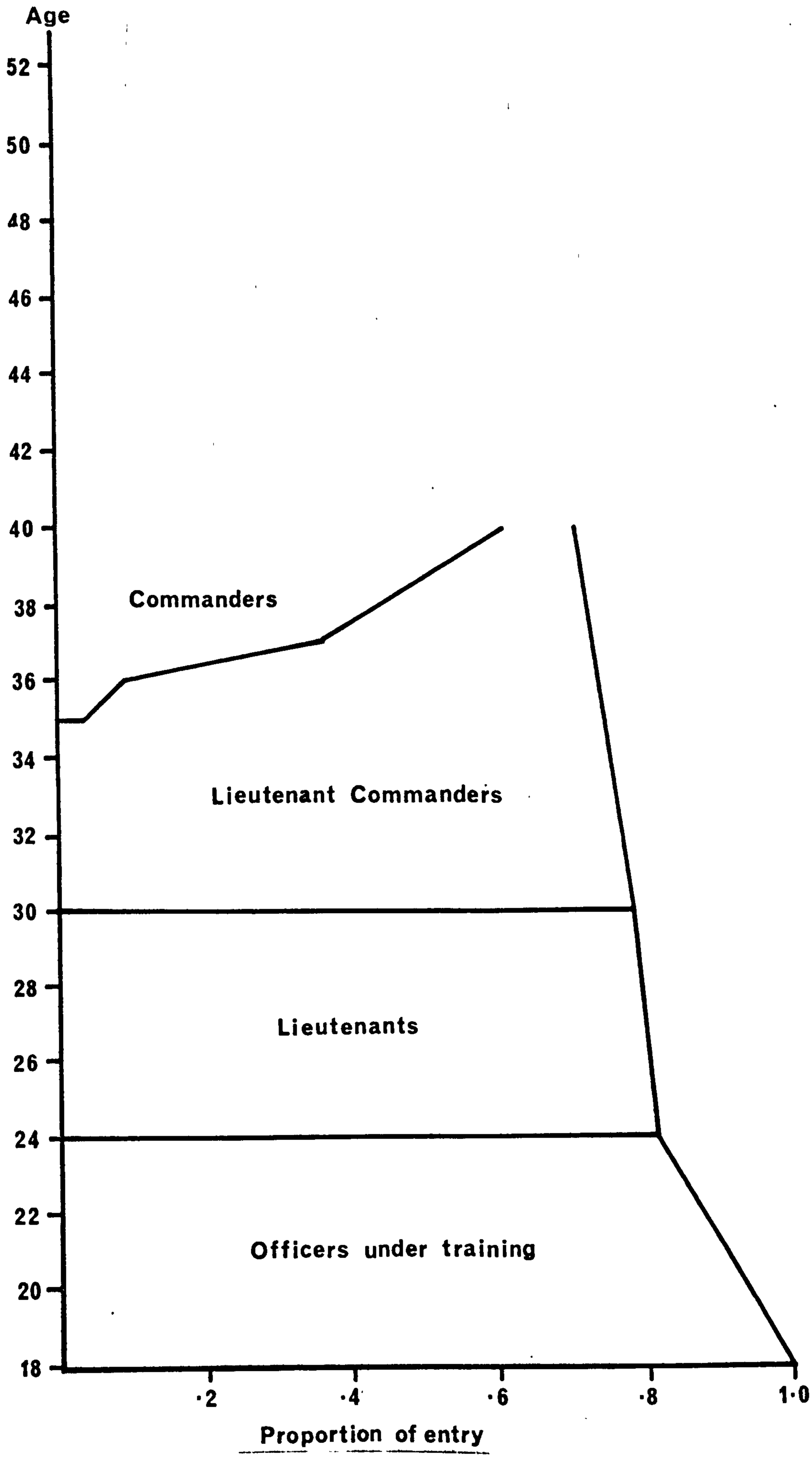


FIG 7.4 CAREER STRUCTURE 'L' OFFICERS

CHAPTER 8

PRE-ENTRY DATA

1. Information relating to the pre-entry period is all derived from the records of the Civil Service Commission examinations and of the Admiralty Interview Board. The variables used in the analyses are listed in Figure 8.1.

The CSC Examinations

2. Candidates for Special Entry cadetships in the Royal Navy, Royal Marines, Army or Royal Air Force all sat the CSC examinations. Those who wished to be considered for "S" cadetships in the RN were required to pass in Mathematics and in the aggregate of English, General, Mathematics and two other subjects chosen out of ten. Candidates for "X" and "E" cadetships were also required to pass in Physics. The variables used in the analysis are:-

ENGL	-	The mark for English, out of 200
GENL	-	" " " General, out of 100
MATH	-	" " " Mathematics, out of 100
PHYS	-	" " " Physics, out of 100
T.EXAM	-	The aggregate mark, not including Physics, out of 800.

3. Candidates for Special Entry (Electrical) cadetships in the RN were not required to sit the CSC examinations but had to obtain Higher School Certificate passes in Mathematics and Physics instead.

The Admiralty Interview Board

4. Those X, E and S candidates who passed the CSC examinations, and all L candidates, were invited to appear before the Admiralty Interview Board in groups of eight. The AIB objective was to arrive at an agreed judgment of the candidates' total personality using a procedure which included the following:-

a. Pencil and paper selection tests. Details of these cognitive tests are given below (see "SP Tests"). The candidates' scores on the test battery were interpreted for the board by the psychologist and were considered by the board members, along with other data, in arriving at their marks.

b. Biographical questionnaires. Each candidate completed a questionnaire, known as SP Form Q78, the layout of which is shown in Appendix 1. The completed forms were used by board

members as an aid during interviews.

c. Individual command and group tasks. Practical tasks, designed to test candidates' behaviour in group and leadership situations, were observed by all board members. A typical task is briefly described in Appendix 2.

d. Group discussions. The candidates assembled for group discussions on a number of suggested topics. The discussions were informal and the group was left to itself while board members listened and made judgments of each candidate's contribution in terms of quickness of thought, soundness and maturity of ideas. Behaviour characteristics such as sense of humour, tolerance, and acceptability of individuals could also be observed.

e. Short talks. After the discussions each candidate had to give a short talk to the board, lasting not more than three minutes, on a subject chosen from a list of three. He was given three minutes to prepare. Here the candidate was removed from the security of the group situation and characteristics such as control of awkwardness and embarrassment, extent of vocabulary, power of expression and maturity of outlook, could all be observed by the board members.

f. Individual interviews. Each candidate had two interviews, one conducted by the President who had with him all members of the board except the psychologist, the other conducted separately by the psychologist. At the board interviews members also had available to them the headmasters' reports.

g. AIB meeting and assessment of board mark. At the conclusion of the interviews the board met to consider the evidence available from the various tests, observed behaviour and psychologist's and headmasters' reports. Each board member awarded a mark out of 300 and the average mark was then used as a basis for discussion. The adjusted average was recorded as the "Board mark". There was no "pass mark" but the board could and did recommend that certain candidates were unsuitable when forwarding the marks to the Admiralty.

5. Finally the board marks were added to the CSC examination marks to give an order of merit from which candidates were selected, as far as possible, for the branch of their choice.

6. Variables corresponding to AIB data are considered under the headings shown in Figure 8.1. viz Biographical, Interests, SP Tests and Board Marks.

Biographical

7. Most of the biographical data is derived from the biographical questionnaires. The following variables are used in the analyses:-

a. Indicators of leadership potential and drive

CORPS	Value 1 for any rank held above the lowest in JTC, ATC, Scouts, etc; otherwise 0.
SOCS	Value 1 for officer of a school society or membership of more than 3 societies; otherwise 0.
GAMES	Value 1 for games official or school first team; otherwise 0.
PREF	Value 1 for school prefect; otherwise 0.

b. Indicators of home and school background.

ON.CH.	Value 1 for an only child; otherwise 0.
PAR.DD	Value 1 if one or both parents dead; otherwise 0.
FAT.RN	Value 1 if father a regular officer in the RN; otherwise 0.
F.ARMY	Value 1 if father a regular officer in Army or RAF; otherwise 0.
HMC.SC	Value 1 if attending a school represented on the Headmasters Conference as listed in the 1948 edition of the Public and Preparatory Schools Year Book; otherwise 0.

c. Age, preference and previous failure.

B.PREF	Value 1 if candidate subsequently joined branch of first choice; otherwise 0.
PR.ATT	Value 1 if candidate had previously attempted either the CSC examination or the AIB unsuccessfully; otherwise 0.
A.AIB	Age in years at mean date of AIB's.
A.ENT	Age in years at date of joining RN.

d. T.HSC Time in years from passing school certificate in required subjects to mean date of AIB's.

The possible usefulness of this variable was suggested by a paper by Barnett, Holder and Lewis (1968) in which the authors suggest an association between length of time spent in post-'O' level school study and university success, the assumption being that brighter students tend to take 'O' level younger but maturity is also important.

e. F.OCC An index of socio-economic background defined in terms of father's occupation as follows:-

1 = Professional and High Administrative.
2 = Managerial and Executive.
3 = Supervisory, higher grade.
4 = Supervisory, lower grade.
5 = Skilled manual.
6 = Semi-skilled manual.
7 = Unskilled manual.

A detailed account of the derivation of this scale and of its conceptual background is given by Glass (1954) and by Hall and Jones (1950). The underlying assumption is that the community consists of strata arranged in hierarchical form and that status can be assigned on an arbitrary scale in terms of occupation. More precise definitions and examples of each grade are given by Glass. Few studies of the correlation of socio-economic origin and career success have been published, but one by Porter (1965) found no significant relationship in a particular business environment.

Interests

8. This battery of thirty variables is taken directly from page 1 of the Q78. Values assigned were:-

0 = Not interested
1 = Indifferent
2 = Very interested.

SP Tests

9. The battery of tests used for all X, E and S candidates included the following:-

GT35 A parallel to N.I.I.P. Group Test 33, devised by Sir Cyril Burt. A test of verbal reasoning incorporating

opposites, analogies, mixed sentences, completing sentences and abstractions.

SP96 A test of verbal comprehension derived from a USN test battery

SP21 A clerical aptitude test, based on N.I.I.P. Clerical Test 25, which indicates capacity for care and was found useful by the Army for prediction of examination performance.

SP117E Electrical information test used to sample knowledge of everyday electrical matters on the assumption that such acquired knowledge is an indicator of technical interest and potential.

SP117M Similar to SP117E, but for mechanical knowledge.

SP97 Memory for designs test.

SP160 Cox's Mechanical Models. A test of mechanical comprehension.

In each case the values used are the actual test scores recorded for each candidate. The following derived scores used by the AIB have also been included:-

V.ED A composite verbal-educational score equal to GT35 + 5 x SP96.

K.M A composite spatial-mechanical score equal to SP97 + SP117 + SP160.

10. Of the above tests only GT35 was used for 'L' candidates but in addition the following was used for them:-

SP60 A test of mathematical ability incorporating algebra, calculus, geometry and trigonometry.

Further details of tests and their validation and application are given by Vernon and Parry (1949).

Board Marks

11. The marks (out of 300) awarded to each candidate by the board are used under the following variable names:-

Variable	Mark awarded by:-
PRES	The President of the board, an Admiral
DP	The Deputy President, a Captain RN
CS	The Civil Service representative
EO	An RN Engineer Officer of Commander's rank
SO	An RN Supply officer of Commander's rank

PSYCHO	The board psychologist
TO	The board testing officer
B.MARK	Board members collectively, after discussion

The following derived variables have also been used:-

B.MEAN	The unadjusted average of PRES, DP, CS, EO and SO.
B.SD	The r.m.s. deviation of the marks of PRES, DP, CS, EO and SO about the value of B.MEAN. This variable is a measure of the variability of opinion on candidates.
B.AGG	The aggregate mark, T.EXAM plus B.MARK, used for final grading of candidates.

Unsuccessful Candidates

12. Records are available for 250 candidates who attended the AIB but were not selected for a place. These have been used for certain analyses and the sample is identified as Group F. In those cases where a candidate was unsuccessful on more than one occasion the records of the first attempt only have been used.

PRE-ENTRY DATA					
BIOGRAPHICAL	INTERESTS		CSC EXAM	SP TESTS	BOARD MARKS
CORPS	MUSIC	COUNTRY	ENGL	GT35	PRES
SOCS	LISTENING-IN	GARDENING	GENL	SP96	DP
GAMES	DANCING	ANIMALS	MATH	SP21	CS
PREF	PARTIES	PEOPLE	PHYS	SP117E	EO
ON.CH	ART GALLERIES	CHILDREN	T.EXAM	SP117M	SO
PAR.DD	THEATRES	ORGANISING		SP97	PSYCHO
FAT.RN	CINEMA	RELIGION		SP160	TO
F.ARMY	READING	POLITICS		V.ED	B.MARK
HMC.SC	WRITING	SCIENCE		K.M	B.MEAN
B.PREF	DRAWING	ELECTRICAL			B.AGG
PR.ATT	MUSEUMS	WOODWORK		GROUP 'L' ONLY:-	B.SD
F.OCC	COLLECTING	HANDICRAFTS		SP60	
T.HSC	PHOTOGRAPHY	SAILING			
A.AIB	TRAVEL	DOMESTIC			
A.ENT	SPORTS	MECHANICAL			

PRE-ENTRY DATA VARIABLES

FIGURE 8.1

CHAPTER 9

TRAINING DATA

1. The training phase, shown in Figure 9.1, can be considered in two main parts. Stage one, devoted to naval familiarisation and general naval training, was similar for all Special Entry cadets. Stage two consisted of periods of education, specialist training and sea experience appropriate to each branch, X, E, S or L. Training data variables are summarised in Figure 9.2.

Stage One Training

2. The basic naval training of all Special Entry cadets included one term at Dartmouth followed by two terms in the cadet training cruiser, HMS DEVONSHIRE. Group 'D' cadets, having completed eleven terms at Dartmouth, joined up with the Special Entry cadets in HMS DEVONSHIRE.

3. Records of Special Entry results at Dartmouth are available only for Group E. The following examination results have been used:-

Variable	Definition				
N	Navigation	mark	out	of	450
X	Seamanship	"	"	"	"
E	Engineering	"	"	"	"
L	Electrics	"	"	"	150
M	Mechanics	"	"	"	"
S	Signals	"	"	"	"
T.DART	Total	"	"	"	1800

4. In HMS DEVONSHIRE cadets gained experience of ship life and of the organisation and activities of the various departments. At the end of the second term they were awarded marks for each departmental subject and for "Officer-like qualities". These have been used in the analyses and are identified as follows:-

Variable	Definition				
ELEC	Electrical department	mark	out	of	50
GUNY	Gunnery	"	"	"	" 100
TAS	T.A.S.	"	"	"	" 100
NAVN	Navigation	"	"	"	" 350
COMM	Communications	"	"	"	" 100
ENGG	Engineering	"	"	"	" 200
SEAM	Seamanship	"	"	"	" 250
OLQ	Officer-like-qualities	"	"	"	250.

Note: TAS = Torpedo and Anti-Submarine

The total of the above marks was used to place officers in an order of merit and to determine a class of pass.

D.TOT	Total mark out of 1400		
D.CLASS	Class of pass.	Class	D.TOT
		1	1050–1400 (> 75%)
		2	910–1050 (65–75%)
		3	700–910 (50–65%)

Officers who failed were either back-classed to repeat the second term or withdrawn from training.

Stage Two Training

5. Information relating to the Midshipman's and Sub Lieutenant's sea training periods has not been used. Vernon (1961) found that the reports (Form S202) covering these periods for X officers were "very unreliable" for the purposes of analysis.

6. Stage two shore training was directed towards preparing officers for early appointments in their own branch, or specialisation, and also providing them with a broader educational background, enabling them to gain maximum advantage from early experience.

Seaman Officers' Courses

7. Seaman officers completed the Junior Officers' War Course and a series of specialist courses covering all aspects of their profession. At the end of each specialist course they were awarded a 1st, 2nd or 3rd class pass. The following variables have been used in the study of Group X.

Variable	Definition
XS	Seamanship course result – Class 1, 2 or 3
NS	Navigation " " " " " " "
G	Gunnery " " " " " " "
T	T.A.S. " " " " " " "
A	Air " " " " " " "
C	Communications " " " " " " "
D	Divisional " " " " " " "
DC	Damage Control " " " " " " "
CO	Combined Operations " " " " " "
R	Radar " " " " " " "

Engineer Officers' Courses

8. Engineer (mechanical) officers courses, conducted at the Royal Naval Engineering College, were split into two parts, separated by a period of sea training. The first part, known as the Basic Engineering Course, was devoted to fundamental engineering studies and lasted two years. At the end of this course officers were examined and officers failing to achieve a satisfactory standard were back-classed or withdrawn from training. The following examination results have been used:-

ECON	Economics	mark out of 100
MATHS	Mathematics	" " " 200
MECH	Mechanics	" " " 450
ENG.SC	Engineering Science	" " " 450
CHEM	Chemistry	" " " 200
ELECT	Electrical Engineering	" " " 200
PRAC	Practical Engineering	" " " 400

The total of the above marks was used to place officers in an order of merit and to determine a class of pass.

BC.TOT	Basic Engineering Course total marks out of 2000		
B.CLAS	Class of pass.	Class	BC.TOT
		1	1400-2000 (> 70%)
		2	1200-1400 (60-70%)
		3	1000-1200 (50-60%)

9. At the end of the Basic Engineering Course officers were allocated to one of the three mechanical sub-specialisations, Marine (ME), Air (AE) or Ordnance (OE). They then went to sea as Sub Lieutenants, ME and AE officers for a year and OE officers for eight months, during which time they gained the marine engineering watchkeeping certificate.

10. On return to the RNEC officers completed a Specialist Course in which they learnt about the equipments and practices peculiar to their sub-specialisation. For ME and AE officers this course lasted for one year; for OE officers the duration was fifteen months.

11. At the end of the Specialist Courses officers were awarded a total mark. These totals have been treated as a single variable identified as follows:-

SC.TOT Specialist Course total mark out of 1000.

Electrical Officers' Courses

12. The training of Electrical officers also began with a period of fundamental engineering education, in this case lasting three years. The majority of officers read for the Mechanical Sciences Tripos at Cambridge University, though some went to other universities.

13. Degree course results have been used in the analyses. In cases where officers took both Part 1 and Part 2 of the Cambridge Tripos the results in Part 1 only have been used since the published results of Part 2 are not suitable for analysis. The following variable has been used in the analyses:-

DEGREE	Value	Degree result
	4	Honours class 1
	3	" " 2
	2	" " 3
	1	Ordinary
	0	Fail

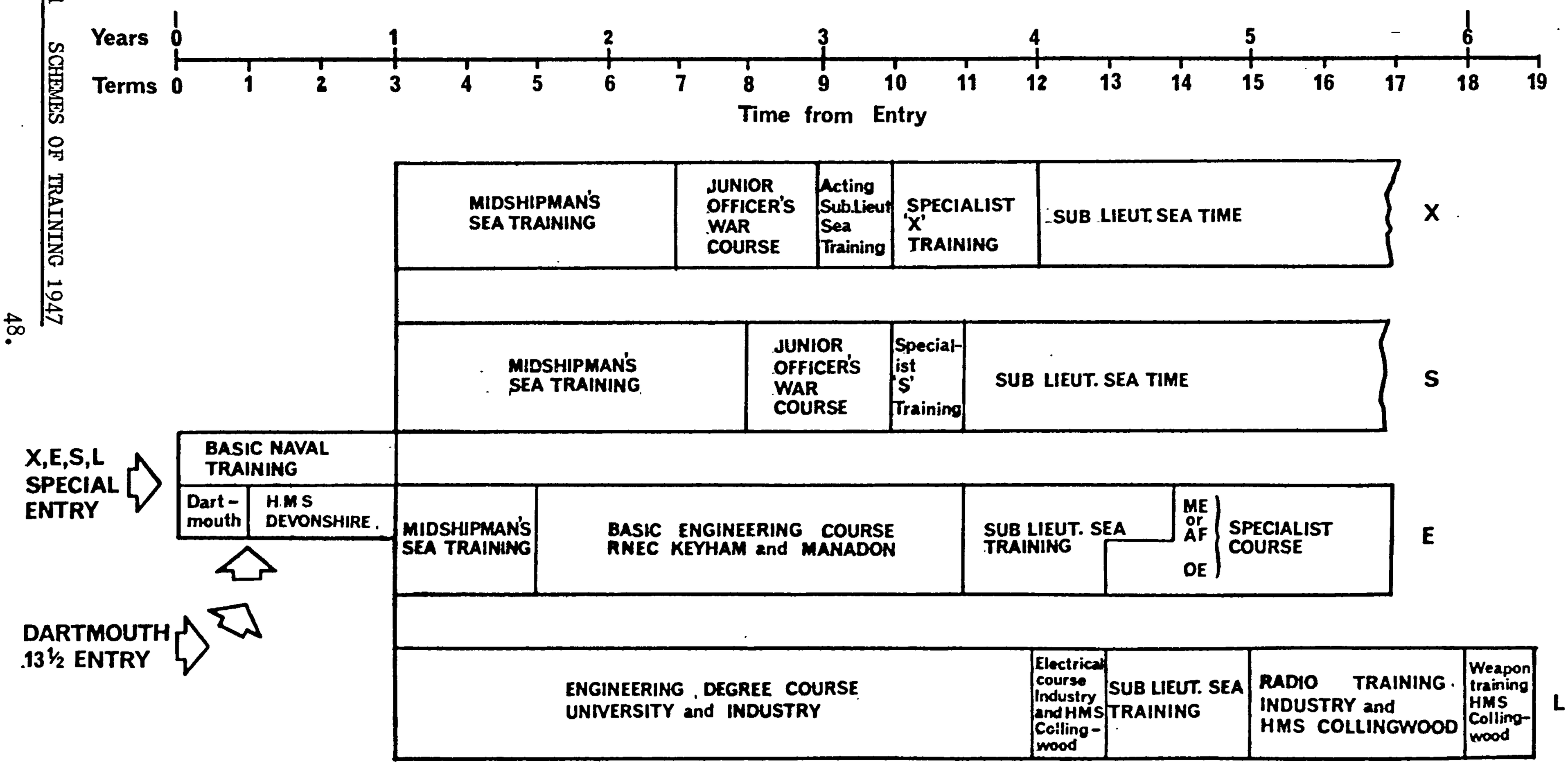
14. After the degree course officers completed a specialist course in electrical power followed by sea training, then by courses in radio (communications and radar), and in weapon control systems. The following variables have been used in the study:-

POWER	Electrical power examination mark out of	200
R.COMM	Radio (communications) " " " "	200
R.RAD	Radio (radar) " " " "	300
WEAPON	Weapon control systems " " " "	300

Seniority Award

15. At the end of training each officer's seniority was adjusted by an amount depending on the classes of pass achieved in the various stages of training. The effect of this adjustment was to vary the duration of service from date of joining to date of promotion to Lieutenant Commander. A variable called T.LCDR has been included in the post-training data to enable the effects of this adjustment to be studied.

FIG 9.1 SCHEMES OF TRAINING 1947



TRAINING DATA									
DARTMOUTH		HMS DEVONSHIRE		X SPECIALIST COURSES		RNEC COURSES		L COURSES
NAVIGATION	N	ELECTRICAL	ELEC	SEAMANSHIP	XS	ECONOMICS	ECON	DEGREE
SEAMANSHIP	X	GUNNERY	GUNY	NAVIGATION	NS	MATHEMATICS	MATHS	POWER
ENGINEERING	E	T.A.S.	TAS	GUNNERY	G	MECHANICS	MECH	WEAPON
ELECTRICS	L	NAVIGATION	NAVN	T.A.S.	T	ENGINEERING SCIENCE	ENG.SC	R.COMM
MECHANICS	M	COMMUNICATIONS	COMM	AIR	A	CHEMISTRY	CHEM	R.RAD
SIGNALS	S	ENGINEERING	ENGG	COMMUNICATIONS	C	ELECTRICS	ELECT	
TOTAL	T.DART	SEAMANSHIP	SEAM	DIVISIONAL	D	PRACTICAL	PRAC	
		O.L.Q.	OLQ	DAMAGE CONTROL	DC	BASIC COURSE TOTAL	BC.TOT	
		TOTAL	D.TOT	COMBINED OPS	CO	BASIC COURSE CLASS	B.CLASS	
		CLASS	D.CLASS	RADAR	R	SPECIALIST COURSE TOTAL	SC.TOT	
GROUP E		GROUPS X, E, L, D		GROUP X		GROUP E		GROUP L

TRAINING DATA VARIABLES

FIG 9.2

CHAPTER 10

POST-TRAINING DATA

1. Variables corresponding to the post-training phase are considered under two general headings, viz S206 Reports and Career Criteria. A comprehensive list of the variables is given in Figure 10.1.

S206 Reports

2. At least once every year throughout his career each officer is assessed by his commanding officer on a report form known as the S206. The collected set of reports provides a comprehensive record of the superiors' opinions of the officer and is available both to the appointing officers and to the promotion board.

3. The S206 is divided into a number of sections, the most important of which for the present study is Section II. Here the reporting officer gives his assessment of the individual in numerical terms. A list of personal qualities is given and marks are awarded for each of these on a scale of 0 to 9.

4. Before December 1960 there were five qualities listed, but since that time the form has included ten*. For the first stage of the analyses of the report data each of the qualities was treated as a separate variable, the value used being the mark awarded. This gave rise to the following variables:-

PRE '60

P.ABIL	Professional ability
M.QUAL	Mental qualities
LEADER	Leadership
A.ABIL	Administrative ability
P.QUAL	Personal qualities

POST '60

P.ABIL*	Professional ability
ENERGY	Zeal and energy
RELIAB	Reliability
COMMON	Commonsense
INTELL	Intelligence and reasoning power
INTIVE	Initiative and alertness
LEADER	Leadership

EXPRES	Power of expression
O.ABIL	Organising ability
TACTCO	Tact and co-operation
SOCATT	Social attributes

Note: Professional ability is not now in Section II but has been included for E and L officers.

5. Three other variables were derived for each report, as follows:-

MEANMK	The mean value of the reported qualities
REP.SD	The r.m.s. deviation of marks about MEANMK This is a measure of the degree to which individual qualities depart from the mean.
TIMREP	The time of the report in months relative to time of promotion to Lieutenant Commander.

6. By reference to Figure 7.1 it will be seen that the time of the change of format of the S206 coincides closely with the average time of promotion to Lieutenant Commander of the groups studied. Thus, provided all reports in the three years or so of the transition are ignored, the "old-type" reports refer to Lieutenants and the "new-type" to Lieutenant Commanders. This convenient coincidence is utilised in the analysis of the report data.

7. Examination of the S206 form reveals a good deal of other information potentially useful for analysis of career performance. In particular the pen-pictures given in Sections I and III are undoubtedly of considerable value to the promotion board. The attempt by Vernon (1961) to quantify such data reveals that such an exercise is unlikely to provide substantially better analytical results than are provided by Section II data alone. The reason for this apparent conflict is the difficulty of formulating a quantitative scale capable of reflecting the infinite variety of verbal description. Such a formulation has not been attempted in the present study.

8. The variables listed under the "First Factoring" and "Second Factoring" headings in Figure 10.1 represent data derived as a result of Factor Analyses. Full details of the derivation of these variables are given in Part 4 but a brief account of their meaning is included at this point since they are used in a series of investigations.

9. In the first factor analysis of the S206 scores the five and ten dimensional sample spaces of the pre and post '60 data were reduced to two-dimensional test spaces. In other words, two pairs of factor loadings were derived which adequately accounted for the correlations between markings in the two sets of reports.

10. From all the available reports the last four before TIMREP = - 18 and the first four after TIMREP = + 18 were selected and two- factor scores were calculated for each of the eight occasions. Thus F1T1 and F2T1 are a pair of scores which adequately represent the marks for P.ABIL, M.QUAL, LEADER, A.ABIL, P.QUAL on occasion one. Similarly F1T5 and F2T5 are scores which represent the marks for the ten reported qualities on occasion five.

11. A second factor analysis was then performed to derive a pair of scores, described as F1 and F2, which represent the eight pre '60 scores F1T1 to F2T4. Similarly F1A and F2A represent the eight post '60 scores F1T5 to F2T8.

12. Thus F1 and F2 are two variables which represent the information contained in the twenty marks in four pre '60 reports. F1A and F2A represent the information in forty marks in four post '60 reports.

Career Criteria

13. As outlined in Chapter 5, there are numerous ways of viewing success. The conceptual basis and the derivation of five criteria variables used in this study are described below.

14. T.LCDR. This variable is defined as the duration of service in years between date of joining the RN and date of promotion to Lieutenant Commander. For officers who left the service as Lieutenants a hypothetical value is derived by adding eight years to the seniority date as Lieutenant. As already discussed in Chapter 9, the variance in this variable reflects overall training "success" as defined by the service for the purposes of seniority award. However, the value of the variable also indicates the extent to which experience as a Lieutenant is shortened, since the award of seniority at the end of training has the effect of "back-dating" promotion to Lieutenant, and promotion to Lieutenant Commander occurs automatically on attainment of eight years seniority as a Lieutenant. This shortening of early experience may put the officers with the best all-round performance in training at a disadvantage. On

the other hand, those officers who succeed best in training may be able to learn most rapidly from experience. This point is investigated in the analyses.

15. T.CDR. Since all officers of a branch are considered by a central board for promotion to Commander as they pass through a specific zone of seniority, and as the mean promotion rate does not vary significantly, an apparently simple measure of success may be defined as follows:-

T.CDR = (Seniority as Commander) - (Seniority as Lt Cdr)
= Length of time taken (in years) to achieve promotion.

In other words, officers promoted early are considered more successful than those promoted later. Such a definition of success seems likely to give a reliable measure of superiors' assessments because the board is able to consider reports from a variety of sources on all officers in the zone in the branch concerned.

16. Full details of the distribution of this variable for each Group are given in Part 4 but a general impression may be gained from Figure 10.2. which shows the relative distributions for groups X, E, S and L, expressed as a proportion of the number promoted.

17. Difficulty arises in the use of this variable as a success criterion, however. From Figure 7.3 it will be seen that, typically, about 35 to 40% of the original entry are promoted (or about 60% of those remaining in the service at the top of the zone). For the remainder the value of T.CDR is indeterminate. To overcome this problem a "synthetic" criterion was devised and designated S.INDA.

18. S.INDA. Success Index A is defined as ten minus the nearest integer to T.CDR for officers promoted and as zero for officers not promoted. Thus S.INDA varies from 0 for officers not promoted to 6 for officers promoted at 4 years seniority. Here again the measure of success is "speed of promotion".

19. Unfortunately, although the problem of indeterminacy is overcome by this method, the resulting distribution of the criterion is both skew and double-humped. The effect of introducing the value zero for officers not promoted is equivalent to adding a column of height 0.6 at T.CDR = 10.5 in Figure 10.2. Thus the variable fails to differentiate among two-thirds of the sample and such non-normality also leads to difficulty in the

significance testing of results. Another criterion, labelled S.INDB, was devised to overcome this deficiency.

20. S.INDB. The basis of Success Index B is "usefulness to the service". Among those promoted, "speed of promotinn" may reasonably be supposed to reflect worth. Among the remainder, length of service appears to be a suitable measure of value.

21. After a good deal of experiment the following scale was derived for S.INDB:-

Value	Definition
9	Promoted at seniority < 5.00
8	" " " 5.00 - 5.99
7	" " " 6.00 - 6.99
6	" " " ≥ 7.00
5	Not promoted, still serving at seniority ≥ 9.50
4	Left service as Lt Cdr of seniority < 9.50
3	" " " Lieutenant
2	" " during training after first year
1	" " " first year of training.

Those "discharged dead" were treated as missing values but all others were given a score in accordance with the scale.

22. The distribution of S.INDB in the total of Groups X, E and S is shown in Figure 10.3. Though it appears that the shape of this curve could be improved around S.INDB = 6 and 7 the boundaries have been chosen to give the best curve for each group individually, as well as for X, E and S collectively. Complete details of the distributions are given in Part 4.

23. A possible criticism of the chosen scale is that, if success is viewed from the point of view of progress of the individual rather than value to the service, the values 1 to 4 are not necessarily compatible with 5 to 9. This point has been examined. Almost all those who left during training were withdrawn for failure. This would appear to make the values 1 and 2 entirely compatible. Study of the S206 reports of those whose scores were 3 and 4 reveals that most of these too were achieving only moderate progress. It is possible that they may have succeeded better in other occupations after leaving the service but this is not relevant to this study.

24. If the scale is considered in terms of personal satisfaction rather than satisfactoriness it again appears reasonably sound. Those who are withdrawn from training can have derived little satisfaction from the career. Those who are promoted earliest may be supposed to have derived considerable satisfaction. Those who have left in mid-stream have presumably decided that there is greater satisfaction to be obtained elsewhere.

25. Thus S.INDB is a synthetic criterion of career success which appears to reflect both satisfaction and satisfactoriness and which has a distribution for all samples which is sensibly normal.

26. SINDC. One further criterion which has been used in certain analyses is a simple dichotomous variable, Success Index C, defined as follows:-

Value	Definition
0	Officers who were not promoted to Commander
1	Officers who were promoted to Commander.

This variable has been particularly useful for deriving predictors of probability of promotion.

POST-TRAINING DATA				
"ANNUAL" REPORTS - S206				CAREER CRITERIA
PRE-'60	POST-'60	FIRST FACTORING	SECOND FACTORING	
P.ABIL M.QUAL LEADER A.ABIL P.QUAL MEANMK REP.SD TIMREP	P.ABIL ENERGY RELIAB COMMON INTELL INTIVE LEADER EXPRES O.ABIL TACTCO SOCATT MEANMK REP.SD TIMREP	F1T1 F1T5 F2T1 F2T5 F1T2 F1T6 F2T2 F2T6 F1T3 F1T7 F2T3 F2T7 F1T4 F1T8 F2T4 F2T8	F1 F2 F1A F2A	T.LCDR T.CDR S.INDA S.INDB S.INDC
GROUPS X, E, L		GROUPS E, L		GROUPS X, E, S, L

POST-TRAINING DATA VARIABLES

FIG 10.1

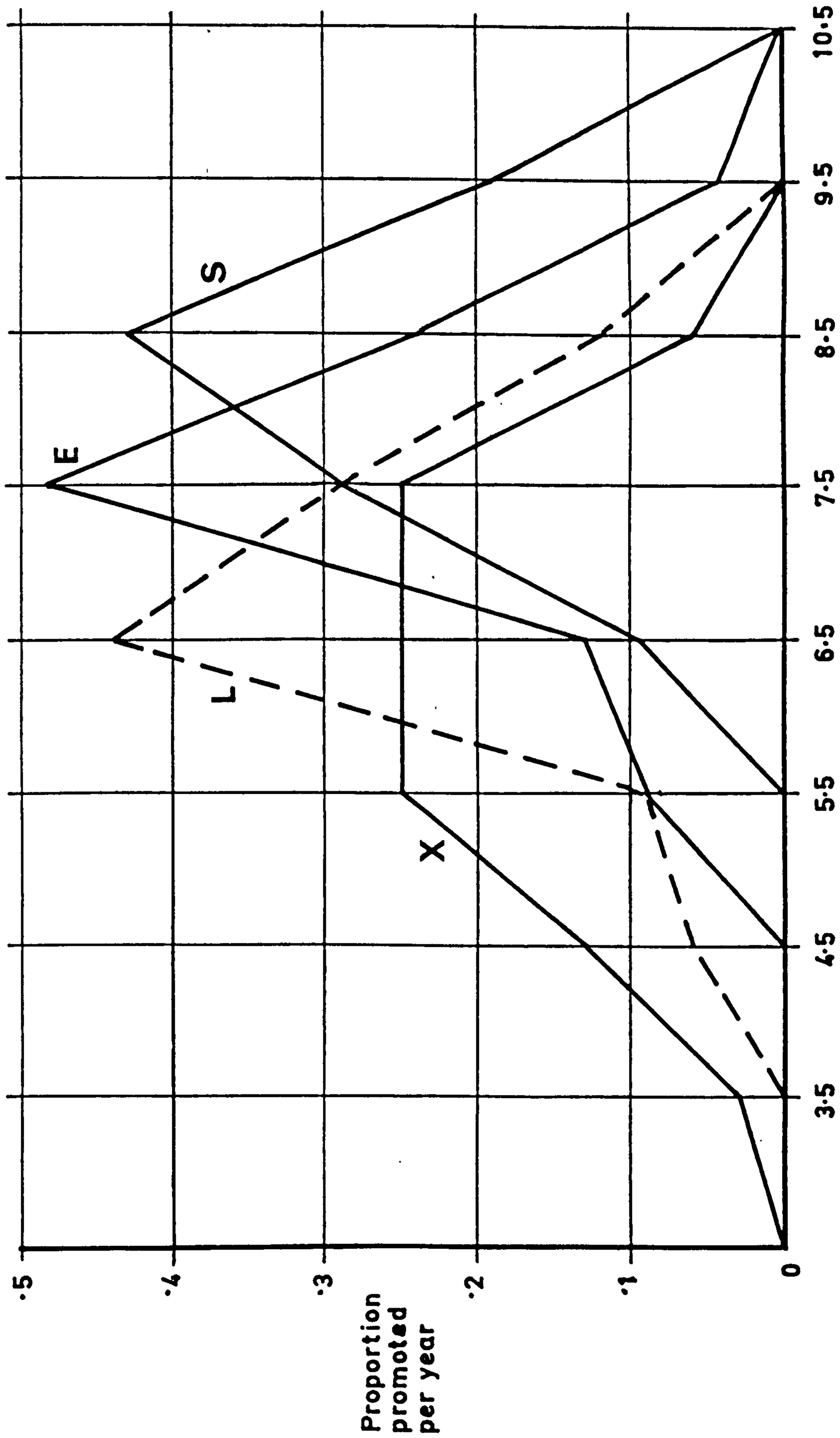


FIG. 10.2 DISTRIBUTION OF T.CDR

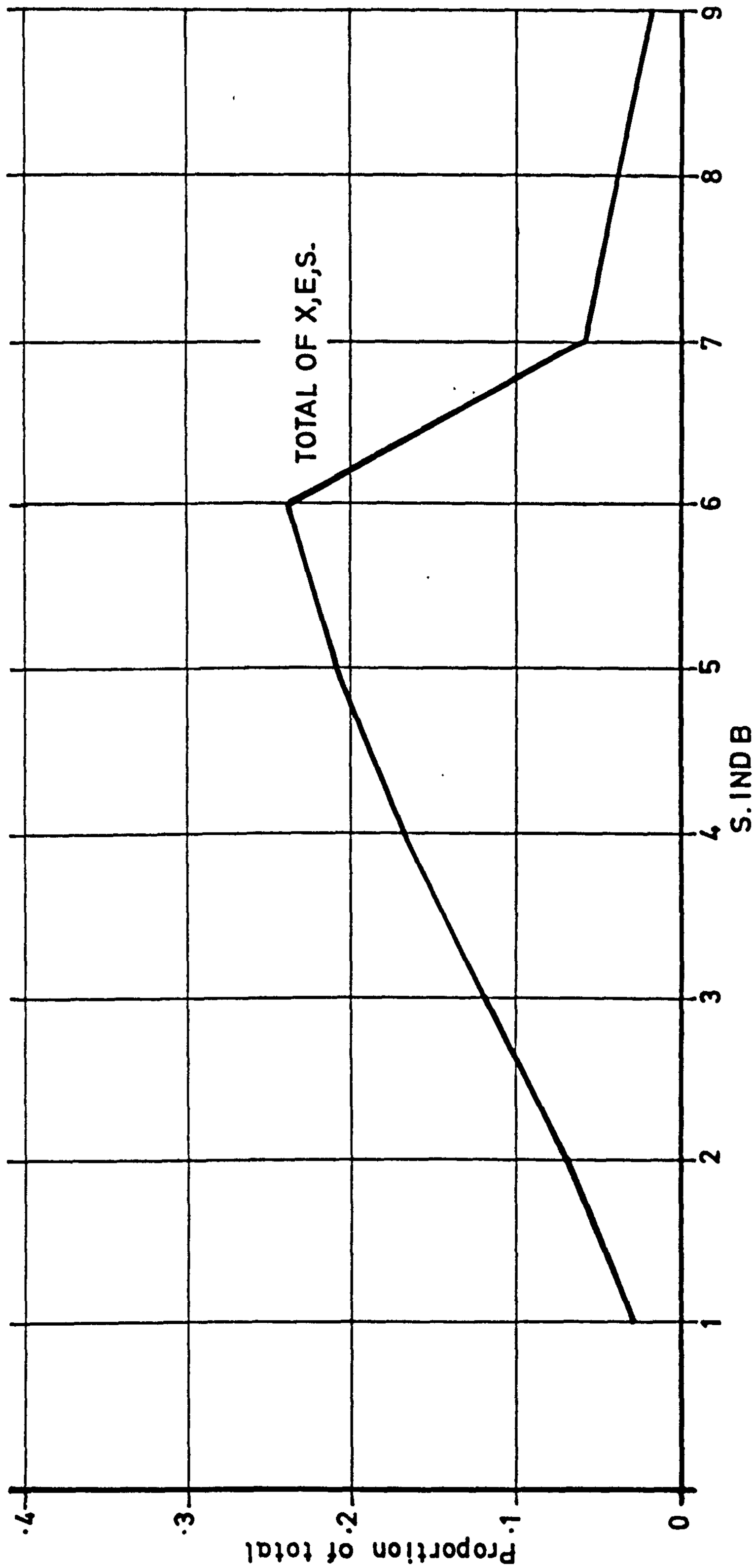


FIG 10.3 DISTRIBUTION OF S.INDB FOR TOTAL OF X, E, S

CHAPTER 11

DELINEATION OF SAMPLES

Sample Selection Ratios

1. The relationship of the sample groups to the selection boards and the corresponding selection ratios are shown in Figure 11.1.

2. Samples X, E and S are each derived from the first six Special Entry boards. The table shows the total number of candidates who sat the CSC examinations. About half the candidates qualified in this examination and of these about a quarter were subsequently interviewed by the AIB. (Candidates for the Army and Royal Air Force sat the same CSC examination). About half of those interviewed were finally accepted so that the selection ratio, expressed as a percentage of those sitting the CSC examination, was about 7%.

3. Successful candidates normally joined the service in the January, May or September following selection. Exceptionally, board number 5 provided two entries, one in September 1948 and one in January 1949.

4. Sample L is derived from the first three Special Entry (Electrical) boards. Candidates did not sit the CSC examination but had to qualify by means of Higher School Certificate instead. About one fifth of the candidates interviewed were accepted. Successful candidates joined the service in the September following selection.

5. A general appreciation of the performance of officers selected by each board is given in the last two columns of Figure 11.1. The proportion withdrawn from training averaged about 8% of the entry and just over a third of the Special Entry were promoted to Commander. The proportions promoted from the three Electrical entries vary considerably. Possible reasons for this are examined in detail later.

Depletion

6. The effect of wastage on sample size is shown in Figure 11.2. This table shows total depletion at each of three career points and includes all wastage, whatever the cause. Thus the difference between number remaining at end of training and number joined is attributable to withdrawal from training, sickness, death and resignation. Wastage during later service may be due to resignation, sickness, death, voluntary retirement, redundancy or court martial.

Data Available for each Sample

7. A summary of the blocks of data available for each sample is given in Figure 11.3. Definitions of the variables in each of the data blocks have already been given in Chapters 8, 9 and 10.

8. The precise composition of samples X, E, S and L has been made clear in Figure 11.1. Sample F includes all those candidates who appeared before boards one to six but were not accepted with the exception of repeated failures. Sample D comprises those officers of the Dartmouth $13\frac{1}{2}$ year-old entry who joined the Seaman branch and who were trained in HMS DEVONSHIRE at the same time as Samples X, E and S. This sample is included only for certain comparisons with the X group. A more comprehensive study is not possible because the D entry was not subject to the new-type AIB procedure.

9. Pre-entry data for sample L is limited because the second electrical entry was selected by the old-type procedure. (The reasons for this are discussed in Admiralty Docket CW 10557/48). For boards L1 and L3 the results of SP Tests GT35 and SP60 are available, but for L2 the only pre-entry data is age at entry and board mark and the latter was the result of a brief interview only and not of the full procedure of psychological tests, group tasks, discussions, etc. This anomaly has provided an opportunity for comparing the effectiveness of new- and old-type procedures, though the samples available in the separate L entries are small.

Missing Values

10. In the analysis of personnel records one is frequently faced with the problem of incomplete data. In this study the problem appears in three forms:-

a. The values of an individual variable for a particular person may be missing, e.g. a particular entry in a record may be indecipherable or an item may be omitted in source data such as the biographical questionnaire.

b. The values of a block of variables for a particular person may be missing because the person was not assessed at that stage, usually due to sickness at the time of examinations.

c. No data is available after individuals leave the service. The effects of sample depletion have been discussed above.

11. Three techniques have been used in this study for dealing with the problem of missing values.

a. In analyses where only a few individual values are missing a regression procedure has been used to derive values for them using the present values as predictors.

b. Where blocks of data are missing the mean values of variables have been used.

c. In some cases, where sample depletion becomes a dominant influence, the study has been confined to officers remaining in the service.

BOARD TYPE	BOARD NUMBER	DATE OF BOARD	NUMBER OF CANDIDATES WHO SAT CSC EXAM	CANDIDATES WHO PASSED CSC EXAM		NUMBER INTERVIEWED BY AIB	NUMBER ACCEPTED				TOTAL ACCEPTED AS % OF TOTAL INTERVIEWED	TOTAL ACCEPTED AS % OF TOTAL SITTING CSC EXAM	NUMBER WITHDRAWN FROM TRAINING AS % OF NUMBER JOINED	NUMBER PROMOTED TO CDR AS % OF NUMBER JOINED
				NUMBER	%		X	E	S	TOTAL				
SPECIAL ENTRY	1	Feb 1947	816	390	48	95	17	21	8	46	48	5.6	11	35
	2	Aug 1947	898	448	50	98	15	18	9	42	43	4.7	7	33
	3	Nov 1947	189	85	45	39	7	11	6	24	62	12.7	4	50
	4	Feb 1948	660	355	54	87	12	18	8	38	44	5.8	5	34
	5	July 1948 (2)	745	446	60	125	23	39	16	78	62	9.6	8	31
													10	49
	6	Jan 1949	488	252	52	74	12	21	8	41	55	8.4	7	27
	TOTAL		3796	1976	52	519	86(1)	128(1)	55	269	52	7.1	8	36
										L				
SPECIAL ENTRY ELECT-RICAL	L1	Aug 1947				108				20	19		5	90
	L2	Aug 1948				98				18	18		6	39
	3	Aug 1949				57				18	32		11	50
	TOTAL					263				56	21		7	61

Note: (1) Three officers transferred from E to X during training, making these totals 89 and 125 respectively.
(2) This board provided two entries.

SAMPLE SELECTION RATIOS

FIG 11.1

	X	E	S	X + E + S	L
Total Joined Service	89	125	55	269	56
Number remaining at end of training	84	105	50	239	46
Number remaining at promotion to Lt Cdr	73	86	43	202	44
Number remaining at Lt Cdr + 9.5	54	66	35	155	40

SAMPLE SIZE DEPLETION

FIG 11.2

Type of Entry	Group	Sample Designation	Number in sample at entry Date	PRE-ENTRY DATA					TRAINING DATA			POST-TRAINING DATA	
				Biographical	Interests	CSC Examination	SP Tests	Board Marks	Dartmouth	HMS DEVONSHIRE	Branch Training	S206 Reports	Career Criteria
Special Entry	Seaman Officers	X	89 (1)	/	/	/	/	/		/	/ X Specialist Courses	/	/
	Engineer Officers	E	125 (1)	/	/	/	/	/	/	/	/ RNEC Courses	/	/
	Supply Officers	S	55	/	/	/	/	/					/
	Failed Candidates	F	250 (2)			/	/	/					
Special Entry (Electrical)	Electrical Officers	L	56	(7)			(4)	(5)		/	HMS COLLINGWOOD & Univ /	/	/
Dartmouth 13½ year old	D tmouth Seaman Officers	D	231 (3)							/			(6)

Notes:
1. After allowing for transfers during training
2. Not including repeated failures at AIB
3. Seaman Officers only
4. GT35 and SP60 only (not Board 2)
5. B.MARK only.
6. S.INDC only.
7. A.ENT only.

SUMMARY OF DATA FOR EACH SAMPLE

FIG 11.3

PART 4

INVESTIGATION

Chapter 12 Outline of Analytical Work

13 Univariate Analyses

14 Predictive Associations and Correlations

15 Investigations of Pre-entry, Training and Criteria Data Structure

16 Analysis of Interests Data

17 Condensation of S206 Report Data

18 Discriminatory Analyses

19 Multiple Regression Analyses

CHAPTER 12

OUTLINE OF ANALYTICAL WORK

1. The statistical studies fall into three categories, viz preliminary analyses, investigations of structure, and derivation of predictor functions.

Preliminary Analyses

2. The report of the analyses begins, in Chapter 13, with details of the univariate studies of the distributions of all variables in each of the samples and continues, in Chapter 14, with an examination of predictive bivariate associations and correlations. Key relationships are illustrated and values of significant correlation coefficients are tabulated.

Investigations of Structure

3. In Chapters 15 to 17 accounts are given of generalised studies of correlations in the investigations of the underlying structure of the various data-blocks and in the condensation of S206 data. The multivariate methods used in these investigations are Principal Component Analysis and Factor Analysis, the models for which are discussed below.

Principal Component Analysis

4. Principal Component Analysis, developed by Hotelling (1933), is used to find linear combinations of variables with large variance. The principal components satisfy two conditions:-

a. they form an orthonormal set, ie they are uncorrelated and for each component the sum of squares of coefficients is unity;

b. the first principal component is the normalised combination with maximum variance; the second is a normalised combination, uncorrelated with the first, with as large a variance as possible and so on.

5. In effect, transformation of the original vector of variables to the vector of principal components amounts to a rotation of co-ordinate axes. The significance of each of the new axes is measured by the variance of the corresponding principal component. The model for Principal Component Analysis is:-

$$z_i = \sum_{j=1}^{n} a_{ij} F_j \qquad (i = 1, 2, \ldots\ldots\ldots, n)$$

where each of the n observed variables is described linearly in terms of

n new uncorrelated components F_1, F_2, ... F_n.

6. The principal components are, in fact, the eigenvectors of the correlation matrix, and their variances are the corresponding eigenvalues. In this study the eigenvectors and eigenvalues were calculated using the QR algorithm described by Bowdler, Martin, Reinsch and Wilkinson (1968).

Factor Analysis

7. In contrast, Factor Analysis is a procedure for condensing the information contained in a set of original variables into a smaller set of new variables with minimum loss of information, ie for removing redundancy in the original measurements. By tests of significance the minimum number of dimensions, or factors, that account adequately for the total matrix of correlations among a larger number of variables may be determined.

8. The basic Factor Analysis model may be expressed in the form:-

$$Z_i = \sum_{j=1}^{b} a_{ij}F_j + e_i \qquad (i = 1, 2, \ldots\ldots, n)$$

where each of the n observed variables is described linearly in terms of b ($< n$) common factors and a unique factor. The common factors account for the correlations among the variables, while each unique factor accounts for the remaining variance of the corresponding variable.

9. In matrix notation the model may be expressed as:-

$$Z = AF + E$$

The basic problem of Factor Analysis is the estimation of the factor loading matrix A such that AA' best reproduces the observed correlations. Various methods are available, most of which assume that the observations are "true" population values. The "Maximum-Likelihood" method, derived by Lawley (1940), has been used in this study. This provides a statistical basis for estimating universe values of factor loadings from the sample data and for testing the significance of the residual matrix.

10. An iterative algorithm described by Hemmerle (1965) has been used to compute A and W, the diagonal matrix of uniquenesses. Significance testing is discussed at length by Harman (1967).

11. The use of the factor scores matrix as a lower rank approximation to the data matrix is considered in detail by Horst (1965). He concludes that factor scores may be used to eliminate random or irrelevant variance from data and to increase the degrees of freedom in regression analyses where the number of variables is comparable with the numbers of observations. These concepts have been used in the regression analyses of S206 report data. The estimate of factor scores, Y, which best accounts for the observations on a regression model is given by:-

$$Y = (A'A)^{-1} A'Z$$

In this study the values have been derived by the simpler transformation

$$Y = A'Z$$

since the rotation and scaling represented by $(A'A)^{-1}$ is a linear transformation, the effect of which is only to modify the β-coefficients in the subsequent regression analyses.

Derivation of Predictor Functions

12. The third phase of this study is devoted to the derivation of predictor functions, for which the methods of Discriminatory Analysis and Multiple Regression Analysis have been used. The former is particularly suitable for prediction of the dichotomous criterion "promotion/no promotion" and for other more intricate classifications. The latter, which is more conventional in personnel selection work is appropriate for measured criteria such as course results. Results of these analyses are given in Chapters 18 and 19 respectively.

Discriminatory Analysis

13. The principle of discriminatory analysis is that a data matrix can be partitioned into groups, defined as required, and an identification routine is then derived so that a new set of observations can be assigned to the groups in such a way that the probability of incorrect assignment is minimised.

14. A geometrical representation of a hypothetical discriminatory analysis is given in Figure 12.1. Each ellipse is the locus of points of equal density in two bivariate groups of observations, A and B. Thus the outer ellipses might represent the contours within which 95% of the observations in each group lie and the inner ellipses the 50% contours.

15. L1 is defined by the intersections of corresponding contours of the two groups. The distributions are projected onto L2 which is perpendicular to L1 so that the overlap of distributions is minimised.

16. The linear discriminant function is defined so as to transform an observation (x_1, x_2) into a single discriminant score, which is the location of the observation on L2. The point where L1 intersects L2 divides the one-dimensional discriminant space into two regions, one indicating probable memberships of Group A, the other of Group B. In general the n-dimensional test space is reduced to an r-dimensional discriminant space, where r = min (K-1, n), K being the number of groups.

17. A theoretical treatment of discriminatory analysis is given by Anderson (1958).

Multiple Regression Analysis

18. The basic assumption here is that a single dependant variable, the criterion, can be approximated by a linear function of several independant variables, or predictors. The regression model:-

$$\hat{Y} = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots\ldots + E$$

embodies assumption of additivity and linearity, and of the distribution of E.

19. Two analytical procedures have been used in the studies. In most cases the regression set has been formed by a stepwise procedure such that each coefficient is significantly non-zero in the t-test sense at a specified level of significance.

20. In some of the analyses, however, advantage has been taken of an algorithm discussed by Beale, Kendall and Mann (1967). This procedure selects that subset of predictors with the minimum error sum of squares of any subset of that size.

Limitations

21. Because the sample sizes are, perforce, limited, it has been necessary to rely to some extent on statistical inference rather than the more pragmatic cross-validation. Tests of significance are, however, dependant on the nature of distributions and the results must be interpreted in the light of distribution data given in Chapter 13.

22. It is particularly important that the predictor functions derived in Chapters 18 and 19 should not be used for predictive purposes in other samples. Rather should they, together with the results of investigations of data structure, be regarded as providing an insight into ability/success relationships, ie as aids to model construction, facilitating more general deductions and providing a starting point for future investigations.

23. The extent of sample truncation has been indicated in Chapter 11. The effect of this high degree of selection is to distort structural relationships and to reduce the variance of distributions and the size of correlations. No follow-up information is available on candidates who were not selected and no attempt has been made to correct for selection. Methods of correction are described by Thorndike (1949) and an idea of the results which might be achieved may be obtained from the CISSB validation reported by Vernon (1950).

Computation

24. In the statistical studies extensive use has been made of the ICL 1905 Computer at the City University. The statistical analysis package XDS3 and the survey analysis package XDSB have been found particularly suitable for many of the investigations undertaken. Full details of the procedures are given in the relevant ICL manuals.

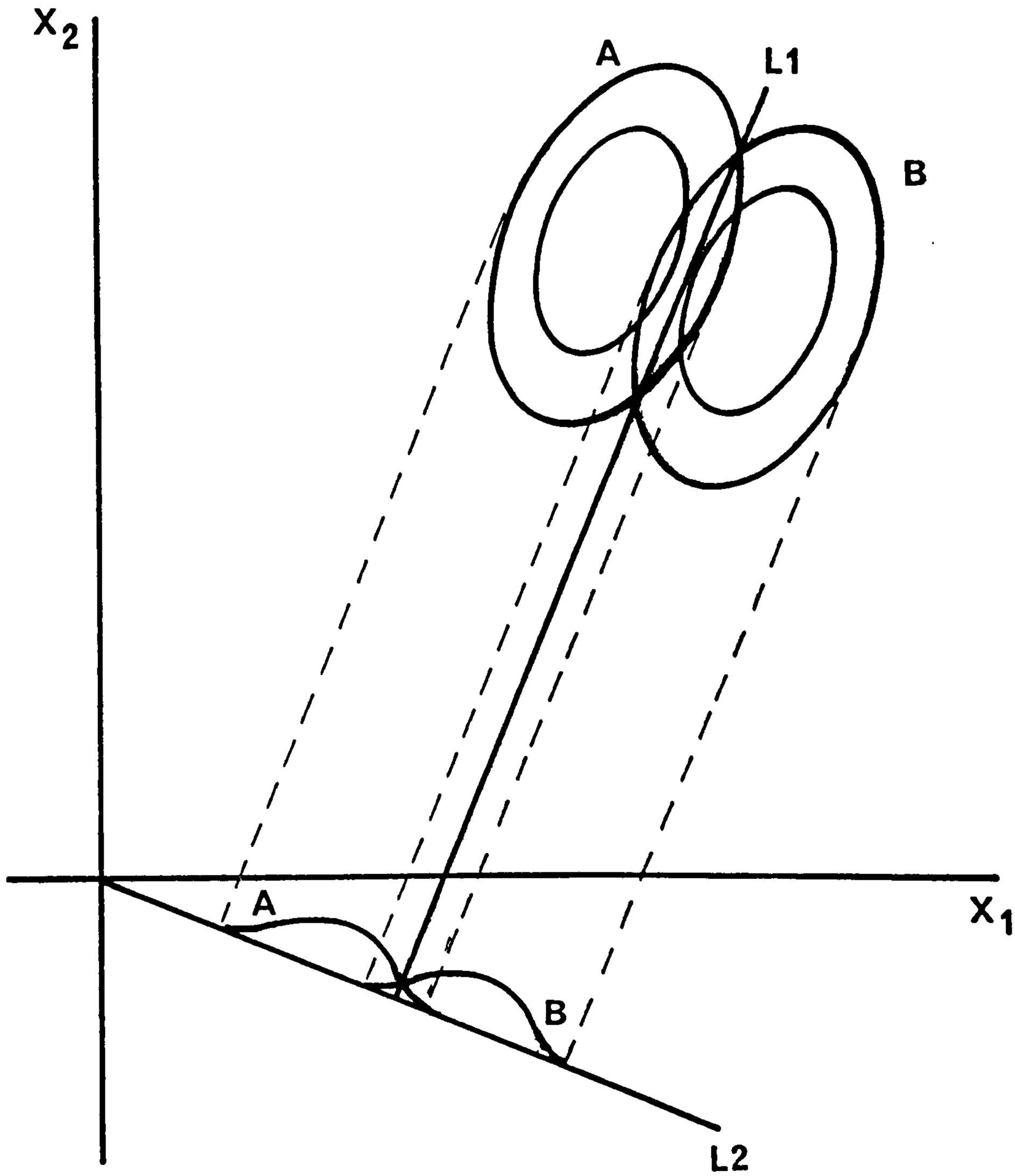


FIG 12.1 ONE-DIMENSIONAL DISCRIMINANT MODEL

CHAPTER 13

UNIVARIATE ANALYSES

Means and Standard Deviations

1. The values of the means and standard deviations of all variables in each sample are given in Appendix 4. Sample sizes quoted in each table are maxima. In most cases the number of missing values for any particular variable is small and such values have been omitted in calculations of means and standard deviations.

2. Although the primary object of including this data is to define the characteristics of variables used in subsequent analyses the tables also yield interesting information about the samples.

3. Comparison of mean scores on AIB and HMS DEVONSHIRE variables shows that the performance of X officers was significantly superior to that of E officers in almost every case, and in some cases the differences are highly significant. Thus the difference of means of B.AGG, the selection criterion, is 12 times its standard error. These differences are reflected, whether by design or coincidence, in the values of career criteria. From the HMS DEVONSHIRE scores there is, however, no evidence of any significant difference between X and D officers.

4. The performance of L officers tends to be better that that of X officers in general and particularly so in the case of the first L entry. Thus, the difference in D.TOT means would arise only 1.6 times in 100 by chance and the difference in post '60 S206 MEANMK only once in 200 times. There are, however, substantial differences between the three L entries, L1 scores being significantly higher on most variables. The weakness of the "old-style" selection procedure used for the L2 entry is also apparent here. Although the mean B.MARK for L2 was marginally higher than for L1, the mean D.TOT for L1 was higher than that for L2 by 3.8 times the standard error of the difference, a "highly significant" difference, the probability of which arising by change is negligibly small. The Spearman rank correlations of B.MARK and D.TOT in L1 and L2 are in fact 0.13 and -0.24 respectively. Later training and promotion results are similarly better in L1 than L2 but comparison with L3 suggests that L1 may be a special case.

5. Means and standard deviations are given also for the merged samples (X, E, S), (X, E, S, F), and (X, E, D), where appropriate, since these

merged samples are used in the study of the structure of data at various stages, though the individual sample differences make pooling for prediction purposes questionable.

Distributions

6. The distributions of non-dichotomous variables are tabulated in Appendix 5. For ease of manipulation most of the variables have been standardised to a mean of 500 and standard deviation of 100. The table columns thus represent half-sigma cell intervals. Mean values have been substituted for missing values.

7. The use of the binary scale for the dichotomous biographical variables enables their distributions to be seen directly from their mean scores in Appendix 4. Thus HMC Schools provided 67% of X officers, 46% of E officers and 57% of S officers. Some 12% of all X, E and S officers came from naval families and 26% had no brothers or sisters. Whereas 97% of X officers joined the branch of their choice, only 47% of E officers did so. The proportions of each sample which held positions of leadership at school are also indicated.

8. From the distribution of F.OCC it will be seen that the largest proportion, a total of some 44%, came from class 2 backgrounds, ie fathers had managerial or executive occupations, though almost 10% came from classes 5 and 6. ie fathers had manual occupations, and almost a third came from classes 3 and 4, ie fathers had supervisory occupations.

Distribution Tests

9. To enable the consequences of assumptions about the distribution of each variable to be assessed, the results of a series of tests are tabulated in Appendix 6.

10. On the hypotheses that populations are adequately represented by total available samples, and that populations are normally distributed, values of χ^2 are derived for each variable. These values are obtained from

$$\chi^2 = \sum \frac{(f_o - f_e)^2}{f_e}$$

where f_o and f_e are observed and expected frequencies in each of ten cells,

cell widths being calculated to give equal expectancy. The values of χ^2, listed in Table APP 6.1, show that, on the basis of this test, 16 out of the 41 variables are non-normal at the 99% confidence level. There is, however, considerable controversy about testing, for normality and non-normality does not necessarily imply significant error in deduction. Indeed, in samples of the sizes considered in this study the observed departures from normality are unlikely to be important. Nevertheless they should be borne in mind, particularly when assessing the results of significance tests which are distribution dependent.

11. In Table APP 6.2 the results of comparisons of the distributions of all variables for each of the six boards are given. The values of χ^2 are obtained on the hypotheses that the median value of the total available sample represents the population median, and that individual board medians do not differ from the population median more than is expected by chance.

12. Examination of the table reveals no consistent pattern of difference in standards between boards but exceptionally high values of χ^2 occur in variable SP97. This indicates widely varying standards of marking on this test in different boards. The explanation for this probably lies in the subjective nature of the marking of a "memory for designs" test. It is noteworthy that SP97 was removed from the test battery in 1949, which suggests that its unreliability was known.

13. In order to compare the seven entries, as distinct from the six boards, the distributions of HMS DEVONSHIRE variables in each entry are examined in Table APP 6.3. Values of χ^2 are derived on the same hypotheses as for Table APP 6.2. Again there is no evidence of any consistent difference in standards between entries.

Conclusions Drawn

14. From a statistical viewpoint there are significant differences between the samples, X, E, S, and L, and the direction of the differences is consistent for most variables though the magnitude varies.

15. Consequently, for most of the analyses the samples have been considered separately, though for investigations of structure and of associations all data relevant to a particular phase has been pooled.

16. There are no consistent differences between the various entries or boards for the X, E and S samples, and all entries in each sample have been pooled for analyses. In the case of the L sample some of the analyses have been repeated for the second entry separately since there is evidence of heterogeneity, probably as a result of the change of board procedure.

CHAPTER 14

PREDICTIVE ASSOCIATIONS AND CORRELATIONS

1. Two of the main objectives of this study were to assess the effectiveness of the selection procedure for prediction of short and long-term success and to assess the usefulness of various classes of data for such prediction.

2. A direct approach to both of these problems is to study the bivariate associations and correlations between criteria, ie variables whose values are measures of success, and predictors, ie variables which may be thought likely to have some influence on success. Variables which are regarded as criteria in an early phase of the study may, of course, become predictors in a later phase.

Associations

3. One of the simplest ways of studying a relationship between two variables is by means of the contingency table and expectancy chart. The results of analyses of the principal relationships by these means are described below. The results are illustrated in Figures 14.1 to 14.6 and the corresponding data is tabulated in Appendix 7.

Early Training v. Selection

4. The stage one training of X and E officers followed a common pattern and all officers were marked at the end of HMS DEVONSHIRE training on a single scale. Consequently the X and E data has been pooled for an investigation of the relationship between HMS DEVONSHIRE score, D.TOT, and selection score, B.AGG. The S sample could not be included because the HMS DEVONSHIRE training of S officers followed a different pattern and was separately marked. L officers have been excluded because of the heterogeneity introduced by the change of board procedure.

5. HMS DEVONSHIRE total marks for X and E officers have been classed as above or below the median score, ie as "superior" or not. Selection scores have been classified into the quartile ranges shown in Table APP 7.1. The proportion of officers who were marked superior in HMS DEVONSHIRE shows a strong association with selection score. Indeed, on the hypothesis that there is no association the χ^2 value of 27.8 in the 4 x 2 contingency table indicates that the observed degree of departure from non-association

would occur by chance much less often than once in a 1000 trials.

6. The results of this analysis are shown pictorially in Figure 14.1. The effectiveness of the total selection score in predicting early training success is very evident. An officer placed in the upper quartile as a result of CSC examination plus AIB interview was more than 3 times as likely to be superior in HMS DEVONSHIRE as an officer in the lower quartile.

Promotion v Selection

7. Each branch has its own promotion structure and in order to assess the relationship between long-term success and selection performance it is therefore necessary to consider each sample separately. In order to eliminate the effects of sample differences the selection board ranking for each branch was used as a predictor rather than the scores. The totals of the proportions of X, E and S officers promoted to Commander from the upper and lower halves of the selection board ranking of each entry of each branch are shown in Table APP 7.2. An expectancy chart for the combined total is given in Figure 14.2, showing that 42% of officers in the upper half of each entry were promoted, compared with 31% of those in the lower half. On the hypothesis that there is no association between promotion and selection ranking, the χ^2 value of 3.5 could be expected to occur by chance about 6 times in 100, a result which is marginally significant statistically.

Promotion v Early Training

8. To what extent does performance in early training predict long-term success? Expectancy charts showing the probability of promotion to Commander for upper, middle and lower thirds of HMS DEVONSHIRE results of X and E officers are given in Figures 14.3 and 14.4. Corresponding data is summarised in Table APP 7.3.

9. The charts show that the probability of promotion for those in the upper third of HMS DEVONSHIRE results was between two and three times the probability for those in the lower third. On the hypothesis of no association the probability of the observed χ^2 value of 12.8 for the total sample occurring by chance is about .002, ie the degree of association is "very highly significant".

10. Thus, an officer's performance in stage one training may be seen as a powerful predictor of long-term success, and much more reliable than selection board rankings. Indeed, HMS DEVONSHIRE scores are almost as good a predictor of promotion to Commander as selection scores are of HMS DEVONSHIRE training results, a result which is remarkable in view of the relative time intervals involved. Prediction of promotion typically spans some twenty years; prediction of early training success a little over a year.

Later Training v Selection

11. For E officers it was possible to examine the association between stage two training results and selection performance. Figure 14.5 shows the proportion of officers with selection scores above and below the median who were "superior" in the Basic Engineering course. The corresponding data is given in Table APP 7.4.

12. Officers with superior selectinn scores were about 1.7 times as likely to be superior in this later training. On the hypothesis of no association the probability of the observed χ^2 value of 7.3 occurring by chance is about .007.

13. Though prediction of these later training results is not as effective as that of early training, nevertheless the association is "highly significant".

Promotion v Later Training

14. Is performance in stage two training a better predictor than early training assessment? For E officers the probability of promotion for those above and below median score in the Basic Engineering course is shown in Figure 14.6. Supporting data is given in Table APP 7.5.

15. In this case officers with superior training results were about 1.5 times as likely to be promoted as those with inferior results. The χ^2 value of 2.8 is, however, barely significant, since the associated probability is about .09.

16. Thus the predictive value of performance in stage two E training is comparable with that of the selection board rankings and substantially poorer than that of HMS DEVONSHIRE training results. A possible explanation of this apparent anomaly is that in HMS DEVONSHIRE the officers were assessed in a wide variety of activities whereas in the Basic Engineering

course the emphasis in results was on academic performance. The HMS DEVONSHIRE total also includes a mark for "officer-like-qualities" which probably reflects adaptability or ability to acquire the preferred behaviour pattern. This problem is investigated in the analyses of structure.

Final 'E' Training Relationships

17. For E officers the final phase of training was a Specialist course. Tables APP 7.6 and APP 7.7 show the association of SC.TOT with B.AGG and with Promotion respectively. While selection scores were poor predictors of Specialist course results the latter were about as effective as Basic Engineering course results in predicting long-term success.

'L' Associations

18. Tables APP 7.8 and APP 7.9 show associations between D.TOT and B.MARK and Promotion respectively. Predictive value in both cases is poorer than in other samples. This may be attributed to a number of possible causes including the following:-

a. B.MARK is the AIB mark only. B.AGG, which is available for other samples, includes the CSC Examination mark, T.EXAM.

b. The pooling of L1, L2 and L3 is probably not justified because the procedures used for assessing B.MARK differed. In the first entry B.MARK was assessed out of a maximum of 300 by the same procedure as for X, E and S. The board procedure for the second entry reverted to the old-style short interview. The third entry, though assessed under the new-style procedure, were marked out of 400 and although the marks have been scaled there is evidence of a significant widening of marking range. The resulting incompatibility of scores has already been discussed in Chapter 13.

c. The officers selected for the L entry were probably a more homogeneous sample in terms of abilities than those selected for other branches; this is suggested by the comparative ranges of corresponding marks, eg D.TOT.

Conclusions Drawn

19. From the analysis of associations in the X, E and S samples there is clear evidence that the selection procedure considered as a whole (ie as represented by B.AGG) was an effective predictor of HMS DEVONSHIRE training

results and that the latter were equally effective for prediction of long-term success. Selection scores were relatively poor predictors of later training results and long-term success. Specialist E training results are not as useful as HMS DEVONSHIRE results for long-term prediction.

20. The results of these simple analyses of associations between key variables show that a more detailed examination of predictive relationships and of data structure is worthwhile. In particular it is of interest to compare the values of psychometric and judgmental prediction, ie whether the selection board judgment of the candidates (a composite assessment of available data) was a better predictor than the raw data (scores on all variables).

Correlations

21. Complete product moment correlation matrices has been derived for all variables in each sample. At this stage of the report, however, interest centres on predictive correlations. The relationships within groups of variables, as distinct from those between predictors and criteria, are studied in Chapters 15 to 17.

22. A summary of all significant predictive correlations is given in Appendix 8. Table APP 8.1 shows, for each sample, the values of all significant correlations with each of the criteria. Critical values of the correlation coefficient for each sample are given in Table APP 8.3. These are derived on the hypothesis that the population coefficients are zero and in each case four values are given, corresponding to 1% and 5% probabilities on one-tailed and two-tailed tests. In psychometric studies it is customary to use one-tailed tests, since it is assumed that the direction of a correlation is known. There are some correlations in this study for which such an assumption may not be considered valid, however, eg the relationship of success with F.OCC and HMC.SC.

23. Correlations have qualified for inclusion in Table 1 if they exceed the values appropriate to the 5% one-tailed test, ie the observed value would occur by pure chance no more than once in twenty trials. Values which are"highly significant", ie they would occur by chance no more often than once in 100 trials, are distinguished by shading. Since the emphasis is on predictive correlation only those variables which precede each criterion chronologically have beenconsidered.

24. It is usual to find that, by absolute standards, correlation coefficients in psychometric work are low and particularly so where there is a high degree of selection. This study is no exception. No attempt has been made to correct for the effects of selection though this would raise the values of coefficients considerably. Many of the values are, however, highly significant in the statistical sense and of considerable interest from a practical point of view. Some of the implications of each group of correlations are considered below.

B.MARK

25. The value of B.MARK awarded to each candidate represents the consensus of judgment among the members of the AIB of the candidate's potential. It is based on their observations of all the data and of the candidate's behaviour in various situations.

26. It is therefore a matter of interest to investigate to what extent the boards were, in fact, influenced by the various items of information available to them.

27. The SP tests appear to have had little influence on the marking of successful candidates. The correlation with verbal : educational facility reached statistical significance in the total group of X, E, S and F samples because of the large number in the group but the value has no practical significance. This phenomenon is again apparent in the influence of ability as shown by the CSC examinations. It is, however, interesting that there are negative correlations between CSC examinations and B.MARK in the X and E samples, ie that high ability in the written examinations of successful candidates was associated with low board marks.

28. In the biographical data there is evidence that membership of corps was a significant factor and that candidates from HMC schools tended to score better marks. Father's occupation is consistently significant and the correlation is negative indicating that the higher the F.OCC score, (ie the lower down the socio-economic scale), the lower the board mark.

29. As might be expected, the correlations of B.MARK with the individual board members' marks are all high. There is a tendency for the Psychologist and the Testing Officer to have the lowest correlation with B.MARK, suggesting that they were considering a rather wider range of data. A particularly interesting correlation in the board marks data

is the highly significant negative value of B.SD for sample X. This implies a strong tendency for board marks to be lower for those candidates over whom opinions varied most widely.

T.DART

30. Dartmouth training results were available only for E officers and in this group there was no significant correlation between Dartmouth aggregate mark and any of the board marks, either aggregate or individual. The physics and mathematics papers of the CSC examination were, however, good predictors of Dartmouth performance and these contributed to a highly significant correlation with B.AGG (B.AGG = B.MARK + T.EXAM).

31. SP Tests of the verbal-educational group, as well as the clerical aptitude and electrical information tests were useful predictors.

32. The only significant correlation in the biographical data is with T.HSC, the length of time between passing school certificate and joining the RN.

33. Correlations with N, X, E, L, M, S reflect the linear dependancy of T.DART on individual subject marks.

D.TOT

34. Passing out results in HMS DEVONSHIRE are significantly correlated with many of the AIB variables. All the SP tests were good predictors, either for X or for E officers. It is interesting that spatial:mechanical tests, which are particularly well correlated for X officers, are not significant for E officers. This reflects the effect of selection; the range of mechanical aptitude is much less in those selected to be Engineer officers than in those selected to be Seaman officers.

35. The prediction of performance by the interview board was better for E than for X officers but again the CSC examinations were a good guide and consequently there is a highly significant correlation with B.AGG.

36. For the E officers there are high correlations between HMS DEVONSHIRE results and Dartmouth marks.

BC.TOT and SC.TOT

37. Here again the CSC examinations and SP tests showed much higher correlations than the board marks and again B.AGG depended for its

usefulness on the written examinations.

38. Biographical data provided no useful pointers but Dartmouth and HMS DEVONSHIRE results were generally well correlated with success in these later stages of training, particularly those subjects with some mathematical or engineering content. OLQ marks were not such a good guide to success at this juncture.

T.LCDR

39. As explained in Chapter 10, this variable is a general criterion of overall success in training since it is a measure of the seniority awarded at the end of training. The scale of the variable is an inverse one, the more successful the individual, the smaller the value of T.LCDR. It is therefore to be expected that most of the correlations will be negative.

40. SP tests and CSC examinations again provide a number of highly significant correlations, the latter again contributing to good values for B.AGG.

41. Board marks provide little useful information about overall prospects in training, though in the combined X, E, S group the large numbers make very low correlations statistically significant both in the board marks and in the biographical data.

42. As might be expected, there are high correlations between T.LCDR and most of the training results.

S.INDA AND S.INDB

43. These two variables are measures of long-term success. In both cases the most successful individuals have the largest scores. S.INDA, which might be regarded as a "purer" measure, has a less satisfactory distribution than S.INDB, and it is therefore of interest to compare the two sets of correlations. Mutual correlations, shown at the bottom of Table APP 8.1, indicate a large proportion of common variance.

44. In neither case do B.MARK or B.AGG achieve the "highly significant" level, except in the X, E, S sample, and then only because the large number in the sample makes a very small coefficient statistically significant.

45. Some of the SP tests correlate significantly, in some cases negatively. Interesting examples are SP96 (verbal comprehension) for 'S' officers, and SP117M (mechanical information) for 'E' officers, the latter showing that aptitudes which are relevant to early success do not necessarily remain so in the long-term.

46. Correlations of the two criteria with biographical data are fairly consistent, significant levels being achieved with CORPS, GAMES and F.OCC in both cases. 'X' officers from higher socio-economic backgrounds tended to do better, as did 'S' officers from non-HMC schools.

47. Many of the training results and particularly the HMS DEVONSHIRE scores correlate quite well with the long-term criteria and it is noteworthy that the HMS DEVONSHIRE OLQ mark values are much higher at this stage than with the earlier criterion, T.LCDR.

48. Both S.INDA and S.INDB correlate well with T.LCDR in the X sample, indicating that X officers who did well overall in training tended to do well in the long-term in spite of the shortening of early experience. The effect is less marked with L and E officers, though the direction remains the same.

S.INDB and INTERESTS

49. Of the total of thirty "interest" variables only four correlated significantly with S.INDB in any of the samples; these are shown in Table APP 8.2.

50. In three cases the coefficients are negative indicating that the presence of these interests tended to be associated with low success scores. The most interesting of the four is the negative coefficient for X officers with an early interest in "organising". This is the only "highly significant" value amongst the "interest" variables.

S.INDB and S206 data

51. The relationships between S.INDB and S206 report data are considered in Chapter 17.

Conclusions Drawn

52. The findings of the association analysis are confirmed and it is clear from the correlation analysis that:-

a. the CSC examinations were better predictors of training success

than was B.MARK and that this helped to ensure the short-term efficiency of the selection procedure.

b. the selection boards appear to have been little influenced by the candidates' performances in the SP tests, though these were valuable predictors of early success.

c. the most effective predictors of long-term success are the HMS DEVONSHIRE results (and Dartmouth results where available).

d. certain types of biographical data are potentially useful for prediction purposes.

e. the form of "interests" data available on Form Q78 is of little direct value for prediction purposes.

53. These analyses show that the purely judgmental variable, B.MARK, was a relatively poor predictor and that composite psychometric predictor functions are likely to be substantially more efficient. Such functions have been derived and an account of some of the results is given in Chapters 18 and 19.

54. It is also clear, however, that impressions gained from a simple bivariate study of predictive relationships may be deceptive, since important inter-correlations may not be appreciated. In consequence of this false conclusions may be drawn, particularly in such complex data situations as in this study. It was therefore considered important to investigate the structure of the data and to construct ability/success models to enable the predictive relationships to be more fully appreciated.

X and E EARLY TRAINING v SELECTION

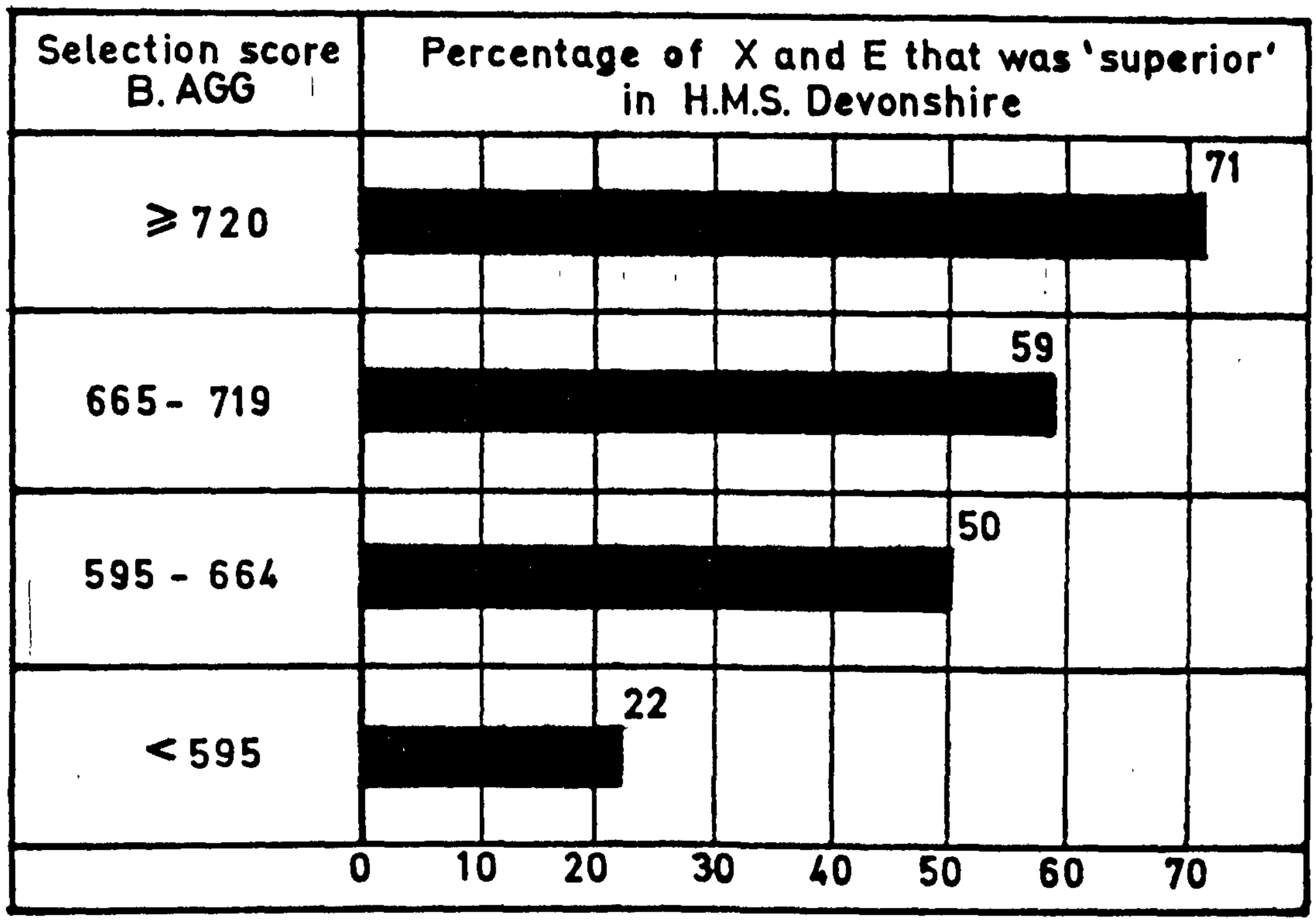


FIG 14.1 HMS DEVONSHIRE TRAINING PERFORMANCE v SELECTION SCORE. ALL X AND E OFFICERS

X,E and S PROMOTION v SELECTION

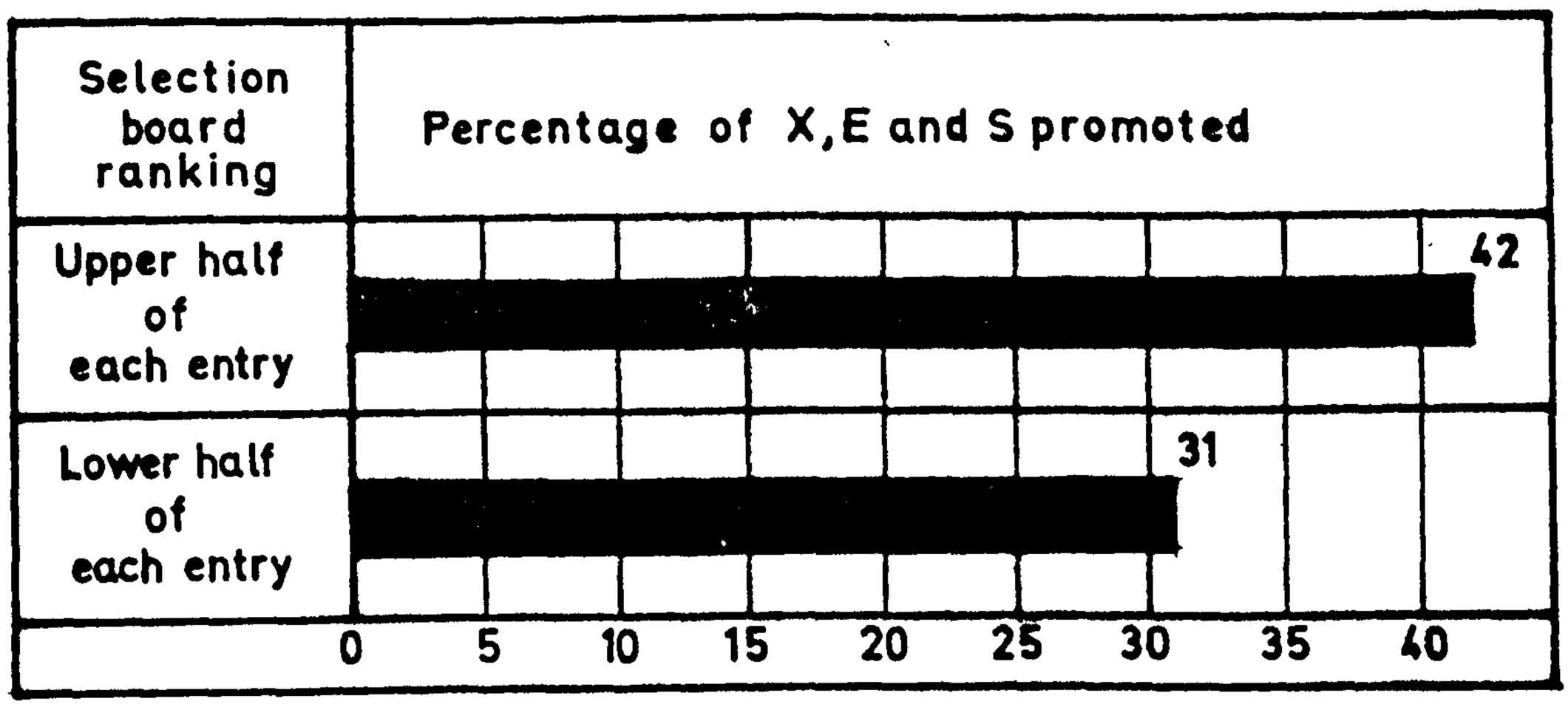


FIG 14.2 PROMOTION v SELECTION BOARD RANKING ALL X, E AND S OFFICERS

X and E PROMOTION v EARLY TRAINING

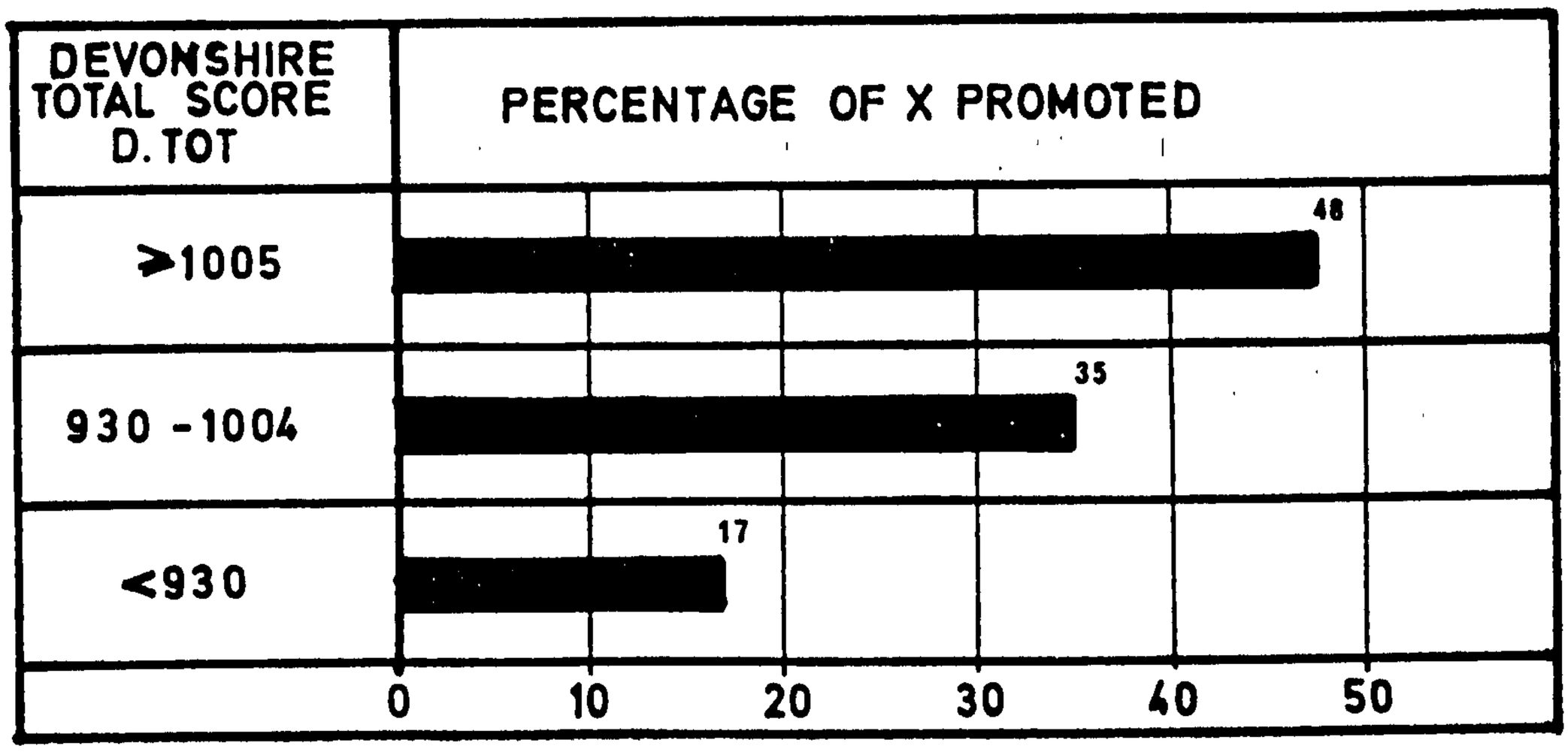


FIG 14.3 PROMOTION v HMS DEVONSHIRE TRAINING PERFORMANCE. ALL X OFFICERS

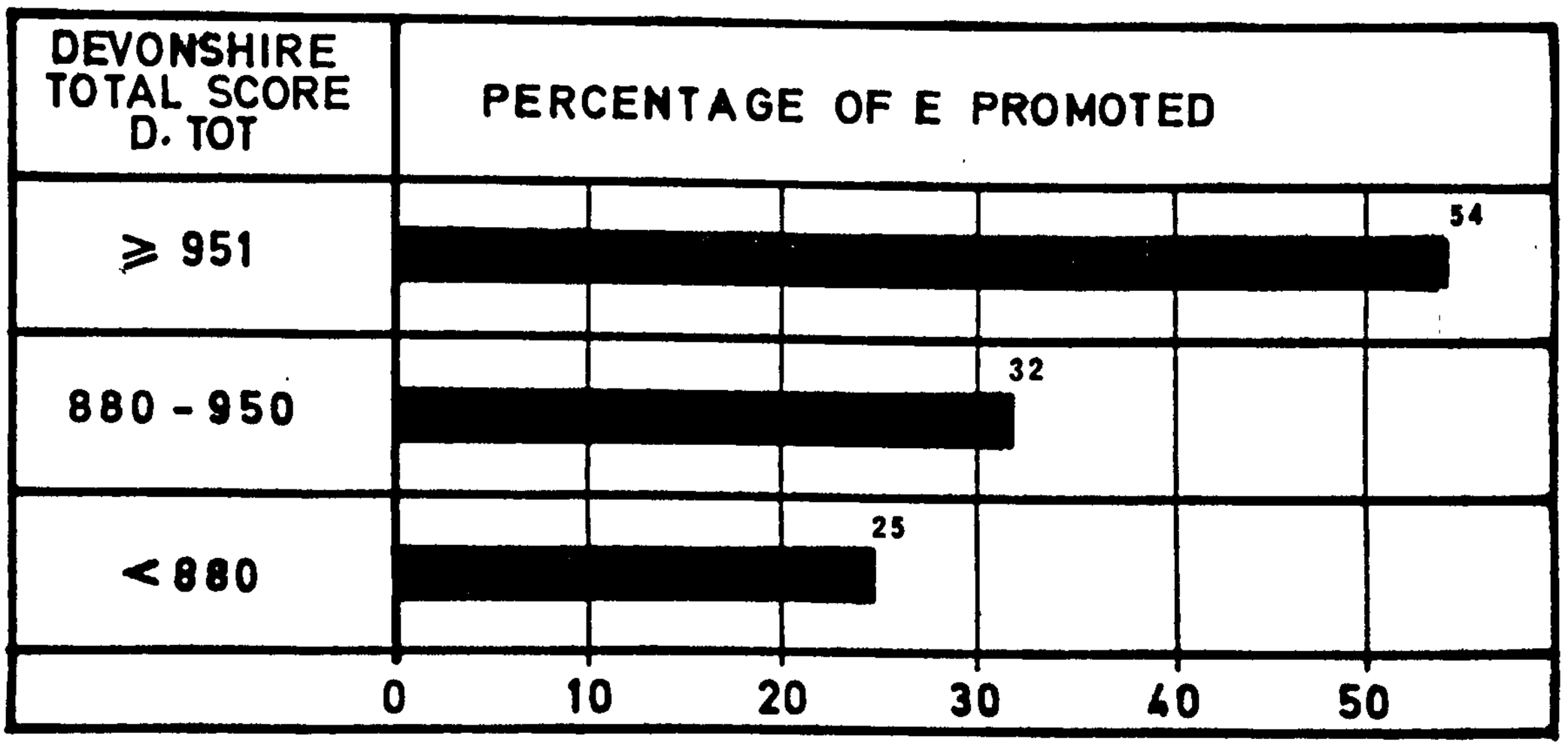


FIG 14.4 PROMOTION v HMS DEVONSHIRE TRAINING PERFORMANCE. ALL E OFFICERS

E LATER TRAINING v SELECTION

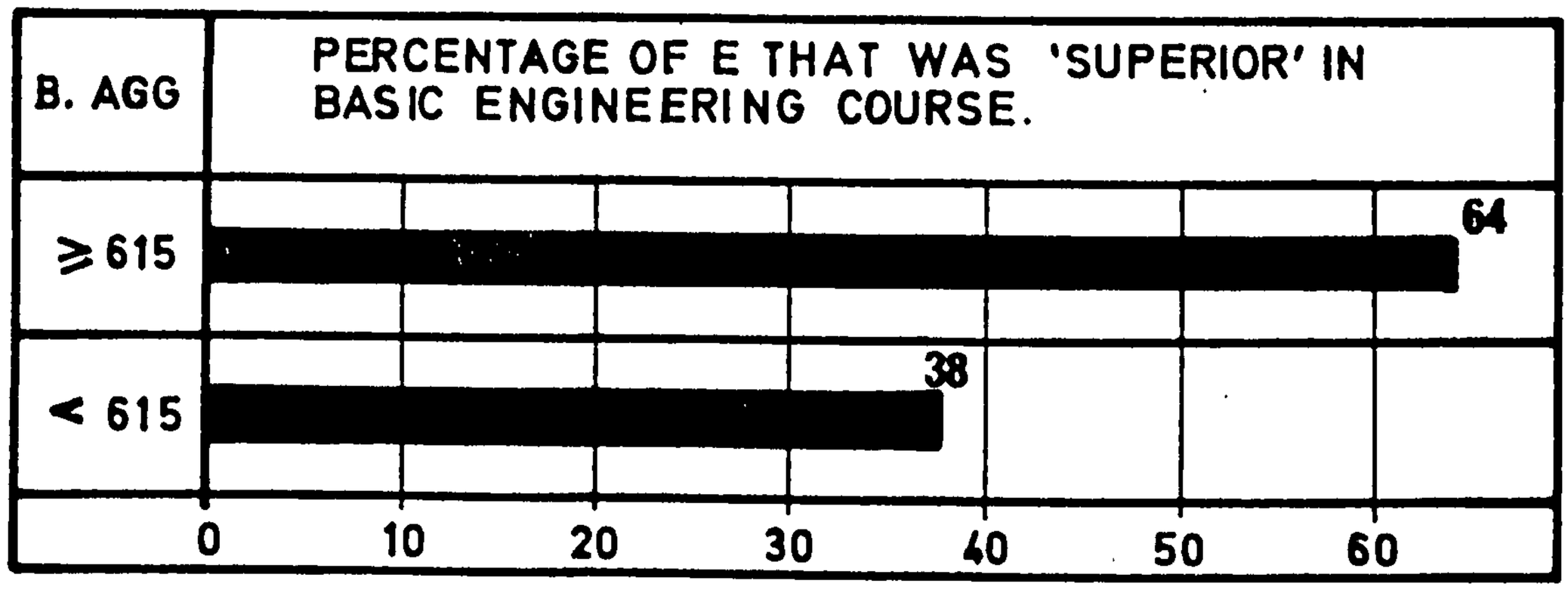


FIG 14.5 BASIC ENGINEERING COURSE PERFORMANCE v SELECTION SCORE. ALL E OFFICERS

E PROMOTION v LATER TRAINING

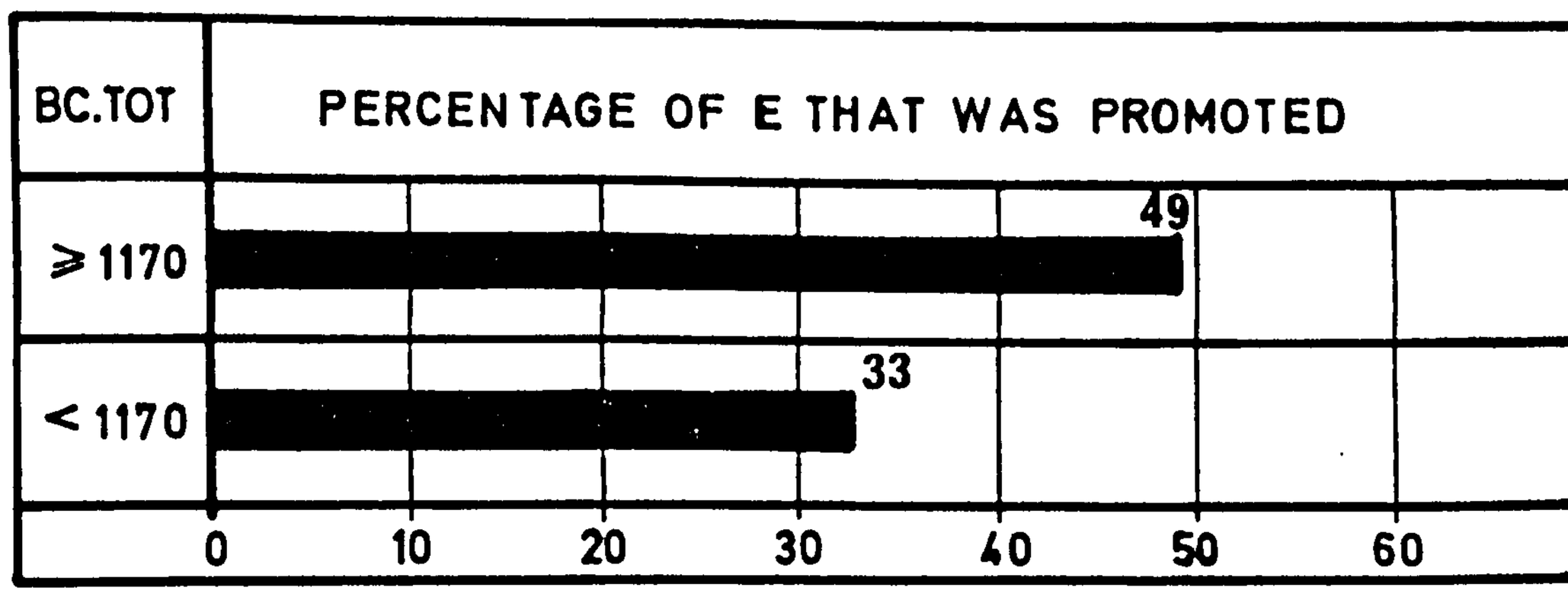


FIG 14.6 PROMOTION v BASIC ENGINEERING COURSE PERFORMANCE. ALL E OFFICERS

CHAPTER 15

INVESTIGATIONS OF PRE-ENTRY, TRAINING AND CRITERIA DATA STRUCTURE

1. To enable ability models to be constructed to provide a clearer understanding of the structural relationships among the large number of available variables a series of principal component and factor analyses of the various samples has been completed. Principal Component Analysis derives a set of axes such that the first represents that linear combination of normalised original variables with maximum variance; the second is that combination, uncorrelated with the first, with as large a variance as possible; and so on. There is therefore a tendency for the vectors of original variables to cluster around the axes. This makes a geometrical representation, using component axes, easier to visualise than is the case with Factor Analysis, in which rotation of axes is usually necessary before a basic structure can be discerned. For this reason the results of the Principal Component Analyses are described and illustrated. The Factor Analysis solutions, which are structurally very similar, would be more appropriate if the models were to be used for predictive purposes.

2. For the first analysis all available data on the complete X, E, S, F sample was used. This provided a conceptual framework of the relationships of SP tests, board marks and CSC examinations in a large and relatively heterogeneous sample of selected and rejected candidates.

3. This was followed by an analysis of the relationships of all pre-entry variables in the total sample of selected candidates, the X, E, S group. The results show the location of biographical vectors in the framework of ability axes.

4. Finally, analyses of all available data on the separate X, E and S samples provide an insight into the differing locations of training and criteria vectors in the framework in each individual sample. They also demonstrate the distortion of structure which may occur as a result of a high degree of selection.

The Structure of AIB Data

5. In order to obtain as large a sample as possible and to minimise the effects of sample selection the analysis of AIB variables was conducted on the X, E, S, F data. This provided a total of 520 observations on the 22 variables of the three data groups, CSC examinations, SP tests and board marks. The inclusion of rejected candidates provided considerably

greater ranges in most variables.

6. The results of the analysis are shown diagramatically in Figure 15.1 and are listed in Table APP 9.1. The diagram shows the orientation of the vectors of all variables in the three-dimensional hyperplane formed by the first three principal components . (The C_2C_3 plane is shown in the form of a third-angle projection from the C_1C_2 plane).

7. Complete representation of the results demands a 22-dimensional structure, but as the first three components account for 63% of the total variance, and subsequent components for one tenth of this, or less, the three-dimensional structure gives a reasonably good account of the relationships.

8. Examination of the arrangement of vectors in the C_1C_2 plane shows an almost pure structure, in which all board marks are clustered together and almost all written tests and examinations are clustered around a general direction almost orthogonal to the board marks.

9. The C_2C_3 projection shows that the SP tests separate into two distinct clusters in the vertical direction, one comprising the verbal : educational tests, the other the spatial : mechanical. CSC examinations are distributed according to their relationships to those two clusters.

10. It would clearly be possible to define three meaningful orthogonal axes which might be labelled "Verbal-Educational Ability" (V:ED); "Spatial-Mechanical Ability", (K:M), and "Behavioural Characteristics" or "Personality", (P). The SP tests and board marks would then be clustered closely around these three axes. The vectors of the CSC examinations would fall into the "cognitive plane" containing V:ED and K:M, Mathematics and Physics with approximately equal V:ED and K:M loadings, English and General roughly orthogonal to Mathematics and Physics with high V:ED and low K:M loadings. The three dimensional configuration is illustrated in Figure 15.1a.

11. It is interesting to compare these findings with the model of educational ability proposed by Vernon (1950) and reproduced in Figure 15.2. The "cognitive plane" may be identified with Vernon's "general intelligence" plane in which "g" is visualised as a bond between V:ED and K:M. Similarly B.MARK may be identified with Vernon's "X" factor, ie personality, which is unrelated to g.

12. The near-orthogonality of V:ED, K:M and B.MARK shows that the board was little influenced by the results of SP tests and that B.MARK may be

regarded as a relatively pure measure of P (or Vernon's X), though the vertical fanning of the board marks shows that the Psychologist, the Engineer officer and the testing officer were all influenced to a limited extent by K:M. The slight horizontal dispersion also shows that the Psychologist was rather more influenced than others by V:ED.

13. The results of this investigation again underlined the possibility that psychometric prediction might be more effective than purely judgmental. In order to assess the relative merits it is, however, necessary to locate the criteria and biographical vectors in the framework.

14. Unfortunately some of the biographical and all of the criteria data is unavailable for those candidates who were rejected and it is therefore necessary to analyse the relationships of pre-entry and criteria variables in a truncated sample. The largest for which the necessary data is available is the combined X, E, S group, a study of which is discussed below.

Locating Biographical Variables in the Structure

15. The results of a principal component analysis of all pre-entry and criteria data for 262 officers of the X, E, S group are shown in Figure 15.3 and Table APP 9.2.

16. Comparison of Figure 15.3 with Figure 15.1 shows clear evidence of distortion of the basic structure due to sample truncation; nevertheless the related clusters are still clearly identifiable and the general relationship of the V:ED, K:M and B.MARK vectors is similar, B.MARK remaining almost orthogonal to the plane containing V:ED, K:M and T.EXAM, and their associated variables.

17. The vectors of some of the biographical variables have been included to show their relationship to the general framework. T.HSC, a measure of the length of time between attaining the necessary school certificate passes and joining the RN, is almost collinear with T.EXAM, indicating that those who spent longest in sixth form study achieved the best all-round CSC examination results. PAR.DD is similarly located, suggesting that those who had been deprived of one or both parents also tended to do well in the examinations. Neither T.HSC nor PAR.DD is significantly related to B.MARK, ie these two factors had little effect on the personality score.

18. A.AIB, the candidates age at the time of attending the Admiralty Interview Board, and GENL, his score in the CSC "General" paper, are almost identical vectors. The direction of the A.AIB vector has been reversed for plotting; thus high GENL score corresponds to low A.AIB, ie successful young candidates did best on this paper. The GENL vector lies in the cognitive plane in a direction of negative K:M, ie candidates with high scores on the "General " paper tended to have low spatial : Mechanical ability.

19. The vector representing socio-economic origin, F.OCC, has been reversed, so that high value indicates high status, and is closely aligned with B.MARK, ie candidates from high-status backgrounds tended to achieve high "personality" marks, but this was uncorrelated with cognitive ability. The vectors HMC.SC and CORPS also lie in the same general direction, indicating similar relationships for candidates from HMC schools and those who held leadership positions in school corps.

20. Perhaps surprisingly the vectors of GAMES and SOCS are relatively close to the cognitive plane, indicating that cognitive abilities were more relevant to positions of responsibility in school societies and games, though there are small loadings in the B.MARK direction.

21. The locations of three criteria vectors have also been shown, though these must be treated with caution since they represent the pooling of measures which may differ from one branch to another. The first, T.LCDR, is a composite measure of training success whose direction has been reversed to accord with the general principle that increasing magnitude indicates increasing success. The other two, S.INDA and S.INDB are long-term criteria. All three lie close to the cognitive plane in this merged sample, but their precise relationships are investigated more fully in the separate samples.

<u>The structure of pre-entry training and criteria variables in each sample</u>

22. Vernon (1950) has shown how occupational aptitude may be related to educational abilities. His model, reproduced in Figure 15.4, suggests that the qualities associated with success might differ from one branch to another and also that long-term success might be more closely related to some aspects of training than to others.

23. The importance of these two points has been examined in a series of three principal component analyses, one on each of the samples X, E and S. For these analyses all available variables were included and some

caution is necessary in interpreting the graphical illustrations since three dimensional hyperplanes account for only about one third of total variance, though factor analysis using three factors gives similar results.

Sample E

24. The results of the analyses of the E sample are shown in Figures 15.5 to 15.8 and Table APP 9.3. To avoid confusion only the key vectors are shown in Figure 15.5 and the individual Dartmouth, HMS DEVONSHIRE and RNEC training variables have been shown separately in Figures 15.6 to 15.8.

25. Some further distortion of cognitive vectors in this highly selected sample is apparent from Figure 15.5, but the essential structure is still clearly discernible. The personality vector, B.MARK, which in this case is nearly coincident with the C_2 axis, is almost orthogonal to the cognitive plane containing V:ED and K:M, which in this case is the C_1C_3 plane.

26. It is at once apparent that, in this sample of engineer officers, the various training variable vectors form a discoid cluster close to the cognitive plane. This suggests that B.MARK has little relevance in forecasting training performance in this technical branch, though it is a relatively good predictor of OLQ, the officer-like-qualities assessment in early training. The contribution of OLQ to D.TOT, the HMS DEVONSHIRE training aggregate score, also ensures that B.MARK has rather more predictive value for D.TOT than for the later training aggregates BC.TOT and SC.TOT.

27. As in the merged sample the biographical variable, F.OCC, lies close to B.MARK, and this measure of socio-economic background also gives a useful pointer to OLQ mark, and hence in turn to D.TOT.

28. The direction of T.LCDR has again been reversed for conformity. This vector, which is a measure of overall training success, lies close to the cognitive plane and, although the contribution of HMS DEVONSHIRE training ensures a small correlation with B.MARK, the CSC examinations and the verbal-educational tests are much better predictors.

29. It is particularly interesting that the long-term success vectors, S.INDA and S.INDB also lie in the cognitive discoid, almost unrelated to B.MARK, but close to the early, rather than the later, training vectors. Thus Dartmouth and HMS DEVONSHIRE training results are relatively good predictors of long-term success, though almost any of the measures of cognitive ability would be usable, those of K:M negatively.

Sample X

30. The structure of data for Seaman officers, shown in Figures 15.9 and 15.10 and Table APP 9.4, exhibits striking similarities to that of the E sample.

31. Again the V:ED and K:M vectors lie in a plane almost orthogonal to B.MARK. Most of the training variables lie close to this plane, and again B.MARK is a relatively good predictor of OLQ, with F.OCC lying between them.

32. There is, however, a marked difference between the structures in the orientation of long-term success vectors. In the X sample these indicate a pronounced "personality" component and it is the OLQ component of D.TOT which helps to ensure that the latter is still a good predictor of S.INDB. Overall training success, which also contains strong directional cognitive contributions from specialist course results, is a particularly good indicator of long-term potential.

Sample S

33. Data structure for the sample of Supply officers, shown in Figure 15.11 and Table APP 9.5, is rather more similar to that of the E than the X sample.

34. Again the basic structure, with B.MARK orthogonal to a plane containing V:ED, and K:M is apparent, and in this case T.EXAM, the CSC examination aggregate, lies very close to this plane. Individual training course results are not available but T.LCDR, the overall training criterion, is close to T.EXAM.

35. Long-term success, as measured by S.INDB, is almost wholly cognitive dependant, again with negative K:M. There is rather more divergence between S.INDA and S.INDB in this sample, probably because of the small sample size.

Conclusions Drawn

36. Three near-orthogonal axes were identified in the relatively unselected sample X, E, S, F. These axes might be labelled V:ED, K:M and P. (Verbal:educational ability, spatial:mechanical ability, and behavioural characteristics, or personality, as represented by board marks).

37. In the selected samples (X, E, S; X; E; S) the structure was distorted but in each case the P axis remained almost orthogonal to the cognitive plane containing V:ED and K:M.

38. Training success vectors tend to lie close to the cognitive plane but long-term success vectors vary. In the E sample S.INDA and S.INDB are close to the cognitive plane and particularly to D.TOT. In the X sample they fall between the cognitive plane and B.MARK and are relatively close to the composite training success vector T.LCDR (which is closely aligned with specialist course results). In the S sample there is a greater distinction between S.INDA and S.INDB but the latter is again essentially cognitive.

39. These ability/success models provide a greater insight into the data relationships. They show clearly the potential of psychometric prediction but they also illustrate the dangers of drawing false conclusions on the one hand from merged samples and on the other from highly selected samples. It would be possible to use the results of the principal component analyses for derivation of predictor functions but is was decided to preserve the identity of the original variables since these are more readily interpreted and since there were no computational difficulties.

40. There are, however, two blocks of data which have not so far been considered. The first consists of observations on the thirty "Interests" variables and the second is some fifteen years' worth of S206 reports on each officer. These are considered in Chapters 16 and 17.

CONTAINS PULLOUTS

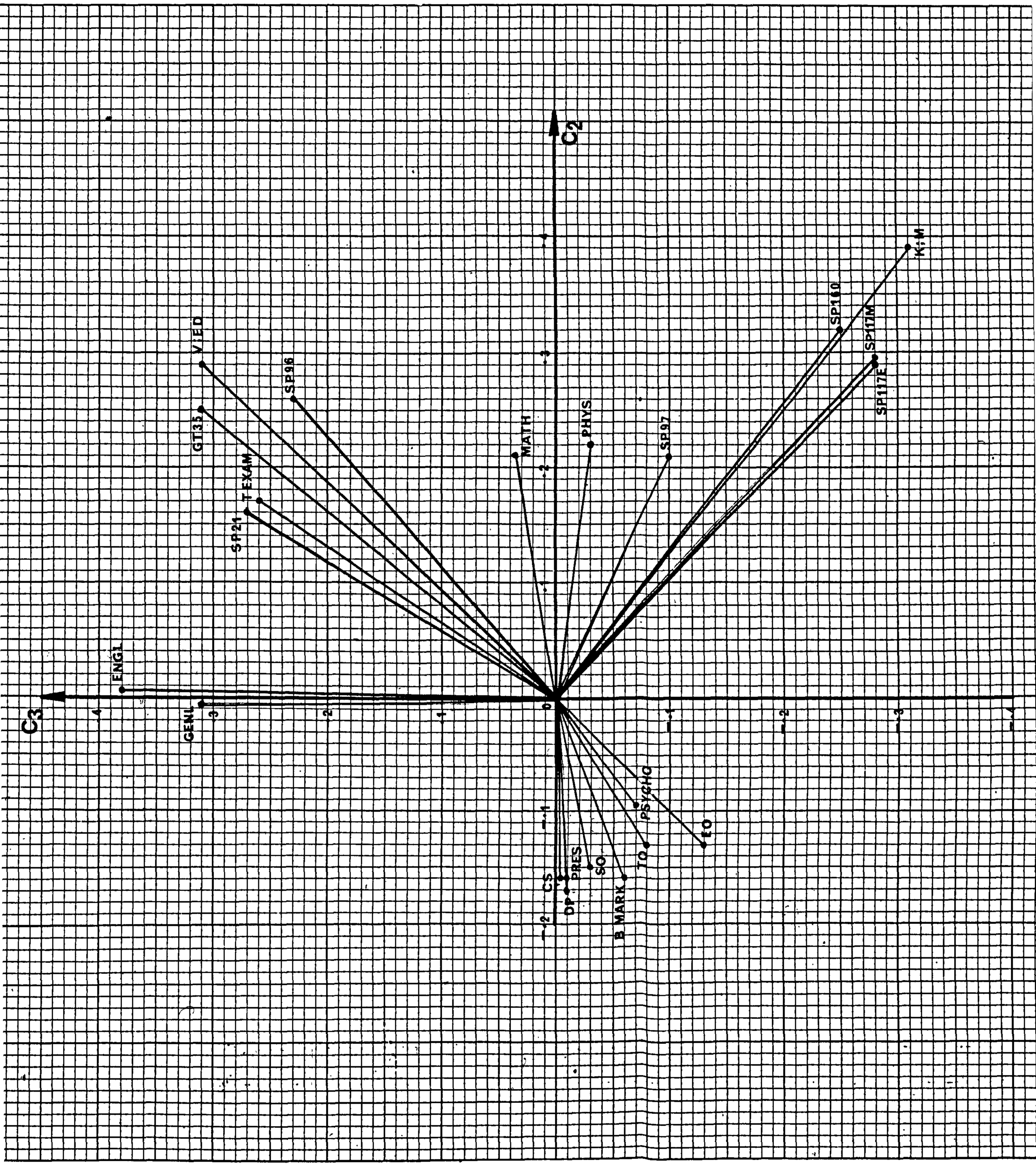
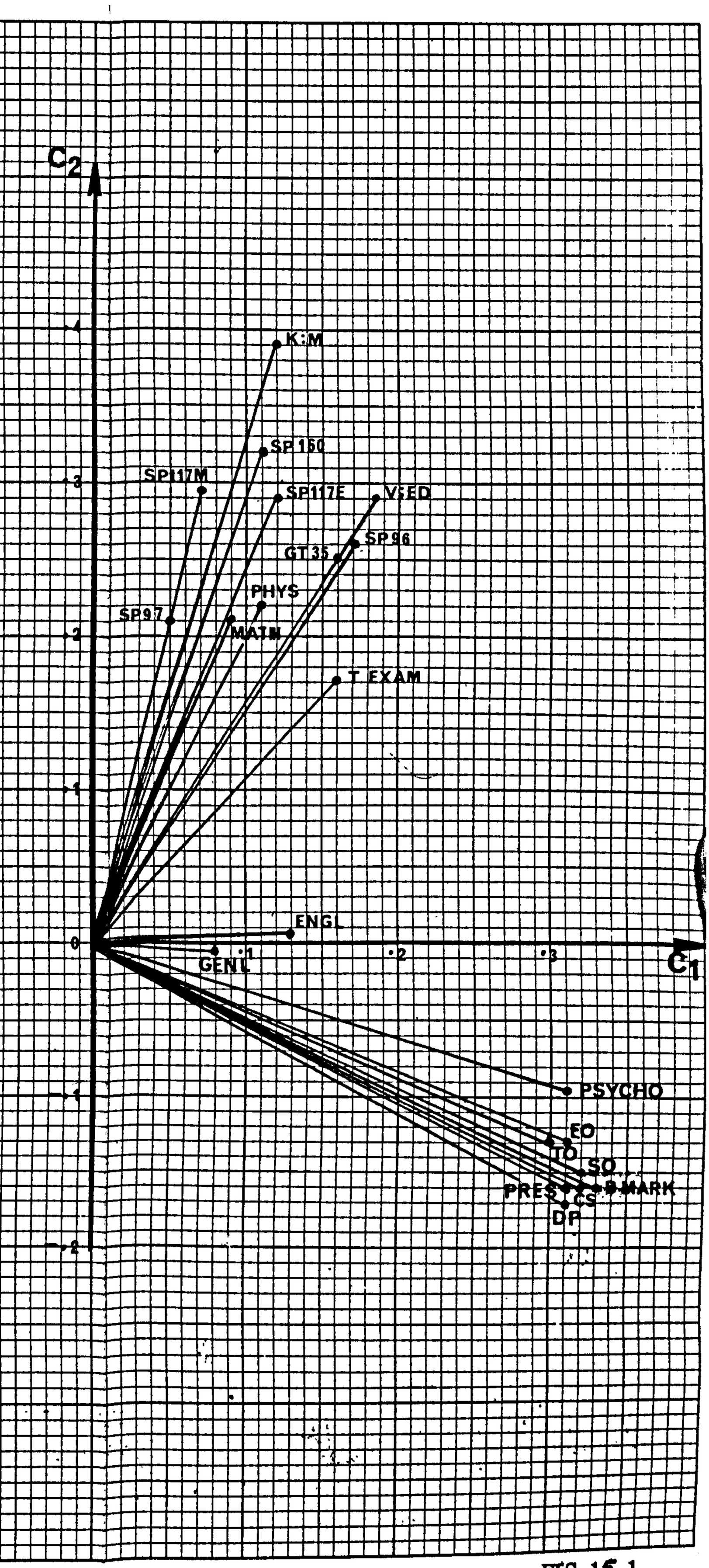


FIG 15.1 PROJECTIONS OF FIRST THREE PRINCIPAL COMPONENTS OF AIB DATA: X, E, S, F SAMPLE


C2
.4
.3
.2
.1
0
-.1
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K:M
SP 150
SP117M
SP117E
VSED
SP96
GT35
PHYS
SP97
MATH
T EXAM
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FIG 15.1

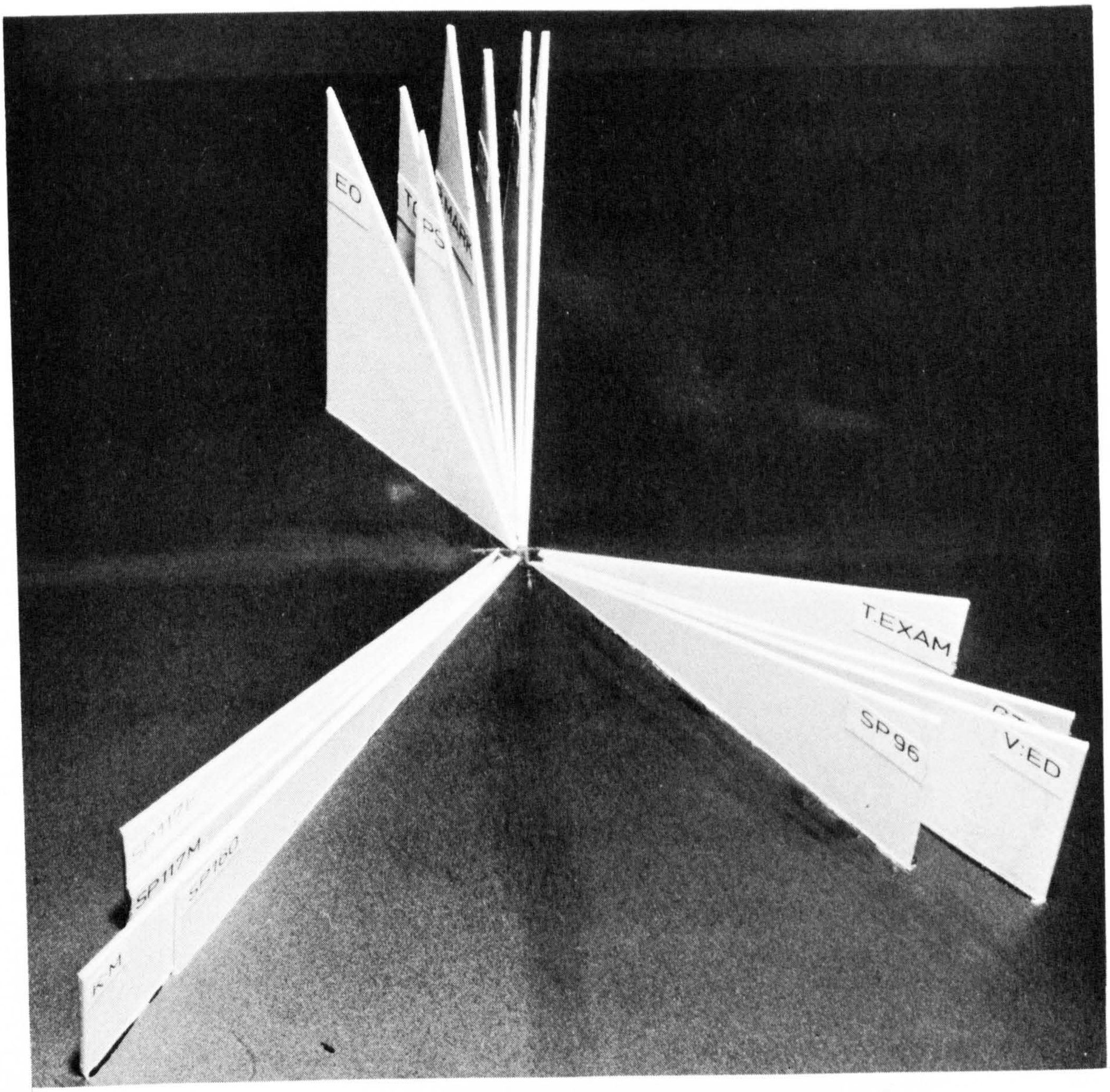


FIG 15.1a SAMPLE XESF P.C.A. MODEL

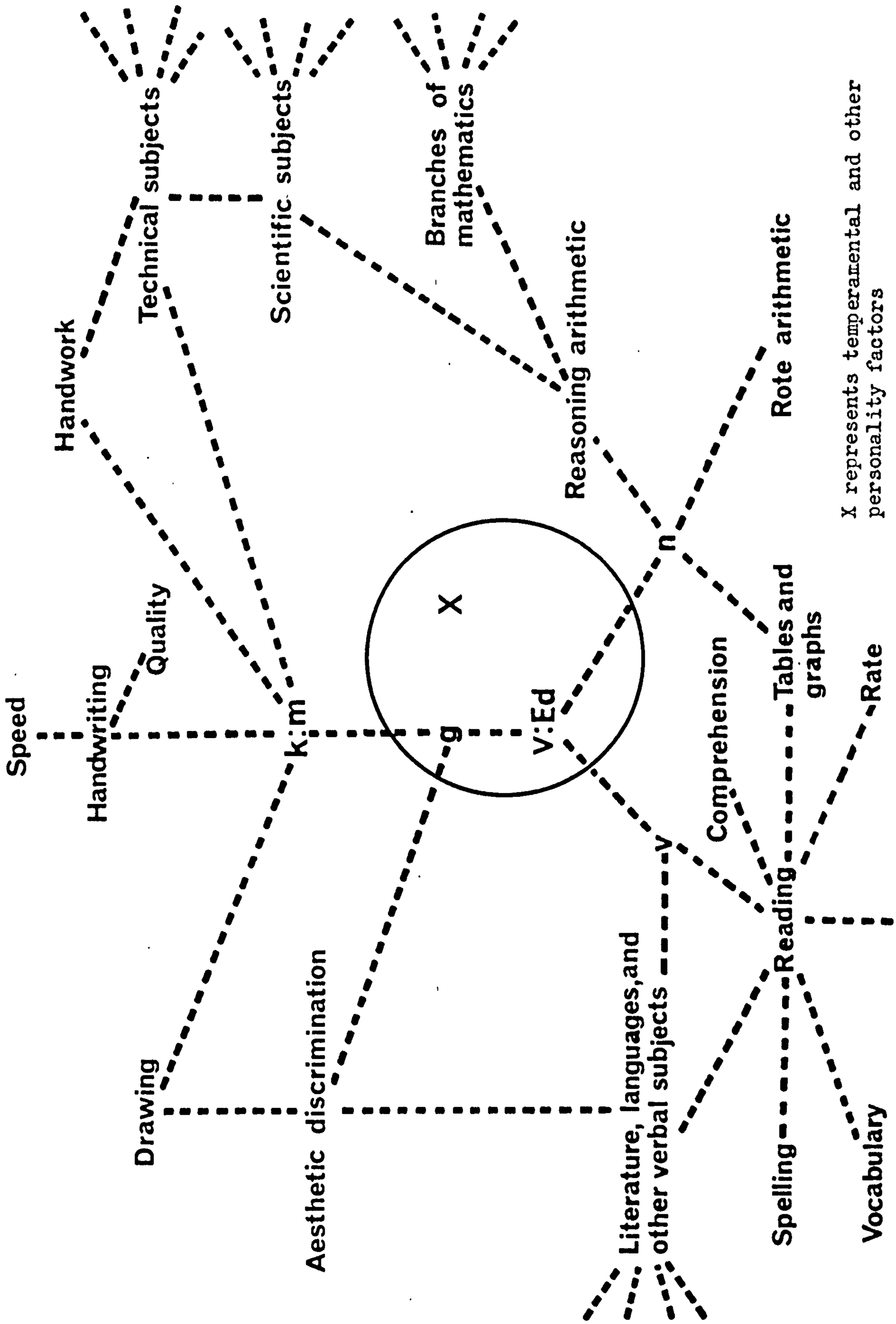
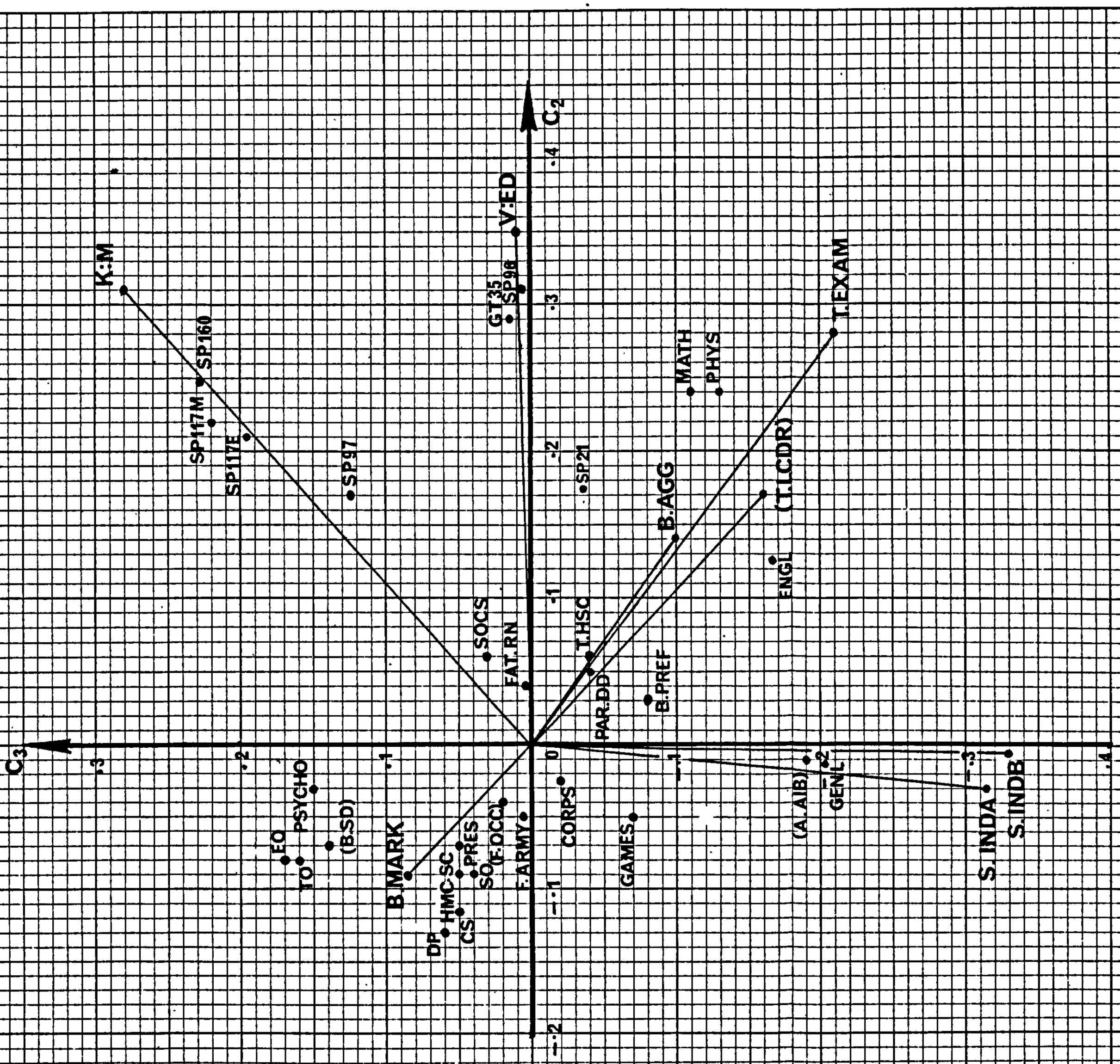
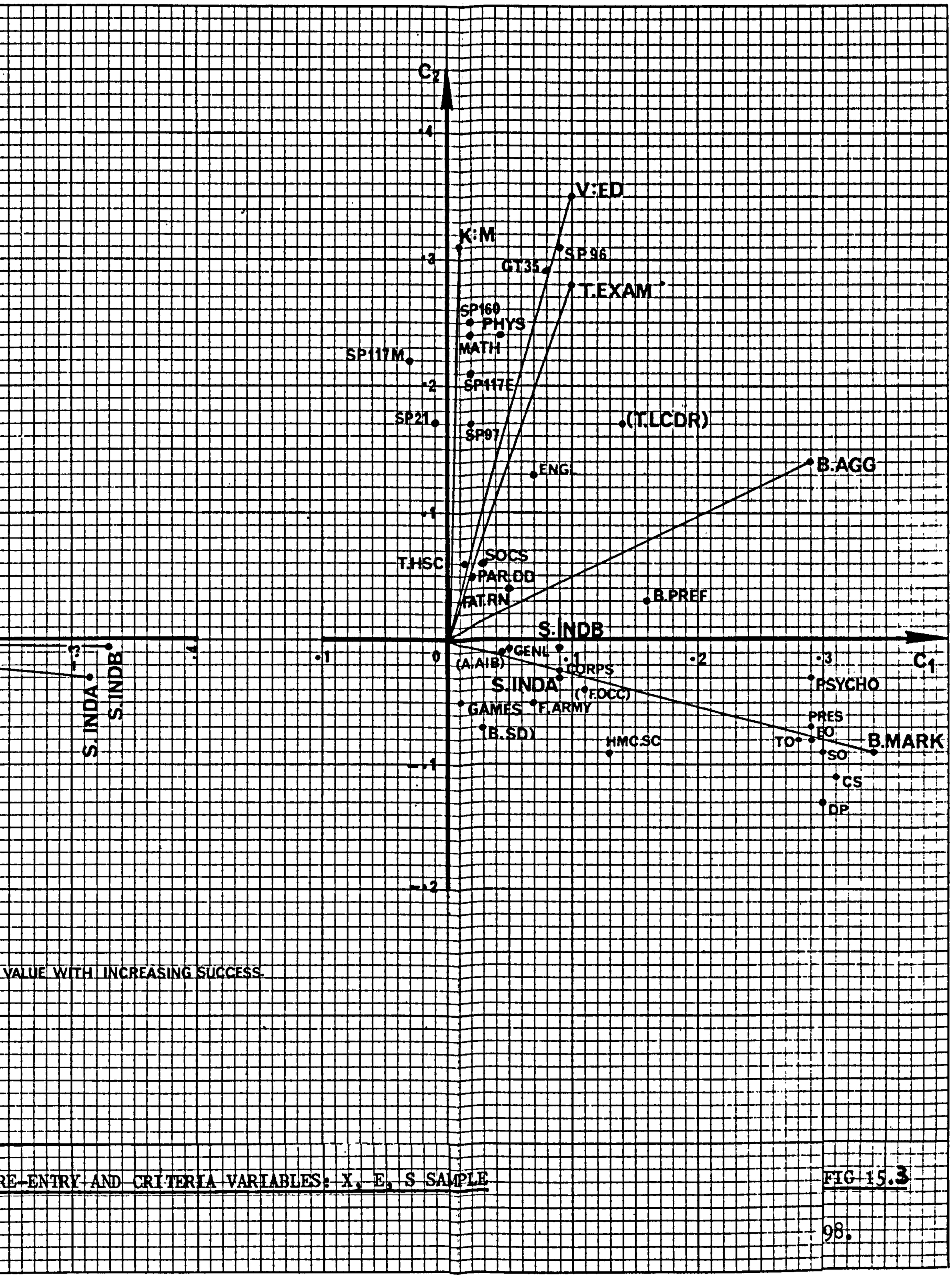


FIG 15.2 STRUCTURE OF EDUCATIONAL ABILITY (VERNON)



NOTE: VECTORS SHOWN ( ) ARE REVERSED TO RELATE INCREASING VALUE WITH INCREASING SUCCESS.

FIG 15.2 PROJECTIONS OF FIRST THREE PRINCIPAL COMPONENTS OF PRE-ENTRY AND CRITERIA VARI



RE-ENTRY AND CRITERIA VARIABLES: X, E, S SAMPLE

FIG 15.3

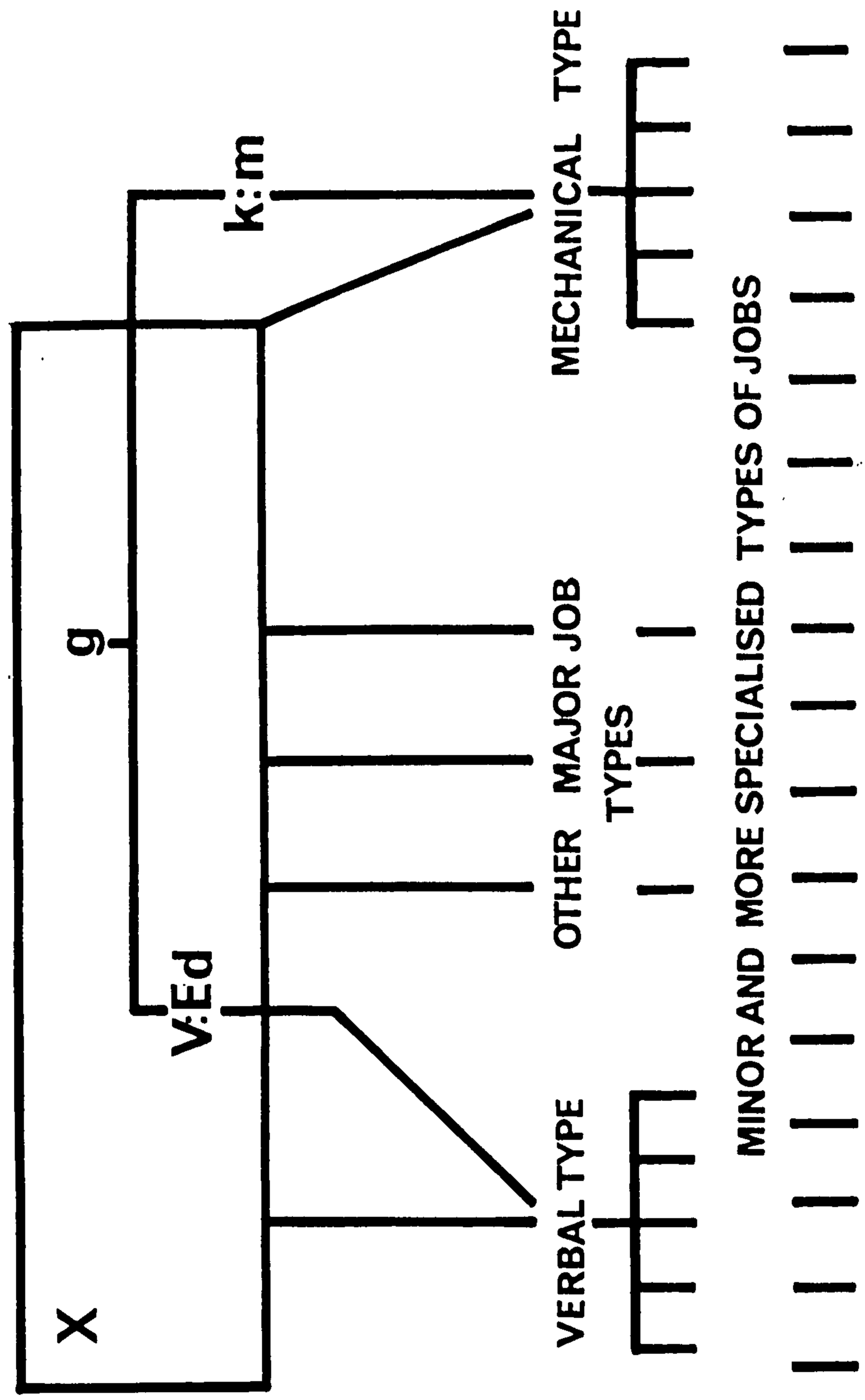


FIG 15.4 RELATIONSHIP OF OCCUPATIONAL APTITUDE TO EDUCABILITY (VERNON)

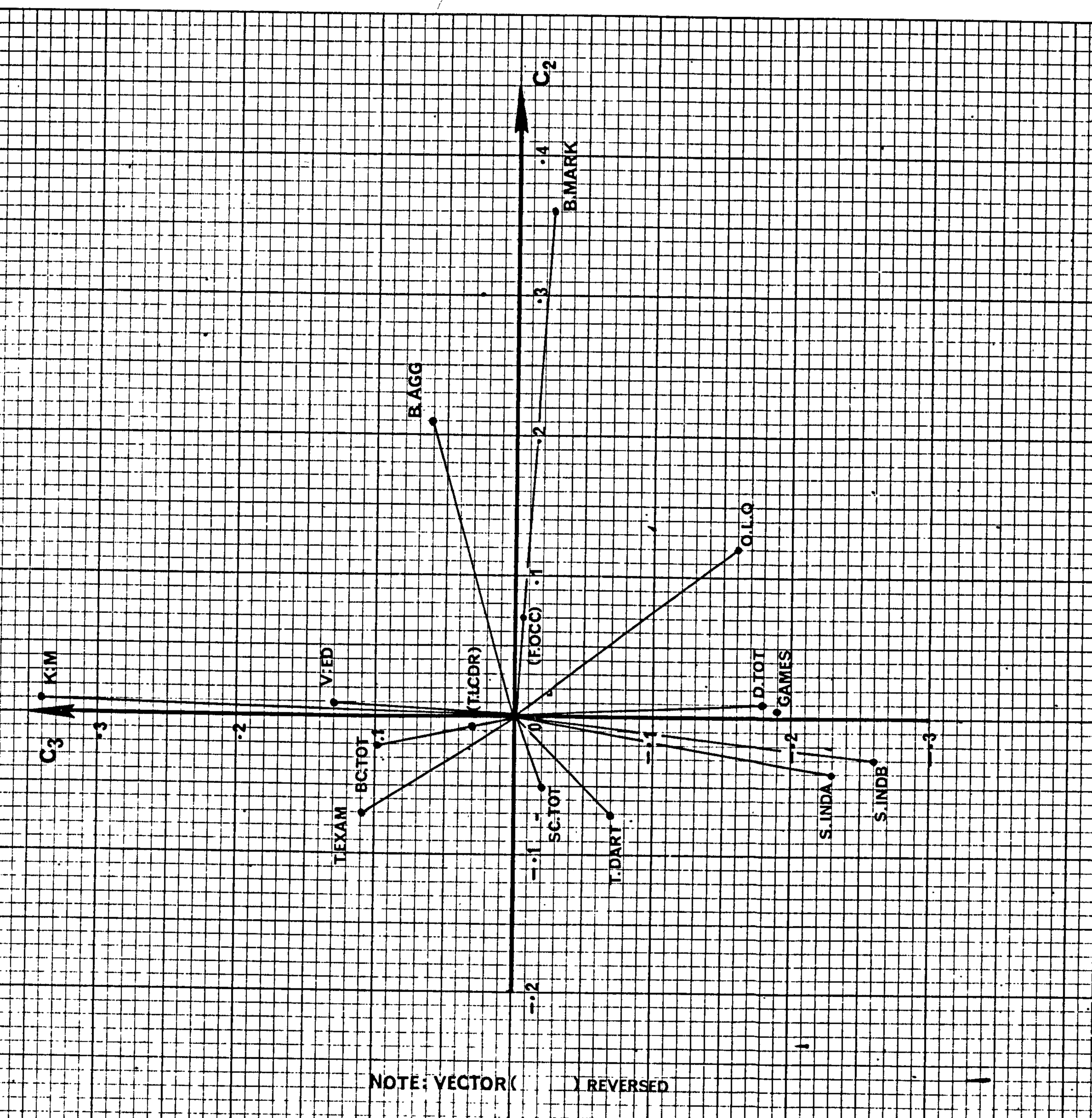
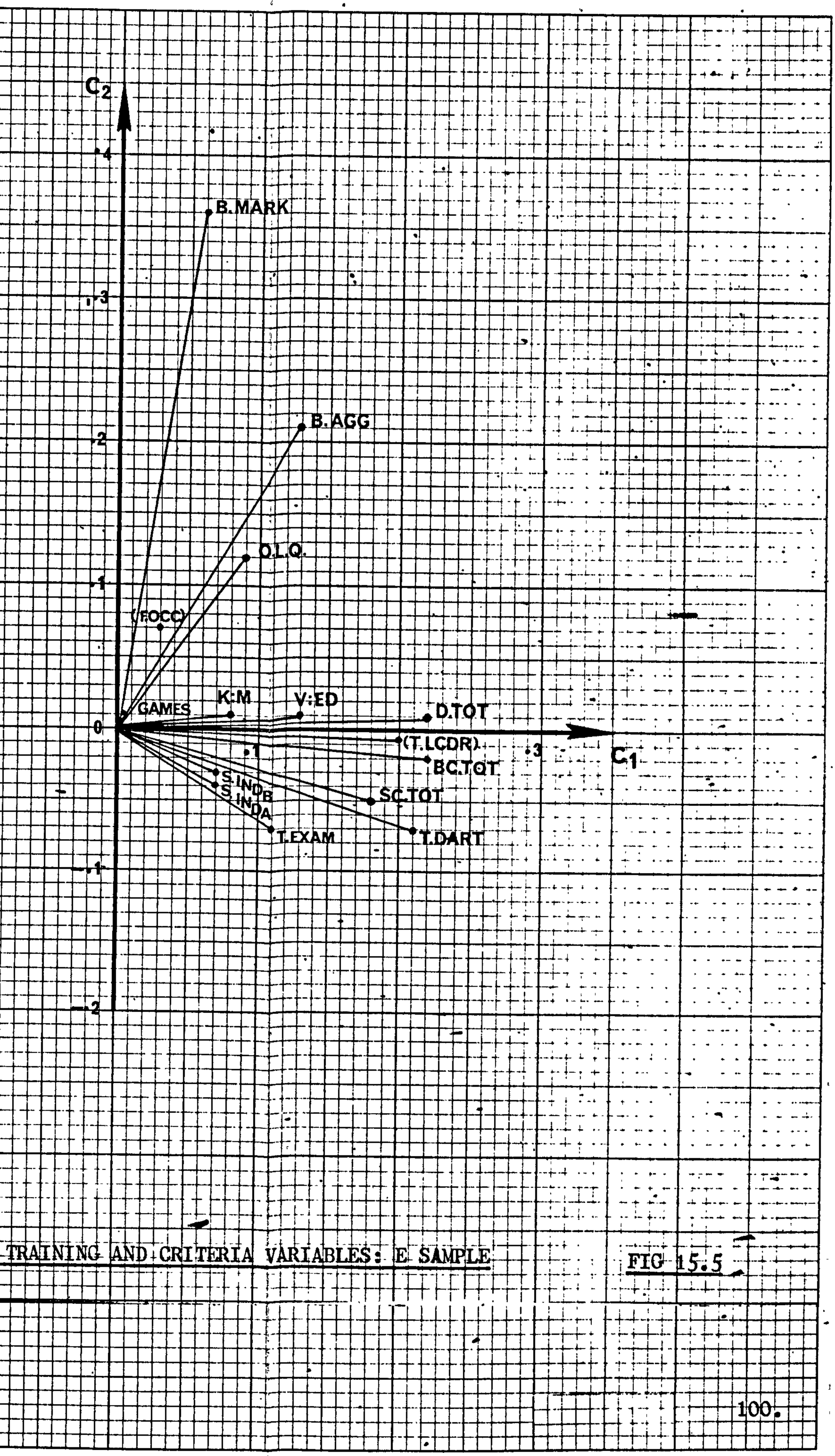
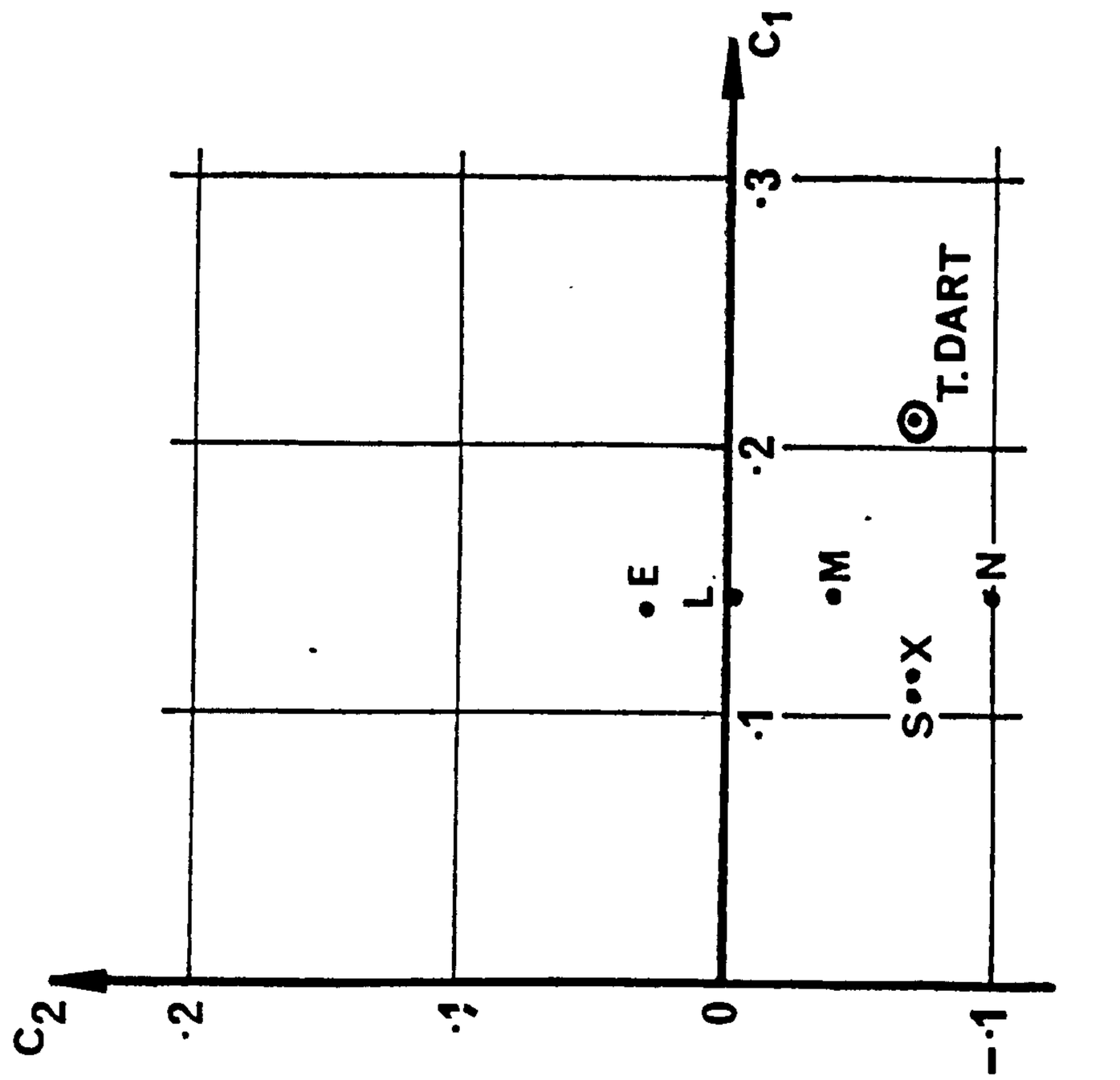


FIG 15.5 PROJECTIONS OF FIRST THREE PRINCIPAL COMPONENTS OF PRE-ENTRY,



TRAINING AND CRITERIA VARIABLES: E SAMPLE

FIG 15.5



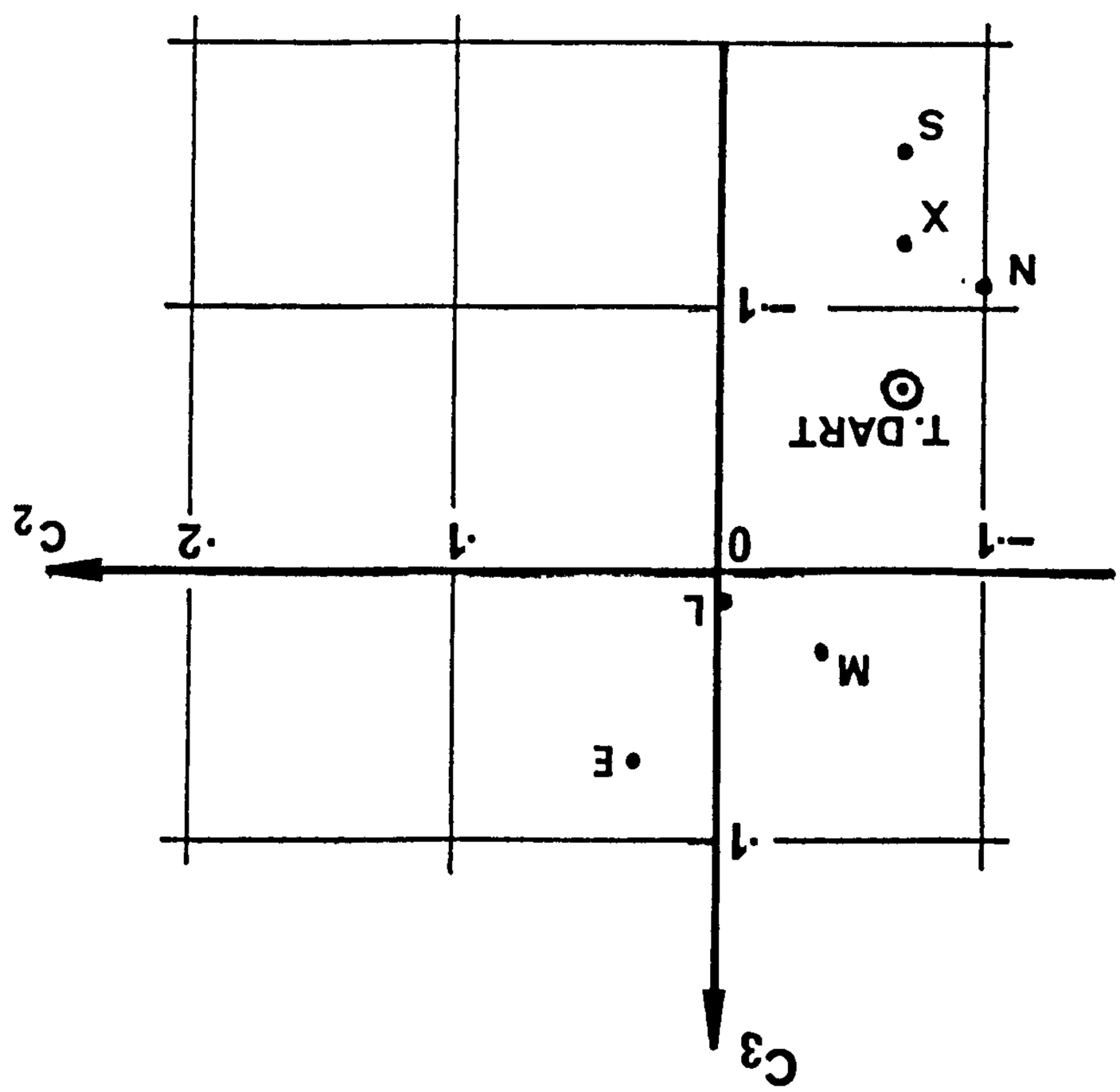


FIG 15.6 ORIENTATION OF DARTMOUTH VARIABLES: E SAMPLE

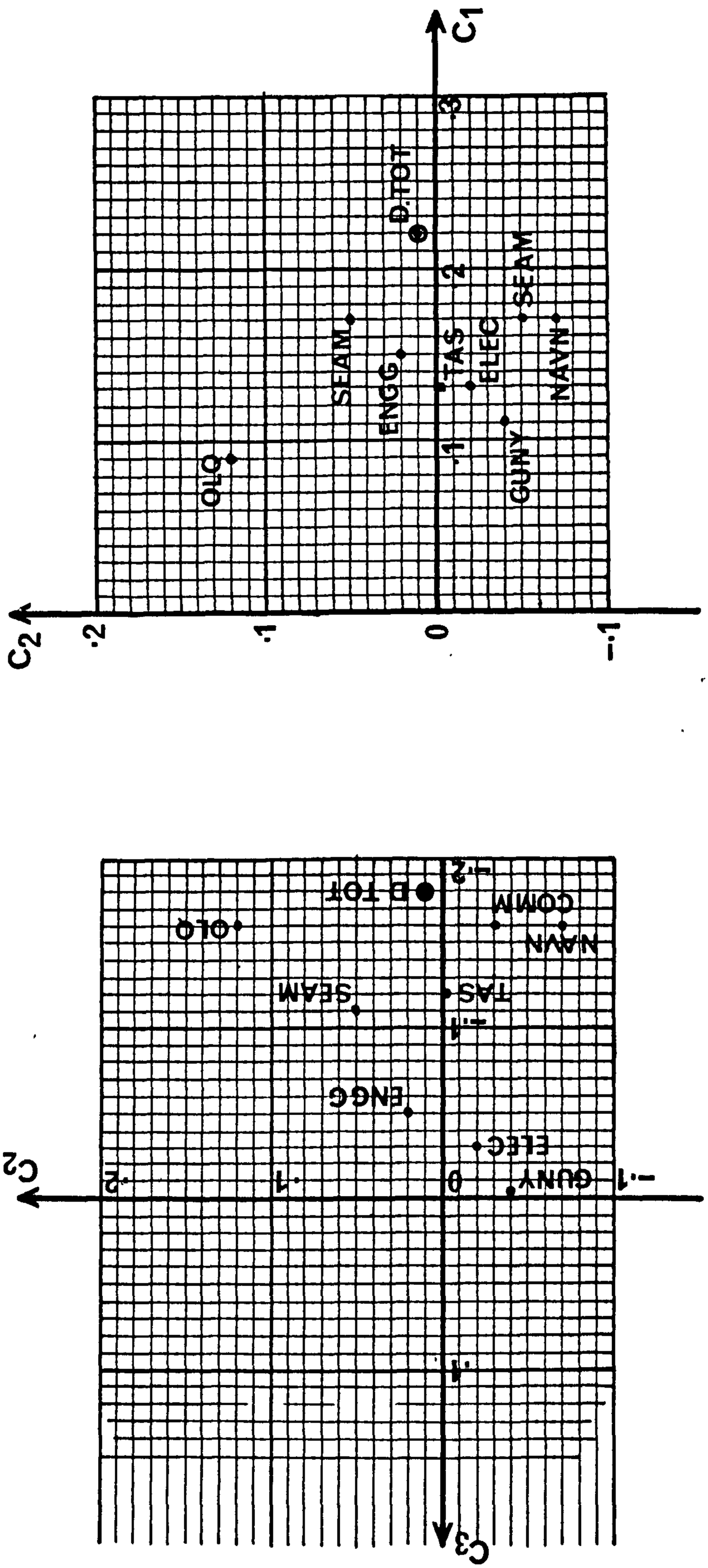


FIG 15.7 ORIENTATION OF HMS DEVONSHIRE VARIABLES: E SAMPLE

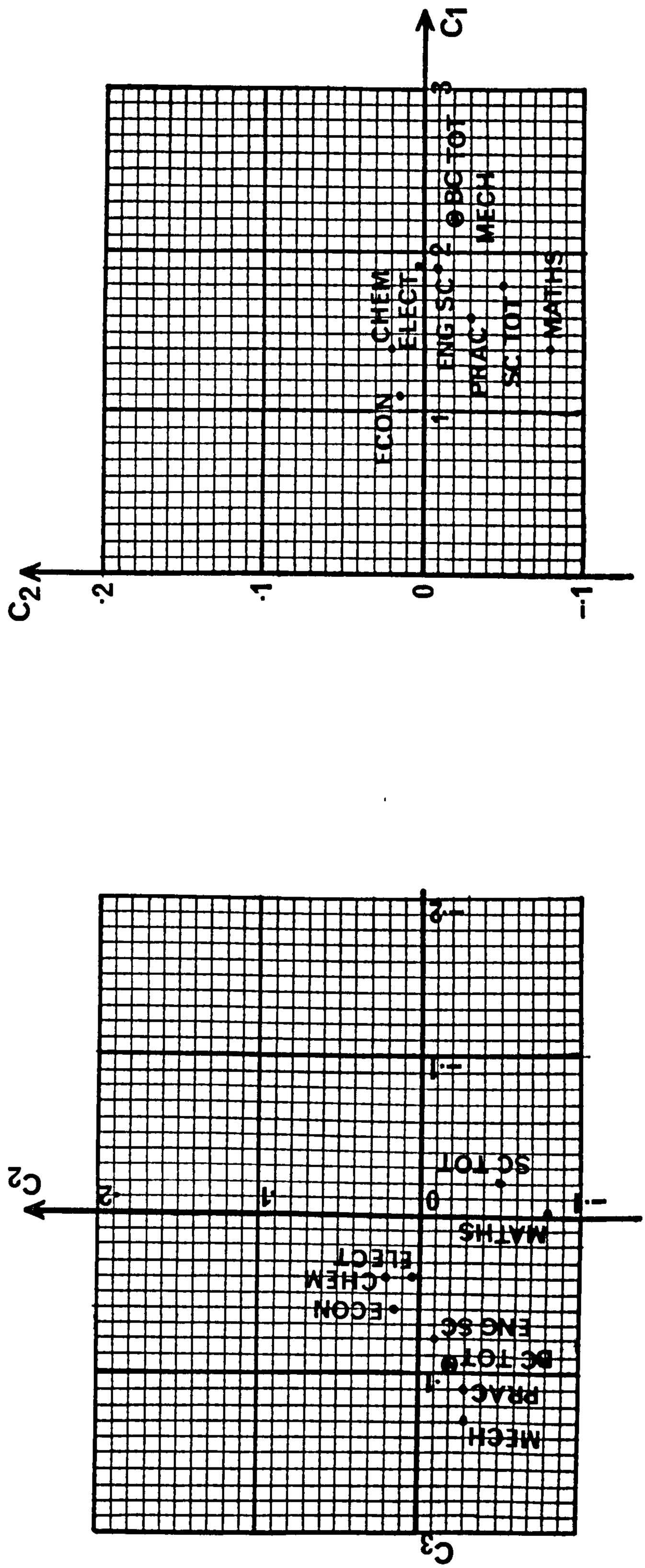
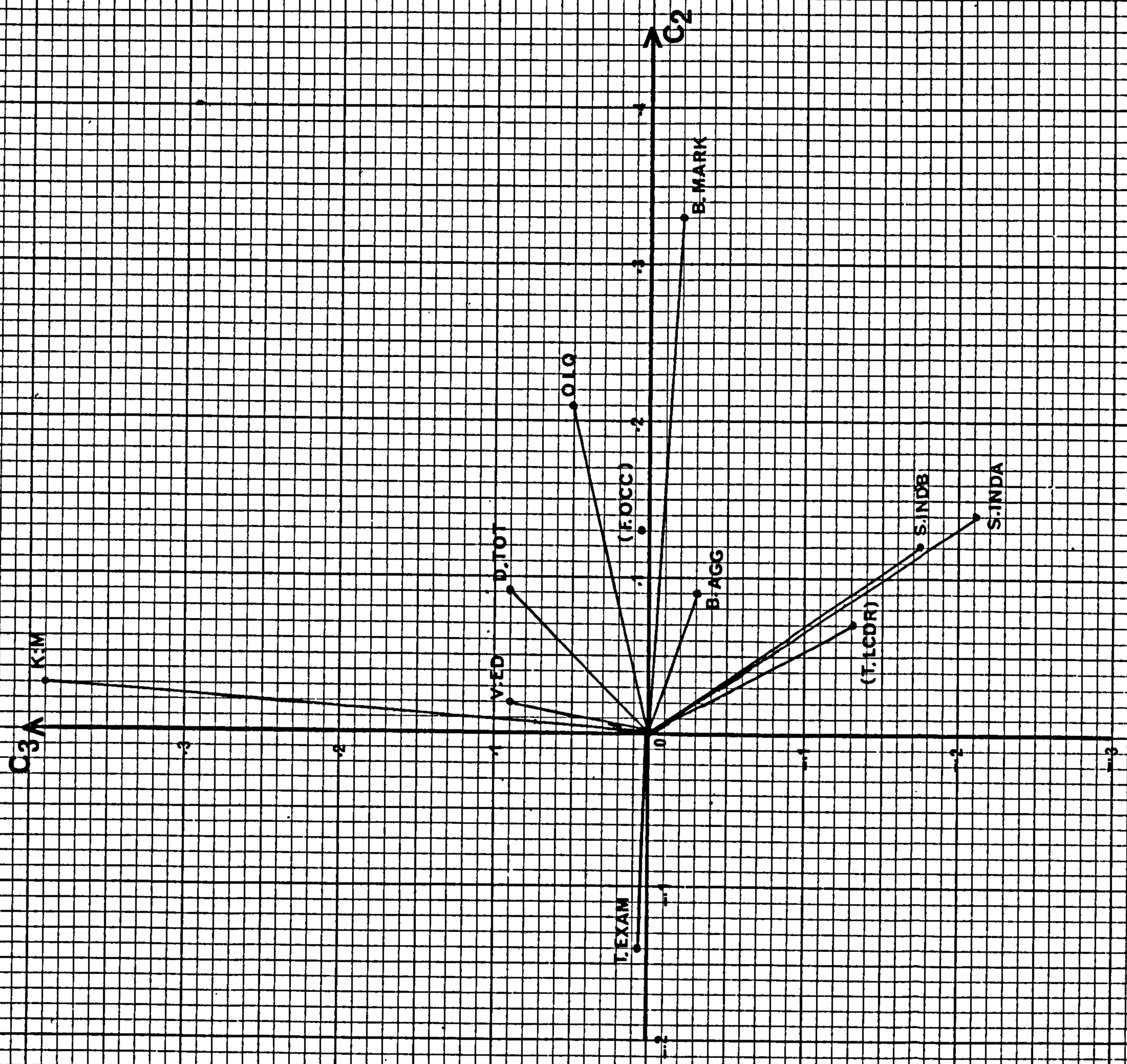
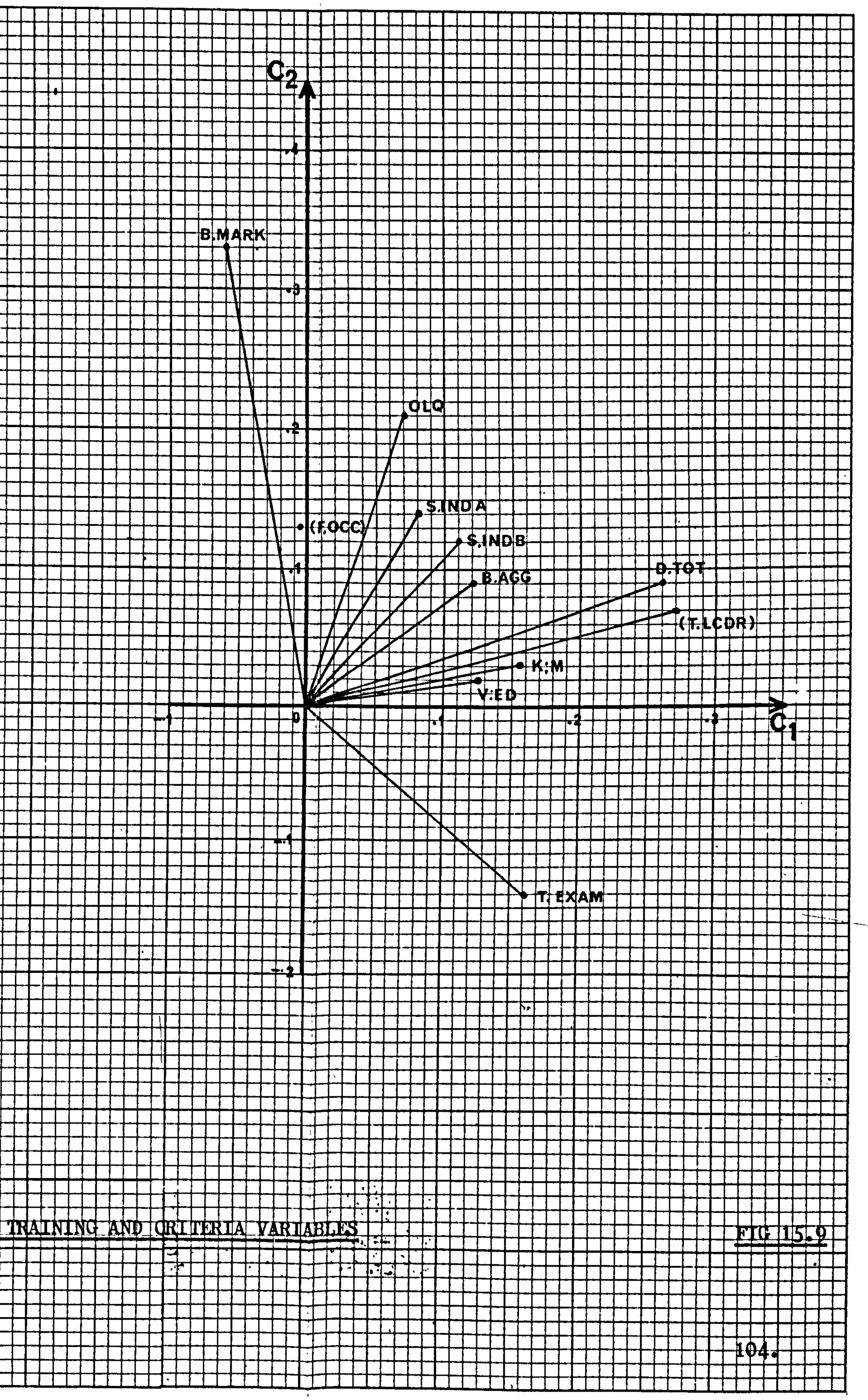


FIG 15.8 ORIENTATION OF RNEC VARIABLES: E SAMPLE



NOTE: VECTOR ( ) REVERSED

FIG 15.9 PROJECTIONS OF FIRST THREE PRINCIPAL COMPONENTS OF PRE-ENTRY, X SAMPLE



TRAINING AND CRITERIA VARIABLES

FIG 15.9

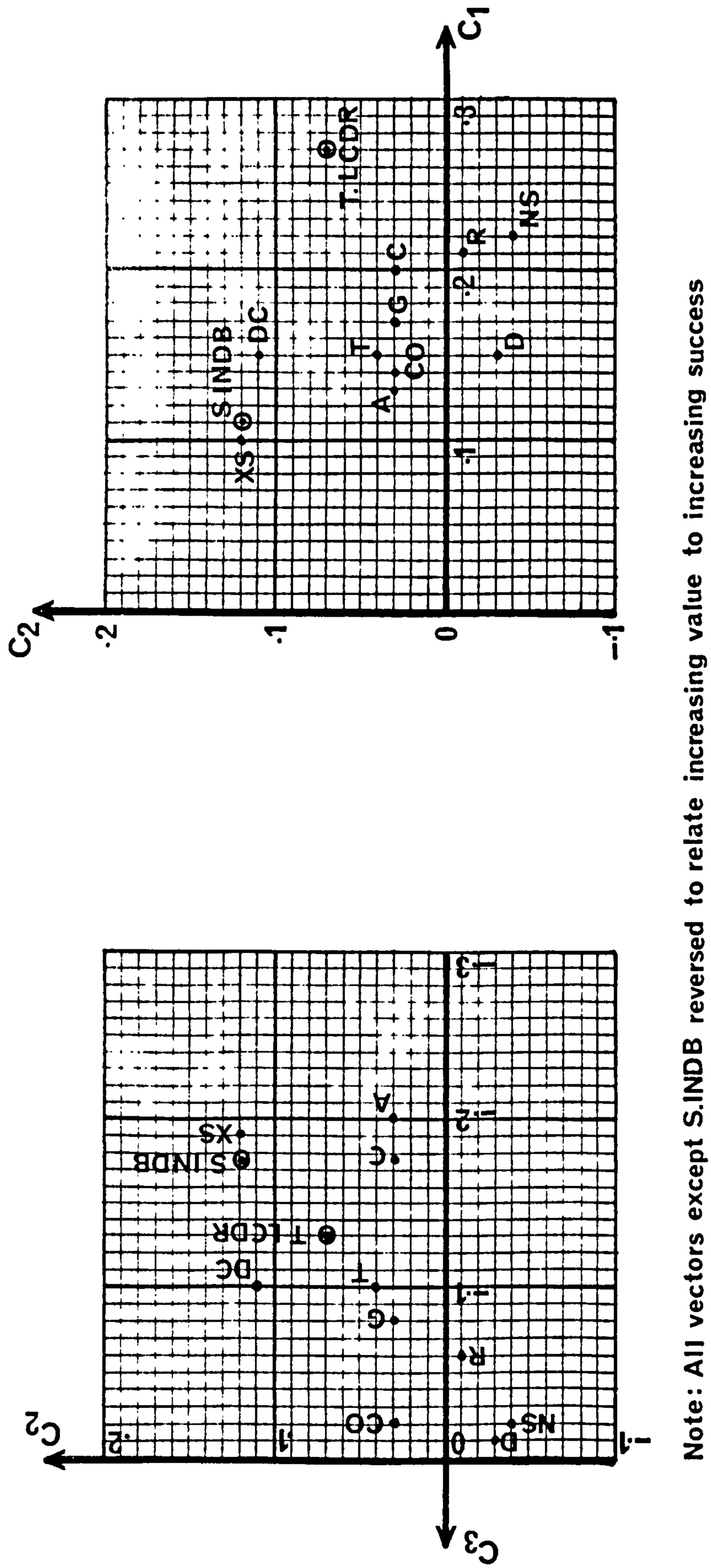
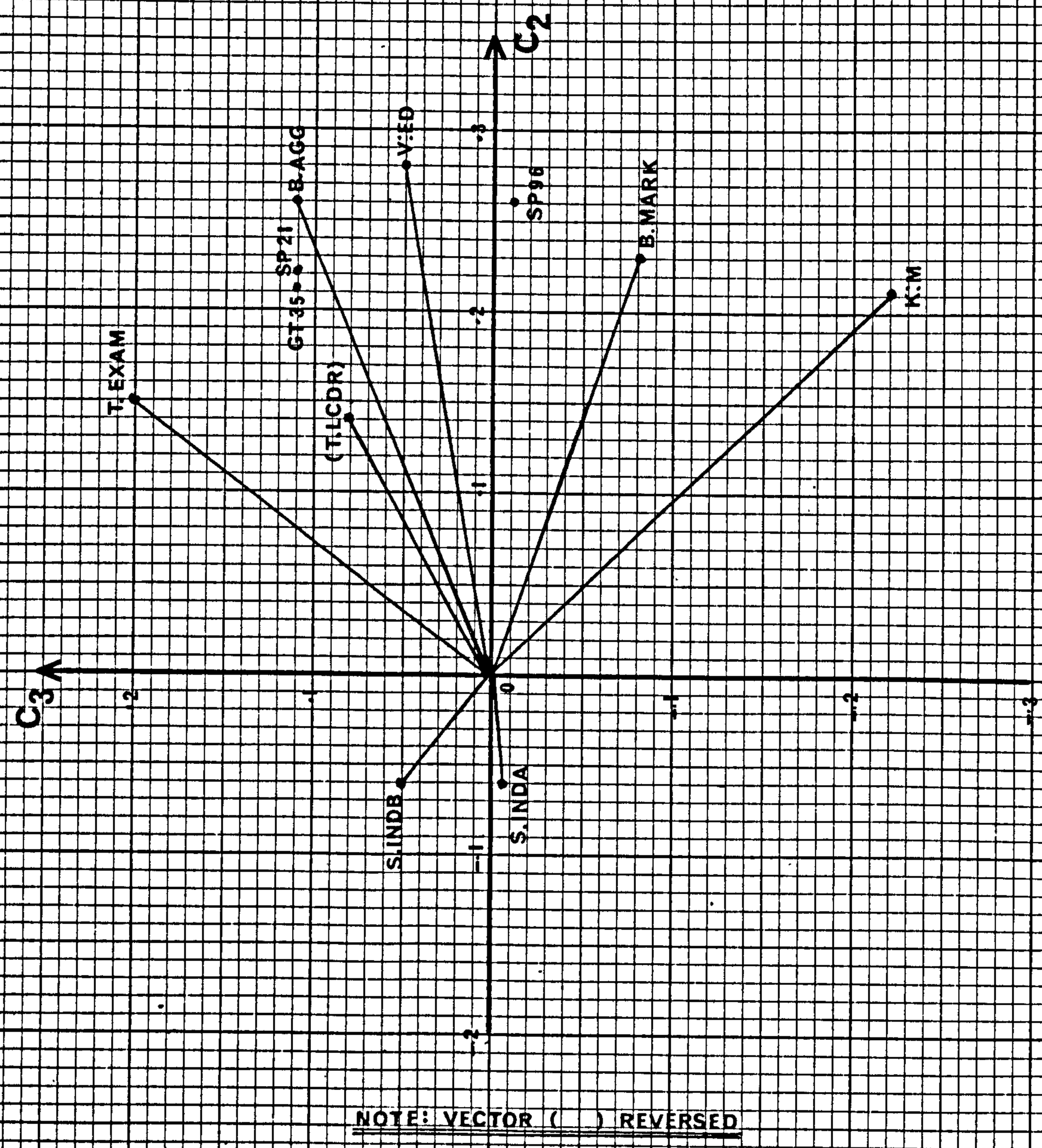
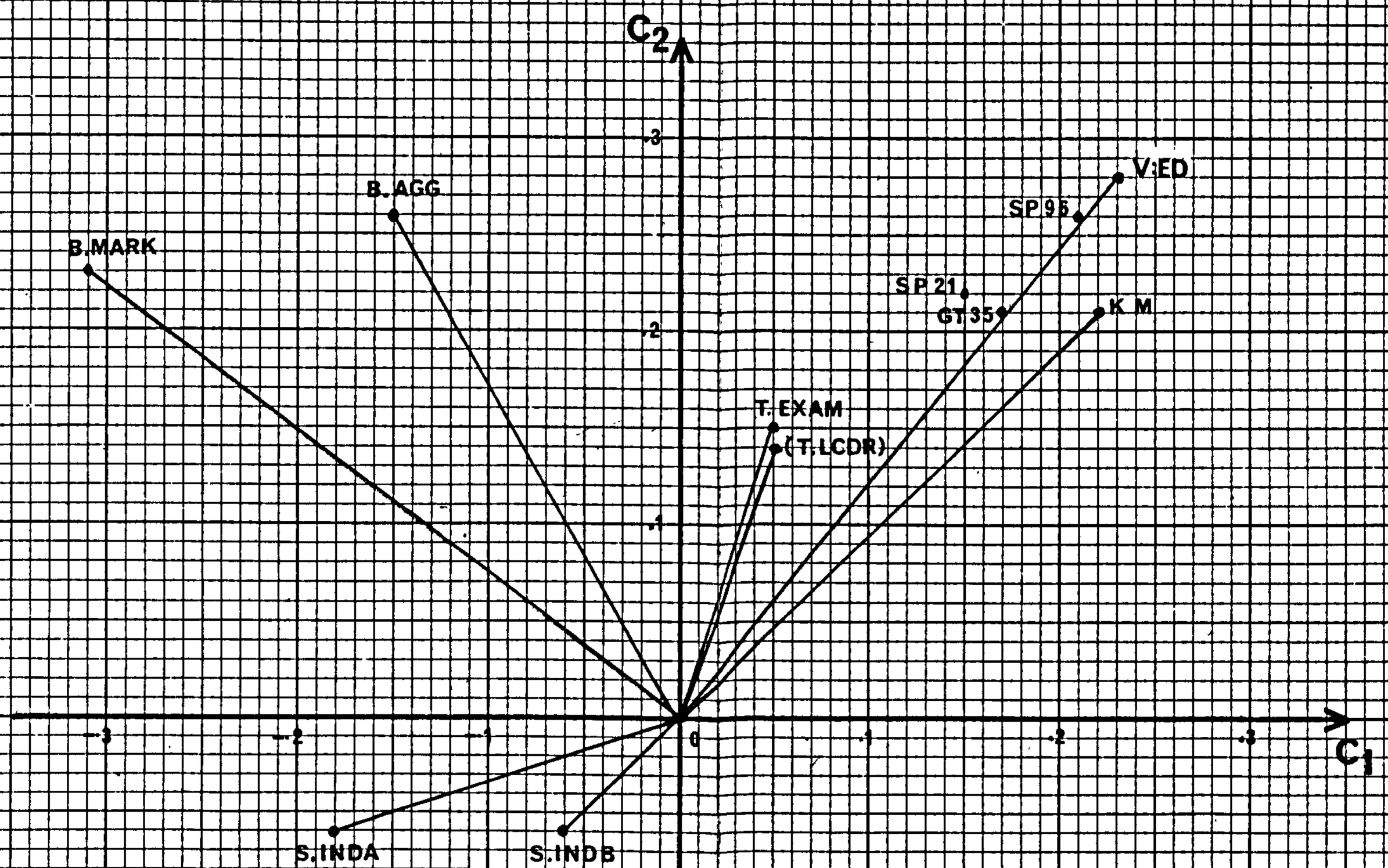


FIG 15.10 ORIENTATION OF X SPECIALIST COURSE VARIABLES: X SAMPLE



NOTE: VECTOR ( ) REVERSED

FIG 15.11 PROJECTIONS OF FIRST THREE PRINCIPAL COMPONENTS OF



KEY VARIABLES: S SAMPLE

FIG 15.11

CHAPTER 16

ANALYSIS OF INTERESTS DATA

1. Although the correlations of individual interests variables with success criteria were generally insignificant it was thought that there might be a detectable clustering of interests. If groups of related interests could be identified these groups might be located in the data models and used for predictive purposes in preference to the raw variables.

2. An obvious choice of analytical technique for such a problem is principal component analysis, since this enables the minimum number of components needed to explain the correlation matrix to be identified.

3. As it might be expected that different patterns of interests would be associated with the different branches (Seaman, Engineer and Supply), separate component analyses were completed for each of the three samples, X, E and S. In each case the long-term success criterion S.INDB was included with the thirty interests variables so that components with heavy success loadings might be identified.

4. For purposes of comparison a further analysis was completed on the pooled XES sample but in this case S.INDB was omitted.

5. The results of the four analyses are summarised in Tables APP 10.1 and APP 10.2. The former shows the eigenvalues (component variances) for each sample and in the latter the component loadings of each variable on each of the first five components for each sample are listed.

6. Examination of Table APP 10.1 shows that there is little hope of producing a meaningful condensation of the data. Using the method of significance testing described by Rao (1955), the number of degrees of freedom is $\nu = [(p - k)^2 - p - k] / 2$, where p is the number of variables and k the number of components required to explain the correlations. For positive ν the maximum value of k is 23 in the X, E and S analyses and 22 in the pooled XES analysis.

7. The test of the hypothesis that k components are adequate is given by ascribing appropriate confidence limits to the function

$$\chi^2 = -(n - 1) \log_e (\lambda_{k+1} \ldots\ldots\ldots \lambda_p)$$

Using k = 23 (or 22) gives the values of χ^2 shown in Table APP 10.1. These confirm that, even with 23 (or 22) components the correlations are not adequately explained.

8. The problem of significance testing in component and factor analysis has been discussed extensively in the literature. Harman (1967) summarises the situation lucidly when he says "The distinction between statistical significance and "practical significance" should be borne in mind". Nevertheless, in the case under consideration there is no apparent prospect of identifying a small number of meaningful components.

9. In order to study whether there was any common pattern between samples those component loadings which exceed 75% of the maximum loading in each sample on the first component have been shaded in Table APP 10.2. Again no meaningful pattern emerges.

10. The first component with substantial S.INDB loadings is the fourth. Here again there appears to be no coherent structure to the pattern of heavy loadings and since the maximum variance in this component is less than 8% of the total the relationships are unlikely to be useful for regression.

Conclusions Drawn

11. The block of interests variables was included in the study to enable relationships between early interests and long-term success to be explored.

12. Correlations between S.INDB and the raw variables proved small and principal component analyses yielded no evidence of meaningful groupings and no prospect of data condensation. It is possible that Cluster Analysis might yield better results, but this seems unlikely.

13. The data, which was obtained from Forms Q78 (see Appendix 1), was originally intended primarily for the purpose of stimulating discussion at the interview and not for analysis. It seems likely that the single word definitions of interests are too vague to ensure reliable data and that error variance obscures any underlying structure. It is probable that psychometric prediction demands the use of a suitably designed questionnaire. It is possible also that the constraint imposed by integer values of the observations may have contributed to the masking of the structure.

14. In view of these conclusions it was decided not to attempt to use the interests data for the purpose of deriving predictor functions.

CHAPTER 17

CONDENSATION OF S206 REPORT DATA

1. Information relating to post-training career development was available for X, E and L officers in the form of S206 reports. A description of the S206 and of the changes made to it in 1960 has already been given in Chapter 10.

2. It was considered important to investigate the relationship of the report data structure to that of pre-entry and training data and, if possible, to use the report assessments in the predictive studies. It was, however, clear that some form of condensation was necessary because the structure of the report information was essentially three-dimensional. (Reports were written for each individual on a series of occasions and on each occasion a number of qualities was assessed).

3. The amount of data available for each group is shown below:-

PHASE	GROUP	NO OF OFFICERS	NO OF REPORTS	NO OF SCORES PER REPORT
PRE '60	X E L	82 116 48	653 702 292	5
POST '60	X E L	72 101 46	767 922 445	10

4. The problem of condensation was complicated by the fact that the number of occasions varied from one individual to another and because the number of qualities changed from five to ten in 1960/61.

Condensation of 'Personal Qualities'

5. It was decided to examine first the structure of the data and to assess whether the correlations between reported personal qualities could be adequately reproduced by a smaller number of variables. A series of six principal component analyses was completed, two for each group, one pre '60 and one post '60. For these analyses the variables were the five or ten personal qualities and each report provided one set of observations. The results are shown in Figure 17.1 and Table APP 11.1.

(only two dimensions have been shown since in each case the first two components account for about 70% or more of the total variance and subsequent components for less than one tenth of this).

6. It is at once apparent that there are striking similarities both between groups, and between pre '60 and post '60 structures, and that there are rational explanations for differences.

7. Examination of the X and E pre '60 structures shows that the vectors lie between the two extremes "Mental Qualities" and "Personal Qualities". It would be possible to rotate the axes to coincide with these vectors and the axes might then be identified as "Intelligence" and "Social (or Behavioural) Skills". "Leadership" and "Administrative Ability" are then seen to be composed of both intelligence and social skills, administrative ability predominantly the former and leadership mostly the latter. "Professional Ability" is closely related to intelligence in E officers but depends substantially on social skills as well as intelligence in X officers.

8. In the L pre '60 structure "Professional Ability" is closely aligned with intelligence and the remaining qualities are also clustered. It is, however, probable that some distortion of the structure is caused by the very small sample. (Although there were 292 reports, these were on only 48 officers).

9. The X and E post '60 structures exhibit a strong resemblance to their pre '60 connterparts. The following qualities may be equated:-

Pre '60			Post '60		
M.QUAL	=	Mental Qualities	INTELL	=	Intelligence and Reasoning Power
A.ABIL	=	Administrative Ability	O.ABIL	=	Organising Ability
LEADER	=	Leadership	LEADER	=	Leadership
P.QUAL	=	Personal Qualities	(TACTCO (	=	Tact and Co-operation
			(SOCATT	=	Social Attributes

10. Again the extremes are definable as intelligence and social skills. The L post '60 structure is more similar to the X and E structures than its pre '60 counterpart, probably because of the larger number of reports and the smaller proportion of missing values.

11. The essential similarities of structure, both between groups and between pre '60 and post '60 phases suggested that the structure was stable and that reduction of the dimensionality of the data in both pre '60 and post '60 phases was justifiable. In the pre '60 analyses two components accounted for about 80% of the variance and in the post '60 for about 70%. It was therefore decided to conduct Factor Analyses on both pre '60 and post '60 data, extracting initially two factors in each case.

12. Because of the evidence of instability in the L data, and the possibility that this was caused by the small number of individuals, it was decided to concentrate further study on the largest group, viz E.

13. The results of the Factor Analyses are shown in the upper half of Figure 17.2 and Table APP 11.2. The structures are similar to those of the Component Analyses though there are minor differences which occur because of the changes in the assumptions implicit in the models.

14. The adequacy of the two solutions was assessed using the test of significance proposed by Lawley, viz

$$U = N \sum_{i<j=1}^{p} \frac{\bar{r}_{ij}^2}{(1 - h_i^2)(1 - h_j^2)}$$

where U is a weighted sum of squares of residuals

N is the number of observations from which the correlation matrix is computed

$\bar{r}_{ij} = r_{ij} - \hat{r}_{ij}$, i.e. the difference between observed and estimated correlation coefficients

h_i is the communality of variable i.

U is distributed as χ^2 with $[(p - k)^2 - p - k] / 2$ degrees of freedom where p is the number of variables and k the number of factors.

15. For the pre '60 solution U = 0.32 with 1 degree of freedom, a value well below the significant level, indicating that the two factor solution gives a highly satisfactory account of the correlations.

16. For the post '60 solution U = 264 with ν = 26. Such a value indicates significant residuals but when three, and subsequently four factors were extracted it was found that the values of U were not substantially improved in relation to ν. (For three factors U = 101 with ν = 18, and for four factors U = 53 with ν = 11).

17. It was thought likely that the constraint imposed on the data by the integer values of the variables may lead to a pessimistic interpretation of residuals. Since the pre '60 and post '60 structures showed close similarities and since the residual variances were small it was decided to use the two factor solutions in both cases for the next stage of the condensation process.

Condensation of 'Occasions'

18. Since the number of reports on each officer varied it was necessary to select a set of 'occasions' which would be similar for as many individuals as possible. Three problems were encountered.

a. Early reports contain a substantial proportion of missing values, where qualities have been assessed as IK (Insufficient Knowledge).

b. Promotion to Lieutenant Commander occurred in a band of time during which the changeover from pre '60 to post '60 report format took place.

c. Promotion to Commander occurs at various times after four years as Lieutenant Commander.

19. In order to preserve the greatest consistency of data for all individuals the following reports were used:-

a. the last four reports before $6\frac{1}{2}$ years seniority as a Lieutenant;

b. the first four reports after $1\frac{1}{2}$ years seniority as a Lieutenant Commander.

20. This eliminated the early, incomplete, reports and the reports in the changeover band, and ensured that there were as few as possible individuals with missing data. It also ensured that reports were related to corresponding lengths of experience for each officer.

21. The factor loadings obtained from the condensation of personal qualities were used to obtain pairs of factor scores for the eight selected occasions for each individual. The sixteen variables so derived were named F1T1, F2T1, F1T2, F2T2, and so on up to F2T8. Thus F1T1 to F2T4 are eight variables, the scores on which for each individual represent two dimensional condensations of his S206 markings on each of four occasions during his Lieutenancy. Similarly, F1T5 to F2T8 represent the markings achieved as a Lieutenant Commander.

22. Two further Factor Analyses were conducted with the object of condensing the eight pre '60 and eight post '60 variables into two pairs of variables for use in predictive studies. Preliminary studies were undertaken with the variable S.INDB included so that the relationship of this success vector to each of the sets of eight report vectors could be established. The results of these analyses are shown in the lower half of Figure 17.2 and in Table APP 11.3.

23. From the post '60 plot it can be seen that the F1T5, F1T6, F1T7 and F1T8 vectors are clustered in a direction closely associated with S.INDB. The corresponding F2 vectors are similarly clustered in a direction orthogonal to S.INDB. The pre '60 vectors exhibit a broadly similar arrangement but there is greater divergence, illustrating a tendency for markings of qualities to develop more rapidly during this early experience.

24. Analyses were repeated with S.INDB excluded so as to provide two sets of factor loadings for F1T2 to F2T4 and F1T5 to F2T8 respectively. In both cases it was impossible to extract more than two factors because the eigenvalues of the factor matrix became negative, and so two factors were accepted as satisfactory. From these factor loadings pairs of factor scores were derived for each individual. The four variables so derived were labelled F1 and F2, corresponding to the condensed pre '60 reports, and F1A and F2A corresponding to the post '60. Thus each individual's scores on F1 and F2 represent the information contained in the markings in four selected reports during his service as a Lieutenant. Similarly scores on F1A and F2A correspond to the marks on four selected reports during service as a Lieutenant Commander. Comparison of the results of the first and second factorings reveals that the final F1 and F1A axes correspond approximately with "Intelligence", while F2 and F2A approximate to "Social Skills".

Conclusions on S206 Condensation

25. The Factor Analyses of S206 report data show that there is a definable underlying two dimensional structure, the axes of which may be identified as "intelligence" and "social skills". It seems likely that these axes may be located in the three-dimensional ability/success model, the former in the cognitive plane, the latter close to the P (personality) axis.

26. The essential features of the structure were unchanged by the

modifications in 1960. The effect of the introduction of five more reported qualities was to facilitate more precise reporting in the region between the extremes of "intelligence" and "social skills", though there is some evidence of clustering, indicating halo effect in reporting.

27. The properties of this structure have been used in the evaluation, for each individual in the E and L samples, of two pairs of scores representing the sixty variables in eight reports. One pair of scores, labelled F1 and F2 provides a measure of reports during experience as a Lieutenant. The other pair, labelled F1A and F2A, provides a measure of reports during service as a Lieutenant Commander. The F1 and F1A scores approximately represent assessment of intelligence, while the F2 and F2A scores approximate to social skills.

28. These four variables have been used in the derivation of predictive functions described in Chapters 18 and 19.

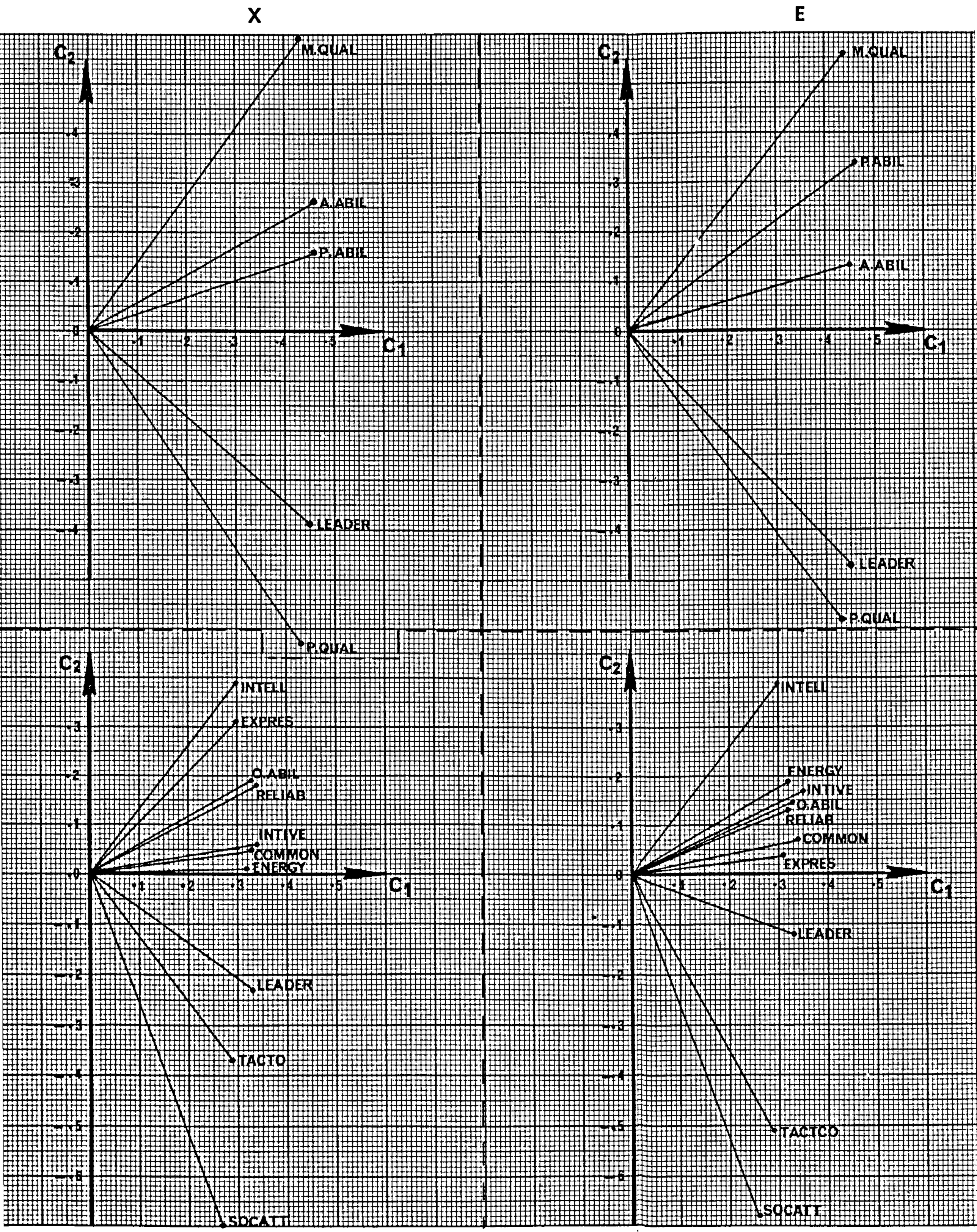


FIG 17.1 PRINCIPAL COMPONENT ANALYSES OF X, E AND L S206 REPORT DATA

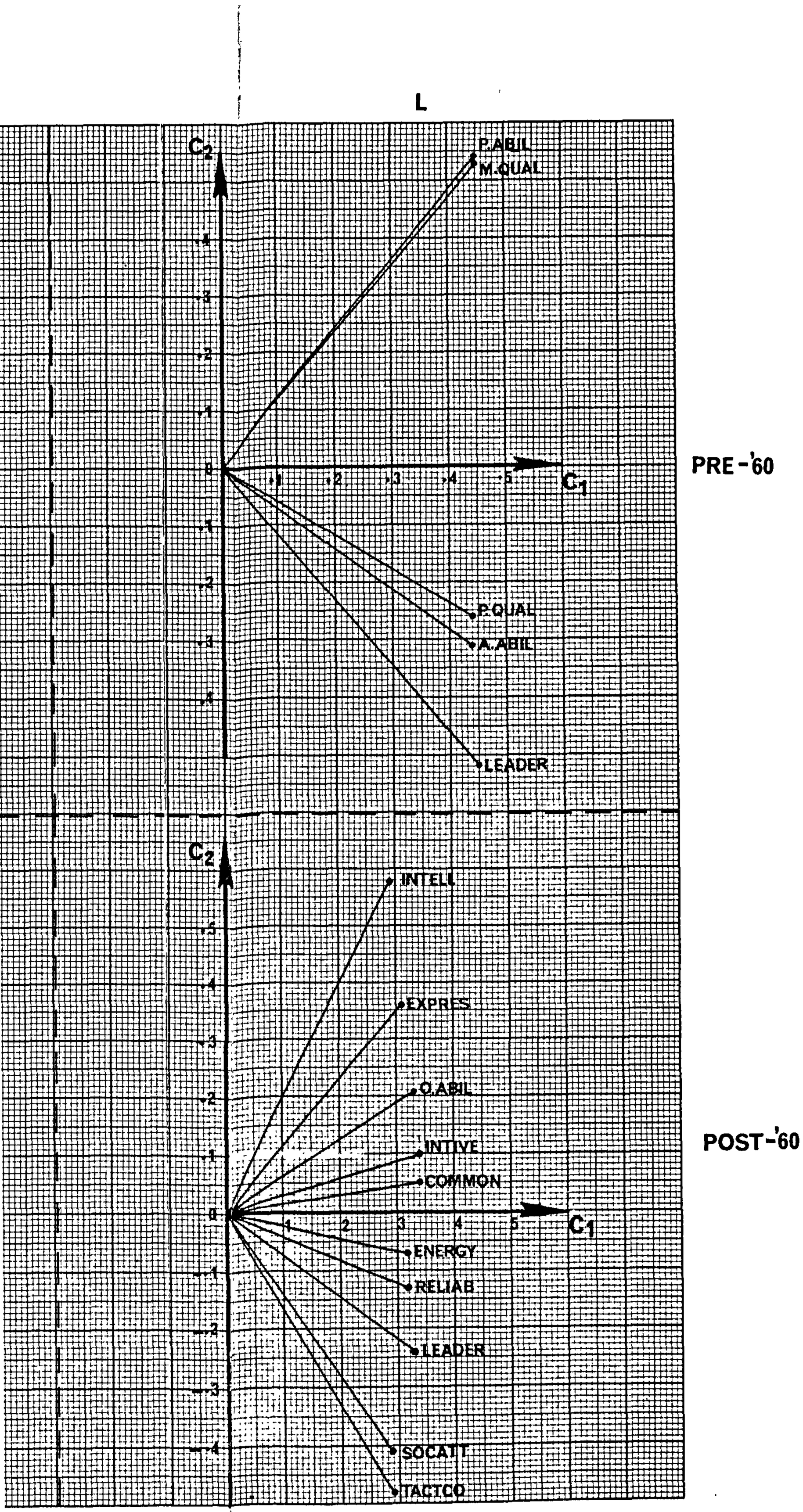

L
C2
P.ABIL
M.QUAL
.1
.2
.3
.4
.5
0
.1
.2
.3
.4
.5
C1
P.QUAL
A.ABIL
LEADER
PRE-'60
C2
INTELL
EXPRES
O.ABIL
INTIVE
COMMON
ENERGY
RELIAB
LEADER
SOCATT
TACTCO
POST-'60

FIG 17.1

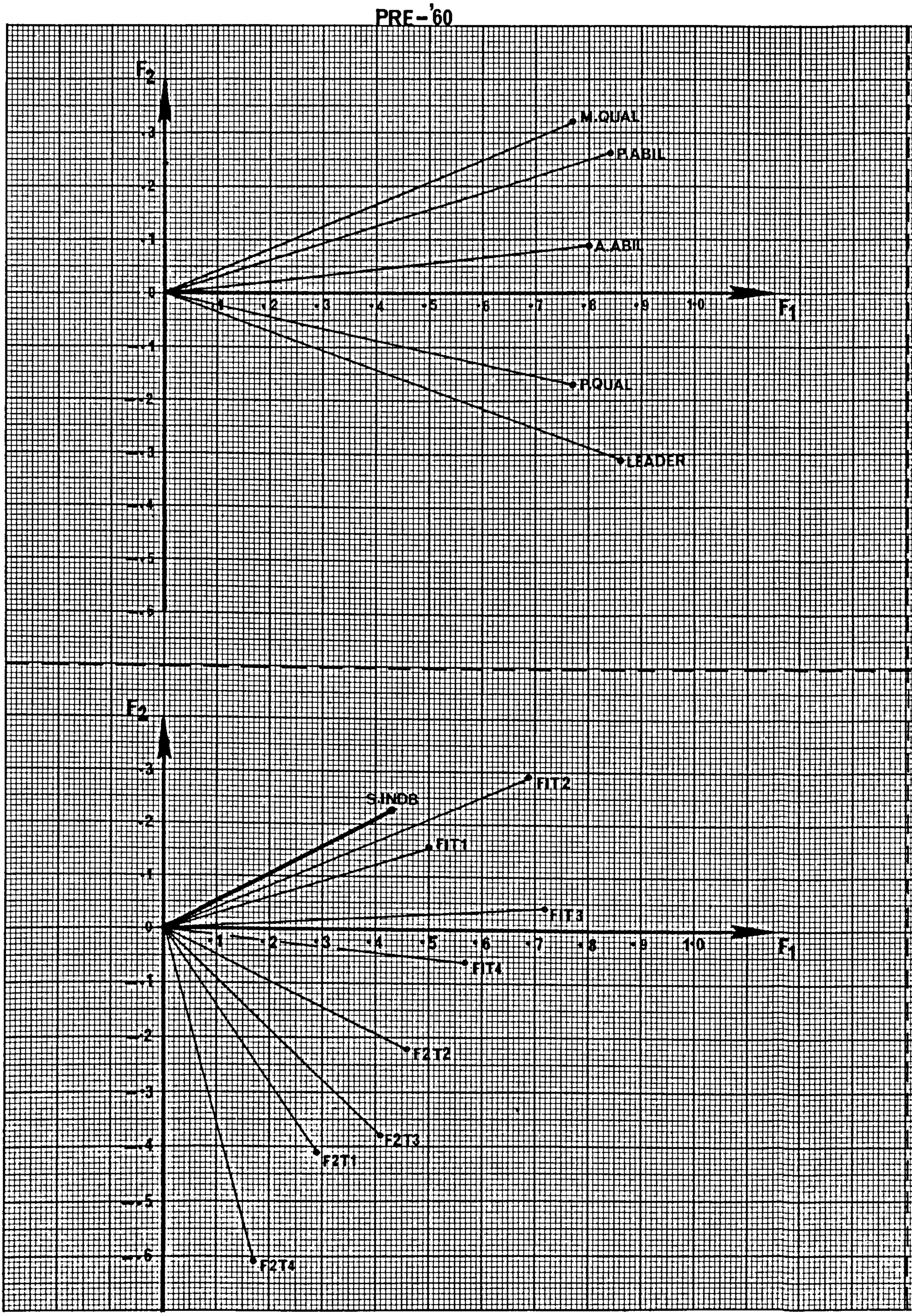


FIG 17.2 FACTOR ANALYSES OF E S206 REPORT DATA

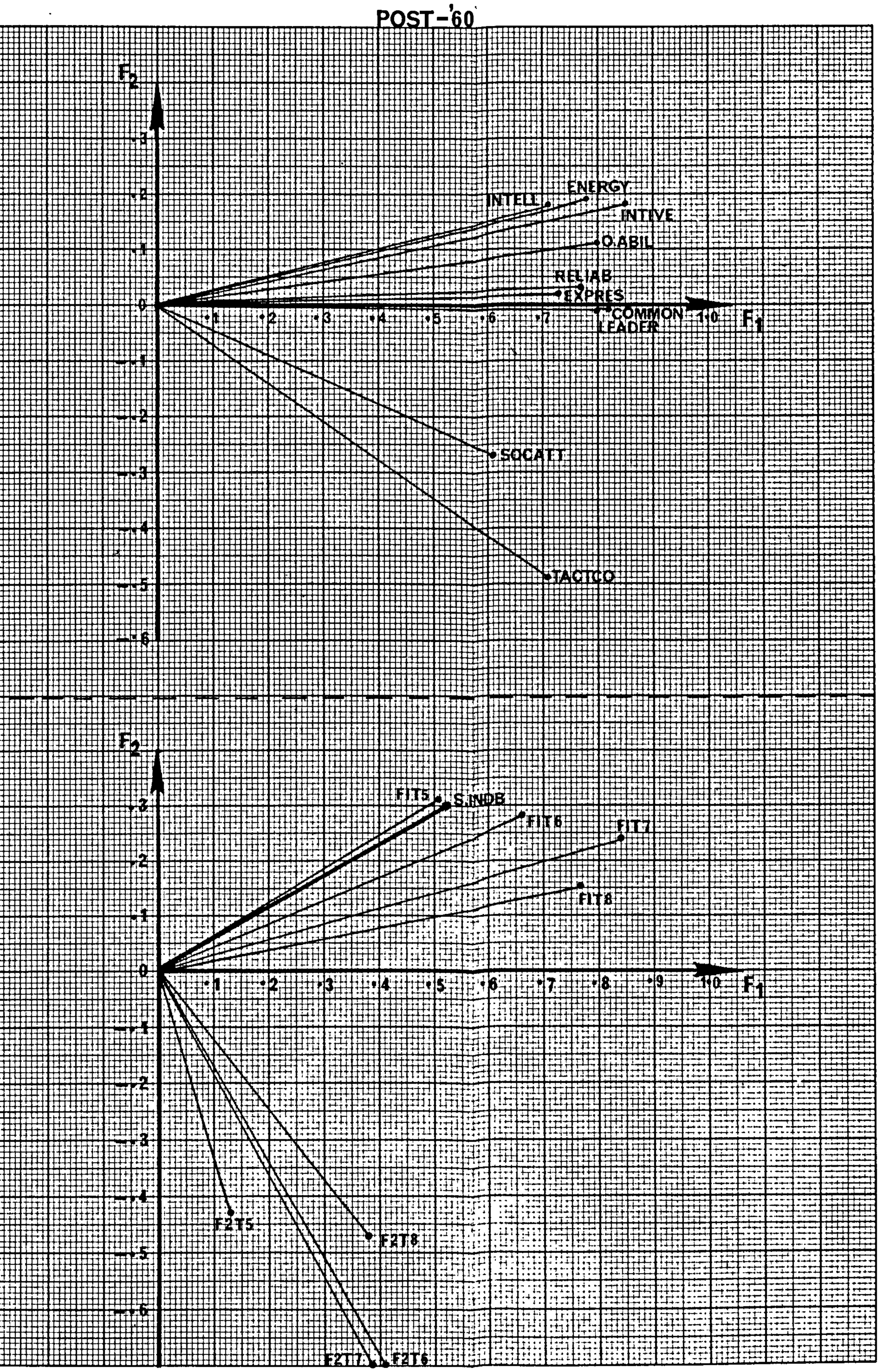

POST-'60
F2
F1
INTELL
ENERGY
INTIVE
O.ABIL
RELIAB
EXPRES
COMMON LEADER
SOCATT
TACTCO
FIRST FACTORING
F2
F1
FIT5
S.INDB
FIT6
FIT7
FIT8
F2T5
F2T8
F2T7
F2T6
SECOND FACTORING

FIG 17.2

CHAPTER 18

DISCRIMINATORY ANALYSES

1. In its simplest terms, long-term success can be considered as a categorical variable, those officers promoted to Commander being regarded as more successful than those not promoted.

2. The technique best suited to prediction of a categorical variable is discriminatory analysis, in which a linear discriminant function is derived, enabling a discriminant score to be calculated for each set of observed values. This estimated score may then be compared with a critical value to determine probable membership of one group or another.

3. The technique may be extended to the prediction of more than two categories and in such a case a set of discriminant functions is derived, one less in total than the number of categories.

4. Two sets of analyses have been completed in order to assess the usefulness of the various classes of data, and of the technique, for long-term prediction. In the first set a two-group classification has been used, viz promotion/no promotion, and results have been derived for each of the samples X, E, S and L. The results indicate that "no promotion" is not a homogeneous category and three-group analyses have been completed for samples X, E and S using the classification:- promoted/not promoted, still serving after reaching top of promotion zone/left service before reaching top of promotion zone.

5. A selection of the results of these analyses is included. For the two-group studies of X and E samples a series of four analyses is reported in each case, showing the effects of introducing data available at various successive career stages. In the case of the L officers a comparison between the L1, 3 sample and the L1, 2, 3 sample is also included to illustrate the effect of including candidates selected by the old-type procedure. No training data is available for S officers and the study is confined to pre-entry data. The three-group studies are illustrated by the results obtained from pre-entry data for X and S samples.

6. In each case the results of the analyses are tabulated in Appendix 12. Columns headed "Eigenvector" give the coefficients of each variable

in the discriminant function. The numbers in the "Order" column are the rank order of positive and negative coefficients in the scaled eigenvectors derived by multiplying each coefficient by the standard deviation of its associated variable. They thus represent the relative contributions of variables to deviation of discriminant score, as distinct from absolute value.

7. Beneath each table the values of discriminant score at the group centroids are given, showing the relative values of scores associated with success and no success. A "Hits and Misses" table shows the results of applying the discriminant function to its own group. Results of three of the two-group and both three-group analyses are illustrated in Figures 18.1 to 18.5 and a comparison of prediction accuracies in Figure 18.6.

Two-Group Analyses

8. In each of these analyses the classification used was promotion/no promotion.

Sample S

9. No training data is available for this sample and so analysis has been confined to pre-entry variables, i.e. Biographical data, CSC examination results, SP tests, and board mark.

10. The results of the analysis are shown in Figure 18.1. From the table it will be seen that the most important contributions to a low discriminant score (which in this case means high probability of promotion) are scores on GT35, PREF, GAMES, SP160 and SP21. B.MARK ranks only seventh. The strongest predictors of "no promotion" are SP96, F.OCC, T.HSC and A.AIB. (Note that high score on F.OCC means low socio-economic status of father and high score on T.HSC means that a long time elapsed between taking school certificate and joining the RN).

11. The apparent conflict shown by opposite coefficients for GT35 and SP96, (and similarly by SP160 and SP117M) is not unusual in this type of study. It probably occurs in this case because the vectors of these variables in this highly selected sample are not as closely aligned as they might be in a more heterogeneous group (see Figure 15.11) and because one of the variables is acting as a suppressor, i.e. it has the effect of removing unwanted variance contributed by another.

12. The prediction accuracy of the discriminant function, when applied to its own group, may be seen from the "Hits and Misses" table and from the chart in Figure 18.1. The table shows that 81% of those actually promoted, and 91% of those actually not promoted, are predicted. The chart shows the distribution of discriminant scores on the 55 observations and illustrates how the forecast distributions overlap.

13. It would be surprising if a completely accurate forecast of promotion success could be made on data available twenty years earlier, and the total hit rate of 87% may appear unexpectedly high. Comparison of the discriminant function with the structural analysis shown in Figure 15.11 suggests, however, that the results in this sample are particularly sensitive to the definition of success. This is probably attributable to the small sample size. Thus, although the results show that this technique is capable of producing impressive results, the function derived from this particular sample cannot be considered more generally valid on this evidence alone.

14. Cross-validation is not feasible because the sample is too small to partition and because some of the biographical data is not held for subsequent entries. An analysis restricted to those variables for which data is available in subsequent entries gives the following discriminant function:-

$$D = -.0040\ (GT35) + .0354\ (SP96) - .0027\ (SP21) + .0116\ (SP117E) + .0096\ (SP117M) - .0073\ (SP160) - .0012\ (B.MARK) + .0047\ (ENGL) + .0030\ (GENL) - .0015\ (MATH) - .0001\ (T.EXAM)$$

15. This function is essentially similar to the more general one in Figure 18.1 but the removal of biographical data reduces prediction accuracy; on its parent observations a total hit rate of 71% is achieved. When applied to the two subsequent entries the function gives a total hit rate of 82%. This unexpected rise probably occurs because the sample sizes are small, but the figures suggest that the function is not unrepresentative in the short-term.

Sample X

16. The results of four analyses of the X sample are summarised in Table APP 12.1. The first is confined to CSC examination results, SP tests and board mark, i.e. those variables on which data is available for subsequent entries. The second incorporates the

biographical variables, the third includes also the HMS DEVONSHIRE training variables and the last uses all data available up to the end of training. The total hit rates on parent data are 74%, 85%, 87% and 92% respectively, showing the progressive improvement attainable in prediction as more data is included. The improvement achieved by incorporating biographical data is particularly pronounced and it is also striking that an accuracy of 92% can be achieved at the end of training, some 15 years before promotion occurs.

17. As in the case of the S sample, cross-validation is restricted to the first analysis where a total hit rate of 63% is achieved on the two subsequent entries.

18. This first discriminant function has also been applied to all candidates of sample F, i.e. those who were rejected. Out of 250 candidates only 15 achieve scores indicating probable promotion, and most of these are marginal. This is particularly interesting because in the discriminant function high T.EXAM score contributes to a "no promotion" forecast.

19. Comparison of the four discriminant functions reveals marked similarities. In each case GT35, SP96, MATH and PHYS are useful predictors of success while T.EXAM and SP117M contribute consistently to "no success", as might be anticipated from the structure in Figure 15.9. Some of the biographical variables are particularly useful, e.g. CORPS, GAMES, F.OCC, high score on the latter again contributing to a "no success" forecast. In the last two analyses, in which training data is used, the HMS DEVONSHIRE OLQ score is the best single predictor of success but high GT35 and low F.OCC scores also contribute almost equally.

20. The relative efficiencies for group separation purposes of the functions derived from pre-entry data and pre-entry plus all training data are illustrated in Figures 18.2 and 18.3. The effect of introducing the training variables is to give denser distributions, thus raising forecast probability levels and reducing the area of overlap. The small number of "strays" in the distribution tails represent data deficiencies, i.e. the omission of significant information from the predictor function. It would be instructive to examine each "stray" individually to determine what factors contribute to an incorrect forecast, since in this way the function may be made more efficient.

Sample E

21. The results of the following four analyses of sample E are given in Table APP 12.2:-

a. pre-entry data;

b. pre-entry plus early training data;

c. pre-entry plus all training data;

d. pre-entry plus all training plus derived S206 data.

The total hit rates achieved on parent samples are not as high as for corresponding X analyses on early data, being 70%, 76%, 88% and 95%, respectively. Nevertheless the figure of 88% on data available at the end of training is again encouraging in view of the time lapse before promotion.

22. Cross-validation has again been restricted to a study of CSC examination results, SP tests and board marks, in which total hit rates of 69% on the parent sample and 62% on the subsequent two entries were achieved. The discriminant function in this case was:-

$$D = .0045\ (SP96) - .0018\ (SP21) - .0084\ (SP\ 117E) + .0081\ (SP117M) + .0043\ (SP160) - .0003\ (B.MARK) - .0004\ (ENGL) - .0084\ (GENL) - .0027\ (MATH) - .0037\ (PHYS) + .0009\ (T.EXAM).$$

23. The contributions of variables in this function are essentially similar to those in the analysis involving biographical data. Indeed, in this case the inclusion of biographical data does not improve the efficiency of the forecasts, probably because of the strong contributions of cognitive data to prediction for Engineer officers. The pattern of contributions in the four analyses listed in Table APP 12.2 is rather less consistent than in the X study, probably because of the large number of variables and the tendencies mentioned under "Sample S" above. There is. however, a clear pattern amongst a substantial proportion of variables. T.EXAM is consistently a good predictor of "no success" (compare Figure 15.5) and B.MARK is of little predictive value. The CSC examination results MATH and PHYS are consistently useful indicators of potential promotion as are later training variables of similar type. Spatial;mechanical ability, as represented by SP160, is strongly associated with "no promotion".

Samples L

24. Data available for the L entries is not as extensive as for X, E and S and complications are caused by the reversion to an old-type selection board for the second entry. Results of analyses of the following are given in Table APP 12.3.

a. Entries 1 and 3 - Entry and training data.

b. Entries 1, 2 and 3 - Entry and training data.

c. Entires 1, 2 and 3 - Entry, training and S206 data.

Exceptionally high hit rates of 100% and 98% are achieved in the first and third analyses. The diversifying effect of the old-type selection procedure in the second entry is apparent in the lower hit rate of 87% for the second analysis.

25. There is good consistency between analyses. Degree results and the technically orientated training results, ELEC, ENGG, POWER and R.RAD are all predictors of success, as also is the HMS DEVONSHIRE OLQ assessment. The AIB assessment B.MARK and the HMS DEVONSHIRE seamanship score SEAM are associated with "no promotion", as is high score on T.LCDR, i.e. poor overall training success.

26. The sample sizes in these three analyses are small and cross-validation is not feasible. It would therefore be unjustifiable to draw general conclusions. Nevertheless the usefulness of the technique as an instrument for investigation is again apparent and the results help to complete a pattern in conjunction with those derived from the X, E and S samples.

Three-Group Analyses

27. The consistent association of high T.EXAM score with low success (i.e. no promotion) in X, E and S samples suggests that the "no promotion" category is not homogeneous, i.e. that it embraces some other form of success. The category has consequently been divided into two parts and in this second series of analyses discriminant functions have been derived for prediction of membership of three groups:-

1. Promoted.
2. Not promoted, still serving after reaching zone top.
3. Not promoted, left service before reaching zone top.

Thus group 1 corresponds to values from 6 to 9 in S.INDB, group 2 to a value of 5, and group 3 to values from 1 to 4.

28. For three categories the discriminant space is two-dimensional, and two discriminant vectors are required to locate an estimate in the space.

29. A series of analyses of this type has been completed using pre-entry data. Two of these are described below and results are listed in Table APP 12.4.

Sample X

30. The results of the three-category analysis of pre-entry data for sample X are illustrated in Figure 18.4. The two orthogonal axes represent the two discriminants, D_1 and D_2. Each prediction, using the eigenvectors listed in Table APP 12.4, produces a pair of D_1, D_2 scores, enabling the point to be plotted in the 2-D discriminant space. The solid lines through the space indicate the boundaries of equal probability, thus defining the three forecast groups.

31. An identification routine has been completed on the parent observations and each observation has been plotted in such a way that discrepancies between forecast and reality can be seen. As might be expected, there is some overlap at the boundaries. There are, however, few cases where major differences between prediction and reality have occurred.

32. It is apparent that membership of group 2 is associated with low scores on both D_1 and D_2, i.e. that such officers tend not to achieve promotion and tend to stay in the service. Those with high D_1 scores tend to leave prematurely and those with high D_2 scores tend to be promoted.

33. Examination of Table APP 12.4 shows that contributions to D_2 are closely similar to those in the two-group analysis, i.e. that promotion is associated with high scores on GT35, SP117E and PHYS and with low scores on T.EXAM, F.OCC and SP117M.

34. Premature leaving is associated with high scores on B.SD, F.OCC and T.HSC, i.e. with individuals over whom there was greatest difference of opinion in the AIB, those from the lower socio-economic backgrounds, and those who took school certificate early.

35. Those who continue to serve though not promoted tend to have high scores on SP117M and T.EXAM and to have been prefects at school, to have fathers in the RN, to be only children and to have attended an HMC school.

36. A summary of prediction accuracy is given in the form of "hits and misses" in Table APP 12.4. The total hit rate of 75% shows that a good forecast of long-term outcome in these three categories can be made from pre-entry data. Again it would be useful to examine each of the cases where large discrepancies occur between observation and forecast to attempt to determine whether these could have been predicted, by taking other data into consideration.

Sample S

37. Three-category analysis of the pre-entry data for sample S yields results shown graphically in Figure 18.5 and listed in Table APP 12.4.

38. The boundaries drawn on the plot reveal a structure very similar to that shown in Figure 18.4, showing that predictions of membership of the three groups may be defined in relation to variations in D_1 and D_2 scores in much the same way for both X and S samples.

39. D_2 is again closely aligned with the two-group eigenvector, shown in Figure 18.1, so that high probability of promotion is associated with the same variables.

40. High scores on T.EXAM and SP117E are associated with those who continue to serve though not promoted. The similarity with the X case is again striking.

41. Tendency to leave prematurely is shown by high scores on SP96, SP117M, MATH, F.OCC, A.AIB, CORPS, SOCS and FAT.RN.

42. Prediction accuracy is again indicated in a "hits and misses" table, the total hit rate being 82%.

Conclusions Drawn

43. These discriminatory analyses show clearly the power of the technique for investigations of this type and the potential of psychometric functions for long-term prediction.

44. Criteria used for the selection of candidates are seen to be very imperfect predictors of long-term success. B.MARK is of little value for any of the samples. T.EXAM is a good predictor of "no promotion" and the three-group analyses show that it best predicts propensity to continue to serve though not promoted.

45. SP tests provide valuable contributions, though the loadings differ considerably in the various samples. Most of the biographical variables are useful predictors and some, such as CORPS, SOCS, GAMES, F.OCC and T.HSC, particularly so.

46. The effect of introducing training variables into predictor functions is to improve the forecasts but in the X and S samples the forecasts available on pre-entry data alone are relatively good. There is a tendency for the introduction of training variables to lead to apparent inconsistencies because opposing contributions are sometimes required to suppress unwanted components of variance.

47. A summary of prediction accuracies for the various samples and data blocks is given in Figure 18.6.

48. Important differences in the qualities associated with long-term success are discernible in the functions derived for the various samples, emphasizing the need for each to be treated separately.

49. The findings of these analyses generally confirm and amplify those of the investigations of structure in Chapter 15. Taken together the two sets of results give considerable insight into the relationships associated with long-term prediction.

Variable	EIGENVECTOR		Order	
	−	+	P	NP
GT35	·0101		1	
SP96		·0326		1
SP21	·0023		5	
SP117E		·0064		12
SP117M		·0133		6
SP97		·0009		
SP160	·0094		4	
B.MARK	·0006		7	
B SD		·0013		
ENGL		·0023		11
GENL		·0027		
MATH		·0002		
PHYS		·0070		5
T.EXAM		·0008		10
F.OCC		·0590		2
T.HSC		·1204		3
A.AIB		·2343		4
CORPS		·0852		9
SOCS		·1140		7
GAMES	·2209		3	
PREF	·2579		2	
ON. CH	·0785		6	
FAT. RN		·1209		8
HMC.SC		·0247		

GROUP CENTROIDS	
Promoted	4·4706
Not promoted	4·7996

PREDICTION ACCURACY HITS and MISSES		
	Actually promoted	Actually not promoted
Forecast promoted	17	3
Forecast not promoted	4	31
% hits	81	91

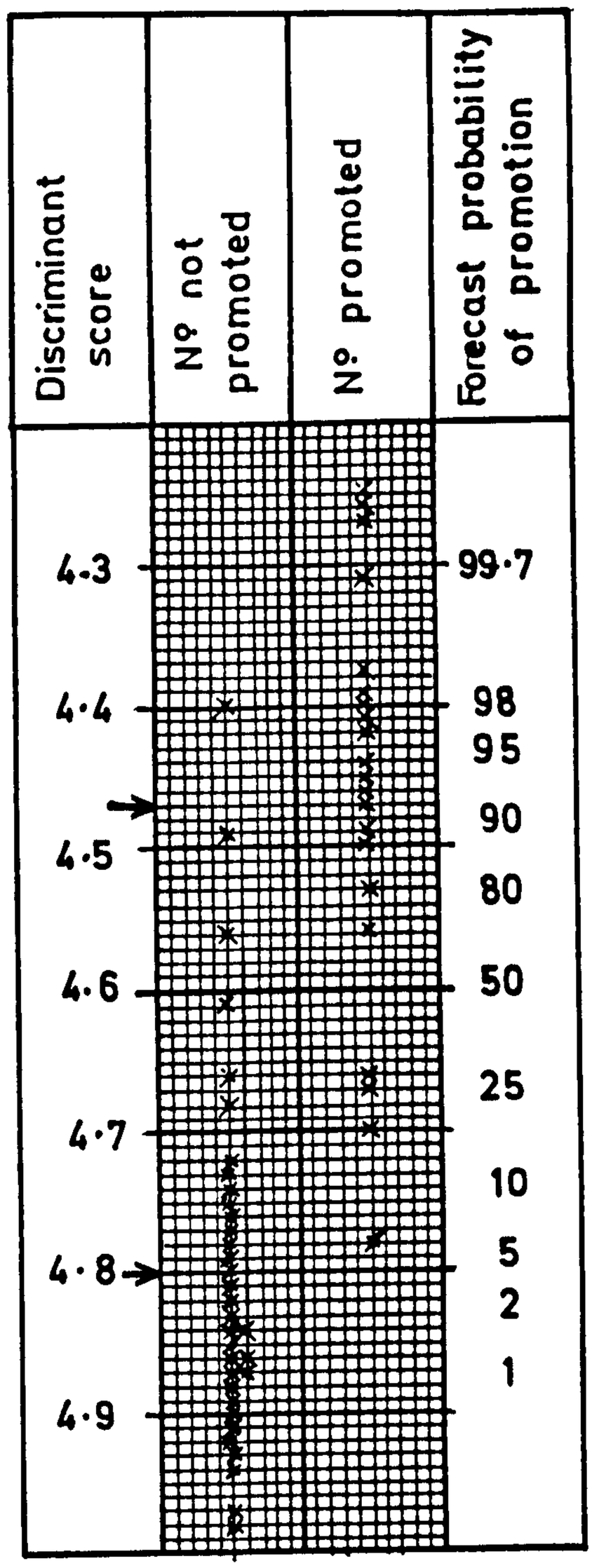


FIG 18.1 DISCRIMINATORY ANALYSIS OF 'S' PRE-ENTRY - TWO GROUPS

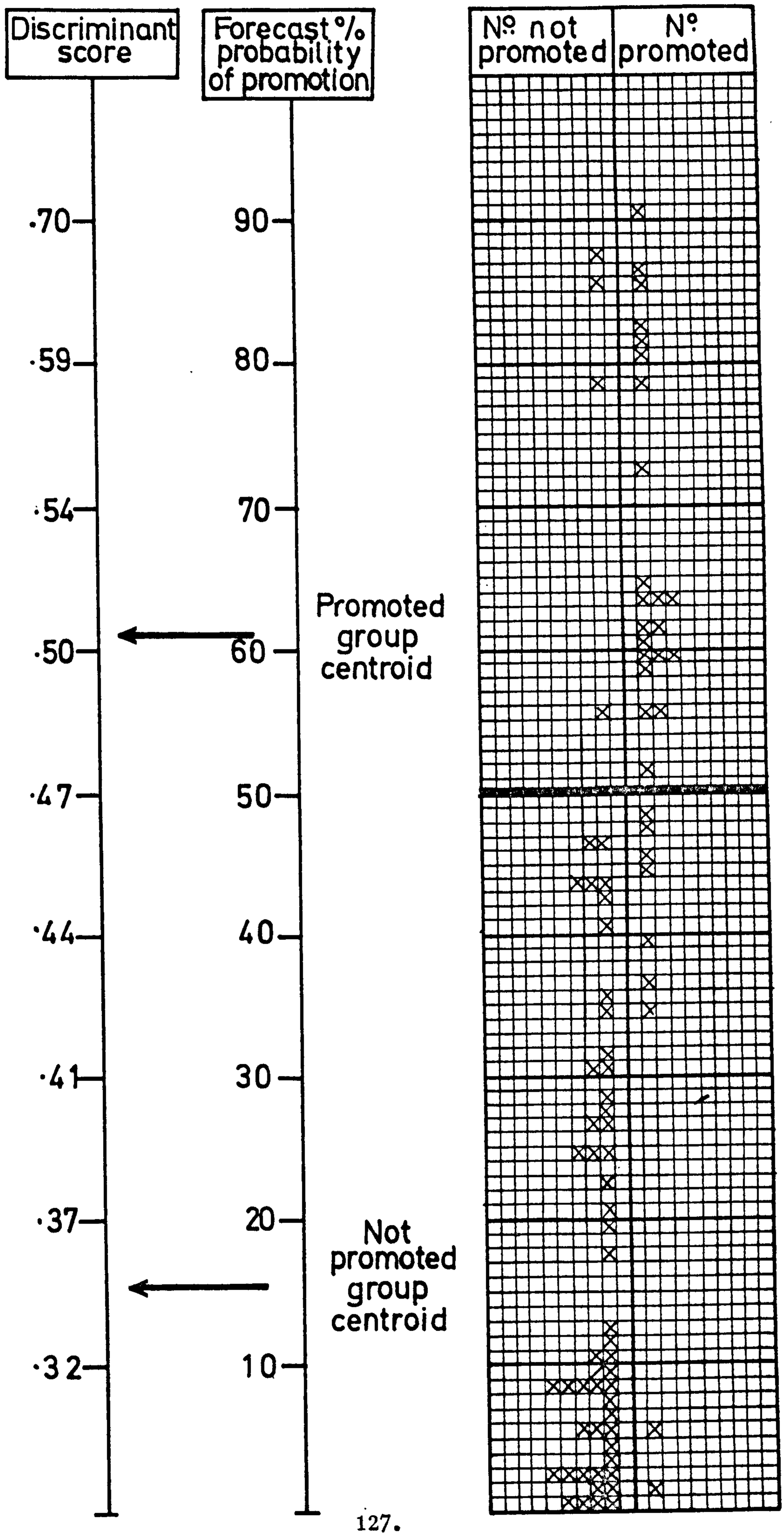


FIG 18.2 DISCRIMINATORY ANALYSIS OF X PRE-ENTRY DATA - COMPARISON OF FORECAST AND ACTUAL PROMOTION

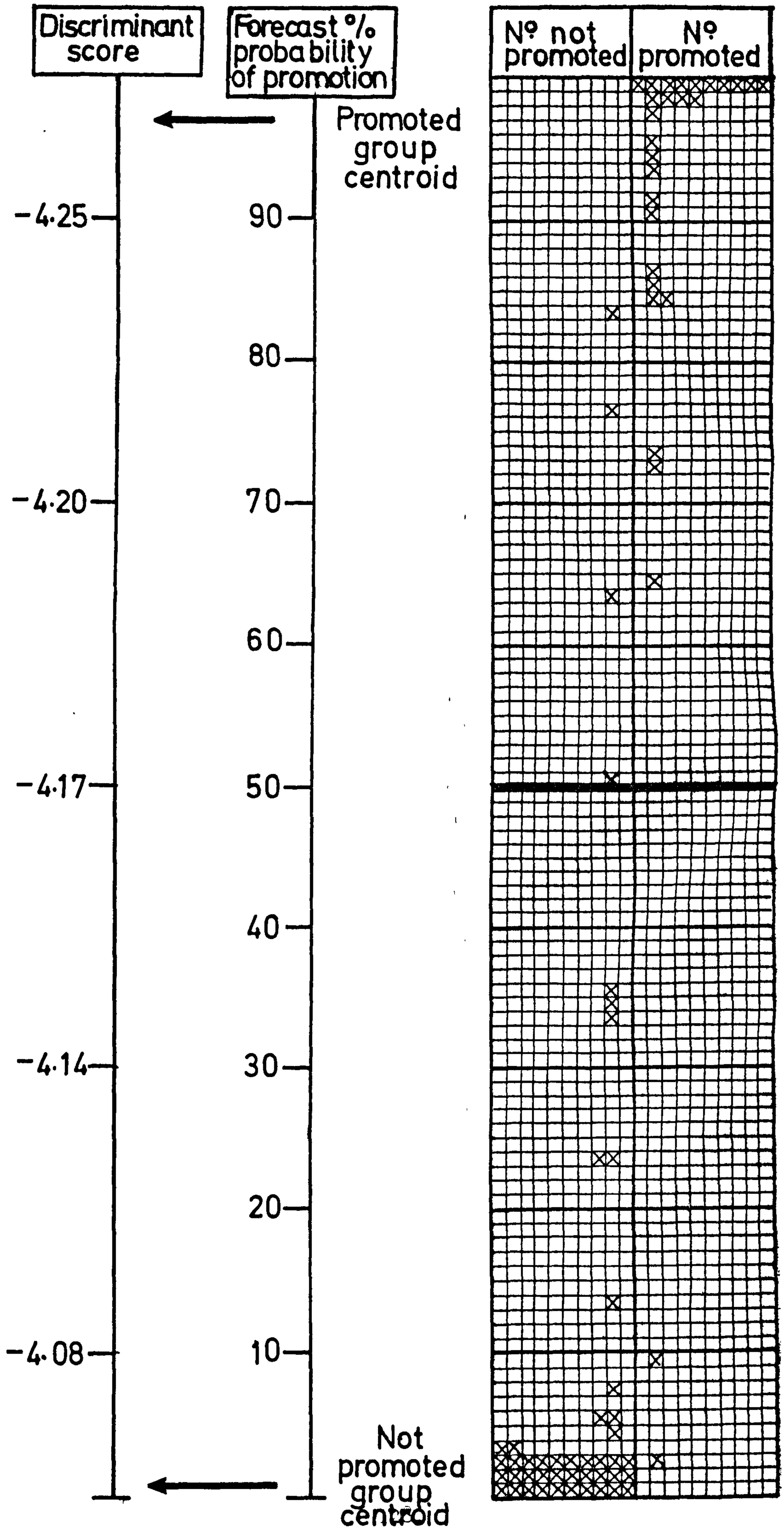


FIG 18.3 DISCRIMINATORY ANALYSIS OF X PRE-ENTRY AND TRAINING DATA - COMPARISON OF FORECAST AND ACTUAL PROMOTION

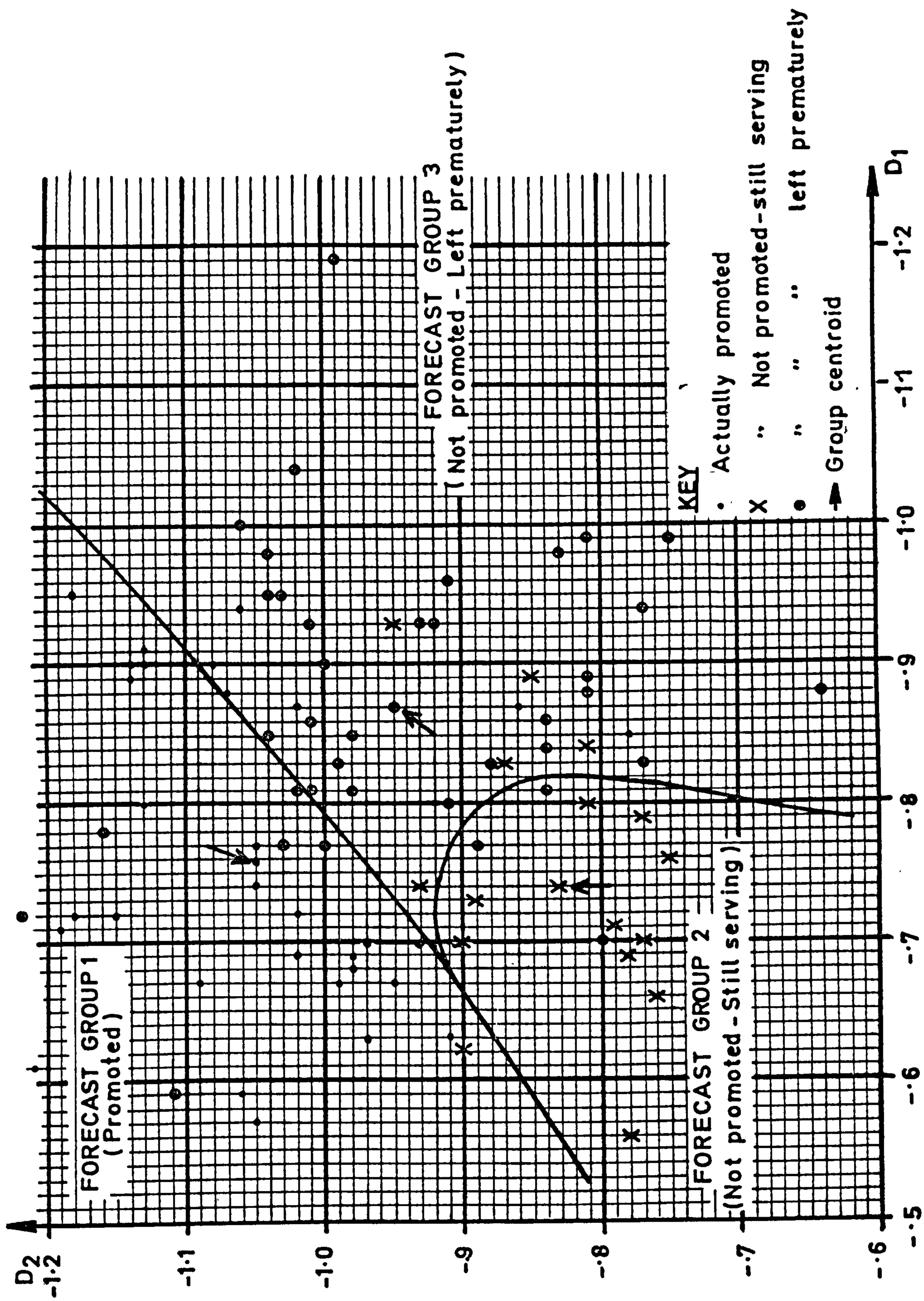
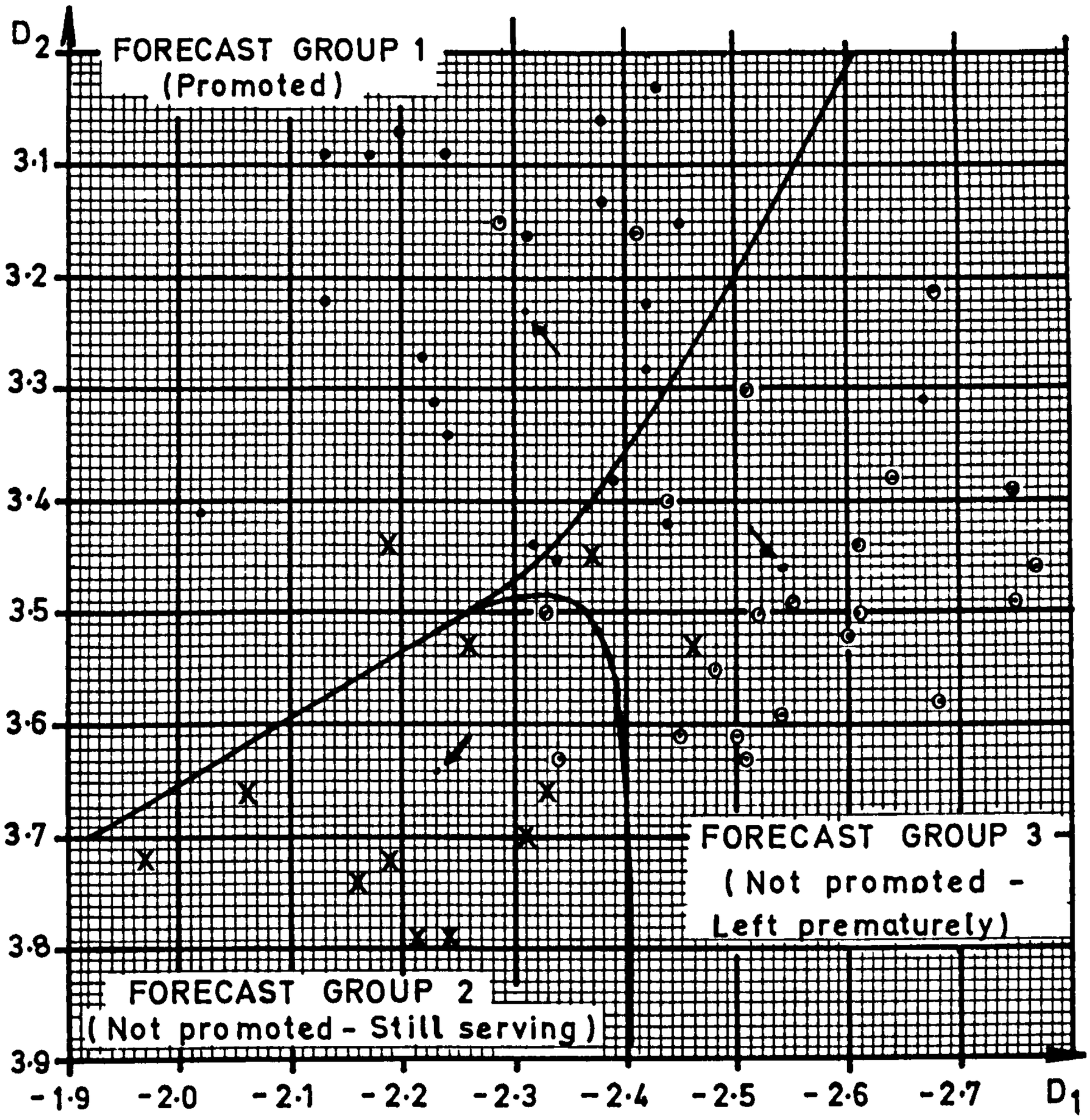


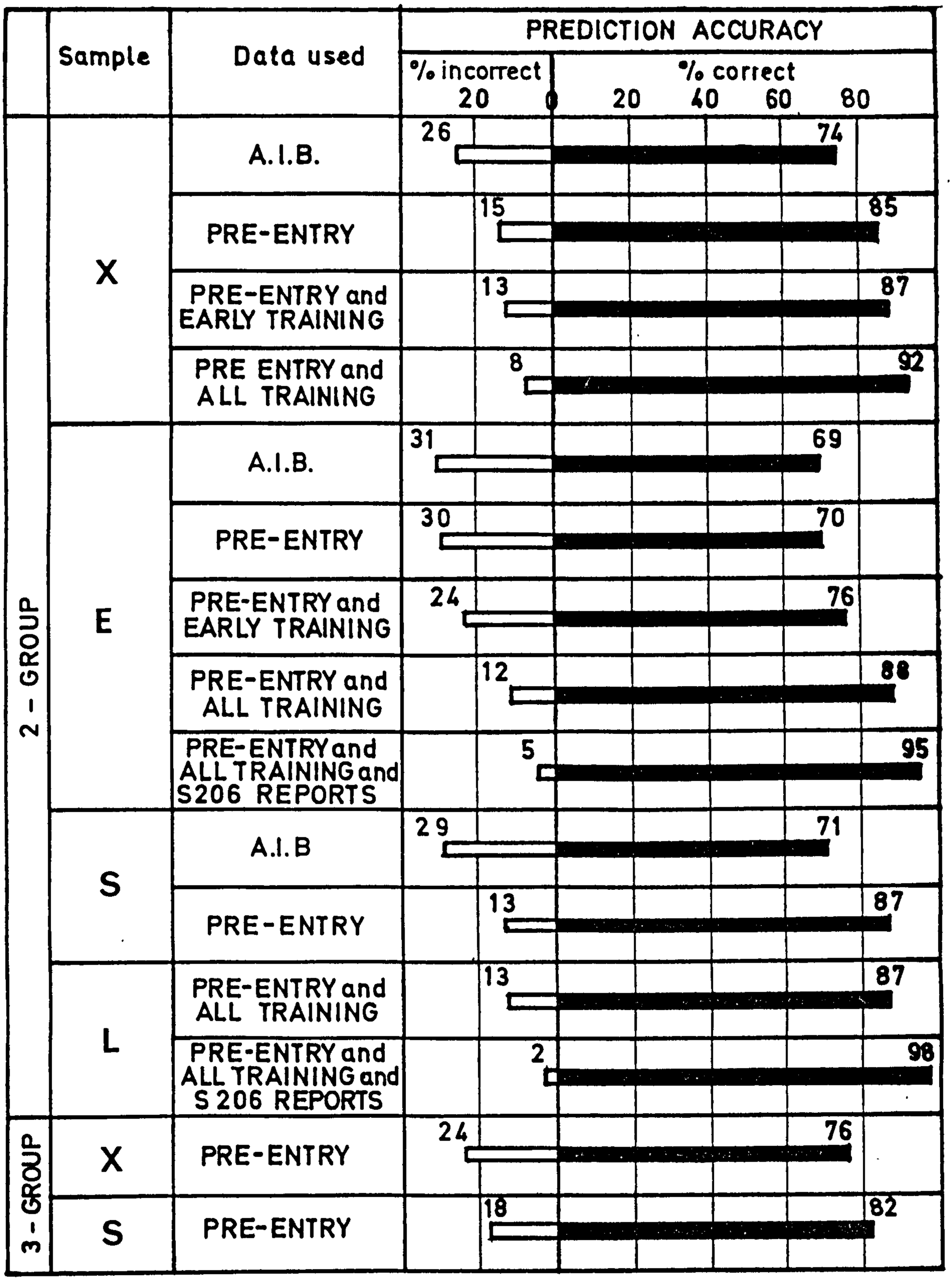
FIG 18.4 DISCRIMINATORY ANALYSIS OF X PRE-ENTRY DATA - COMPARISON OF FORECAST AND ACTUAL GROUPINGS IN THREE SUBSETS



KEY

- • Actually promoted
- X " not promoted, still serving
- ⊙ " " " left prematurely
- → Group centroid

FIG 18.5 DISCRIMINATORY ANALYSIS OF S PRE-ENTRY DATA - COMPARISON OF FORECAST AND ACTUAL GROUPINGS IN THREE SUBSETS



Note: A.I.B = C.S.C. Exams, S.P. Tests, and Board marks.
Pre-entry = A.I.B plus Biographical.

FIG 18,6 DISCRIMINATORY ANALYSES - COMPARISON OF PREDICTION ACCURACIES

CHAPTER 19

MULTIPLE REGRESSION ANALYSES

1. In contrast to Discriminatory Analysis, which is concerned with categorical prediction, the model of Multiple Regression Analysis assumes that an estimate of a measured criterion may be made from a linear combination of predictor scores. It is therefore a convenient instrument for investigation of ability/success relationships using test and examination results.

2. In situations where the number of predictors is large it is necessary to adopt a technique for selectinn of the most useful variables for construction of the regression function. Various techniques have been devised, some mathematical, some statistical and some essentially subjective.

3. Two techniques have been used in this study. The first, which has been termed Procedure 1, is based on the principle of minimising the error sum of squares and uses an algorithm discussed by Beale, Kendall and Mann (1967). The second is a stepwise procedure which ensures that each coefficient is significantly non-zero in the t-test sense at a specified level of significance.

4. Where the correlations between some of the predictors are high in comparison with correlations with the criterion there is often a variety of regression functions which are almost equally good predictors. Care is needed in the interpretation of results in cases such as these, and the models devised as a result of structural analyses reported in Chapter 15 are particularly useful aids to such interpretation.

5. As in Discriminatory Analysis, in functions using variables which measure a mixture of abilities it is not unusual to find that some tests contribute negatively to a prediction. This usually indicates that unwanted variance contributed by some other variable is being suppressed.

6. Regression functions have been derived for each sample for prediction of performance at various stages of training and subsequent career. At each stage a series of analyses examines the use of variables available at the various chronologically preceding stages. Thus, functions are derived for X officers for prediction of HMS DEVONSHIRE performance, (as measured by D.TOT), in terms of pre-entry variables,

and for the prediction of long-term success, (as measured by S.INDB), in terms both of pre-entry variables and of pre-entry plus training variables. In the case of the E and L samples relationships with derived S206 variables are also examined.

7. A large number of analyses has been completed and an attempt is made to summarise the implications of results. A representative selection of them is reported in more detail. In reports of Procedure 2 analyses all those regression coefficients whose 't' values reach the 20% significance level are indicated in the tables by + or -, according as their contribution is positive or negative. Those coefficients whose 't' values reach the 5% significance level are indicated by ++ or --. In all the Procedure 1 results quoted all coefficients are significant at the 5% level.

Sample X

8. The results of analyses of the X sample, summarised in Table APP 13.1, emphasize the differences between short-term and long-term success which are apparent from the model shown in Figure 15.9. The long-term results are also closely similar to those of the Discriminatory Analysis discussed in Chapter 18.

9. Examination of Table APP 13.1 shows that, although B.MARK and T.EXAM are useful predictors of HMS DEVONSHIRE training success, the contribution to long-term success of the latter is strongly negative. The CSC Physics exam, on the other hand, is a good predictor of S.INDB.

10. Of the SP tests, GT35 is a consistently good long-term predictor, but the spatial mechanical tests, though positive in the short-term become negative with S.INDB, particularly when training results bring in mixed cognitive contributions.

11. Biographical data makes a valuable oontribution, particularly in the long-term predictions. The multiple correlation for S.INDB is almost doubled by the inclusion of GAMES, F.OCC and A.AIB, the strongest contribution being that of F.OCC.

12. Using all significant pre-entry data multiple correlations of 0.650 and 0.515 are achieved with D.TOT and S.INDB respectively. Inclusion of training data raises the latter to 0.775.

13. Equations have also been derived using procedure 1. In both cases the regression functions represent the best subset of five predictors, having minimum error sum of squares of any subset of five. The functions are:-

$$\text{D.TOT} = 5.56\ (\text{SP117M}) + 3.71\ (\text{SP97}) + 2.04\ (\text{SP160}) + 0.49\ (\text{B.MARK}) + 0.60\ (\text{T.EXAM}) + 254. \qquad (R = 0.58)$$

$$\text{S.INDB} = 0.024\ (\text{GT35}) + 0.033\ (\text{GENL}) + 0.038\ (\text{PHYS}) - 0.006\ (\text{T.EXAM}) - 0.356\ (\text{F.OCC}) + 1.24. \qquad (R = 0.35)$$

14. The first equation shows particularly well the value of CSC examinations and SP tests for prediction of training success, and that a smaller contribution of B.MARK to B.AGG would have been more effective.

15. When applied to the subsequent two entries these equations both give accuracies of 71% in forecasting above/below median D.TOT and promotion/no promotion respectively.

Sample E

16. The results for sample E, shown in Table APP 13.2, again indicate important differences between short and long-term predictors. As with the X sample, B.MARK is a useful pointer to HMS DEVONSHIRE performance but has little long-term value. T.EXAM again contributes negatively in the long-term. The individual CSC examination scores on MATH and PHYS and GENL are all useful, indicating the greater connection of success with cognitive ability in the technical branch (see also the structure of S206 reports in Figure 17.1). Biographical data is also useful, particularly F.OCC in the short-term and GAMES in the long-term. Verbal-educational tests make a strong positive contribution to prediction of training success, but in this highly selected sample the spatial-mechanical tests contribute negatively. SP21 is a useful long-term predictor.

17. The inclusion of condensed S206 data raises the multiple correlation coefficient for S.INDB to 0.85 and it is interesting to observe that a function for regression of S.INDB on F1T1 to F2T8 alone gives R = 0.66, and on F1, F2, F1A, F2A gives R = 0.59. Thus the use of S206 data alone extracts 40% of criterion variance, but this is improved to 72% by use of pre-entry and training data.

18. For this sample only, an additional group of functions has been derived for prediction of S.INDC, the dichotomous variable indicating promotion/no promotion. The results generally agree with those for S.INDB, but are particularly interesting because the use of the value 1 for promotion and 0 for no promotion means that the predicted values are estimates of the probability of promotion. When the numbers of those for whom the estimates are above and below 50% are compared with actual promotion/no promotion the following total hit rates are deduced:-

Data used	Hit rate %
Pre-entry	67
Pre-entry + Dartmouth	67
Pre-entry + Dartmouth + HMS DEVONSHIRE	87
Pre-entry + all training	82*
Pre-entry + training + early S206	86*
Pre-entry + training + all S206	92*

* samples reduced by wastage

Thus, the long-term prospects of two out of three would be correctly predicted at entry. By the end of early training the accuracy of the forecast rises to 87%, and with the inclusion of condensed S206 data to 92%. These results are illustrated in Figure 19.1.

19. The best subsets of five predictors of D.TOT and S.INDB have again been derived using procedure 1:-

$$\text{D.TOT} = 1.56\ (\text{GT35}) - 3.19\ (\text{SP160}) + 0.43\ (\text{B.MARK}) + 1.73\ (\text{MATH}) + 2.14\ (\text{PHYS}) + 474. \qquad (R = .55)$$

$$\text{S.INDB} = 0.015\ (\text{SP21}) - 0.057\ (\text{SP117M}) - 0.030\ (\text{SP160}) + 0.037\ (\text{GENL}) + 0.026\ (\text{PHYS}) + 1.35. \qquad (R = .33)$$

20. When applied to the two subsequent entries these equations give success rates of 77% and 73% in forecasting above/below median D.TOT and promotion/no promotion respectively.

Sample S

21. Since no training data is available for the 'S' sample the investigations have been confined to prediction of S.INDB and are tabulated in Table APP 13.3.

22. As in X and E samples B.MARK has little long-term predictive value. Cognitive scores are useful, GT35 being strongly positive.

23. Procedure 1 analysis gave the following result with five predictors:-

$$S.INDB = 0.030\ (GT35) - 0.108\ (SP96) - 0.047\ (SP117M) - 0.051\ (GENL) + 0.008\ (MATH) + 5.93$$

with R = .44.

24. When applied to the subsequent two entries this equation correctly predicts 82% of promotions/no promotions, though the sample is very small.

Sample L

25. Because there is less AIB data for entry two, analysis is confined to entries one and three. The results are shown in Table APP 13.4, though the sample is very small and cannot be regarded as representative.

Sample F

26. The equations derived by procedure 1 for prediction of D.TOT and S.INDB in sample X were applied to the data for the rejected candidates, sample F. Out of a total of 250, 11 were predicted as above median D.TOT and 3 as probable promotions. The same three were forecast as probable promotions using the equation derived for sample E.

Conclusions Drawn

27. The results of the regression analyses generally confirm those of the structural analyses reported in Chapter 15, and of the discriminatory analyses in Chapter 18, and throw further light on the usefulness of various categories of data for prediction purposes.

28. The inclusion of biographical data enables relatively high multiple correlations to be achieved and in the absence of cross-validation of these functions there must remain some doubt whether the improvements are partly a result of capitalising on change associations. Some of the contributions, such as those of F.OCC and A.AIB appear so generally consistent, however, that there is reason to suppose them reliable.

29. Of the two measures used for selection purposes, viz B.MARK and T.EXAM, the former is a useful predictor of early training performance but is generally less so in the long term. T.EXAM is clearly associated with "no promotion". Individual examination scores on the other hand are valuable indicators, though there are clear differences between branches,

particularly in the long-term.

30. The predictive value of cognitive scores generally is high in comparison with judgmental and it must be concluded that greater dependance on the former would be justified, though the consequences of sample truncation are difficult to assess.

31. Despite all the reservations which must be made multiple correlations in the order of 0.8 for prediction of long-term success fifteen years earlier, at the end of training, are encouraging. There appear to be good grounds for expending effort on further cross-validation when this is feasible and for optimising the functions with a view to assessing the implications on selection procedure.

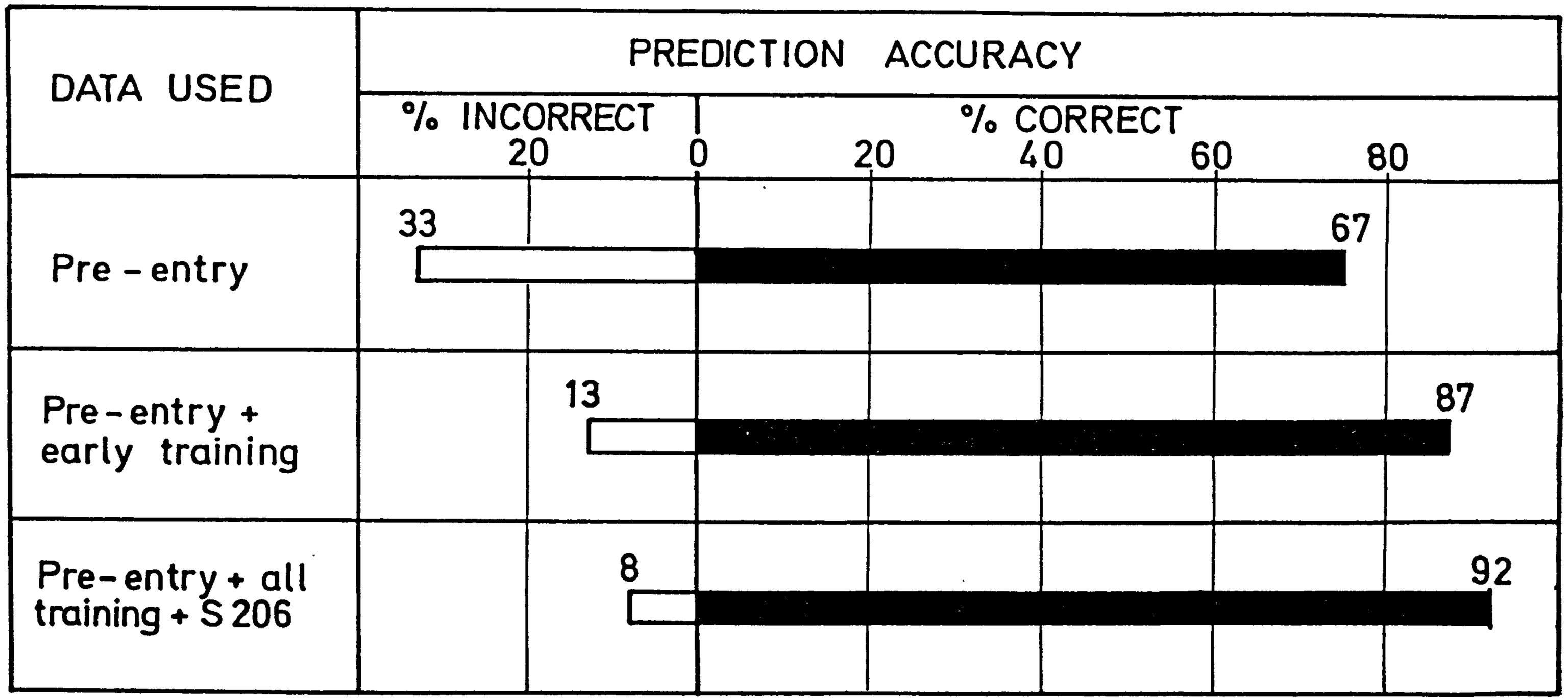


FIG 19.1 'E' REGRESSIONS - ACCURACY OF PROMOTION PREDICTIONS

PART 5

C O N C L U S I O N

Chapter 20 An Overview of the Primary Investigations

21 Conclusions from the Primary Investigations

CHAPTER 20

AN OVERVIEW OF THE PRIMARY INVESTIGATIONS

1. This paper is the report of a follow-up of naval officers to age forty. The investigations span some twenty years of training and subsequent career. They are aimed at identifying the abilities associated with success and assessing the effectiveness of the selection procedure and of training criteria for determining these abilities. The usefulness of various classes of cognitive, biographical and judgmental data for predictive purposes is examined.

The Data

Reference: Part 3

2. The samples used in the statistical investigations include some 300 officers who joined the Seaman, Engineer, Supply and Electrical branches via Special Entry cadetships between February 1947 and August 1949. Data relating to a further 250 rejected candidates has also been examined.

3. Information used in the analyses comprises biographical items, selection scores (CSC examinations, psychological tests, and interview board marks), training course results and subsequent career reports. Success criteria include training course aggregates, a composite measure of overall training achievement and a synthetic variable denoting long-term success.

Officer Selection Procedure

Reference: Chapters 2 and 8

4. An entirely new procedure for the assessment of candidates for Special Entry cadetships in the Royal Navy was introduced in 1947, replacing the old-style brief interview.

5. Under the new procedure candidates for the Seaman (X), Supply (S) and Engineer (E) branches were considered for selection on the basis of their performances in:-

a. (as before) a group of written educational examinations, some compulsory, some optional, set by the Civil Service Commissioners, the individual subject marks being summed to give a total score, T.EXAM.

b. a series of individual and group tasks, interviews and psychological tests, after consideration of which, together with details of background and school reports the Admiralty Interview Board awarded a "total personality" score, B.MARK.

6. The two scores, T.EXAM and B.MARK, were added in the proportions 8 : 3 to produce an aggregate selection score, B.AGG. For selection purposes candidates were placed in order of merit of B.AGG score, though there were certain other qualifications such as minimum medical standards and minimum subject marks for specific branches.

7. Candidates for the Electrical (L) branch were required to attain a minimum standard in Higher School Certificate and were placed in order of merit on the basis of B.MARK alone. In the special case of the second electrical entry the AIB reverted to the "old-type" procedure in which marks were assessed after only a brief 10-15 minute interview and consideration of school report.

Analysis of Selection Data

Reference: Chapters 8, 15 and 16

Basic Structure

8. Investigations on a sample of 520 selected and rejected candidates have shown that a model can be constructed in which three near-orthogonal clusters, or components, may be discerned among the variables on which all X, E and S candidates were scored during the selection process. These may be identified, as shown in Figure 20.1, as verbal-educational ability, V:ED, spatial-mechanical ability, K:M, and personality, P.

9. V:ED and K:M were measured by a battery of SP tests, the results of which were not used directly but were available as one item of information which the AIB might consider in arriving at B.MARK. The near-orthogonality of P, as measured by B.MARK, to the cognitive plane containing V:ED and K:M shows that the board was little influenced by the SP tests. (There is evidence that certain board members, viz the Psychologist and the Engineer officer, were a little more influenced than others).

10. The vectors of the CSC examinations lie in the cognitive plane, Mathematics and Physics having almost equal loadings on V:ED and K:M (i.e. bisecting the angle between them) and English and General roughly orthogonal to Mathematics and Physics, associated with high V:ED and low K:M. The total examination score vector, T.EXAM, which includes optional examination subjects falls close to V:ED.

Biographical Data

11. Analyses of data on 262 selected candidates have shown that some items of biographical data are useful predictors of later performance. These variables have been located in the model and although generally the biographical variables are loaded on all three primary components, certain of them are relatively pure.

12. T.HSC, A.AIB, SOCS and GAMES all lie close to the cognitive plane, though the last two have some P loading. T.HSC is almost collinear with T.EXAM, showing that those candidates who spent longest in sixth-form study did best in the CSC examinations (and had the highest V:ED ability). The vector - (A.AIB) is almost coincident with that of the CSC General examination, showing that the youngest candidates did best in this subject. It is interesting that positions of leadership in school societies and games are associated more with cognitive abilities than with personality.

13. Three biographical vectors which lie close to the personality axis are CORPS, HMC.SC and F.OCC. Those candidates who held positions of leadership in school corps, those who attended an HMC school, and those whose fathers' socio-economic status was highest all tended to achieve high P ratings but their cognitive ratings were little different from others.

14. As an aid to interviewing candidates were asked to indicate amongst a battery of thirty activities those in which they were particularly interested or disinterested. Analysis of this data was attempted, with a view to identifying groups of interests which might have some bearing on future performance. This analysis failed to reveal any significant clusters of interests and it is concluded that the vagueness of the definitions introduced too much error for any meaningful results to be derived. It is likely that a suitably designed questionnaire would be needed for useful results to be derived by analytical means.

Use of the Model

15. These analyses of selection data provide a conceptual basis for investigations of prediction of performance during officers' training and their subsequent careers. It would have been possible to derive scores representing each individual's ratings on the three primary characteristics, and to use these scores for predictive purposes. It was decided rather to locate the training and career variables in the structure for reference and to use "raw" variables, which are more tangible, for predictor functions. This approach has the additional advantage that the predictive investigations help to throw further light on the adequacy of the model.

Analysis of Training Data

Reference: Chapters 9, 14, 15 and 19

Training Data

16. Formal training has been considered in two stages. The first, common to all branches, included a period of one term at Dartmouth followed by two terms in the cadet training cruiser, HMS DEVONSHIRE, and was devoted to naval familiarisation and general naval training. The second stage included periods of further education and of specialist training, the duration and content of which varied from one branch to another.

17. Variables representing results in the various courses have been used in the analyses, individual subject marks as predictors for long-term studies and course aggregates as criteria for short-term follow-up. A general criterion of training success, T.LCDR, indicative of the amount of seniority gained in training, has also been used.

Prediction of Training Success

18. Analyses of data structure for each branch show that, although considerable distortion occurs as a result of the high degree of selection, the basic three-dimensional framework is still clearly discernible.

19. Three-dimensional models, depicting the relationships of selection and training variables for E and X branches, are illustrated in Figures 20.2 and 20.3 (which are based on Figures 15.5 and 15.9). Almost all of the individual training course results vectors, and the overall

training success vector T.LCDR, lie close to, or in, the cognitive plane containing V:ED and K:M, a result which accords closely with Vernon's model of educability (Figure 15.2). Thus the CSC examinations and SP tests are generally good predictors of training success as measured by course results. The AIB assessment B.MARK, on the other hand, is a relatively poor predictor in these terms. It is important to note, however, that some examinations and tests may be much better predictors than others for a particular course result, depending on the content of the course, or rather its examination i.e. the relative V:ED, K:M loadings.

20. An important exception to the general rule is apparent in the results of HMS DEVONSHIRE training. The aggregate score, D.TOT, for this course included a mark for "officer-like-qualities", OLQ. Although all other subject vectors lie close to the cognitive plane the OLQ vector has a large P loading. Thus B.MARK is a good predictor of OLQ and hence contributes significantly to prediction of HMS DEVONSHIRE total. The results of cross-classification analysis, illustrated in Figure 14.1, show that aggregate selection score, B.AGG, containing, as it did, a large proportion of T.EXAM and a smaller proportion of B.MARK, was a good predictor of HMS DEVONSHIRE total.

21. The large proportion of T.EXAM and the minimum cut-off level in Mathematics and Physics helped to ensure also the success of prediction in terms of later specialist course results for X and E officers.

22. Multiple regression analysis has been used to derive optimum five-variable predictor functions for D.TOT using variables selected from CSC examinations, SP tests and board mark. The equations, for seaman and engineer officers respectively, are:-

$$\text{D.TOT} = 5.56\ (\text{SP117M}) + 3.71\ (\text{SP97}) + 2.04\ (\text{SP160}) + 0.49\ (\text{B.MARK}) + 0.60\ (\text{T.EXAM}) + 254 \text{ with } R = 0.58$$

$$\text{D.TOT} = 1.56\ (\text{GT35}) - 3.19\ (\text{SP160}) + 0.43\ (\text{B.MARK}) + 1.73\ (\text{MATH}) + 2.14\ (\text{PHYS}) + 474 \text{ with } R = 0.55$$

23. These equations illustrate the value of SP tests and educational examinations for prediction of training performance and show that a reduced proportion of B.MARK in the selection score would have given a better prediction of HMS DEVONSHIRE aggregate mark. This is clearly apparent from the ability/success models which show that the optimum

B.MARK contribution is entirely dependant on the weighting of OLQ in D.TOT.

24. The equations also illustrate the importance of individual test and examination scores, as distinct from aggregates, for prediction purposes. The models indicate that some, whose vectors lie close to the required direction, may be much better predictors than others, though all lie in the cognitive plane, and this is demonstrated in the predictor function for engineer officers.

25. The inclusion of biographical variables whose coefficients are significant at the 20% level raises the X and E multiple correlations to 0.65 and 0.63 respectively. Thus, although there is some possibility that these improved forecasts are the result of capitalising on chance association, nevertheless they suggest that the psychometric use of biographical data is worthwhile, particularly where non-cognitive contributions are significant.

26. Summing up, selection score markings effectively predicted success of naval officers in their early role as students, but the forecasts could have been improved by using appropriately weighted combinations of cognitive and biographical variables in addition to B.MARK and T.EXAM.

Analysis of Post-Training Data

Reference: Chapters 10, 14, 15, 17, 18 and 19

S206 Reports

27. Throughout his career each officer is assessed by his commanding officer, at least once a year, on report form S206. The assessments are both verbal and numerical. Before 1960 numerical assessments were given on five personal qualities and after 1960 on ten.

28. A study by Professor Vernon in 1961 showed that analysis of the verbal comments adds little to the information obtainable from numerical assessments, probably because of difficulties of quantification. (There is an infinite variety of expression which, though of value to a promotion board of experienced officers, is difficult to convert into purely numerical terms.) Analyses have consequently been confined to the numerical assessments.

29. Structural analyses of some 3,781 reports on 246 X, E and L officers show that the structures of pre '60 and post '60 reports are essentially

similar. In both cases, and for all branches, a two-dimensional model can be constructed in which the vectors of the various personal qualities fall between oblique axes which may be identified as "intelligence" and "social skills". It seems likely that the "intelligence" vector lies in the cognitive plane of the pre-entry and training data, (i.e. Vernon's "g" factor), and that the "social skills" vector may be closely identified with the P axis, (i.e. Vernon's "X" factor), though these relationships have not been studied analytically.

30. An important difference between Engineer and Seaman branches, which is apparent from the structural analyses, is illustrated in Figure 20.4. For Engineer officers, particularly Electrical, the "professional ability" vector lies relatively close to the "intelligence" axis. For Seaman officers "professional ability" has a substantial loading on "social skills". It seems reasonable to expect that long-term (i.e. managerial) success is related to both intelligence and social skills, but, since professional ability plays an important part, it is also likely that long-term success of Engineer officers may be less related to "social skills", and more to "intelligence", than that of Seaman officers.

31. In order to assess the predictive value of S206 reports vis-a-vis pre-entry and training data it is necessary to condense the report data. A selection of eight reports on each Engineer officer has been processed to give two pairs of factor scores, one pair representing performance as a Lieutenant, the other pair as Lieutenant Commander.

Long-term Criteria

32. Long-term success has been measured primarily in terms of promotion to the rank of Commander. All officers are considered for this promotion by a central selection board every six months as they pass through a zone of seniority as Lieutenant Commanders. The smoothed extraction rates are roughly constant (at about one third of original entry for the groups considered). The dichotomous classification "promotion/no promotion" is therefore a simple measure of the service's assessment of officers' managerial worth.

33. Success may also be considered in terms of length of service, since those who are least satisfactory and those who are least satisfied are likely to leave soonest. A three-way classification "promoted/not

promoted - still serving at zone top/not promoted - left prematurely" therefore combines the concepts of satisfaction and satisfactoriness.

34. Both the two-way and the three-way classifications have been used for a series of discriminatory analyses, discussed below, but a more elaborate measure of long-term success, termed S.INDB, has been designed for use as a criterion in multiple regression analyses.

35. This variable takes account of time-to-promotion and length-of-service and in effect provides a graded scale based on the three-way classification. Officers promoted earliest have the highest score and those withdrawn from training the lowest.

Prediction of Long-Term Success

36. The location of the S.INDB vector in the three-dimensional model of selection and training data varies from branch to branch. In E and S branches the vector lies close to the cognitive plane but in the X branch it has a substantial "personality" loading.

37. The vector locations for the E and X branches are shown in Figures 20.2 and 20.3. These illustrations tend to confirm the conclusions drawn from the structural analysis of S206 report data and show that B.MARK has little relevance to the prediction of long-term success in the E branch, though rather more in the X branch.

38. The predictive value of cognitive data varies considerably and the importance of isolating individual tests and examinations which are appropriately orientated for the particular branch is clearly apparent from the structural, discriminatory and regression analyses. The three-category discriminatory analyses show that in X and S branches the selection examination total, T.EXAM, is a good predictor for the class "not promoted - still serving at zone top". In both discriminatory and regression analyses the verbal reasoning test, GT35, proves to be a good guide to promotion prospects in X and S branches, and similarly the CSC General and Physics examinations in X and E branches. The clerical aptitude test, SP21, is a useful predictor for E officers but spatial-mechanical tests appear negatively for E and S branches.

39. Optimum five-variable regression functions, which have been derived for prediction of S.INDB in X, E and S groups, illustrate the value of individual cognitive contributions.

X officers:-

$$S.INDB = .024\ (GT35) + .033\ (GENL) + .038\ (PHYS) - .006\ (T.EXAM) - .356\ (F.OCC) + 1.24 \text{ with } R = 0.35$$

E officers:-

$$S.INDB = .015\ (SP21) - .057\ (SP117M) - .030\ (SP160) + .037\ (GENL) + .026\ (PHYS) + 1.35 \text{ with } R = 0.33$$

S officers:-

$$S.INDB = .030\ (GT35) - .108\ (SP96) - .047\ (SP117M) - .051\ (GENL) + .008\ (MATH) + 5.93 \text{ with } R = .44$$

40. The use of significant biographical variables in the regression functions raises the variance extracted from about one tenth to one quarter. This may be partly due to chance associations but some contributions, such as socio-economic status, are strikingly consistent. The three-category discriminant analysis shows that, in X and S branches, low status indicates propensity to leave the service early. It is interesting that this P-orientated variable is a more useful long-term predictor than B.MARK.

41. HMS DEVONSHIRE training total score, D.TOT, provides a better forecast of long-term success than later training, chiefly because of the low K:M loading of the examinations and the P loading of the OLQ score. Inclusion of HMS DEVONSHIRE results in the regression functions enables about 40% of criterion variance to be accounted for. Later training results improve this to 60% for X officers but only to 47% for E officers. Use of condensed S206 report data enables the latter to be raised to about three-quarters of the total, compared with 40% using S206 data alone.

42. Most of the predictors of long-term success are derived in terms of S.INDB, a synthetic measure of career performance. Use of an alternative, dichotomous, measure for the E sample demonstrates one approach to prediction of probability of promotion. Tests on the parent sample show that two-thirds of promotions could have been correctly predicted from pre-entry data and almost 90% at the end of HMS DEVONSHIRE training.

43. In the discriminatory analyses also the inclusion of training data improves the forecasting accuracy, but the hit rates of 85%, 70% and 87%

on X, E and S pre-entry data alone are surprisingly high, referring as they do to promotions some twenty years later. Again there is a possibility that chance associations in biographical data inflate the scores, and cross-validation has been limited to cognitive functions and data. The results of three-category analyses are particularly interesting, since they enable the attributes associated with various propensities to be clearly identified whilst avoiding the necessity for the synthetic variables, assumed to be linear, required in regression analysis.

Summary

44. Many predictor functions have been derived, both discriminant and regression, illustrating the contributions of various types of variable to the forecasting of student and managerial success. The potential variety of these functions may readily be understood when the problem of prediction is viewed against the conceptual models of educability and occupational aptitude in which the success vectors are located in relation to a cognitive, or general intelligence, plane and an orthogonal personality axis. There is a multiplicity of functions, many of them equally good from a statistical viewpoint, each depicting an appropriate "mix" of measures of intelligence and personality for a particular forecast.

Training Success

45. Training success vectors lie almost wholly in the cognitive plane, illustrating their dependance on measures of verbal-educational and spatial-mechanical ability. The most appropriate predictors vary considerably according to the content of the training courses (cf Figure 15.2), but success in training, as measured by course results, is determined almost entirely by intelligence. Exceptionally, the total score for early training performance in HMS DEVONSHIRE included a mark for "officer-like-qualities", the latter having a high personality loading. Because of this the composite measure of educability and personality used at selection was a successful predictor of HMS DEVONSHIRE performance, though it would have been more successful with a smaller personality weighting.

Long-term Success

46. The factors associated with post-training career performance vary from branch to branch (cf Figure 15.4). Professional ability and

managerial success in the Engineering branches are closely related to "intelligence". In the Seaman branch "personality" plays an important part. Within the intelligence plane the contribution of spatial-mechanical ability to long-term success is generally much smaller than that of verbal-educational ability. Indeed in these highly selected samples K:M tends to contribute negatively to managerial success. Selection score rankings are only a mediocre guide to long-term success amongst selected candidates and considerably better forecasts can be obtained by appropriate choice of predictors (individual selection examination marks, psychological test scores and biographical variables).

47. The results of Engineer officers' courses are not particularly relevant to long-term success since they tend to be too heavily loaded on K:M, though individual subjects with relatively high V:ED loading, such as mathematics, electrical engineering and chemistry, are better pointers. Seaman officers specialist courses, with their low K:M loadings, are considerably better predictors. The best forecasts of long-term success are, however, given by the HMS DEVONSHIRE total score, with its combination of low K:M and some personality loading.

Prediction Techniques

48. The use of regression analysis for the validation of selection procedures is traditional but this investigation shows that, for the practical problem of personnel selection, discriminatory analysis has distinct advantages. From a mathematical viewpoint the avoidance of the need to design synthetic and assumedly linear criteria has obvious merit. From a more practical viewpoint, selectors are normally concerned with categorical, (i.e. suitable/unsuitable) rather than quantitative, (i.e. how suitable), prediction. The potential value of discriminatory analysis for categorical prediction is clearly demonstrated in the three category analyses for X and S branches.

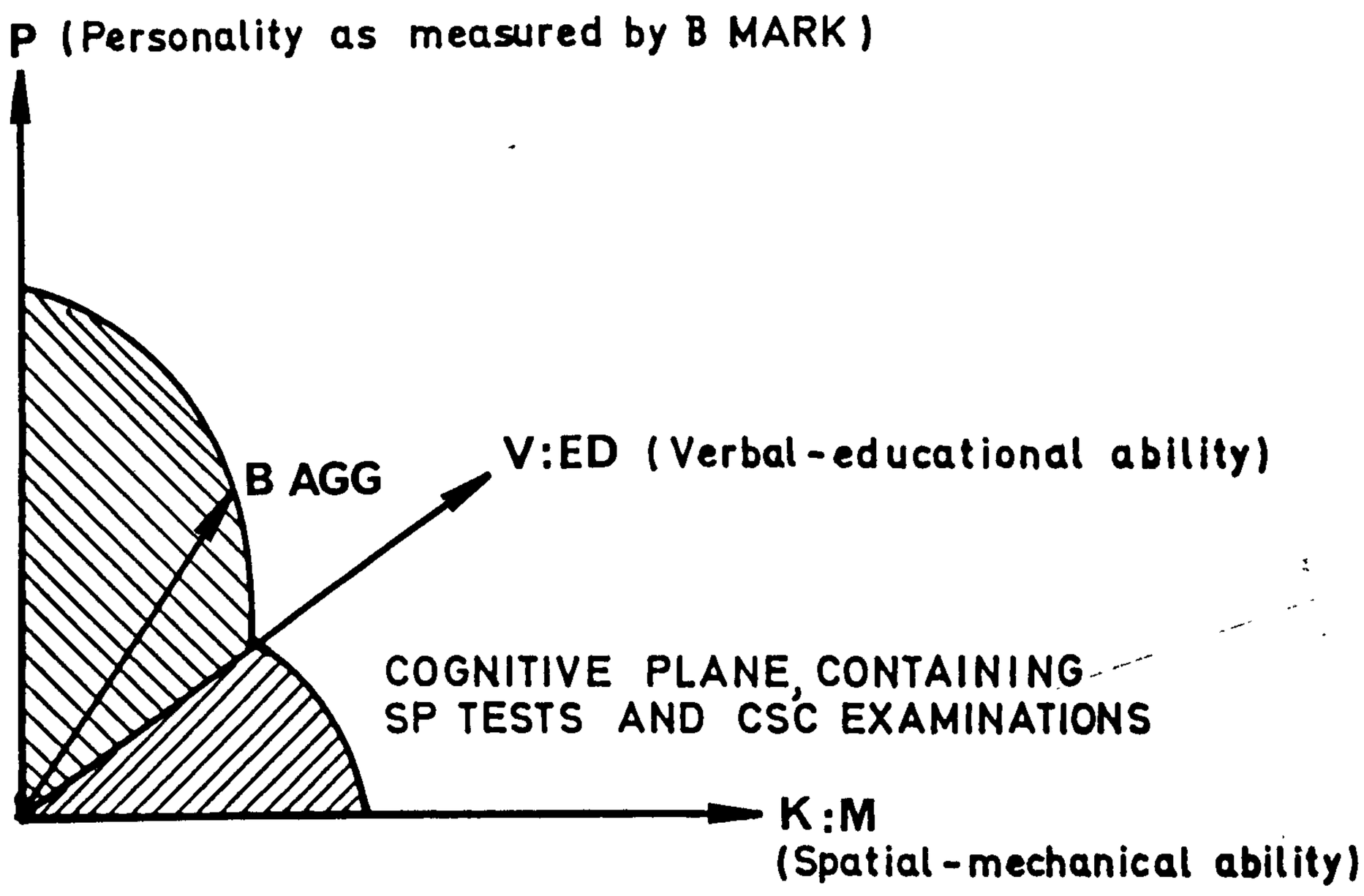


FIG 20.1 STRUCTURE OF SELECTION VARIABLES

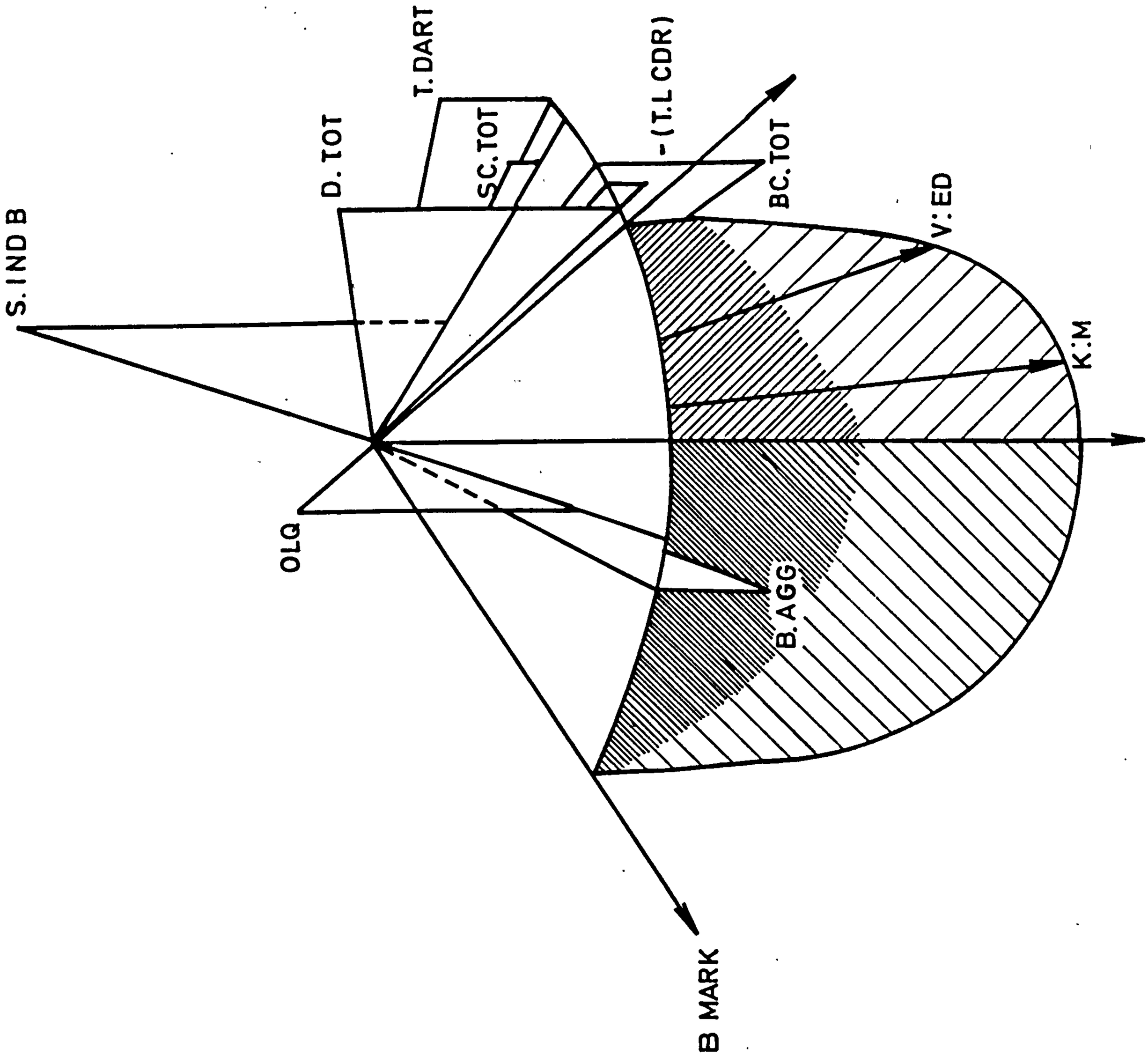


FIG 20.2 STRUCTURE OF KEY VARIABLES: E

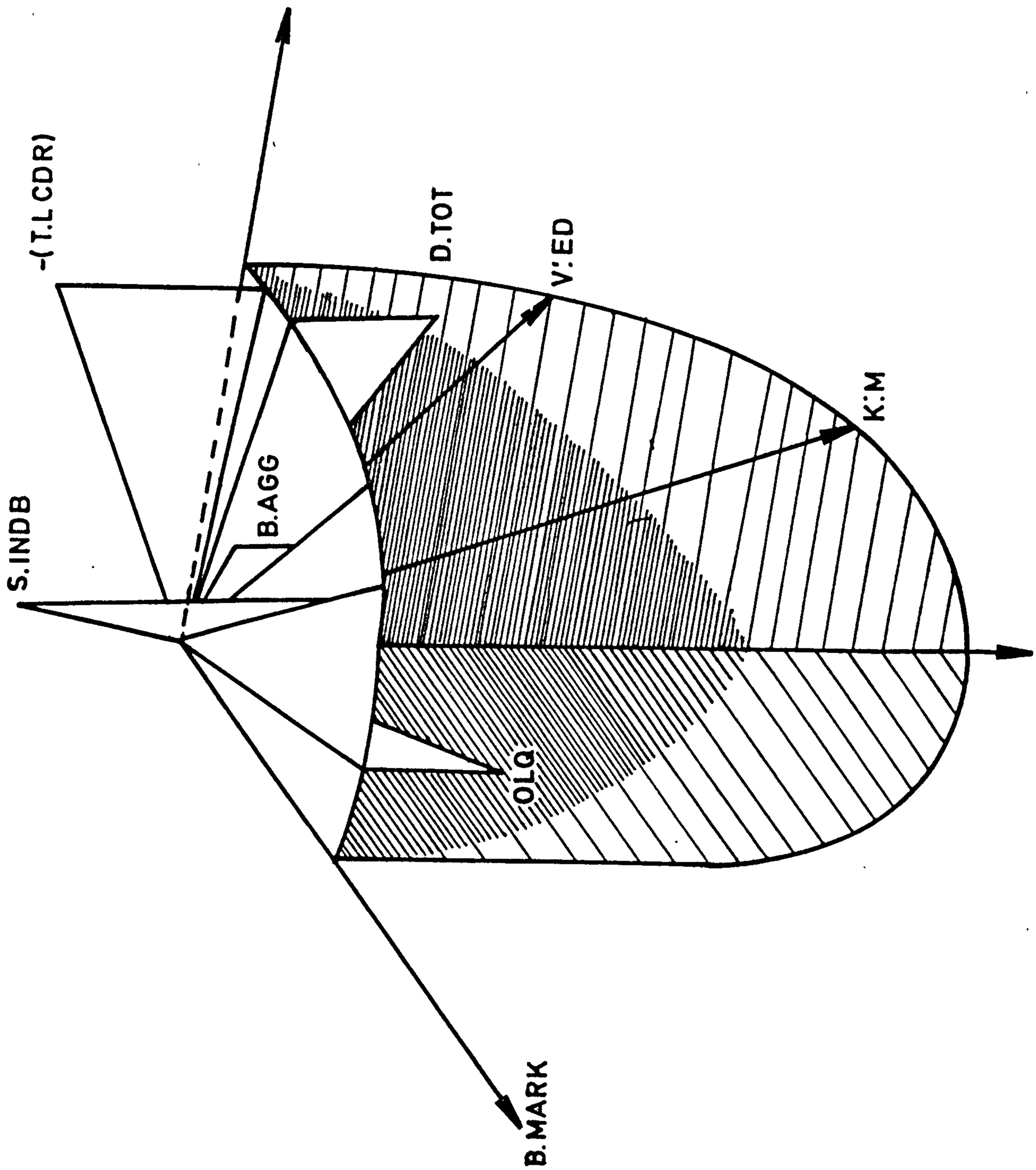


FIG 20.3 STRUCTURE OF KEY VARIABLES: X

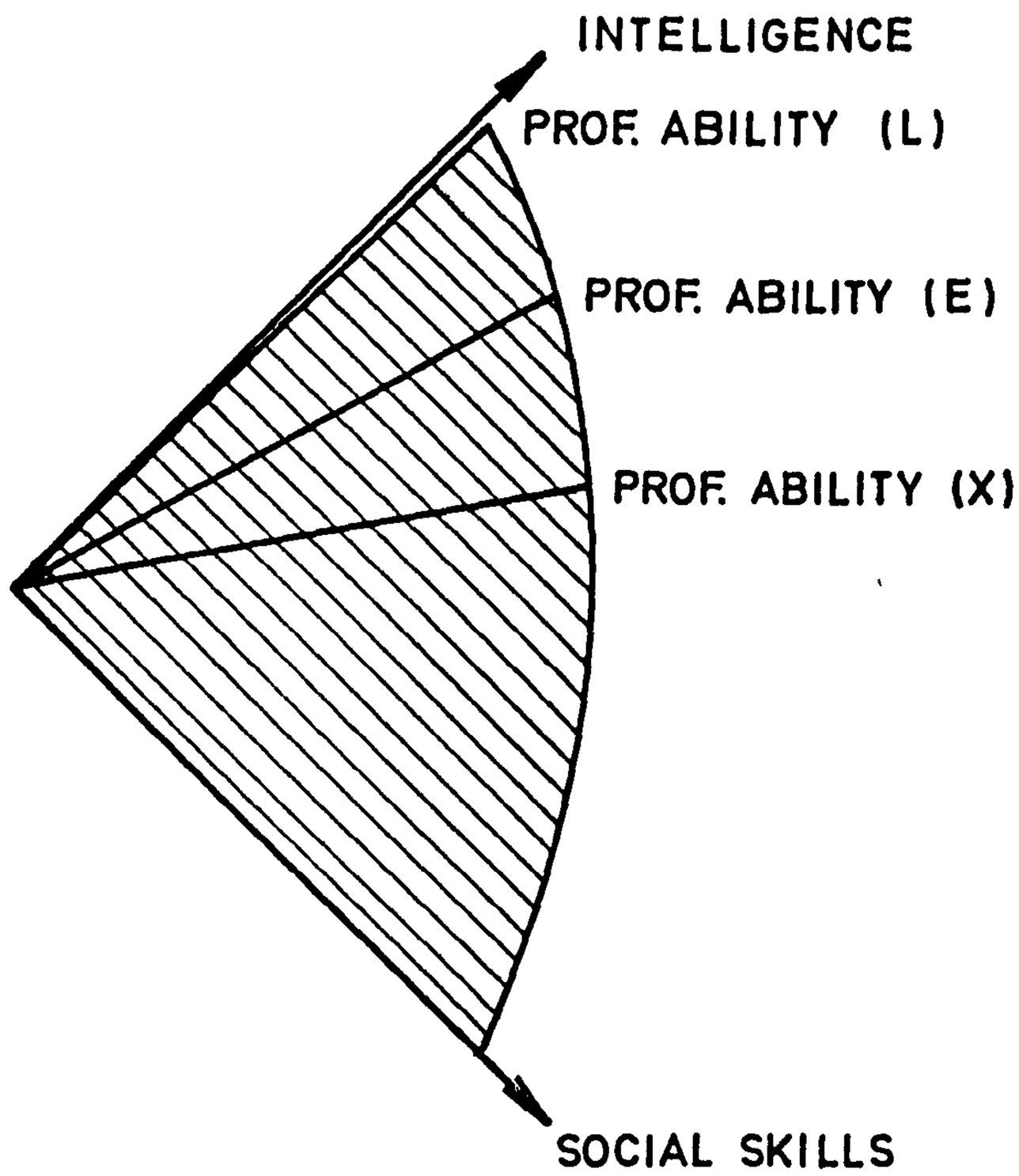


FIG 20.4 STRUCTURE OF S206 DATA

CHAPTER 21

CONCLUSIONS FROM THE PRIMARY INVESTIGATIONS

1. A quarter of a century has passed since the Board of Admiralty approved the introduction of a new and more elaborate selection procedure, designed to filter candidates for officer cadetships in the Royal Navy by means of a composite measure of educability and personality.

2. This investigation has sought to identify the abilities associated with success using data recorded during selection and throughout the careers of some 300 officers. It examined the effectiveness of the "new-type" selection procedure for determination of these abilities, and in the more pragmatic terms of the direct relationships between promotion, length of service, training course results and selection scores.

3. The usefulness of various classes of data for predictive purposes has been assessed and the merits of judgmental and psychometric prediction have been compared. For the purposes of psychometric prediction the classificatory techniques of discriminatory analysis have been considered as well as the more conventional regression analysis.

What are the abilities associated with success?

4. Three-dimensional models have been constructed depicting the loadings of training and career success on intelligence (verbal-educational and spatial-mechanical abilities) and personality.

5. These models show that training success, as measured by course results, is almost wholly associated with intelligence, predominantly of the verbal-educational type. Relative loadings of verbal educational ability, (V:ED), and spatial-mechanical ability, (K:M), vary from one course to another and tend to be highest on K:M in specialist courses for Engineer officers and lowest in those for Seaman officers, as well as in early general naval training.

6. Career success loadings exhibit considerably greater differences from branch to branch. In the Engineer and Supply branches they are almost wholly associated with intelligence. In the Seaman branch there is a strong personality loading. In the intelligence plane, high spatial-mechanical ability is a handicap to managerial success.

How effective was the criterion used for selection?

7. The two components of the composite selection score were CSC examination total and AIB mark. Considered individually, the former gives a good all-round forecast of training course results, but tends to be associated with "no promotion but long service" in the long term, while the latter is not a significant predictor of either, though it gives a fair forecast of early officer-like-qualities assessment. The optimum predictive "mix" of these two scores varies considerably from short-term to long-term and from branch to branch.

8. The composite selection score used between 1947 and 1949 consisted simply of the weighted sum of CSC examination total and AIB mark in the proportions 8 : 3 and was used for all branches (except Electrical). If it is assumed that a single criterion was necessary for grading the candidates, that it must take account of both short and long-term prospects, and that it must apply equally to all branches, then the one which was used was a reasonable compromise, though its overall validity would have been improved by reducing the proportion of AIB mark.

Could the available data have provided better forecasts?

9. The ability/success models show that the blend of intelligence and personality associated with student success, as measured by training course results, is quite distinct from that associated with managerial success, as measured by promotion. It also varies markedly from one branch to another. Furthermore the nature of relevant intelligence varies, spatial-mechanical ability being a handicap in the long-term.

10. Consequently it is possible to construct separate predictors for short and long-term prospects for each branch individually that are more efficient than a single composite selection score. Suitably weighted combinations of individual CSC examination and psychological test scores, together with biographical data and AIB marks, giving the appropriate blend of V:ED, K:M and P, are capable of providing good forecasts of training course marks and probability of promotion in each branch. The accuracies attainable by use of such psychometric functions are greatly superior to those provided by the purely judgmental AIB mark. There must be some doubt that the success of some of the predictor functions

which have been derived is attributable partly to capitalising on chance associations but the results are generally consistent and logical. Cross-validation has been limited by sample sizes but where it has been possible it has confirmed the stability of results.

How valid is training success?

11. The best predictions of long-term success are provided by the results of early training at Dartmouth and in the cadet training cruiser, HMS DEVONSHIRE. Seaman officers specialist training results and seniority awards for overall training performance also correlate significantly with promotion. In the case of Engineer officers neither the engineering training results nor the seniority award provides a good forecast of long-term success. Though this appears to throw doubt on the validity of engineering training assessments, it is probable that Engineer officers experience a substantial change of role in mid-career. Training success is probably more relevant to early technical appointments than to later administrative ones.

How useful are the "annual report" markings?

12. The personal qualities on which each officer is regularly marked by his superiors can be depicted in a two-dimensional model whose axes are "intelligence" and "social skills".

13. There is some evidence of information redundancy, usually described as "halo" effect, in the reports for both Seamen and Engineer branches. The clustering of "Organising Ability" and "Reliability" and of "Initiative and Alertness" and "Zeal and Energy" shows that each of these pairs is being used to assess a single quality and that there would be little loss of information if the number of qualities assessed were correspondingly reduced.

14. Assessment of "professional ability" is closely related with "intelligence" in the Engineer branches but has a substantial "social skills" loading in the Seaman branch. This accords with the relationship between promotion success and the three-dimensional ability structure discussed in para 6 above.

15. Predictions of promotion success attainable from the numerical markings of the reports alone are no more accurate than those from pre-entry and training data alone. The two sets of information together

provide much improved forecasts, thus illustrating the importance of career development and the value of a complete history of performance in identifying potentially successful officers.

How relevant are the findings today?

16. Recruiting conditions have changed. Whereas in 1947 the emphasis was on avoiding selection of an unsuitable candidate it tends now to be on avoiding rejection of a possibly suitable one. This has led to examination of the merits of lowering the selection standards.

17. In such recruiting conditions definition of selection objective becomes crucial and the availability of valid predictors doubly important. This study demonstrates that the problem is not one of lowering standards but of choice of relevant standards. The differences in qualities associated with success in the various branches emphasise too the importance of optimum placement as distinct from simple selection. The techniques of discriminatory analysis, extensively used in this study, are highly relevant to such problems of classification. Relatively simple examples have been given of the use of discriminatory techniques to identify qualities associated with promotion and with propensity to leave the service prematurely, i.e. the contributions of both satisfactoriness and satisfaction to success. Such techniques are demonstrably powerful and could make a valuable contribution to selection in present-day conditions by providing for each candidate an estimate of probability of membership of categories such as long-term success/short-term success/failure in each branch. Appropriate cut-off probabilities could then be determined in relation to the estimated cost of wrong decision, either bad candidates selected or good ones rejected.

18. The data available for selection purposes has, however, been materially reduced by the substitution of a minimum standard in 'A' levels for the CSC examination rankings. Thus the measures of intelligence, on which efficient predictions of success are so dependent, are now relatively crude. Greater weight is given to the judgmental measure of personality which the analyses have shown to be a relatively inefficient predictor.

19. Because of these changes the predictor functions derived in this investigation cannot be used directly for selection purposes today, nor should they be used without rigorous cross-validation. The models which have been constructed as a result of the predictive studies and

analyses of data structure depict relationships of training and career success to intelligence and personality which do, however, provide the essential starting point for a comprehensive review of selection methods in the light of current conditions. The methodology of this study also suggests how the problem might be approached.

20. The relatively good forecasts of long-term success provided by early training results suggest that there is some merit in the concept of probationary service, as already envisaged in the Civil Service as a result of the reconstruction following Fulton. The improvement in forecasting efficiency attainable from a combination of pre-entry, training and annual report data shows too the importance of career development, as well as of early measures of ability in determining long-term success.

21. Lest the findings of this investigation appear unduly critical of selection procedure it must be pointed out that its introduction was a milestone in naval psychology and that it has, for many years, provided a satisfactory supply of officer cadets. Further it was the foresight and scientific wisdom of those responsible for its design and introduction which has ensured that suitable records were available for this study to be possible. It is with the advantage of these records and of hindsight that it is possible to envisage ways of improving the procedure in the light of current conditions.

Topics for Further Study

22. This investigation has been an exploration of an area which is vitally important in the services as in many other fields today, the identification of potentially successful students and managers.

23. The investigation has shown the power of multivariate techniques generally and the part which might be played in selection and placement by discriminatory techniques in particular.

24. In the course of the studies it has become apparent that many other aspects could usefully be examined. Some of these are listed in Appendix 14.

25. Of the topics listed the one which holds the greatest prospect of practical return is a comparable study of the current selection situation, using the methodology of this investigation, with a view to redesigning selection procedure using discriminatory techniques for optimum selection and placement of present-day candidates.

26. Further investigations reported in Volume 2 show how such a study might begin by identifying the loadings of currently available data on the three principal axes, personality, verbal-educational ability and spatial-mechanical ability. It is envisaged that a battery of validated psychological tests would overcome the inherent weakness of national academic examinations for predictive purposes and would help to reduce the difficulties now experienced with diverse forms of entry at various ages. The loadings of success vectors determined in the present research could then be used to determine discriminant functions, in terms of the adopted predictors, capable of providing optimum allocations of candidates to desired categories such as probable long-term success, probable short-term success, probable failure, in each branch. Given policy decisions concerning the acceptable cost of wrong allocation appropriate cut-off probabilities could be specified for the functions. Candidates could then be offered the category of service in which they are most likely to succeed, and hence to derive the greatest satisfaction. Offers might embrace choice of branch and choice of engagement, short-service or permanent. The measures of performance derived in early training might well be used to confirm the allocations, providing, as they do, greater accuracy of forecast.

APPENDIX 1

SP FORM Q78

SP FORM Q78

Surname _____ Today's Date _____

First Names _____

Examination Number _____ Age now _____ Date of Birth _____

Name the Schools you have attended:

_____ Age _____ to _____

_____ Age _____ to _____

_____ Age _____ to _____

_____ Age _____ to _____

_____ Age _____ to _____

Present form (or form on leaving school) _____

What was your best school subject? _____ And weakest? _____

Which subject did you like best? _____ And least? _____

Extra coaching in _____

Have you a School Certificate? _____ A Higher School Certificate? _____

Have you passed or been exempted from the London Matriculation? _____

Have you ever failed any such examination? _____

Give the dates and detail the results of any School Certificate or HSC examinations you have taken _____

Scholarships, prizes or other distinctions gained _____

Were you in the JTC, ATC, Scouts or any similar organisation? What was your rank?

What School societies did you belong to? Were you an officer in any of them?

Games record (mention games you like and dislike, teams you played for, and any you captained) _____

35	
21	
96	
97	
117	
160	

Do not write here

Did you hold any other positions of responsibility at school (e.g. as a prefect)?

_____

_____

Underline any of these things which interest you very much. Put a cross through any you are not keen about. Add any others if necessary:

music	theatres	museums	country	organising	woodwork
listening-in	cinema	collecting	gardening	religion	handicrafts
dancing	reading	photography	animals	politics	sailing
parties	writing	travel	people	science	domestic
art galleries	drawing	sports	children	electrical	mechanical

Others _____

Chief holiday activities _____

_____

_____

Most people are subject at times to minor upsets. Underline any to which you are subject. Add others if necessary

bilious attacks	catarrh	breathlessness	nightmares
hay fever	insomnia	muscular pains	sleep-walking
headaches	tiredness	muscular tremblings	sweating hands
giddiness	dead fingers	travel sickness	sensitive skin

Others _____

Number of brothers _____ Ages _____ Number of sisters ____ Ages ___

Parents resident abroad? _____ Dates _____

Have you ever lived abroad? _____

Parent(s) deceased _____ Dates _____

Family occupations

Father _____ Mother _____

Paternal Grandfather _____ Maternal Grandfather _____

Brothers _____ Sisters _____

_____ _____

_____ _____

Traditional family occupations? _____

Religious denomination(s) of family _____

Marked family interests (Social, literary, artistic, mathematical, religious, etc.)

_____

_____

If you are unable to join the Royal Navy, what other jobs will you consider?

_____

_____

_____

Why do you want to join the Royal Navy?

What do you think are your main qualifications for becoming a Naval Officer?

What qualities do you think you will have to develop more in order to become a successful Naval Officer?

APPENDIX 2

A TYPICAL AIB PRACTICAL TASK

APPENDIX 2

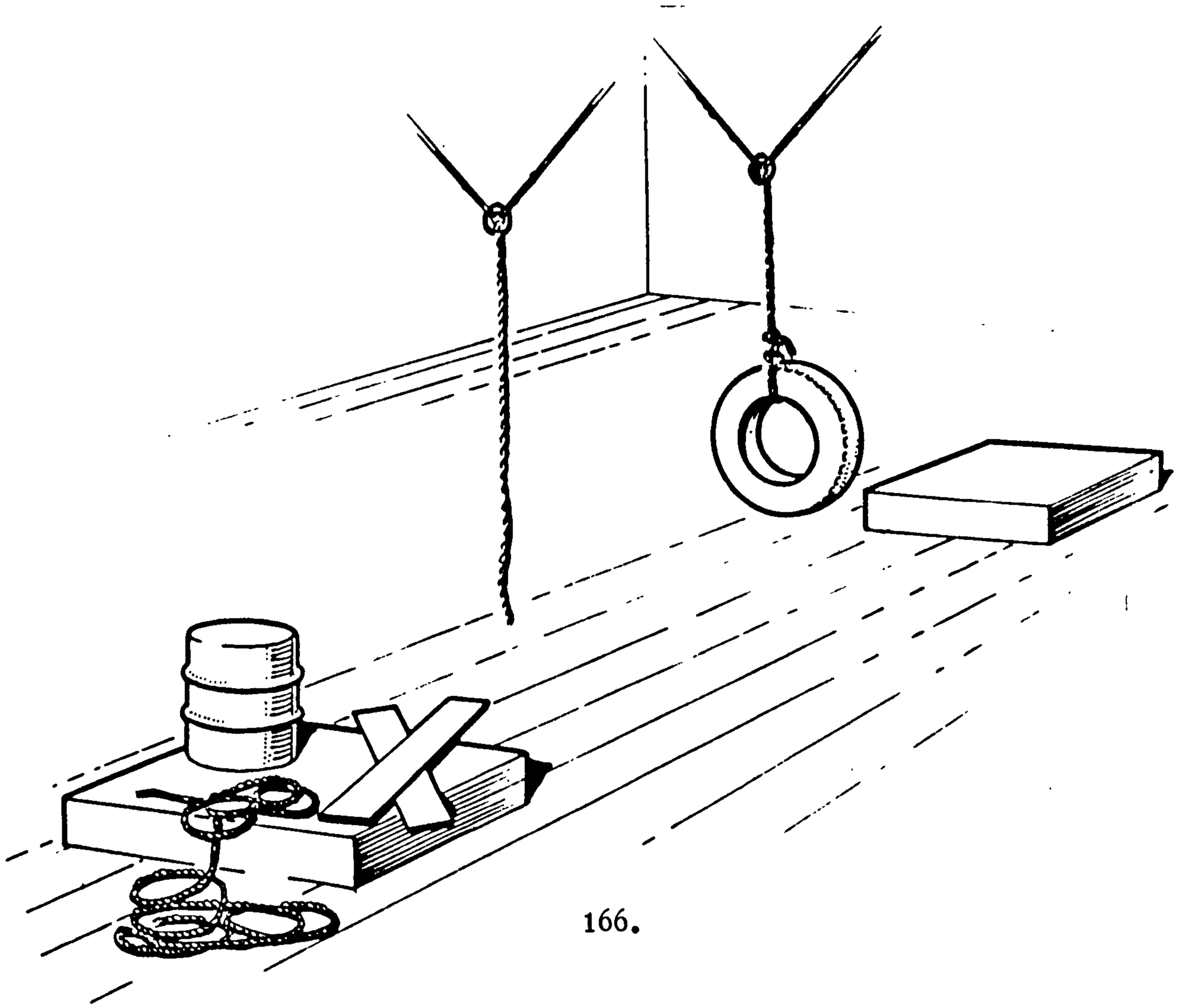
A TYPICAL A.I.B. PRACTICAL TASK

The gear in this example of a practical task consists of two platforms representing the banks of a river. On the near platform are an oil drum, two planks and a coil of rope, while hanging from the roof are two climbing ropes to one of which is attached a motor tyre. The candidates are briefed:

> "You are a party stranded on this bank of a river across which you are trying to transport this delicate piece of equipment (indicating the oil drum) and yourselves. Hanging over the river you have these two climbing ropes, one of which supports a motor tyre. You have also these planks and this coil of rope and you can make any use you like of any or all of this gear - but none of it may touch the floor between the two platforms. You have eight minutes from now to get yourselves across."

The candidates are then left to themselves.

In the Group tasks all the candidates are present at the briefing and no-one is put in charge; but in the Command Situations, only the candidate in charge is briefed, the remainder of the team wait outside until the one in charge is ready. Then he in turn briefs the others.



APPENDIX 3

REPORT FORM S206

S.206 (Revised Oct. 1966)

STAFF-IN-CONFIDENCE

Occasion for report .....

Date of birth	Rank	Seniority	Christian names	Surname

Ship or establishment ..... Station or command .....

Period of report { From ..... To .....

Specialisation:
Sub-specialisation:

List

Duties on which employed:

SECTION I Specialisation/Departmental Report

Technical or professional ability (see para. 8 of Instr'ns):

Signature and rank .....

SECTION II

Zeal & energy	
Reliability	
Commonsense	
Intelligence & reasoning power	
Initiative & alertness	
Leadership	
Power of expression	
Organising ability	
Tact & co-operation	
Social attributes	

SECTION III **General Report**

SECTION IV

Suitability for promotion

a **If eligible:** NOW, NOT YET, NO, I.K.

b **If not eligible:** EARLY, IN ORDINARY COURSE, LATE, NOT AT ALL, I.K.

SECTION V **Appointing Information**

a Suitability to sub-specialise:

b Suitability for any special type of appointment:

c Proficiency in languages:

d Proficiency at games, athletic prowess:

I have informed this officer of any adverse comments made in Section I and III above which are within his powers to remedy. ☐ (Tick this box if the officer has been so informed)

Date..... Signature and rank.....

SECTION VI **Remarks of Senior Officer**

Date..... Signature and rank.....

APPENDIX 4

MEANS AND STANDARD DEVIATIONS

APPENDIX 4

MEANS and STANDARD DEVIATIONS

Sample sizes given in each table are maxima. Missing values are omitted in calculating individual Means and SDs. All values to 3 sig figs.

VARIABLE	SAMPLE											
	X		E		S		F		X, E, S		X, E, S, F	
	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
CSC EXAM												
ENGL	109	17.6	103	14.7	113	15.6	99.5	16.0	10.7	16.4	103	16.6
GENL	54.1	7.17	51.9	6.93	55.1	7.99	50.5	7.51	53.3	7.32	51.9	7.53
MATH	75.2	15.3	70.2	13.6	68.7	16.9	65.5	14.1	71.6	15.0	68.7	14.9
PHYS	67.4	12.2	62.9	10.3	59.8	14.9	58.7	13.0	64.4	11.8	61.3	12.3
T.EXAM	499	61.7	446	53.6	486	48.2	423	46.7	472	60.2	448	59.3
SP TESTS												
GT35	150	15.0	146	16.6	152	13.6	141	16.9	149	15.6	145	16.7
SP96	24.7	2.51	23.4	3.12	24.9	3.61	22.4	3.76	24.1	3.12	23.3	3.55
SP21	124	17.4	122	18.9	125	17.7	118	20.0	123	18.1	121	19.2
SP117E	18.8	3.43	19.1	2.98	16.7	4.40	16.6	4.13	18.5	3.56	17.6	3.96
SP117M	16.8	4.05	18.8	4.47	15.7	4.67	15.7	4.78	17.5	4.55	16.6	4.75
SP97	38.8	5.16	38.5	5.02	38.2	4.59	37.9	4.85	38.5	4.99	38.2	4.93
SP160	34.3	8.17	34.9	7.50	33.0	7.59	30.7	8.43	34.4	7.74	32.6	8.25
V.ED	273	22.3	263	27.6	276	26.7	252	31.0	269	26.3	261	29.8
K.M	109	14.5	111	13.4	104	15.4	101	16.7	109	14.4	105	16.0
BOARD MARKS												
PRES	231	44.8	167	57.6	184	45.2	109	73.4	193	59.7	152	78.3
DP	214	40.5	167	48.8	176	45.5	111	65.4	184	49.8	149	68.5
CS	225	46.3	165	53.3	178	46.6	107	69.9	188	56.4	148	75.4
EO	202	45.2	161	47.7	168	42.0	110	59.5	176	49.2	144	63.6
SO	213	37.7	166	47.0	195	39.9	114	64.4	188	47.5	152	67.4
PSYCHO	197	52.5	149	60.1	170	43.0	98.6	59.0	169	58.1	135	68.4
TO	199	55.2	155	55.1	162	45.6	106	63.1	171	56.6	140	68.0
B.MARK	218	39.4	162	50.4	183	38.6	105	64.6	185	50.9	147	70.1
B.MEAN											149	66.6
B.AGG	715	59.0	608	69.7	670	60.7			655	80.6	595	103
B.SD	22.9	10.7	21.6	11.3	24.7	12.0			22.8	11.3	21.6	10.9
CAREER CRITERIA												
T.LCDR	12.5	0.27	12.9	0.50	12.4	0.31			12.1	1.38		
T.CDR	6.30	1.20	7.51	0.90	8.20	0.86			10.4	2.64		
S.INDA	1.32	1.96	0.89	1.32	0.69	1.05			0.996	1.54		
S.INDB	5.18	1.87	4.56	1.74	4.76	1.44			5.01	2.01		
S.INDC	0.35	0.48	0.36	0.48	0.38	0.49			0.36	0.48		
No in Sample*	89		125		55		250		269		520	

* Maximum number. The number of missing values varies but except in PHYS, T.LCDR and T.CDR is small.

VARIABLE	SAMPLE							
	X		E		S		X, E, S	
	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
BIOGRAPHICAL								
CORPS	.830	.378	.692	.464	.604	.494	.751	.490
SOCS	.341	.477	.358	.482	.509	.505	.367	.517
GAMES	.477	.502	.600	.492	.377	.489	.552	.521
PREF	.420	.496	.392	.490	.283	.455	.390	.512
ON.CH	.209	.409	.203	.404	.302	.463	.263	.454
PAR.DD	.128	.336	.068	.252	.113	.320	.108	.301
FAT.RN	.163	.371	.051	.221	.208	.409	.120	.481
F.ARMY	.151	.360	.042	.202	0	0	.092	.281
HMC.SC	.674	.471	.456	.500	.574	.499	.548	.501
B.PREF	.966	.181	.472	.501	.636	.485	.668	.472
F.OCC	2.44	1.23	2.84	1.14	2.50	1.30	2.75	1.44
T.HSC	1.79	.655	1.73	.674	1.81	.614	1.76	0.658
A.AIB	17.5	.328	17.6	.296	17.6	.301	17.6	.321
A.ENT	17.9	.335	17.8	.315	17.8	.305	17.8	.323
PR.ATT	.169	.375	.192	.395	.236	.429	.195	.397
INTERESTS								
MUSIC	1.26	.679	1.39	.627	1.42	.570	1.35	.636
LISTEN	1.17	.637	1.27	.594	1.21	.600	1.23	.606
DANCING	1.25	.674	1.19	.719	1.19	.709	1.21	.700
PARTIES	1.24	.613	1.11	.624	1.08	.703	1.15	.639
ART GALL	.595	.623	.661	.630	.679	.613	.634	.622
THEATRE	1.37	.597	1.26	.591	1.32	.613	1.31	.594
CINEMA	1.20	.576	1.18	.608	1.11	.670	1.17	.604
READING	1.59	.562	1.58	.561	1.76	.515	1.62	.553
WRITING	.798	.597	.737	.576	1.06	.718	.817	.623
DRAWING	.714	.737	.873	.734	.736	.684	.790	.726
MUSEUMS	.702	.510	.780	.615	.849	.663	.763	.598
COLLECTING	.869	.773	.958	.697	1.09	.714	.950	.728
PHOTOGRAPHY	.976	.640	1.08	.669	1.00	.588	1.02	.637
TRAVEL	1.66	.503	1.61	.555	1.71	.576	1.61	.541
SPORTS	1.74	.469	1.75	.456	1.64	.522	1.73	.472
COUNTRY	1.51	.570	1.32	.597	1.42	.719	1.41	.617
GARDENING	.643	.614	.678	.715	.642	.736	.653	.682
ANIMALS	1.30	.617	1.24	.550	1.23	.542	1.28	.575
PEOPLE	1.33	.567	1.28	.568	1.15	.662	1.28	.588
CHILDREN	.869	.597	.941	.559	.887	.640	.905	.583
ORGANISING	1.30	.617	1.20	.563	1.38	.527	1.27	.578
RELIGION	1.06	.546	1.01	.577	1.06	.602	1.03	.570
POLITICS	.917	.732	.814	.653	1.13	.680	.912	.692
SCIENCE	1.26	.623	1.58	.528	1.09	.714	1.37	.635
ELECTRICAL	1.04	.610	1.30	.631	1.09	.687	1.16	.649
WOODWORK	1.00	.694	1.10	.632	1.00	.707	1.04	.671
HANDICRAFTS	.917	.662	1.17	.589	.943	.633	1.03	.633
SAILING	1.57	.587	1.50	.535	1.59	.570	1.54	.557
DOMESTIC	.476	.548	.576	.605	.509	.576	.523	.579
MECHANICAL	1.16	.591	1.54	.579	1.02	.635	1.31	.631
NO IN SAMPLE*	84		118		53		262	

* SAMPLES FOR BIOGRAPHICAL AS FOR BOARD MARKS

VARIABLE	SAMPLE							
	X		E		D		X, E, D	
	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
DEVONSHIRE								
ELEC	33.8	4.83	33.3	4.89	32.4	5.50	33.0	5.31
GUNY	67.3	9.72	65.2	9.51	65.9	9.73	66.1	9.71
TAS	68.3	9.16	66.8	9.14	67.0	10.6	67.2	9.93
NAVN	239	37.3	224	35.7	243	34.7	237	36.4
COMM	69.0	9.34	62.8	11.7	68.4	9.68	67.1	10.6
ENGG	136	22.3	137	16.4	134	21.2	135	20.4
SEAM	178	20.9	164	24.7	176	24.1	173	24.3
OLQ	178	23.0	164	23.5	179	24.1	175	24.8
D.TOT	970	93.3	917	89.5	965	94.7	953	96.5
X SPEC COURSES								
XS	1.61	.579						
NS	1.78	.603						
G	1.69	.519						
T	1.61	.567						
A	1.55	.625						
C	1.61	.613						
D	1.93	.683						
DC	1.83	.698						
CO	1.81	.692						
R	1.99	.825						
RNEC COURSES								
ECON			73.2	9.29				
MATHS			138	32.5				
MECH			244	66.6				
ENG.SC			256	61.7				
CHEM			123	24.1				
ELECT			100	36.2				
PRAC			253	32.0				
BC.TOT			1187	206				
B.CLASS			2.51	.909				
SC.TOT			598	71.0				
DARTMOUTH								
N			304	57.7				
X			294	33.3				
E			278	40.1				
L			96.4	31.4				
M			102	23.6				
S			119	16.7				
T.DART			1194	131				
NO IN SAMPLE								
DEV	89		121		236		449	
X.SPEC	75		-		-		-	
RNEC	-		109		-		-	
DART	-		123		-		-	

VARIABLE	SAMPLE					
	X		E		L	
	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
S206 pre '60						
P.ABIL	5.85	1.10	5.70	1.08	6.05	1.07
M.QUAL	5.71	1.01	5.62	.994	5.98	.889
LEADER	5.47	1.13	5.29	1.05	5.41	.792
A.ABIL	5.62	1.07	5.45	.977	5.58	.804
P.QUAL	5.98	1.09	5.72	.997	5.91	.886
MEANMK	5.73	0.92	5.56	.861	5.78	.727
REP.SD	.535	.266	.517	.238	.529	.225
TIMREP	51.9	30.0	49.2	28.3	49.9	28.3
NO IN SAMPLE	653		702		292	
S206 post '60						
P.ABIL	-	-	6.63	.819	6.89	.737
ENERGY	6.58	1.04	6.65	.981	6.62	.878
RELIAB	6.55	1.08	6.68	.920	6.66	.794
COMMON	6.31	.947	6.37	.882	6.45	.767
INTELL	6.30	.949	6.40	.901	6.86	.775
INTIVE	6.26	1.04	6.32	.947	6.49	.877
LEADER	6.12	1.12	6.16	.966	6.13	.896
EXPRES	6.07	.992	6.04	.949	6.19	.909
O.ABIL	6.32	1.01	6.43	.929	6.39	.838
TACTCO	6.31	.990	6.38	.912	6.31	.911
SOCATT	6.26	.968	6.06	.856	6.16	.793
MEANMK	6.31	.828	6.35	.724	6.43	.650
REP.SD	.571	.193	.580	.189	.561	.171
TIMREP	149	23.3	152	27.3	144	25.4
NO IN SAMPLE	767		922		445	
S206 1st FACTORING						
F1T1			-8.34	31.2	-4.77	35.4
F2T1			-1.02	4.41	0	5.06
F1T2			-2.80	30.9	-.307	28.1
F2T2			-.284	3.78	.558	4.11
F1T3			7.72	32.0	6.38	30.8
F2T3			.392	3.85	1.14	3.15
F1T4			12.3	39.1	15.6	34.4
F2T4			1.61	4.02	.833	5.06
F1T5			-36.8	58.2	-21.5	54.6
F2T5			1.01	6.66	-1.33	5.62
F1T6			-2.[illegible]	55.2	-14.5	58.7
F2T6			1.39	5.37	-.500	5.60
F1T7			-15.6	55.7	-15.9	57.6
F2T7			.179	6.04	.167	6.72
F1T8			-8.21	52.2	-10.7	56.9
F2T8			.500	6.28	1.36	5.98
NO IN SAMPLE *			102/78		43/42	
S206 2nd FACTORING						
F1			28.9	171	6.86	171
F2			8.47	150	2.59	114
F1A			.013	268	.024	292
F2A			-0.64	185	-.071	230
NO IN SAMPLE			78		42	

* 1st No = max size of sample for 1st 4 variables
2nd No = " " " " " 2nd " "

VARIABLE	SAMPLE									
	L1		L2		L3		L1, 3		L1, 2, 3	
	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
GT35	154	15.0	-	-	151	12.2	153	13.8	-	-
SP60	83.5	7.65	-	-	72.1	13.9	79.6	10.0	-	-
B.MARK	211	28.0	213	15.8	172	28.5	191	33.9	199	30.8
ELEC	38.7	3.63	32.8	6.08	35.6	4.05	37.3	4.09	35.8	5.27
GUNY	76.4	6.71	71.1	8.15	68.3	8.61	73.7	9.10	72.8	8.80
TAS	76.5	8.16	69.1	10.7	68.4	5.63	72.8	8.14	71.5	9.15
NAVN	261	27.6	238	39.6	242	24.0	252	27.5	247	32.5
COMM	73.9	9.33	66.3	8.11	66.6	8.91	70.6	9.74	69.1	9.36
ENGG	145	13.3	128	21.4	139	21.0	142	17.2	137	19.6
SEAM	169	21.8	157	18.3	161	26.9	165	24.2	162	22.5
OLQ	169	19.7	161	12.5	167	22.9	168	20.9	166	18.6
D.TOT	1010	60.2	924	76.3	947	75.5	981	73.8	962	78.6
DEGREE	1.85	1.04	1.44	.995	1.86	1.03	1.85	1.03	1.71	1.03
POWER	152	7.14	140	16.6	139	11.5	145	10.9	144	12.8
WEAPON	199	27.8	175	43.0	185	30.8	192	29.3	187	34.4
R.COMM	125	20.8	114	22.4	141	19.5	133	21.7	126	23.5
R.RAD	193	27.8	157	32.7	189	19.8	190	24.4	180	31.2
A.ENT	18.3	.451	18.0	.453	18.2	.382	18.3	.422	18.2	.449
T.LCDR	12.6	.237	13.0	.352	12.8	.441	12.7	.342	12.8	.360
S.INDA	3.00	1.56	1.47	1.67	1.88	1.78	2.59	1.73	2.25	1.77
S.INDB	6.50	1.47	4.81	2.06	5.00	2.17	6.06	1.66	5.67	1.87
NO IN SAMPLE	20		18		18		35		53	

APPENDIX 5

DISTRIBUTIONS

APPENDIX 5

DISTRIBUTIONS

HALF-SIGMA CELL INTERVALS; SCORES STANDARDISED TO MEAN 500, S.D. 100 ON 'TOTAL' DISTRIBUTION; MISSING VALUES = MEAN.

VARIABLE	SAMPLE	0 - 299	300 - 349	350 - 399	400 - 449	450 - 499	500 - 549	550 - 599	600 - 649	650 - 699	700 - 999	TOT
GT35	X	0	2	2	14	10	23	13	12	9	2	87
	E	2	3	8	25	17	27	23	15	7	1	128
	S	0	1	2	2	12	14	13	5	5	1	55
	F	15	13	17	50	51	48	27	22	6	1	250
	TOTAL	17	19	29	91	90	112	76	54	27	5	520
SP96	X	0	1	2	4	15	27	15	18	5	0	87
	E	3	3	11	13	33	30	16	14	5	0	128
	S	0	2	5	5	5	7	8	15	8	0	55
	F	14	13	27	42	51	50	19	24	10	0	250
	TOTAL	17	19	45	64	104	114	58	71	28	0	520
SP21	X	1	2	6	8	23	13	12	22	0	0	87
	E	1	6	11	23	21	20	10	34	1	1	128
	S	1	2	4	3	11	13	7	14	0	0	55
	F	13	13	22	45	46	34	34	40	3	0	250
	TOTAL	16	23	43	79	101	80	63	110	4	1	520
SP117E	X	0	1	3	15	12	16	17	18	5	0	87
	E	0	1	2	12	25	26	33	21	8	0	128
	S	4	1	5	9	11	8	10	4	3	0	55
	F	13	14	27	38	53	48	27	22	8	0	250
	TOTAL	17	17	37	74	101	98	87	65	24	0	520
SP117M	X	1	1	5	17	16	21	13	6	5	2	87
	E	1	0	6	18	12	22	32	16	17	4	128
	S	3	1	7	10	11	8	9	2	4	0	55
	F	8	11	23	67	38	39	36	14	12	2	250
	TOTAL	13	13	41	112	77	90	90	38	38	8	520
SP97	X	4	5	5	7	15	15	23	8	5	0	87
	E	3	5	11	15	31	22	21	9	10	1	128
	S	2	1	2	8	17	7	11	5	1	1	55
	F	7	10	30	31	51	45	47	17	11	1	250
	TOTAL	16	21	48	61	114	89	102	39	27	3	520
SP160	X	3	5	3	5	14	20	20	10	7	0	87
	E	0	8	4	11	20	24	28	20	12	1	128
	S	1	2	5	8	10	7	10	11	1	0	55
	F	16	17	23	36	45	48	30	24	11	0	250
	TOTAL	20	32	35	60	89	99	88	65	31	1	520

SP TESTS

CSC EXAMS

VARIABLE	SAMPLE	0 - 299	300 - 349	350 - 399	400 - 449	450 - 499	500 - 549	550 - 599	600 - 649	650 - 699	700 - 999	TOT
ENGL	X	2	0	6	6	13	25	16	10	2	7	87
	E	3	4	11	19	32	17	27	10	3	2	128
	S	0	2	0	5	6	11	12	11	4	4	55
	F	7	10	30	58	50	42	26	18	7	2	250
	TOTAL	12	16	47	88	101	95	81	49	16	15	520
GENL	X	0	1	7	8	19	19	14	14	0	5	87
	E	5	2	9	25	17	24	29	13	3	1	128
	S	1	2	2	4	9	13	6	10	4	4	55
	F	10	9	22	51	48	47	37	18	6	2	250
	TOTAL	16	14	40	88	93	103	86	55	13	12	520
MATH	X	0	5	3	8	12	18	12	10	17	2	87
	E	0	4	13	18	20	32	17	12	9	3	128
	S	0	6	8	9	7	7	3	10	4	1	55
	F	0	22	29	64	33	44	22	22	14	0	250
	TOTAL	0	37	53	99	72	101	54	54	44	6	520
PHYS	X	0	0	2	12	13	18	14	11	10	7	87
	E	1	0	15	16	32	21	21	17	1	4	128
	S	1	1	3	7	13	16	10	2	1	1	55
	F	12	7	39	58	36	36	30	21	8	3	250
	TOTAL	14	8	59	93	94	91	75	51	20	15	520
T.EXAM	X	0	0	1	7	6	22	15	19	2	15	87
	E	0	0	23	21	23	24	16	10	10	1	128
	S	0	0	0	6	8	9	12	8	11	1	55
	F	0	0	67	65	51	35	19	5	7	1	250
	TOTAL	0	0	91	99	88	90	62	42	30	18	520
B.AGG	X	0	0	0	0	0	4	33	28	14	8	87
	E	0	0	3	19	37	35	21	9	3	1	128
	S	0	0	0	0	1	20	20	6	6	2	55
	F	6	28	52	64	48	36	5	8	2	1	250
	TOTAL	6	28	55	83	86	95	79	51	25	12	520

BOARD MARKS

VARIABLE	SAMPLE	0 - 299	300 - 349	350 - 399	400 - 449	450 - 499	500 - 549	550 - 599	600 - 649	650 - 699	700 - 999	TOT
PRES	X	0	0	1	0	3	8	21	35	19	0	87
	E	0	1	7	15	35	22	28	17	3	0	128
	S	0	0	1	1	12	15	16	6	4	0	55
	F	0	51	47	40	45	27	19	18	3	0	250
	TOTAL	0	52	56	56	95	72	84	76	29	0	520
DP	X	0	0	0	0	2	18	20	33	12	2	87
	E	0	0	10	9	23	33	32	19	2	0	128
	S	0	0	2	3	8	20	13	6	3	0	55
	F	13	32	56	28	47	34	23	15	2	0	250
	TOTAL	13	32	68	40	80	105	88	73	19	2	520
CS	X	0	0	0	1	5	12	19	32	17	1	87
	E	0	1	6	17	20	37	29	17	1	0	128
	S	0	0	0	4	9	18	13	10	1	0	55
	F	0	51	40	46	45	31	23	10	4	0	250
	TOTAL	0	52	46	68	79	98	84	69	23	1	520
EO	X	0	0	0	2	8	12	20	24	18	3	87
	E	0	2	7	11	22	40	25	14	7	0	128
	S	0	0	3	1	8	20	13	6	4	0	55
	F	10	29	53	39	47	37	19	11	4	1	250
	TOTAL	10	31	63	53	85	109	77	55	33	4	520
SO	X	0	0	0	0	3	14	28	26	15	1	87
	E	0	2	6	14	24	41	26	13	2	0	128
	S	0	0	0	1	8	13	17	12	4	0	55
	F	15	34	43	40	47	38	19	11	3	0	250
	TOTAL	15	36	49	55	82	106	90	62	24	1	520
PSYCHO	X	0	0	0	6	8	9	22	19	17	6	87
	E	0	3	9	16	16	28	34	14	7	1	128
	S	0	0	1	1	10	15	15	8	5	0	55
	F	0	35	51	52	44	33	23	9	3	0	250
	TOTAL	0	38	61	75	78	85	94	50	32	7	520
TO	X	0	0	1	6	3	17	18	22	15	5	87
	E	0	1	8	18	20	27	30	16	8	0	128
	S	0	0	2	2	13	15	15	7	1	0	55
	F	4	29	51	56	33	33	26	11	7	0	250
	TOTAL	4	30	62	82	69	92	89	56	31	5	520
B.MARK	X	0	0	0	0	2	10	29	30	11	5	87
	E	0	0	8	14	29	32	27	16	2	0	128
	S	0	0	0	2	10	17	14	9	3	0	55
	F	6	50	32	52	47	29	20	10	4	0	250
	TOTAL	6	50	40	68	88	88	90	65	20	5	520
B.SD	X	0	3	7	19	18	13	10	7	6	4	87
	E	0	3	14	26	21	30	16	8	4	6	128
	S	0	0	4	9	15	9	6	3	3	6	55
	F	0	12	32	51	47	44	30	23	4	7	250
	TOTAL	0	18	57	105	101	96	62	41	17	23	520
B.MEAN	X	0	0	0	0	2	10	24	32	18	1	87
	E	0	1	4	15	22	38	29	18	1	0	128
	S	0	0	0	0	11	18	16	7	3	0	55
	F	9	42	39	44	55	22	25	12	2	0	250
	TOTAL	9	43	43	59	90	88	94	69	24	1	520

HMS DEVONSHIRE VARIABLES

VARIABLE	SAMPLE	0 - 299	300 - 349	350 - 399	400 - 449	450 - 499	500 - 549	550 - 599	600 - 649	650 - 699	700 - 999	TOT
ELEC	X	0	2	11	7	17	18	18	7	4	3	87
	E	3	3	9	17	19	29	27	10	5	2	124
	D	13	9	17	33	45	49	42	19	10	1	238
	TOTAL	16	14	37	57	81	96	87	36	19	6	449
GUNY	X	1	1	9	11	16	19	13	6	8	3	87
	E	2	9	10	19	31	18	18	12	4	1	124
	D	6	10	23	39	50	33	36	24	13	4	238
	TOTAL	9	20	42	69	97	70	67	42	25	8	449
TAS	X	1	3	5	11	17	19	14	12	4	1	87
	E	3	2	14	23	23	27	19	8	3	2	124
	D	12	13	16	34	42	53	32	18	10	8	238
	TOTAL	16	18	35	68	82	99	65	38	17	11	449
NAVN	X	2	2	8	17	10	17	14	6	10	1	87
	E	5	11	17	22	22	23	11	8	4	1	124
	D	5	7	20	22	44	53	43	24	17	3	238
	TOTAL	12	20	45	61	76	93	68	38	31	5	449
COMM	X	0	4	2	11	17	20	15	10	5	3	87
	E	9	12	10	20	31	17	16	5	2	2	124
	D	2	12	19	19	51	46	53	22	9	5	238
	TOTAL	11	28	31	50	99	83	84	37	16	10	449
ENGG	X	1	3	2	18	16	16	15	8	4	3	86
	E	0	5	6	16	34	28	16	14	4	1	124
	D	11	8	29	23	50	55	23	22	11	6	238
	TOTAL	12	16	37	57	100	99	54	44	19	10	448
SEAM	X	0	3	2	9	16	24	18	8	5	2	87
	E	9	8	16	20	24	28	9	6	4	0	124
	D	4	9	13	34	42	46	43	28	16	3	238
	TOTAL	13	20	31	63	82	98	70	42	25	5	449
OLQ	X	2	3	6	8	19	20	10	10	6	3	87
	E	5	10	14	24	31	20	14	3	3	0	124
	D	5	8	12	39	30	50	47	23	19	5	238
	TOTAL	12	21	32	71	80	90	71	36	28	8	449
D.TOT	X	1	2	6	9	20	17	13	9	7	3	87
	E	4	12	16	22	28	19	12	8	3	0	124
	D	5	8	18	32	38	49	35	34	15	4	238
	TOTAL	10	22	40	63	86	85	60	51	25	7	449

RNEC VARIABLES - SAMPLE E

VARIABLE	0 - 299	300 - 349	350 - 399	400 - 449	450 - 499	500 - 549	550 - 599	600 - 649	650 - 699	700 - 999
ECON	4	6	6	16	18	22	22	9	5	1
MATHS	2	6	14	14	15	18	22	10	8	0
MECH	2	2	11	27	18	11	23	7	3	5
ENG.SC	3	4	9	15	28	14	15	16	2	3
CHEM	3	7	5	15	31	11	20	8	8	1
ELECT	3	3	9	22	21	18	10	16	5	2
PRAC	1	5	9	23	19	22	11	11	4	4
BC.TOT	2	5	8	22	22	16	16	10	6	2
SC.TOT	1	5	15	16	17	15	26	7	3	4

DISTRIBUTION OF T.CDR

SAMPLE	YEARS							TOT
	3	4	5	6	7	8	9	
X	1	4	8	8	8	2	0	31
E	0	0	4	6	22	11	2	45
S	0	0	0	2	6	9	4	21
X + E + S	1	4	12	16	36	22	6	97
L	0	2	3	15	10	4	0	34

DISTRIBUTION OF S.INDB

SAMPLE	S.INDB										TOT
	1	2	3	4	5	6	7	8	9	OTHER	
X	1	4	10	18	23	10	8	8	5	2	89
E	5	14	15	19	21	35	6	4	0	6	125
S	2	2	7	8	14	19	2	0	0	1	55
X + E + S	8	20	32	45	58	64	16	12	5	9	269
L	2	6	2	4	6	14	15	3	2	2	56

DISTRIBUTION OF AGE OF PROMOTION TO L.CDR

SAMPLE	AGE IN YEARS; LOWER BOUNDARY										TOTAL
	29.0	29.3	29.6	29.9	30.2	30.5	30.8	31.1	31.4	31.7	
X	3	4	10	20	22	15	5	1	0	0	80
E	3	2	3	13	18	16	25	15	9	1	105
S	1	2	9	10	18	7	1	0	0	0	48
X + E + S	7	8	22	43	58	38	31	16	9	1	233

DISTRIBUTION OF A.ENT

SAMPLE	A.ENT IN YEARS; LOWER BOUNDARY								TOTAL
	17.0	17.2	17.4	17.6	17.8	18.0	18.2	18.4	
X	4	15	16	11	20	15	9	0	90
E	6	9	8	26	43	22	9	1	124
S	2	3	9	3	23	9	6	0	55
X + E + S	12	27	33	40	86	46	24	1	269

DISTRIBUTION OF F.OCC

SAMPLE	F.OCC							TOT
	1	2	3	4	5	6	7	
X	15	47	13	5	6	3	0	89
E	5	53	34	17	8	4	0	121
S	14	17	11	6	6	0	0	54
X + E + S	34	117	58	28	20	7	0	264

APPENDIX 6

DISTRIBUTION TESTS

APPENDIX 6

DISTRIBUTION TESTS

VARIABLE	χ^2	VARIABLE	χ^2	VARIABLE	χ^2	VARIABLE	χ^2	VARIABLE	χ^2
GT35	14	PRES	52	ENGL	10	ELEC	27	ECON	8
SP96	17	DP	47	GENL	25	GUNY	19	MATHS	5
SP21	35	CS	30	MATH	26	TAS	11	MECH	20
SP117E	23	EO	44	PHYS	6	NAVN	7	ENGLSC	9
SP117M	39	SO	48	T.EXAM	21	COMM	15	CHEM	18
SP97	42	PSYCHO	12	B.AGG	7	ENGG	9	ELECT	7
SP160	37	TO	20	B.SD	25	SEAM	7	PRAC	11
		B.MARK	29	B.MEAN	34	OLQ	3	SC.TOT	6
						D.TOT	3	SC.TOT	7

TABLE APP 6.1 CHI-SQUARE TESTS ON DISTRIBUTIONS

Hypotheses: 1. Populations are adequately represented by total available samples, i.e. X + E + S + F for pre-entry variables, X + E + D for HMS DEVONSHIRE, and E for RNEC.

2. Populations are normally distributed.

Notes: 1. Degrees of freedom in each case 9 i.e. normality is tested by comparing frequencies observed and expected in 10 equal cell intervals. Minimum expected frequency = 11.

2. Corresponding χ^2 probabilities are:-

χ^2	Probability
17	.05
22	.01
28	.001

VARIABLE	VALUES OF χ^2 FOR AIB NO:-					
	1	2	3	4	5	6
GT35	5.2	0.5	1.5	1.6	6.8	0.2
SP96	0.9	0.6	1.0	1.9	0.2	0.1
SP21	0	0.1	0.1	3.1	1.3	0.1
SP117E	10.9	1.2	0.4	0.2	1.8	0.1
SP117M	2.9	2.5	0.3	0.2	2.6	0.6
SP97	3.8	11.8	25.6	23.3	2.0	0.9
SP160	1.0	0.1	2.4	3.4	9.5	0
PRES	0.1	4.2	0.1	0.3	3.0	0.3
DP	0.1	3.4	0.4	0	2.3	0.1
CS	0.1	9.0	0.5	1.2	2.2	0.2
EO	0.1	8.5	1.9	0	1.9	4.8
SO	0	9.7	0.1	1.0	2.8	0.2
PSYCHO	3.4	9.8	4.4	3.1	7.2	3.3
TO	0.6	4.5	0.9	2.5	3.1	0
B.MARK	0.7	6.4	1.3	2.4	3.9	0.2
ENGL	0.1	0.4	4.0	5.7	5.4	0
GENL	0.6	0	0.3	0.2	2.5	4.7
MATH	13.2	2.5	0.4	0	11.2	6.7
PHYS	0.7	1.2	0.3	1.1	7.2	0
T.EXAM	0.4	0.3	0.3	1.4	0.1	0
B.AGG	0.2	3.6	0.5	2.4	1.4	0
B.MEAN	0.3	6.9	0.5	0.7	3.3	0.8
B.SD	0.9	0	0.7	9.1	0.3	5.5

TABLE APP 6.2 CHI-SQUARE TESTS ON COMPARISON OF BOARDS

Hypotheses: 1. Median value of total available sample X, E, S, F represents population median.

2. Individual Board medians do not deviate from population medians more than is accounted for by chance.

Notes: 1. Degrees of freedom in each case = 1.
2. χ^2 = 3.8 at p = .05; 6.6 at P = .01

VARIABLE	VALUES OF χ^2 FOR ENTRY NO:*						
	1	2	3	4	5	6	7
ELEC	2.1	0.4	2.5	1.0	0.9	0.2	2.8
GUNY	0.2	0.1	0	6.3	2.1	0.5	1.7
TAS	0.5	3.6	0.1	1.8	0.3	0.1	0.8
NAVN	0.2	0.6	2.8	2.5	2.5	0	0.1
COMM	0.1	0.3	0.6	0.9	0.5	0	0.2
ENGG	0.8	0.4	1.4	2.0	1.2	0.3	0.2
SEAM	2.3	0.4	0.5	0.1	0	0	0.7
OLQ	1.6	1.3	0.9	2.6	0.4	0	0
D.TOT	0.7	0.1	2.7	1.0	0.7	0.4	0.2

TABLE APP 6.3 CHI-SQUARE TESTS ON COMPARISON OF ENTRIES

Hypotheses: 1. Median value of total available sample X, E, D represents population median.

2. Individual entries' medians do not deviate from population median more than is accounted for by chance.

Notes: 1. Degrees of freedom in each case = 1

2. χ^2 = 3.8 at P = .05; 6.6 at P = .01

APPENDIX 7

ASSOCIATIONS

SELECTION SCORE B.AGG	HMS DEVONSHIRE TOTAL SCORE D.TOT													TOTAL IN GROUP	% ABOVE MEDIAN D.TOT
	≥ 938							< 938							
	BOARD						TOTAL	BOARD						TOTAL	
	1	2	3	4	5	6		1	2	3	4	5	6		
≥ 720	6	6	2	6	13	4	37	1	2	0	2	5	5	15	52	71
665-719	7	4	1	7	5	8	32	5	4	0	1	8	4	22	54	59
595-664	3	3	6	6	4	5	27	2	3	2	8	11	1	27	54	50
< 595	3	1	5	0	3	0	12	11	10	3	0	12	6	42	54	22
TOTAL	19	14	14	19	25	17	108	19	19	5	11	36	16	106	214	50

χ^2 = 27.8 with 3 d.f.

HMS DEVONSHIRE PERFORMANCE ▼ SELECTION SCORE

X AND E OFFICERS

TABLE APP 7.1

SELECTION BOARD RANKING	SAMPLE	PROMOTED	NOT PROMOTED	TOTAL	% PROMOTED
UPPER HALF OF EACH ENTRY	X	19	26	45	42
	E	25	37	62	40
	S	12	15	27	44
	TOTAL	56	78	134	42
LOWER HALF OF EACH ENTRY	X	12	34	46	26
	E	21	42	63	33
	S	9	18	27	33
	TOTAL	42	94	136	31
T O T A L	X	31	60	91	34
	E	46	79	125	37
	S	21	33	54	39
	TOTAL	98	172	270	36

For 'TOTAL' Sample, $\chi^2 = 3.5$ with 1 d.f.

PROMOTION v SELECTION BOARD RANKING

X, E AND S OFFICERS

TABLE APP 7.2

HMS DEVONSHIRE TOTAL SCORE D.TOT	SAMPLE	PROMOTED	NOT PROMOTED	TOTAL	% PROMOTED
≥ 1005	X	15	16	31	48
≥ 951	E	22	19	41	54
UPPER THIRD	TOTAL	37	35	72	51
930 - 1004	X	11	20	31	35
880 - 950	E	13	27	41	32
MIDDLE THIRD	TOTAL	24	47	72	33
< 930	X	5	24	29	17
< 880	E	10	30	40	25
LOWER THIRD	TOTAL	15	54	69	22
TOTAL	X	31	60	91	34
	E	45	76	122	37
	TOTAL	76	136	213	36

For ' TOTAL ' Sample, χ^2 = 12.8 with 2 d.f.

PROMOTION v HMS DEVONSHIRE TOTAL SCORE

X AND E OFFICERS

TABLE APP 7.3

E LATER TRAINING v SELECTION AND PROMOTION

B.AGG	BC.TOT		TOTAL	% 'SUPERIOR'
	≥ 1170	< 1170		
≥ 615	35	20	55	64
< 615	20	33	53	38

TABLE APP 7.4 BASIC ENGINEERING COURSE v SELECTION

ALL E OFFICERS. χ^2 = 7.3 with 1 d.f.

BC.TOT	PROMOTED	NOT PROMOTED	TOTAL	% PROMOTED
≥ 1170	27	28	55	49
< 1170	18	36	54	33

TABLE APP 7.5 PROMOTION v BASIC ENGINEERINC OCURSE

ALL E OFFICERS. χ^2 = 2.8 with 1 d.f.

B.AGG	SC.TOT		TOTAL	% 'SUPERIOR'
	≥ 596	< 596		
≥ 615	29	23	52	56
< 615	23	26	49	47

TABLE APP 7.6 SPECIALIST ENG COURSE v SELECTION

ALL E OFFICERS

SC.TOT	PROMOTED	NOT PROMOTED	TOTAL	% PROMOTED
≥ 596	26	25	51	51
< 596	17	33	50	34

TABLE APP 7.7 PROMOTION v SPECIALIST ENG COURSE

ALL E OFFICERS

L EARLY TRAINING v SELECTION AND PROMOTION

B.MARK	D.TOT		TOTAL	% SUPERIOR
	≥ 965	< 965		
≥ 212	10	8	18	56
185-211	9	9	18	50
< 185	7	10	17	41
TOTAL	26	27	53	50

HMS DEVONSHIRE PERFORMANCE v SELECTION BOARD MARKING

ALL L OFFICERS

TABLE APP 7.8

D.TOT	PROMOTED	NOT PROMOTED	TOTAL	% PROMOTED
≥ 993	14	4	18	78
940-992	10	8	18	56
< 940	9	8	17	53
TOTAL	33	20	53	62

PROMOTION v HMS DEVONSHIRE TRAINING

ALL L OFFICERS

TABLE APP 7.9

APPENDIX 8

PREDICTIVE CORRELATIONS

CRITERIA

Predictors	B MARK						T.Dart	D TOT			BC Tot	SC Tot	T LCDR					S INDA					S INDB				
	X	E	S	XES	XESF	L	E	X	E	L	E	E	X	E	S	XES	L	X	E	S	XES	L	X	E	S	XES	L
GT 35					·21	-·26	·34	·20	·27		·27	·22		-·21		-·22							·19				
SP 96					·24		·33		·26		·18	·16	-·35			-·24				-·36							
SP 21	-·21						·24		·23															·17		·11	
SP 117E		·17			·15		·21	·26			·16	·21	-·24							-·25							
SP 117M								·24			·19	·16								-·25				·16		·13	
SP 160					·10			·34			·27			-·17		-·11											
SP 60										·39							-·35					·25					·23
V:ED				·10	·26		·40	·20	·31		·27	·22	-·22	-·20		-·26				-·29							
K.M					·10		·19	·46			·27		-·25	-·16										-·16			
PRES	·79	·74	·69	·80	·91			·18								-·22					·13						
DP	·84	·80	·73	·83	·92											-·12		·26		·34	·20					·14	
CS	·80	·84	·84	·86	·94				·21							-·19					·16					·13	
EO	·79	·88	·59	·83	·91				·19							-·14					·11						
SO	·80	·80	·89	·85	·93											-·25		·23		·23	·12						
PSYCHO	·74	·83	·64	·81	·88				·23		·18					-·19											
TO	·72	·77	·70	·77	·86											-·13											
B.MARK									·21							-·22				·26	·15					·14	
B.SD	-·37			-·11			-·20							·17													
ENGL				·11	·28											-·12											
GENL					·17		·16					·16							·22		·13			·18	-·26		
MATH	-·24	-·18			·10		·31	·34	·28		·27	·26	-·19	-·23	-·26	-·21											
PHYS	-·25				·14		·44	·27	·33		·33	·23	-·34	-·26		-·24										·12	
T.EXAM	-·33	-·10			·27		·32	·35	·25		·29	·20	-·28	-·20	-·36	-·35											
B.AGG							·27	·37	·34		·30	·18	-·31	-·25	-·24	-·40					·12					·16	
CORPS		·20		·20														·18			·14		·19			·14	
SOCS									·19				-·22	-·16		-·17											
GAMES															-·24				·16	·35	·17			·25		·16	
PREF									·17																		
ON.CH															-·31	-·11											
PAR DD									·16							-·12											
FAT RN																-·17											
FARMY	·21			·16									·21														
HMC SC	·32	·26		·33																					-·23		
T.HSC							·21																			·10	
B.PREF	·22	·16		·34												-·18											
F.OCC	-·23	-·20		-·23												·11		-·29			-·12		-·20				
A.ENT															-·26											-·12	
A.AIB								-·20							-·23								-·19				
N							·81		·51		·29	·29		-·23					·19					·28			
X							·54		·55		·20	·24		-·30										·23			
E							·59		·36		·40	·31		-·37													
L							·65		·38		·39	·28		-·26										·16			
M							·58		·36		·46	·24		-·36													
S							·51		·50		·17	·20												·22			
T.DART									·69		·50	·42		-·44					·17					·31			
ELEC								·50	·41	·60	·34	·41	-·42	-·34			-·45		·22			·45	·20				·49
GUNY								·58	·43	·52	·27	·35	-·43	-·27			-·23					·26	·28				·25
TAS								·68	·61	·44	·33	·35	-·45	-·33			-·50	·23				·37	·29				·34
NAVN								·79	·74	·69	·47	·46	-·57	-·47			-·38		·27				·21	·27			
COMM								·58	·70	·68	·31	·34	-·42	-·42			-·53						·24	·19			
ENGG								·71	·65	·67	·32	·33	-·57	-·42			-·56	·23					·35				
SEAM								·73	·79	·65	·38	·46	-·47	-·39			-·33		·18			·33	·22	·23			
OLQ								·56	·55	·57	·17	·17	-·20	-·22			-·25	·36	·24			·23	·34	·35			
D.TOT											·52	·56	-·67	-·57			-·62	·28	·29			·33	·39	·34			·30
ECON											·44	·37		-·38													
MATHS											·67	·32		-·53					·22					·19			
MECH											·89	·49		-·73													
ENG.SC											·89	·48		-·69													
CHEM											·62	·42		-·41					·21					·16			
ELECT											·83	·49		-·70					·22					·19			
PRAC											·67	·45		-·49													
BC TOT												·57		-·79					·19					·17			
SC TOT														-·58					·20								
XS													·55					-·26					-·26				
NS													·61														
G													·58														
T													·58					-·22					-·22				
A													·46					-·24					-·25				
C													·54					-·25					-·25				
D													·46														
DC													·56														
CO													·42														
R													·66														
DEGREE																	-·63					·36					·41
POWER																	-·47					·28					·26
WEAPON																	-·54					·24					·25
R COMM																	-·66					·25					·37
R RAD																	-·51					·33					
T LCDR																		-·30	-·19		-·16	-·30	-·33			-·13	
SINDA																		·88	·75	·67	·79	·83	·68	·75	·67	·79	·83
SINDB																											

HIGHLY SIGNIFICANT

VARIABLE	X	E	S
COUNTRY			.27
ART GALLERIES		-.20	
DRAWING		-.20	
ORGANISING	-.32		

TABLE APP 8.2 CORRELATIONS OF INTERESTS WITH S.INDB - SIGNIFICANT VALUES

NOTES ON TABLES 1 AND 2

Significance is assessed on the hypotheses that the population value of the correlation coefficient is 0. The probability of a value of r exceeding any given value by pure chance is then obtained from the normal distribution. Critical values of r at the 5% and 1% probability levels are tabulated below for both one-tailed and two-tailed tests. The use of the one-tailed test, usual in psychological work, implies that the direction of the correlation is known.

SAMPLE	SAMPLE SIZE	σ_ρ STANDARD ERROR OF ρ	PROBABILITY LEVELS			
			1% 2T 2.58 σ	1% 1T 2.33 σ	5% 2T 1.96 σ	5% 1T 1.65 σ
X	89	.11	.27	.25	.21	.17
E	125	.09	.23	.21	.18	.16
S	55	.14	.35	.32	.27	.22
X E S	262	.06	.16	.14	.12	.10
X E S F	520	.04	.11	.10	.09	.07
L	53	.14	.35	.32	.27	.23

TABLE APP 8.3 CRITICAL VALUES OF r

Example:-

The size of a correlation which might be either positive or negative would exceed .27 in sample X only once in 100 trials by pure chance. A correlation which is known to be in a specified direction would exceed .18 in sample E once in 20 trials by pure chance.

APPENDIX 9

PRINCIPAL COMPONENT ANALYSES
of
PRE-ENTRY, TRAINING AND CRITERIA DATA

COMPONENT LOADINGS

VARIABLE	COMPONENT NO				
	1	2	3	4	5
GT35	.16	.25	.31	.27	.05
SP96	.17	.26	.23	.17	.08
SP21	.07	.16	.27	.05	-.37
SP117E	.12	.29	-.28	-.08	.34
SP117M	.07	.30	-.28	.02	.38
SP97	.05	.21	-.10	.20	-.56
SP160	.11	.32	-.25	.13	-.12
V:ED	.19	.29	.31	.26	.0[illegible]
K:M	.12	.39	-.31	.11	-.04
PRES	.31	-.16	-.04	-.03	.01
DP	.31	-.17	-.06	-.02	-.00
XS	.32	-.16	-.03	-.02	-.01
EO	.31	-.13	-.13	.04	-.04
SP	.32	-.15	-.03	-.02	-.01
PSYCHO	.31	-.10	-.07	.06	-.04
TO	.30	-.13	-.06	-.07	-.05
B.MARK	.33	-.16	-.06	-.00	-.02
ENGL	.13	.01	.38	.00	.24
GENL	.08	-.00	.31	-.05	.23
MATH	.09	.21	.04	-.51	-.34
PHYS	.11	.22	-.03	-.52	.13
T.EXAM	.16	.17	.26	-.45	-.07

SAMPLE SIZE - 520

VARIANCES

COMPONENT NO	VARIANCE	ACCUMULATED VALUE AS % OF TOTAL VARIANCE
1	7.78	35.4
2	4.11	54.0
3	2.00	63.1
4	1.38	69.4
5	1.10	74.4
6	0.93	78.6
7	0.83	82.5
8	0.72	85.7
9	0.53	88.1
10	0.50	90.4
11	0.41	92.3
12	0.38	94.0
13	0.35	95.6
14	0.34	97.2
15	0.16	97.9
16	0.14	98.5
17	0.12	99.1
18	0.10	99.5
19	0.09	99.9
20	0.02	100
21	0	100
22	0	100

TABLE APP 9.1 PRINCIPAL COMPONENT ANALYSIS OF AIB DATA - SAMPLE X, E, S, F

COMPONENT LOADINGS

VARIABLE	COMPONENT NO		
	1	2	3
GT35	.08	.29	.02
SP96	.09	.31	.00
SP21	-.01	.17	-.04
SP117E	.02	.21	.20
SP117M	-.03	.22	.22
SP97	.02	.17	.13
SP160	.02	.25	.23
V:ED	.10	.35	.01
K:M	.01	.31	.28
PRES	.29	-.07	.05
DP	.30	-.13	.06
CS	.31	-.11	.05
EO	.29	-.08	.17
SO	.30	-.09	.04
PSYCHO	.29	-.03	.15
TO	.28	-.08	.16
B.MARK	.34	-.09	.09
ENGL	.07	.13	-.16
GENL	.05	-.01	-.20
MATH	.02	.24	-.11
PHYS	.05	.24	-.13
T.EXAM	.10	.28	-.21
CORPS	.09	-.02	-.02
SOCS	.03	.06	.03
GAMES	.01	-.05	-.07
PAR.DD	.02	.05	-.04
FAT.RN	.05	.04	.01
F.ARMY	.07	-.05	.00
HMC.SC	.13	-.09	.05
B.PREF	.16	.03	-.08
F.OCC	-.11	.04	-.02
T.HSC	.02	.06	-.04
A.AIB	-.05	.01	.19
B.AGG	.29	.14	-.10
B.SD	-.03	.07	-.14
T.LCDR	-.14	-.17	.16
S.INDA	.09	-.03	-.32
S.INDB	.09	-.00	-.33

SAMPLE SIZE - 262

VARIANCES

COMPONENT NO	VARIANCE	ACCUMULATED VALUE AS % OF TOTAL VARIANCE
1	7.43	15.8
2	4.45	25.3
3	3.19	32.1
4	3.01	38.5
5	2.54	43.9
6	1.92	48.0
7	1.69	51.5
8	1.60	55.0
9	1.51	58.2
10	1.34	61.0
11	1.16	63.5
12	1.13	65.9
13	1.06	68.2
14	1.04	70.4
15	1.00	72.5
16	0.96	74.5
17	0.91	76.5
18	0.86	78.3
19	0.84	80.1

TABLE APP 9.2 PRINCIPAL COMPONENT ANALYSIS OF PRE-ENTRY AND CRITERIA VARIABLES - SAMPLE M, E, S

COMPONENT LOADINGS

VARIABLE	COMPONENT NO			VARIABLE	COMPONENT NO		
	1	2	3		1	2	3
GT35	.11	.02	.12	F.OCC	-.03	-.07	.01
SP96	.10	.01	.10	T.HSC	.03	-.03	-.07
SP21	.06	-.06	-.05	A.AIB	-.00	.02	.05
SP117E	.07	.04	.19	B.AGG	.13	.21	.06
SP117M	.07	.03	.22	B.SD	-.04	-.01	.00
SP97	.02	-.05	.16	ELEC	.13	-.02	-.03
SP160	.06	.02	.29	GUNY	.11	-.04	-.00
V:ED	.13	.01	.13	TAS	.13	-.00	-.12
K:M	.08	.01	.34	NAVN	.17	-.07	-.16
PRES	.03	.29	-.04	COMM	.15	-.03	-.16
DP	.02	.33	-.07	ENGG	.15	.02	-.05
CS	.04	.33	-.08	SEAM	.17	.05	-.11
EO	.05	.32	.00	OLQ	.09	.12	-.16
SO	.03	.32	-.04	D.TOT	.22	.01	-.18
PSYCHO	.08	.29	.03	ECON	.11	.01	.06
TO	.04	.31	-.02	MATHS	.14	-.08	-.00
B.MARK	.06	.36	-.03	MECH	.20	-.03	.13
ENGL	.03	-.01	.01	ENG.SC	.19	-.01	.08
GENL	.03	-.04	-.13	CHEM	.14	.02	.04
MATH	.10	-.10	.03	ELECT	.19	.00	.04
PHYS	.13	-.04	.09	PRAC	.16	-.03	.11
T.EXAM	.11	-.07	.11	BC.TOT	.22	-.02	.10
PR.ATT	-.01	.03	.07	SC.TOT	.18	-.05	-.02
CORPS	-.01	.08	-.12	N	.15	-.10	-.11
SOCS	.06	.04	.01	X	.12	-.07	-.13
GAMES	.00	.01	-.19	E	.14	.03	.07
PREF	.03	-.01	-.15	L	.15	-.00	.01
ON.CH	-.01	-.01	.01	M	.14	-.04	.03
PAR.DD	.03	.03	-.03	S	.11	-.07	-.15
FAT.RN	-.01	-.02	.04	T.DART	.21	-.07	-.07
F.ARMY	-.01	-.00	-.07	T.LCDR	-.20	.01	-.03
HMC.SC	-.01	.11	-.02	S.INDA	.07	-.04	-.23
B.PREF	.02	.04	-.00	S.INDB	.07	-.03	-.25
A.ENT	.00	.03	.04				

VARIANCES

COMPONENT NO	VARIANCE	ACCUMULATED VALUE AS % OF TOTAL VARIANCE
1	14.0	17.7
2	6.9	26.5
3	4.7	32.4
4	4.4	37.9
5	3.5	42.4
6	2.7	45.9
7	2.5	49.0
8	2.3	52.0
9	2.2	54.8
10	2.0	57.3
11	1.9	59.8
12	1.7	61.9
13	1.6	63.9
14	1.5	65.9
15	1.4	67.7
16	1.4	69.5
17	1.3	71.2

SAMPLE SIZE - 125

TABLE APP 9.3 PRINCIPAL COMPONENT ANALYSIS OF PRE-ENTRY, TRAINING AND CRITERIA DATA - SAMPLE E

COMPONENT LOADINGS

VARIABLE	COMPONENT NO 1	2	3	VARIABLE	COMPONENT NO 1	2	3
GT35	.09	.04	.11	HMC.SC	-.03	.15	.11
SP96	.13	-.02	.02	B.PREF	.01	.09	-.06
SP21	.08	-.08	.02	A.ENT	-.04	.02	-.06
SP117E	.12	-.02	.15	F.OCC	.02	-.13	-.04
SP117M	.10	-.00	.23	T.HSC	.07	-.04	.07
SP97	.09	.05	.24	A.AIB	-.04	.01	-.11
SP160	.11	.04	.36	T.LCDR	-.27	-.07	.13
V:ED	.12	.02	.09	B.AGG	.12	.09	-.03
K:M	.16	.03	.39	B.SD	.07	-.17	-.18
PRES	.00	.27	-.05	ELEC	.17	.00	-.01
DP	-.05	.30	-.07	GUNY	.17	.01	-.05
CS	-.05	.28	-.05	TAS	.21	.06	.11
EO	-.08	.29	.14	NAVN	.22	-.02	.11
SO	-.02	.28	-.12	COMM	.18	-.07	.02
PSYCHO	-.09	.27	.13	ENGG	.21	.07	.05
TO	-.04	.29	.10	SEAM	.17	.13	.08
B.MARK	-.06	.33	-.02	OLQ	.07	.21	.05
ENGL	.06	.00	-.07	D.TOT	.26	.09	.09
GENL	.02	.01	-.22	XS	-.10	-.12	.19
MATH	.12	-.12	.08	NS	-.22	.04	.02
PHYS	.15	-.11	-.06	G	-.17	-.03	.08
T.EXAM	.16	-.14	.00	T	-.15	-.04	.10
CORPS	.04	.04	.02	A	-.13	-.03	.20
SOCS	.06	.02	-.01	C	-.20	-.03	.18
GAMES	-.01	.06	-.02	D	-.15	.03	.01
PREF	-.05	-.02	-.04	DC	-.15	-.11	.10
ON.CH	-.03	-.04	-.08	CO	-.14	-.03	.02
PAR.DD	.01	-.05	-.03	R	-.21	.01	.06
FAT.RN	.05	.05	.05	S.INDA	.08	.14	-.21
F.ARMY	-.07	.05	.04	S.INDB	.11	.12	-.18

SAMPLE SIZE - 86

VARIANCES

COMPONENT NO	VARIANCE	ACCUMULATED VALUE AS % OF TOTAL VARIANCE
1	9.9	15.0
2	7.5	26.3
3	3.7	31.9
4	3.5	37.2
5	3.3	42.3
6	3.0	46.8
7	2.5	50.7
8	2.4	54.2
9	2.1	57.5
10	1.9	60.3
11	1.8	63.1
12	1.6	65.5
13	1.5	67.7
14	1.4	69.8
15	1.3	71.9

TABLE APP 9.4 PRINCIPAL COMPONENT ANALYSIS OF PRE-ENTRY, TRAINING AND CRITERIA DATA - SAMPLE X

COMPONENT LOADINGS

VARIABLE	COMPONENT 1	COMPONENT 2	COMPONENT 3	VARIABLE	COMPONENT 1	COMPONENT 2	COMPONENT 3
JT35	.17	.21	.11	T.EXAM	.05	.15	.20
SP96	.21	.26	-.01	PR.ATT	-.01	.17	.01
SP21	.15	.22	.11	CORPS	-.00	.13	-.03
SP117E	.15	.18	-.15	SOCS	-.08	.04	.12
SP117M	.18	.14	-.04	GAMES	-.13	.10	.27
SP97	.11	.15	-.23	PREF	-.02	.05	.11
SP160	.17	.15	-.19	ON.CH	-.06	.03	.03
V:ED	.23	.28	.05	PAR.DD	.07	.02	.04
K:M	.22	.21	-.22	FAT.RN	.04	.06	-.20
PRES	-.19	.19	-.12	F.ARMY	0	0	0
DP	-.27	.11	-.19	HMC.SC	-.08	.02	-.27
CS	-.27	.15	-.04	B.PREF	.02	.02	-.20
EO	-.19	.22	-.02	A.ENT	.08	.17	.29
SO	-.27	.22	-.07	F.OCC	-.00	-.05	.29
PSYCHO	-.15	.26	-.02	T%HSC	-.11	.06	.26
TO	-.21	.19	-.12	A.AIB	.04	.19	.30
B.MARK	-.31	.23	-.08	T.LCDR	-.05	-.14	-.08
ENGL	-.04	.06	.20	B.AGG	-.15	.26	.11
GENL	-.07	.01	.03	B.SD	.04	.00	-.02
MATH	.16	.15	-.06	S.INDA	-.18	-.06	-.00
PHYS	.18	.03	-.04	S.INDB	-.06	-.06	.05

VARIANCES

COMPONENT	VARIANCE	ACCUMULATED VALUE AS % OF TOTAL VARIANCE
1	6.8	14.5
2	5.0	25.1
3	4.0	33.6
4	3.4	40.8
5	2.7	46.5
6	2.6	52.0
7	2.0	56.2
8	1.8	60.1
9	1.7	63.6
10	1.5	66.8
11	1.4	69.7
12	1.2	72.3
13	1.2	74.7
14	1.1	77.1
15	1.1	79.4
16	1.0	81.6
17	1.0	83.6
18	0.9	85.5
19	0.8	87.2
20	0.7	88.7
21	0.6	90.0

SAMPLE SIZE - 55

TABLE APP 9.5 PRINCIPAL COMPONENT ANALYSIS OF PRE-ENTRY, TRAINING AND CRITERIA DATA - SAMPLE S

APPENDIX 10

PRINCIPAL COMPONENT ANALYSIS of INTERESTS DATA

COMPONENT	SAMPLE			
	X	E	S	X E S
1	3.78	4.09	3.96	3.66
2	3.05	2.92	3.23	2.48
3	2.53	2.25	3.15	2.38
4	2.46	1.91	2.43	1.76
5	1.87	1.68	2.03	1.53
6	1.67	1.47	1.80	1.48
7	1.54	1.40	1.71	1.30
8	1.39	1.35	1.53	1.24
9	1.20	1.26	1.39	1.08
10	1.08	1.04	1.15	1.04
11	0.96	0.92	1.03	0.98
12	0.94	0.89	0.97	0.92
13	0.87	0.89	0.93	0.89
14	0.77	0.87	0.70	0.83
15	0.74	0.84	0.65	0.76
16	0.69	0.70	0.63	0.73
17	0.65	0.67	0.54	0.71
18	0.61	0.64	0.48	0.68
19	0.54	0.59	0.45	0.65
20	0.51	0.56	0.40	0.59
21	0.45	0.51	0.28	0.55
22	0.42	0.49	0.27	0.52
23	0.38	0.46	0.22	0.48
24	0.35	0.43	0.20	0.46
25	0.31	0.40	0.17	0.45
26	0.28	0.38	0.17	0.42
27	0.27	0.34	0.15	0.40
28	0.23	0.33	0.15	0.37
29	0.19	0.29	0.13	0.34
30	0.14	0.23	0.07	0.30
31	0.13	0.19	0.04	
MAXIMUM k	23	23	23	22
χ^2	870	1100	880	1930
DEGREES OF FREEDOM	10	10	10	6

TABLE APP 10.1 COMPONENT VARIANCES FOR INTERESTS DATA

VARIABLE	COMPONENT																			
	1				2				3				4				5			
	X	E	S	XES	X	E	S	XES	X	E	S	XES	X	E	S	XES	X	E	S	XES
MUSIC	·19	·22	·23	·24	·12	·03	·12	·11	·13	·24	·18	·19	·19	·15	·19	·12	·27	03	28	07
LISTENING	·28	·21	·27	·28	-·20	·25	·17	·21	·23	-·03	·07	-·10	-·09	·01	·02	-·09	·06	·19	·10	-·13
DANCING	·11	·19	·28	·21	-·06	·11	·13	·11	·12	·08	-·24	-·07	-·11	-·16	·01	-·20	·03	-·03	-·04	·19
PARTIES	·21	·17	·25	·20	-·03	·30	·24	·21	·15	·03	-·25	-·10	-·29	-·27	-·05	-·33	·15	·05	-·13	·14
ART GALL.	·09	·23	·09	·18	·38	-·06	-·02	-·14	-·08	·06	·11	·28	·18	-·23	-·10	·08	·15	·02	·48	·44
THEATRES	·21	·28	·20	·25	·15	·10	·27	·17	·30	-·15	·14	·09	-·00	·05	·27	-·01	-·04	·20	·11	·08
CINEMA	·30	·14	·12	·19	-·07	·27	·23	·25	·24	-·07	·16	-·05	-·13	-·22	·29	-·31	·14	·08	-·22	·01
READING	·09	·11	-·05	·08	·17	·01	·16	·09	·29	·09	·04	·18	-·04	·22	·03	-·04	·20	-·11	·02	-·11
WRITING	·09	·23	·22	·18	·37	-·11	-·03	-·06	·10	·27	·09	·34	·12	-·17	-·04	-·01	-·06	·08	·16	·03
DRAWING	·18	·28	·15	·24	·27	-·02	-·23	-·18	-·24	·06	·05	·13	·01	-·37	-·20	-·08	·05	·03	·13	·30
MUSEUMS	·14	·30	·20	·23	·29	-·10	-·22	-·18	·04	·16	·15	·19	-·01	-·05	·14	-·08	-·23	-·25	·10	·02
COLLECTING	·14	·07	·18	·11	·09	-·21	-·31	-·23	-·07	·03	·12	·07	-·08	·11	·10	·00	-·41	-·03	·03	-·30
PHOTOGRAPHY	·20	·08	·02	·08	·09	-·31	-·22	-·30	-·15	·01	-·18	·04	-·09	-·07	·05	-·01	·01	·17	·31	-·05
TRAVEL	·04	·08	·22	·13	-·05	·25	-·11	·17	·07	-·07	·19	-·04	·25	·24	-·23	·09	-·07	·07	·16	-·07
SPORTS	·12	·05	·19	·13	-·19	·31	·20	·27	·08	·05	-·07	-·16	·12	·22	·07	·05	-·15	-·09	-·09	-·13
COUNTRY	·28	·13	·16	·15	·04	-·08	·04	-·01	-·04	·27	·18	·11	-·13	·12	-·33	-·27	·26	-·39	-·25	-·27
GARDENING	·19	·02	·14	·07	·18	-·15	-·11	-·21	-·16	·15	·13	·12	-·12	·18	-·18	-·19	-·31	-·34	-·29	-·43
ANIMALS	·25	·01	·12	·08	-·03	·19	·09	·06	-·18	·10	·13	-·07	-·24	-·22	-·18	-·43	·04	-·31	-·05	-·09
PEOPLE	·07	·23	·26	·23	-·11	·29	·21	·28	·15	-·01	·05	-·02	·42	·18	-·13	·25	-·00	·07	-·05	-·04
CHILDREN	·30	·21	·22	·27	-·03	·07	-·02	·01	-·01	·05	·19	·04	·22	-·10	·14	·02	-·09	-·19	-·20	-·19
ORGANISING	·10	·08	·12	·14	-·11	·26	·02	·18	-·07	-·09	·02	-·06	·39	·12	·29	·25	·16	-·12	·23	·09
RELIGION	-·07	·30	·04	·18	·07	-·10	·24	·01	-·15	·18	·06	·17	·31	·19	-·16	·27	·02	·14	-·00	-·13
POLITICS	·17	·18	·02	·17	·03	-·16	·34	·05	·12	·20	·01	·22	·32	·12	-·10	·27	-·16	·24	·16	-·11
SCIENCE	·12	·14	·16	·16	-·28	·11	·03	-·01	-·04	-·21	-·40	-·34	·08	·24	-·12	·16	-·20	-·13	-·01	-·03
ELECTRICAL	·23	·21	·16	·22	-·32	-·13	-·04	-·17	-·14	-·39	-·42	-·38	·05	·17	·19	·16	·09	-·11	-·02	-·03
WOODWORK	·18	·12	·26	·16	-·01	-·12	-·25	-·30	-·32	-·36	-·19	-·23	-·01	-·25	·05	-·16	-·07	-·13	-·26	·08
HANDICRAFTS	·13	·19	·29	·19	·04	-·19	-·30	-·32	-·44	-·39	-·04	-·20	·07	-·06	·13	·01	·01	·11	-·09	·10
SAILING	·04	-·02	·08	·04	·15	·05	·00	-·03	-·23	-·16	-·01	-·01	·04	-·09	-·36	-·13	·47	-·29	·14	·37
DOMESTIC	·28	·16	·16	·18	·07	-·24	-·21	-·20	·07	·03	·17	·11	-·00	·06	-·05	·04	-·24	·19	-·09	-·15
MECHANICAL	·21	·25	·11	·20	-·34	-·15	-·00	-·16	-·20	-·30	-·38	-·37	·01	·20	-·14	·16	·07	-·18	·21	-·01
S.INDB	-·03	-·07	·05		·01	·10	·03		-·07	·02	-·04		-·14	·20	-·33		-·07	·29	·03	
VARIANCE	3·78	4·09	3·96	3·66	3·05	2·92	3·23	2·45	2·53	2·25	3·15	2·38	2·46	1·91	2·43	1·76	1·87	1·68	2·03	1·53

TABLE APP 10.2 LOADINGS OF INTERESTS VARIABLES ON FIRST FIVE COMPONENTS

APPENDIX 11

COMPONENT AND FACTOR ANALYSES of S206 REPORT DATA

PRE-'60 REPORTS

VARIABLE	SAMPLE X COMPONENT 1	SAMPLE X COMPONENT 2	SAMPLE E COMPONENT 1	SAMPLE E COMPONENT 2	SAMPLE L COMPONENT 1	SAMPLE L COMPONENT 2
P.ABIL	.46	.17	.46	.34	.45	.54
M.QUAL	.43	.59	.44	.56	.45	.53
LEADER	.45	-.39	.45	-.47	.45	-.52
A.ABIL	.46	.26	.45	.13	.44	-.31
P.QUAL	.43	-.63	.43	-.58	.44	-.26

COMPONENT	VARIANCE	ACCUMULATED VALUE AS % OF TOTAL VARIANCE	SAMPLE
1	3.61	72.1	X
	3.57	71.4	E
	3.34	66.8	L
2	0.50	82.1	X
	0.56	82.6	E
	0.60	78.9	L
3	0.33	88.7	X
	0.35	89.5	E
	0.45	87.9	L
4	0.29	94.4	X
	0.27	95.0	E
	0.33	94.5	L
5	0.28	100	X
	0.25	100	E
	0.27	100	L

SAMPLE SIZES X = 653, E = 702, L = 292

POST-'60 REPORTS

VARIABLE	SAMPLE X COMPONENT 1	SAMPLE X COMPONENT 2	SAMPLE E COMPONENT 1	SAMPLE E COMPONENT 2	SAMPLE L COMPONENT 1	SAMPLE L COMPONENT 2
ENERGY	.32	.01	.32	.19	.32	-.07
RELIAB	.34	.18	.32	.13	.32	-.13
COMMON	.33	.05	.34	.07	.34	.05
INTELL	.30	.39	.30	.39	.29	.58
INTIVE	.34	.06	.35	.17	.34	.10
LEADER	.33	-.23	.33	-.12	.33	-.24
EXPRES	.30	.31	.31	.04	.31	.36
O.ABIL	.33	.19	.33	.15	.33	.21
TACTOO	.29	-.37	.29	-.51	.29	-.48
SOCATT	.27	-.70	.26	-.68	.29	-.41

COMPONENT	VARIANCE	ACCUMULATED VALUE AS % OF TOTAL VARIANCE	SAMPLE
1	6.70	67.0	X
	6.16	61.6	E
	5.94	59.4	L
2	0.72	74.2	X
	0.82	69.8	E
	0.82	67.6	L
3	0.58	80.0	X
	0.60	75.8	E
	0.56	73.2	L
4	0.45	84.5	X
	0.51	80.9	E
	0.56	78.7	L
5	0.35	88.0	X
	0.43	85.1	E
	0.45	83.3	L
6	0.32	91.1	X
	0.39	89.0	E
	0.41	87.2	L
7	0.27	93.8	X
	0.31	92.1	E
	0.36	91.0	L
8	0.25	96.3	X
	0.30	95.0	E
	0.35	94.5	L
9	0.19	98.3	X
	0.26	97.6	E
	0.29	97.4	L
10	0.17	100	X
	0.24	100	E
	0.26	100	L

SAMPLE SIZES X = 767, E = 922, L = 445

TABLE APP 11.1 PRINCIPAL COMPONENT ANALYSES OF S206 REPORT DATA; SAMPLES X, E AND L

PRE-'60 REPORTS

VARIABLE	COMMUNALITY	SPECIFIC VARIANCE	FACTOR 1	FACTOR 2
P.ABIL	.77	.23	.84	.26
M.QUAL	.70	.30	.77	.32
LEADER	.84	.16	.86	-.31
A.ABIL	.65	.35	.80	.09
P.QUAL	.63	.37	.77	-.17

Weighted sum of squares of residuals = .0009

SAMPLE SIZE = 702

POST-'60 REPORTS

VARIABLE	COMMUNALITY	SPECIFIC VARIANCE	FACTOR 1	FACTOR 2
ENERGY	.64	.36	.78	.19
RELIAB	.59	.41	.77	.03
COMMON	.68	.32	.82	-.00
INTELL	.53	.47	.71	.18
INTIVE	.75	.25	.86	.18
LEADER	.64	.36	.80	-.01
EXPRES	.53	.47	.73	.02
O.ABIL	.66	.34	.80	.11
TACTCO	.74	.26	.71	-.49
SOCATT	.45	.55	.61	-.27

Weighted sum of squares of residuals = .57

SAMPLE SIZE = 922

TABLE APP 11.2 FACTOR ANALYSIS OF S206 REPORT DATA; SAMPLE E

VARIABLE	COMMUNALITY	SPECIFIC VARIANCE	FACTOR 1	FACTOR 2
PRE '60				
S.INDB	.24	.76	.43	.23
F1T1	.27	.73	.50	.16
F2T1	.25	.75	.29	-.41
F1T2	.55	.45	.69	.29
F2T2	.26	.74	.46	-.22
F1T3	.51	.49	.72	.04
F2T3	.31	.69	.41	-.38
F1T4	.33	.67	.57	-.06
F2T4	.41	.59	.17	-.61
POST '60				
S.INDB	.36	.64	.52	.30
F1T5	.35	.65	.50	.31
F2T5	.20	.80	.13	-.43
F1T6	.51	.49	.66	.28
F2T6	.67	.33	.41	-.71
F1T7	.76	.24	.84	.24
F2T7	.64	.36	.39	-.70
F1T8	.62	.38	.77	.15
F2T8	.37	.63	.38	-.47

Weighted sum of squares of residuals - pre '60 = 1.1

post '60 = 0.61

SAMPLE SIZE pre '60 = 102, post '60 = 78

TABLE APP 11.3 SECOND FACTORING OF E S206 REPORT DATA

APPENDIX 12

DISCRIMINATORY ANALYSES

VARIABLE	ANALYSES											
	AIB DATA			PRE-ENTRY DATA			PRE-ENTRY + EARLY TRAINING DATA			PRE-ENTRY + ALL TRAINING DATA		
	EIGENVECTOR	ORDER		EIGENVECTOR	ORDER		EIGENVECTOR	ORDER		EIGENVECTOR	ORDER	
GT35	-.0049	2		-.0039	1		.0041	2		-.0060	2	
SP96	-.0066			-.0092			.0102			-.0056		
SP21	.0006		3	-.0002			.0004			.0014		
SP117E	-.0236	1		-.0118	3		.0041			-.0116		
SP117M	.0177		2	.0113		3	-.0173		2	.0117		6
SP160	-.0006			-.0019			.0001			.0108		4
B.MARK	-.0011	4		-.0005			-.0004			.0010		9
ENGL	-.0005			-.0004			.0001			-.0030	6	
GENL	-.0038			-.0054	4		.0021			.0007		
MATH	-.0004			-.0020			.0017			-.0027		
PHYS	-.0041	3		-.0046	2		.0035	4		-.0040	8	
T.EXAM	.0012		1	.0011		2	-.0016		1	.0022		1
PR.ATT										.0501		
CORPS				-.0940	6		.0975	6		-.1478	9	
SOCS				-.0161			.0417			.0136		
GAMES				-.0751	5		.0363			-.1031	7	
PREF				.0638		5	-.0290			.0486		
ON.CH				.0174			.0055			.0367		
PAR.DD										-.0755		
FAT.RN				.1081		4	-.1173		4	.1121		8
F.ARMY										.0212		
HMC.SC				.0473		6	-.0309			.0839		10
F.OCC				.0668		1	-.0415		3	.0831		3
T.HSC				.0333			-.0097			.0806		5
A.AIB				.0192			-.0274			-.1048		
T.LCDR										-.1224		
B.SD				.0005			-.0003			-.0057	5	
ELEC							.0005			.0030		
GUNY							-.0024		6	.0042		11
TAS							.0066	3		-.0024		
NAVN							-.0004			-.0006		
COMM							.0045	5		-.0007		
ENGG							.0014			-.0034	4	
SEAM							-.0017		5	.0004		
OLQ							.0040	1		-.0046	1	
XS										.0204		
NS										-.1109	3	
G										-.0523		
T										.0753		7
A										.0411		
C										.0322		
D										.0393		
DC										-.0701	10	
CO										.1456		2
R										.0250		

GROUP CENTROIDS

PROMOTED	-1.2350	-.5039	.5423	-4.3165
NOT PROMOTED	-1.1517	-.3531	.3269	-3.9868

PREDICTION ACCURACY - HITS AND MISSES

	ACTUALLY PROMOTED	ACTUALLY NOT PROMOTED	ACTUALLY PROMOTED	ACTUALLY NOT PROMOTED	ACTUALLY PROMOTED	ACTUALLY NOT PROMOTED	ACTUALLY PROMOTED	ACTUALLY NOT PROMOTED
FORECAST PROMOTED	14	6	22	4	25	6	27	4
FORECAST NOT PROMOTED	17	52	9	52	6	52	2	42
% HITS	45	90	71	93	81	90	93	91

TABLE APP 12.1 DISCRIMINATORY ANALYSES OF X DATA - TWO GROUPS

DISCRIMINATORY ANALYSIS OF E DATA - TWO GROUPS

VARIABLE	ANALYSES: PRE-ENTRY DATA				PRE-ENTRY + EARLY TRAINING DATA				PRE-ENTRY + ALL TRAINING DATA				PRE-ENTRY + ALL TRAINING + REPORT DATA			
	EIGENVECTOR −	EIGENVECTOR +	ORDER		EIGENVECTOR +	EIGENVECTOR −	ORDER		EIGENVECTOR +	EIGENVECTOR −	ORDER		EIGENVECTOR −	EIGENVECTOR +	ORDER	
GT35		.0005				.0013		5		.0009				.0001		
SP96		.0013				.0021				.0010			.0003			
SP21	.0010		7		.0001				.0000				.0019			
SP117E	.0061		10		.0006					.0012			.0127			
SP117M		.0060		2		.0021			.0094		9		.0019			
SP160		.0014				.0005				.0027				.0149		1
B.MARK	.0001					.0003				.0004			.0011		12	
ENGL	.0004				.0004				.0044		5		.0029			
GENL	.0066		1		.0068		3		.0102		3		.0057			
MATH	.0020		4		.0007				.0052		1		.0055		6	
PHYS	.0040		2		.0024		7		.0025				.0080		4	
T.EXAM		.0010		1		.0010		1		.0018		1		.0013		6
PR.ATT									.0608				.2338		1	
CORPS	.0403		9		.0634		5		.0922		10		.1192		11	
SOCS	.0493		6		.0409		9		.0297				.0347			
GAMES	.0384		8		.0192				.0173					.0072		
PREF	.0543		5		.0296				.0275				.0485			
ON.CH		.0120				.0195			.0039				.1315			
PAR.DD										.0984				.0947		
FAT.RN	.1463		3		.1334		4		.2342		7		.4874		2	
F.ARMY									.1086				.0550			
HMC.SC		.0407		4		.0503		4		.0175			.0323			
F.OCC		.0183		3		.0047				.0051			.0300			
T.HSC	.0176				.0044					.0289				.1264		4
A.AIB		.0074				.0098				.3402		2		.0554		
T.LCDR														.1549		5
B.SD	.0005				.0012				.0001				.0015			
ELEC					.0046		8		.0096		6		.0161		7	
GUNY					.0029		6		.0017					.0004		
TAS						.0034		3		.0054		4		.0096		2
NAVN					.0015		1		.0013		8			.0003		
COMM						.0004			.0010					.0011		
ENGG					.0008				.0007					.0007		
SEAM					.0004				.0004				.0014			
OLQ					.0021		2		.0016		11			.0006		
ECON										.0040		7		.0058		8
MATHS									.0006				.0007			
MECH									.0003					.0013		3
ENG.SC									.0012		2		.0016		3	
CHEM									.0008				.0015			
ELECT									.0020			4	.0012			
PRAC										.0008			.0011			
SC.TOT										.0004				.0007		10
N					.0001				.0003				.0011		10	
X						.0011		2		.0017		3		.0021		7
E					.0001					.0005				.0007		
L						.0003				.0015		6		.0016		9
M					.0006					.0005			.0006			
S						.0008				.0030		5	.0002			
F1													.0003		13	
F2													.0004		8	
F1A													.0003		9	
F2A													.0005		5	

GROUP CENTROIDS

PROMOTED	-.1572	.4304	-3.2661	2.4790
NOT PROMOTED	-.0730	.3099	-3.4994	2.8536

PREDICTION ACCURACY - HITS AND MISSES

	ACTUALLY PROMOTED	ACTUALLY NOT PROMOTED	ACTUALLY PROMOTED	ACTUALLY NOT PROMOTED	ACTUALLY PROMOTED	ACTUALLY NOT PROMOTED	ACTUALLY PROMOTED	ACTUALLY NOT PROMOTED
FORECAST PROMOTED	19	12	27	12	38	6	42	1
FORECAST NOT PROMOTED	26	68	18	68	7	54	3	32
% HITS	42	85	60	85	85	90	93	97

TABLE APP 12.2

VARIABLE	ANALYSES											
	L1, 3 ENTRY AND TRAINING DATA				L1, 2, 3 ENTRY AND TRAINING DATA				L1, 2, 3 ENTRY, TRAINING AND S206 DATA			
	EIGENVECTOR		ORDER		EIGENVECTOR		ORDER		EIGENVECTOR		ORDER	
	+	-	P	NP	-	+	P	NP	-	+	P	NP
GT35		.0020		9								
SP60		.0178		5								
B.MARK		.0038		6		.0010		6		.0015		6
ELEC	.0779		1		.0189		2		.0115		8	
GUNY		.0082		8	.0112		1		.0229		2	
TAS	.0001				.0044		6			.0051		7
NAVN	.0063		3			.0012		4		.0012		8
COMM		.0004				.0143		1		.0093		5
ENGG	.0081		4		.0010				.0035		7	
SEAM		.0083		3		.0034		3		.0101		1
OLQ	.0041		5		.0042		4		.0049		5	
DEGREE	.0593		6		.0871		3		.2217		1	
POWER	.0202		2		.0053		5		.0109		4	
WEAPON		.0080		1		.0004				.0060		2
R.COMM		.0100		2		.0041		2		.0072		3
R.RAD	.0009		7		.0013		7		.0027		6	
A.ENT		.1880		7	.0527					.0825		9
T.LCDR		.5288		4		.0986		5		.3200		4
F1										.0001		10
F2									.0014		3	

GROUP CENTROIDS

PROMOTED	-7.7922	-.9609	4.9369
NOT PROMOTED	-8.4492	-.5775	5.4166

PREDICTION ACCURACY - HITS AND MISSES

	ACTUALLY PROMOTED	ACTUALLY NOT PROMOTED	ACTUALLY PROMOTED	ACTUALLY NOT PROMOTED	ACTUALLY PROMOTED	ACTUALLY NOT PROMOTED
FORECAST PROMOTED	26	0	31	4	31	0
FORECAST NOT PROMOTED	0	6	2	9	1	11
% HITS	100	100	94	69	97	100

TABLE APP 12.3 DISCRIMINATORY ANALYSES OF L DATA

VARIABLE	SAMPLE X						SAMPLE S					
	EIGENVECTOR D_1	ORDER		EIGENVECTOR D_2	ORDER		EIGENVECTOR D_1	ORDER		EIGENVECTOR D_2	ORDER	
GT35	.0038	1		-.0023	5		.0032	3		-.0086	2	
SP96	.0136	4		-.0026			-.0280		3	.0254		
SP21	-.0011		5	-.0009			.0026	2		-.0013		
SP117E	-.0030			-.0157	2		.0017			.0114		5
SP117M	.0015			.0142		4	-.0037			.0117		4
SP97	-.0183		1	-.0003			-.0212		4	-.0177	5	
SP160	.0016			-.0013			-.0007			-.0105	4	
B.MARK	-.0003			-.0008			.0004	6		-.0005		
B.SD	-.0007			.0001			-.0007			-.0004		
ENGL	-.0005			-.0008			-.0029			-.0002		
GENL	.0009			-.0057	3		-.0063			-.0009		
MATH	.0015	6		-.0015			-.0002			.0008		
PHYS	.0009			-.0049	1		-			-		
T.EXAM	.0001			.0014		2	.0009	4		.0018		2
F.OCC	-.0003			.0782		1	-.0826		1	.0165		
T.HSC	-.0430		3	.0133			-.0907			.0502		
A.AIB	-.0636		4	-.0157			-.0479			.2388		3
CORPS	.1308	2		-.0317			-.0401			.0821		6
SOCS	-.1101		2	-.0850	4		-.1332		6	.0503		
GAMES	.0925	3		-.0325			-.0601	1		-.3272	1	
PREF	.0534	5		.1070		5	.1450	5		-.2052	3	
ON.CH	.0102			.0265			.0930			-.0334		
FAT.RN	.0602			.1629		3	-.1941		5	.0131		
HMC.SC	.0375			.0781		6	-.2133		2	-.1098	6	

GROUP CENTROIDS VECTORS

PROMOTED	-.7603		-1.0476		-2.3119		3.2343	
NOT PROMOTED	-.7384		-.8328		-2.2302		3.6457	
LEFT EARLY	-.8711		-.9483		-2.5397		3.4595	

PREDICTION ACCURACY - HITS AND MISSES

	ACTUALLY PROMOTED	ACTUALLY NOT PROMOTED	ACTUALLY LEFT		ACTUALLY PROMOTED	ACTUALLY NOT PROMOTED	ACTUALLY LEFT	
FORECAST PROMOTED	25	1	6		17	1	1	
FORECAST NOT PROMOTED	0	12	3		0	9	2	
FORECAST LEFT	6	5	29		4	2	18	
% HITS	81	67	76		81	82	86	

TABLE APP 12.4 DISCRIMINATORY ANALYSES OF X AND S DATA - THREE GROUPS

APPENDIX 13

MULTIPLE REGRESSION ANALYSES

PREDICTOR	DATA BLOCK					
	AIB		PRE-ENTRY		PRE-ENTRY + HMS DEVONSHIRE	PRE-ENTRY + ALL TRAINING
	CRITERION					
	D.TOT	S.INDB	D.TOT	S.INDB	S.INDB	S.INDB
GT35		+ +	-	+ +	+ +	+ +
SP160						- -
SP21	+		+			
SP117E				+		
SP117M	+		+	-	- -	
SP160	+ +		+ +			
B.MARK	+ +	+	+ +		-	-
B.SD					+	+
GENL	+		+	+	+	
MATH	+ +		+			-
PHYS		+		+ +	+ +	+ +
T.EXAM	+ +		+ +	- -	- -	-
CORPS				+	+	
SOCS				-		- -
GAMES			+	+ +	+ +	+ +
PREF			-			
PAR.DD				-	-	-
P.ARMY			- -			
FAT.RN					-	-
F.OCC				- -	-	- -
A.AIB			-	- -	- -	- -
NAV.					-	-
COMM					+ +	+
ENGG					+ +	+ +
SEAM					-	- -
OLQ					+ +	+ +
NS						+ +
A						-
D						+
DC						+ +
[illegible]						- -
[illegible]						- -
T.LCDR						- -
MULT.CORR	0.598	0.258	0.650	0.515	0.681	0.775

KEY:
- \+ POSITIVE COEFFICIENT, SIGNIFICANT AT 20% LEVEL
- + + POSITIVE COEFFICIENT, SIGNIFICANT AT 5% LEVEL
- \- NEGATIVE COEFFICIENT, SIGNIFICANT AT 20% LEVEL
- - - NEGATIVE COEFFICIENT, SIGNIFICANT AT 5% LEVEL

TABLE APP 13.1 X REGRESSION FUNCTIONS

E REGRESSION FUNCTIONS

PREDICTOR	DATA BLOCK 1				2				3	4		5	7		2	3	4	5	6	7
	CRITERION																			
	T.DART	D.TOT	BC.TOT	S.INDB	T.DART	D.TOT	BC.TOT	S.INDB	D.TOT	BC.TOT	S.INDB	S.INDB	S.INDB		S.INDC					
GT35	+ +	+ +	+ +		+ +	+ +	+ +	-		+	- -	- -	- -							
SP96	+	+			+	+							+ +				-	-		
SP21		+		+ +		+			+				+							
SP117E	+ +				+ +				-									+	+ +	+
SP117M	- -			- -	-			-	+											
SP160	- -	- -	+	-		- -		-	- -	+ +		-	- -		-	-	- -	- -	- -	- -
B.MARK		+ +	+	+	-	+ +	+		+ +											
ENGL	- -		- -		- -		-		+ +	- -						+	+	+ +	+ +	+
GENL	+ +	+		+ +	+ +	+		+ +			+ +	+ +	+ +		+	+	+ +	+ +	+ +	
MATH	+ +	+ +	+		+	+ +	+ +		+ +							+	+	+	+ +	+
PHYS	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +			+	+	+ +		+	+ +	+ +	+ +	+ +	+ +
T.EXAM			+					-		+	- -	-				-	- -	- -	- -	-
PR.ATT					- -		- -	+	+		+	+ +	+ +				+ +	+	+ +	+ +
CORPS						-	- -		- -		+	+	+ +		+ +	+ +	+ +	+ +	+ +	+ +
SOCS						+			+						+ +	+	+	+		
GAMES					+			+ +			+ +	+ +								
PREF						+									+	+ +				
ON.CH							-	-		-	- -	-	+ +				+	+	+	+
PAR.DD						+		- -	+ +		- -	- -	-				- -	- -	-	
FAT.RN					-		+		+	+ +	+	+	+ +		+ +	+ +	+ +	+ +	+ +	+ +
F.ARMY							-				+	+	+ +							
HMC.SC							-				- -	-	+							
F.OCC					- -	- -	- -	-					+							
T.HSC					+ +			+		-			- -				-	-	- -	- -
A.AIB					+										-	-	-	-		
B.SD					- -	-														+
N									+ +	- -										
X									+ +	-			-			-	- -	- -	- -	- -
E									+ +	+ +			-					-		
L										+			- -							
M									+	+ +	+									
S									+ +											+
ELEC										+ +		+	+ +				+	+ +	+	+ +
GUNY										+	+ +	+ +					+			
TAS										+ +	-	-	- -				- -	- -	- -	- -
NAVN										+ +	+ +	+ +					+ +	+	+	
COMM																	+ +	+ +	+	
ENGG																				
SEAM																			+	+ +
OLQ											+ +	+ +					+ +	+ +		
ECON													-						-	- -
MATHS												+	+					+	+	
MECH												+ +							-	- -
ENG.SC																				+ +
CHEM												+	+					+		
ELECT													+					+		+
PRAC													+ +							
SC.TOT												-								
T.LCDR												+ +							- -	-
F1													+ +						+ +	+
F2													+ +						+ +	+ +
F1A													+ +							+ +
F2A													+ +							+ +
MULT.CORR	.622	.571	.481	.344	.728	.627	.575	.483	.823	.748	.636	.689	.851		.465	.509	.694	.737	.774	.831

KEY TO DATA BLOCKS

1 AIB
2 PRE-ENTRY
3 PRE-ENTRY + DARTMOUTH
4 PRE-ENTRY + DARTMOUTH + HMS DEVONSHIRE
5 PRE-ENTRY + ALL TRAINING
6 PRE-ENTRY + ALL TRAINING + EARLY S206
7 PRE-ENTRY + ALL TRAINING + ALL S206

KEY TO TABLE SYMBOLS:

+	POSITIVE COEFFICIENT, SIGNIFICANT AT 20% LEVEL
+ +	POSITIVE COEFFICIENT, SIGNIFICANT AT 5% LEVEL
-	NEGATIVE COEFFICIENT, SIGNIFICANT AT 20% LEVEL
- -	NEGATIVE COEFFICIENT, SIGNIFICANT AT 5% LEVEL

TABLE APP 13.2

CRITERION S.INDB

PREDICTOR	DATA BLOCK	
	AIB	PRE-ENTRY
GT35	+ +	+ +
SP96	-	-
SP117M	-	- -
SP160		+
GENL	- -	- -
PREF		+
ON.CH		+
PAR.DD		-
FAT.RN		- -
A.AIB		.- -
B.SD		+
MULT.CORR	.427	.646

TABLE APP 13.3 S REGRESSION FUNCTIONS

CRITERION S.INDB

PREDICTOR	DATA BLOCK			
	PRE-ENTRY	PRE-ENTRY + HMS DEVONSHIRE	PRE-ENTRY + ALL TRAINING	ALL
CT35	+	+		- -
SP60	+		-	-
B.MARK	+ +	+ +		
ELEC		+ +	+ +	+ +
GUNY			- -	- -
TAS		+		+ +
NAVN			+ +	+ +
COMM		- -	-	
ENGG		+		
SEAM				+
DEGREE			+ +	+
POWER			+ +	+ +
R.RAD				-
R.COMM			- -	
T.LCDR				+ +
F1				+ +
F2				+
F1A				+ +
F2A				+
MULTI.CORR	.450	.685	.848	.941

TABLE APP 13.4 L REGRESSION FUNCTIONS

APPENDIX 14

TOPICS FOR FURTHER STUDY

TOPICS FOR FURTHER STUDY

1. Analysis of the inter-relationship of the two dimensional model of annual report data and the three dimensional model of selection data.

2. Investigation of time dependency of annual report markings and location of the time track in the ability model.

3. Cluster Analysis of Interests data for identification of meaningful groupings for both descriptive and predictive purposes.

4. Investigation of feasibility of condensation of Biographical data.

5. Comparison of the ability model of a recent sample with that of the original sample in order to assess the relevance of primary investigation findings in present conditions.

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