In N.I.P.R. Only

Master Copy /2

SCIENTIA
WNNR · CSIR

CONTRACT REPORT

C/PERS 180

SELECTION BATTERY FOR PROGRAMMERS - SECOND VALIDATION STUDY

Submitted to

THE COMPUTER SOCIETY OF SOUTH AFRICA

NATIONAL INSTITUTE FOR PERSONNEL RESEARCH
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

CSIR Contract Report, No. C/PERS 180, UDC 658.311.5:681.3.00-05
Johannesburg, South Africa. June 1970.

SELECTION BATTERY FOR PROGRAMMERS -

SECOND VALIDATION STUDY

By

R.S. Hall

D.W. Steyn

R.H. Blake

Submitted to:

THE COMPUTER SOCIETY OF SOUTH AFRICA

June, 1970.

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

ACKNOWLEDGEMENTS

This project was directed by Mr. D.J.M. Vorster. Mr. R.S. Hall acted as coordinator, and Messrs. R.S. Hall, R.H. Blake, D.W. Steyn, and J.M. Schepers acted as the project steering committee for this phase of the project.

The criterion schedule was revised by Mr. D.W. Steyn. The testing of the samples was organised by Mr. D.W. Steyn. The analysis of the data was undertaken by Mr. R.S. Hall. Sections I and VI of the reports were written by Mr. R.H. Blake and section VII jointly by Mr. R.H. Blake and Mr. D.W. Steyn, sections II, III, IV, and V were written by Mr. R.S. Hall. Appendix III was prepared by Miss M. v.d. Merwe.

We wish to express our appreciation of the cooperation extended by the organisations which participated in this study.

SYNOPSIS

This project was initiated in April 1968 by the NIPR in conjunction with the Computer Society of South Africa with a view to improving the selection of personnel in the data processing field.

The first phase of the project consisted of an extensive review of the literature on selection and criterion problems as well as comprehensive job descriptions of operator, programmer and systems analyst jobs. The findings were reported by Van der Merwe (5).

The second phase was concerned with the development of a criterion for programmers and the validation of the first selection of tests. The findings were reported by Steyn (4).

This report covers the third phase which consisted of validating the revised test battery against a revised criterion schedule on two further samples of programmers. The results of this phase were the basis for the recommendations made to the industry on the battery to be used, and for test scores, biographical data, and assessments of performance to be collected on applicants for an initial period for the purpose of a further validation.

CONTENTS

I. INTRODUCTION

The electronic computer has increased man's productivity more than any other recent technological development. It has improved man's ability to manipulate data and processes to such an extent that tasks which were unheard of 30 years ago have now become everyday occurrences. It is ".... recognised as the principal future tool of commercial and industrial management. It is a logical machine able to make unerring decisions at high speed from volumes of information with which no human being could cope. It also offers unrivalled methods of storing and linking data and of promoting rapid access to them. It is already used in business, finance, public administration, research and, increasingly, in control of manufacturing processes, in power generation and transmission, stock control, design, traffic control, transport, telecommunications, health, hygiene and medicine". (British Control Office of Information, see (2)).

The first computer installation in South Africa took place in 1957. By 1968, 340 had been installed, representing an investment of approximately R86 million. To man these machines approximately 2000 programmers, 1000 operators, 500 service engineers and 100 systems analysts were needed. In a recent survey published by the National Development and Management Foundation (1), it was estimated that by 1975 the number of installations may reach the 2600 mark unless there is a trend towards larger and fewer installations. The general view appears to be that a growth rate of 25% per annum compounded will be maintained in the immediate future. The number of people to man these machines will, of course, increase proportionately; it has been estimated by Harvey (6) that some 26000 computer specialists will be needed by 1978. The greatest expansion in the field is thus still to come, and the identification of people with necessary abilities and aptitudes to be trained as computer specialists will very soon assume even greater importance than it has at present.

Present selection policies set rather high educational standards for computer specialists, especially for system analysts and programmers. The system analyst usually has a university degree in the natural sciences, commercial sciences or engineering, as well as a few years' experience as a programmer. A programmer is required to have a minimum educational qualification of Standard Ten, with mathematics as a subject, and an aptitude for analysing problems in the minutest detail. A Standard Eight certificate (again with mathematics as one of the subjects) is the minimum qualification usually expected of an operator, but in the case of certain large computers, a degree in mathematics may be required. From people in these categories, only the top is "creamed off", often by means of aptitude tests.

Such a policy sets high cut-off points, which helps to ensure that intellectually able people are placed in these demanding jobs. However, high cut-off points tend to eliminate people who are not quite in the top category but who would, nevertheless, be able to cope with the demands of the job. Furthermore, the use locally of aptitude tests and norms which were developed abroad is undesirable. Such tests are bound to the culture in which they were developed and should not be used in countries other than the ones in which they were developed without revision and restandardization. In most cases, this appears not to have been done, nor are they always available in Afrikaans. The local population, especially people whose home language is Afrikaans, is thus likely to be at a disadvantage when sitting such tests.

Consequently many people who are potentially able to make a success of jobs in the computer field, especially in the systems analyst/programmer category, are at present being lost to the industry. It is also obvious that, without a revision of present selection techniques the mushrooming demands for personnel in this category will not be met. There is an indication in Appendix III that this may be feasible. It appears inevitable that the cut-off points used in selection will have to be lowered but, if this is not to lead to a greater training wastage, the identification of people with the skills and aptitudes necessary for success in this area will have to be improved.

For these reasons, the NIPR decided to initiate a project, the aim of which would be to produce a battery of locally constructed tests of high reliability, intended primarily for South Africans and available in both official languages, which would be validated against computer specialist jobs, specifically systems analysts and programmers. The demonstration of high validity in predicting success in these two jobs would ensure that it could be used for selection with considerable confidence. The financial aid of the Computer Society of South Africa was enlisted, and the project was begun in the second half of 1968.

This report describes the third stage in the development of that battery.

II. OBJECTIVES

In order to keep the project within reasonable bounds, it was decided to limit it to three key jobs in the industry, namely System Analyst, Programmer and Computer Operator. It was planned to carry out the project in four stages. The first entailed a survey of the literature on research on the selection of data processing personnel, and an analysis of three jobs in a small sample of 5 firms which were a representative cross-section of the industry. Important differences in the nature of the work of data processing staff were expected to be associated with differences in size or the field of operations. It was thought that in the smaller firm programmer and system analyst jobs tend to coalesce and operator jobs to deal with a wider range of equipment on a simpler machine while in the large firm there is greater specialisation, tighter control and more emphasis on selection and training procedures. Such differences would influence the nature of samples drawn for the validation stage and might set different requirements for selection.

Difficulty was anticipated in reconciling evaluations from the different firms from which the validation samples would be drawn. Variation in standards and degree of supervision, in the complexity of the machine and the programming language used, in the quality of staff selected and in methods of training, would produce inconsistencies between assessments and result in reduced test-criterion correlations. It would therefore be necessary to develop a common criterion based on task activities that could easily be identified by supervisors. The first criterion would be for programmers only, as it was advisable to see how it functioned before developing criteria for the other two jobs. The criterion would consist of ratings on programmer activities described in the Job Analysis. Similar criteria had been used overseas, but had unfortunately included vague and diffuse concepts. It was hoped that the use of concrete observable activities would provide a more easily used and more reliable instrument which would minimise differences between raters' standards. Supervisors were to be trained in the use of the schedule and provided with written instructions.

The third stage was to be the validation of selected tests against the criterion schedule. The first plan was to draw a sample of 100 programmers from firms in Johannesburg and Pretoria. However the cost and difficulty of sampling from a large number of small scattered units favoured the alternative of choosing the sample from a limited number of large firms. Apart from administrative simplicity this plan had the advantage that contamination of the criterion by inter-firm differences would be reduced. It was decided to limit sampling to three or four firms and to draw a sample of 30-40 programmers from each. Test scores, criterion schedules and biographical information were to be obtained for samples of programmers from each organisation.

The final stage would be a longitudinal validation. Test scores, biographical data and criterion schedule scores would be collected from firms using the battery and the tests would be validated afresh when a sufficiently large sample became available, possibly in 12-18 months. A validation based on a sample of existing programmers has the disadvantage that tests which are the best selectors suffer restriction of range and receive lower battery weights. Ideally test and criterion results should be collected over a period without using the battery for selection. Unfortunately practical considerations rule this out and it will be necessary to collect results while the battery is being used as a selection instrument. This means that there will be no criterion scores for the unsuccessful applicants. Nevertheless, sufficient information will be available from the distributions of test scores for the applicant population, for those who are initially accepted but fail on the job and for the successful programmers.

III. THE HISTORY OF THE PROJECT

The project was undertaken after a meeting between NIPR staff and a sub-committee of the Computer Society for South Africa in March 1968. Doubts had been expressed over the applicability of programmer aptitude tests normalised for a United States population to a South African population - which accorded with the NIPR's experience with other tests. The Society financed the project and its influence was of great assistance in obtaining the co-operation of the many different organisations that were involved.

The project was carried out in three stages. The first consisted of a summary of the literature on studies of programmer abilities, the construction of programmer aptitude tests, and description of computer operator, programmer and system analyst jobs. This was followed by an actual job analysis of computer operator, programmer and system analyst jobs in five organisations in Johannesburg and Pretoria, namely a large and a small computer bureau, a large semi-government organisation, a large industrial firm and a mining house. At the same time discussions were held with D.P. and Personnel Managers in 16 different organisations on current methods of selecting and evaluating computer personnel.

The job analysts reported a considerable range in the nature of programmers' work. In some firms the programmer handled systems analysis as well as programming, whereas in others there was a hierarchy of project leaders, senior programmers and coders, and there was corresponding variation in the nature and quality of training and evaluation. This was confirmed in discussions with D.P. Managers which revealed a great variety of approaches in the selection, training and evaluation of staff - some firms rely entirely on interviews, the majority use aptitude tests developed overseas by computer suppliers, and others apply their own selection batteries. Methods of training also vary, some firms rely on computer supplier's courses and on-the-job training, others run their own schools. There are equally large differences in methods of evaluation, ranging from the largely intuitive to well designed schedules and careful training in their application.

These findings, which were embodied in a report by Van der Merwe (5) published in October 1968, highlighted the problem of the criterion. It was clear that with such widely differing standards the assessment of programmers across firms presented a major difficulty.

The second stage, therefore, consisted of an attempt to develop a criterion which would permit the comparison of programmers across firms. The basic idea was to have programmers evaluated on a five point scale on a set of 40 to 50 items relating to activities carried out by persons classed as programmers. Emphasis was placed on the concrete rather than the abstract. The activities themselves were based on the job descriptions made at stage I.

At the third stage the criterion schedule and a tentative test battery were administered to programmers in three large organisations. The first version of the schedule was tried out in a large organisation where the staff were well-trained in making assessments. The results were very encouraging. They showed relatively little halo-effect both person-wise and item-wise, test-criterion correlations of the order of .4 and a low criterion-experience correlation. The schedules correlated reasonably well, .5, but not too well as aims differed, with the firm's own evaluation of its staff. These results were published in a second report by Steyn (4) in June 1969.

The schedule was then revised and both old and new forms were applied in a second firm. In this case the results were surprising. While the ratings on the schedules appeared to have been carefully done, none of the correlations turned out as expected. In many cases they were negative.

A number of reasons could be advanced. There was severe restriction of range - tests of mental ability showed that the staff were carefully selected and of high quality. The small sample size, 32, could be another reason. Experience appeared to be a dominating factor, older staff with much experience scored highly on the criterion schedule and less well on the psychological tests, but partialling experience out of the intercorrelation matrix produced only minor improvement. A large proportion of the staff were young university-trained women with short experience who did well on the tests but were not rated so highly on the criterion, but eliminating education or sex did not improve the test-criterion correlations appreciably.

The revised form of schedule was applied to a third organisation, but there again the results were unexpected. Programmers in the last organisation were of a lower educational level and older than those in the preceding samples. As a result correlations with such tests as Mental Alertness (which had been reduced by the restricted range in the other samples) were high. Furthermore it was clear from a tabulation of criterion item ratings that assessment had not been as carefully done as in the other samples.

Although the individual sample test-criterion correlations were disappointing, better correlations were obtained when the two later samples were combined. Further, certain test score distributions of the samples, when compared with the corresponding distributions for the populations on which the tests were originally normalised, showed that some of the tests discriminated well. As a result of these analyses and from the matching of test content and job requirements, the following tests were chosen for the selection battery:-

Pattern Relations,
High Level Mental Alertness,
Gottschaldt Figures and
Concept Attainment.

IV. THE SAMPLES USED

1. Sampling took place at several levels. In the first place there are a number of jobs falling under Data Processing, namely:-

Data Processing Manager
Senior Systems Analyst
Systems Analyst
Senior Programmer
Programmer
Coder
Maintenance Engineer
Senior Operator
Operator
Peripheral Operator
Computer Librarian

It would have enlarged the project beyond the resources the NIPR could afford to devote to it to cover all these jobs. Consequently the study was limited to three of the most important i.e. System Analyst, Programmer and Operator. Two other important jobs i.e. Data Processing Manager and Maintenance Engineer were omitted, but could perhaps be dealt with in subsequent study if the need arose.

2. A large number of different kinds of organisations make use of data processing, for example:-

	Approximate no. of machines in S.A. installed and on order (1968) (7)
Commercial Firms	71
Industrial Firms	102
Mining Houses	11
Financial Institutions	41
Service Bureau	39
Government Departments, etc.	46
Educational Institutions and Research Laboratories	14
	324

The different applications result in differences in environment, methods of selecting, training and assessing staff, and languages and machines used. It was beyond the means of the NIPR to study all categories and the project was therefore limited to commercial D.P. units thus omitting units with a scientific or engineering orientation. To obtain a representative sample of commercial applications five firms were chosen, namely a large and a medium-sized service bureau, a large industrial firm, a mining house and a large state-controlled industrial unit. Four of these units were located in Johannesburg and one in Pretoria. For comparison the geographical distribution of computers installed and on order in 1968 was:

	Johannesburg	Other Reef Towns	Pretoria	Cape Town	Durban	Other
Number	120	33	34	39	29	72

Both large and small, government and private, and commercial industrial and mining organisations were represented thus covering the most important classes of applications.

Within each firm the Data Processing Manager nominated a typical Systems Analyst, Programmer and Computer Operator for interview by the Job Analyst.

In order to minimise the effects of heterogeneous environments the validation samples were limited to a few large organisations which could provide groups of 30 or 40 programmers each. This requirement narrowed the field considerably and ultimately a large State-controlled industrial organisation, a large computer bureau and a government department were chosen. Virtually all available programmers in each were used for the validation samples.

The three validation samples differed markedly in their characteristics as can be seen from the following:

		Sample		
		1	2	3
		%	%	%
Educational level	University	37	52	5
	Matric	63	48	58
	Below Matric	-	-	37
		Yrs.	Yrs.	Yrs.
Mean age		28.9	24.9	31.1
		%	%	%
Sex	Male	90	56	100
	Female	10	44	-
		%	%	%
Home Language	Afrikaans	63	1	73
	English	25	99	27
	Other	12	-	-
		Yrs.	Yrs.	Yrs.
Mean programming experience		2.59	2.15	1.35

From general impressions the combined sample is not representative of the industry in that it has too many below matric and too few with a university degree. The mean age is a little too high, the percentage of females is probably too low, and the English-speaking group is very much under-represented. The mean length of programming experience is probably about right. Certain of these factors are likely to influence test scores. For example, older testees generally have lower and university graduates higher scores. Thus if the distribution of battery scores for the total population of programmers were available it would have a higher mean and a wider spread than that for the combined sample. A cut-off based on the sample will therefore exclude a smaller percentage of the existing population of programmers than that indicated by the sample. These differences increase the importance of collecting test and criterion scores for applicant and selected populations over a period so that the battery can be revalidated on a more representative sample.

The fact that the third sample is older and has lower educational levels than are generally accepted in the industry is of considerable significance for future employment policies. A more detailed study of the organisation from which the third sample was drawn is provided in Appendix III.

V. RESULTS FOR THE SECOND AND THIRD SAMPLES

This section has the two-fold purpose both of providing support for the conclusions reached in this report and for making public information that may assist future research in this field.

1. Criterion Scores

(a) Means and Standard deviations of Second and Third samples compared with the First:

	First Sample	Second Sample		Third Sample
	Old Criterion	Old Criterion	New Criterion	New Criterion
N	60	36	36	38
Mean	140.68	144.91	182.78	152.76
Standard Deviation	25.74	22.91	29.89	28.88
Standard Error of Measurement for Individual scores	5.15	10.45	9.33	9.02
Reliability	.96	.89	.95	.95

The lower reliability coefficient for the Old Criterion schedule in the second sample compared with the first sample must be attributed partly to sampling fluctuation and possibly also to less experience in using such schedules for assessing performance. The difference between Old and New Schedules is partly accounted for by the large number of items and the substitution of improved items in the new schedule.

(b) The correlations between the criterion schedule scores and independent assessments by senior staff of members of the second sample are:-

Assessments v New Criterion schedule score .60
Assessments v Old Criterion schedule score .52
(N = 34)

(c) The correlation between Old and New Criterion schedule scores for the second sample is .75 (N = 32).

(d) A factor analysis followed by a varimax rotation produced the following decomposition of the New Criterion schedule (N = 32):

	Factors				
Item	I	II	III	IV	V
1	.60*	-.07	.22	.25	-.02
2	.86*	.01	.28	.02	.07
3	.09	.32	.56*	.26	-.29
4	.02	.07	.27	.61*	-.13
5	.71*	.30	.17	.17	.18
6	.54*	.00	.49	-.05	-.47
7	.27	.32	-.06	.46	-.03
8	.33	.24	.38	.50*	.05
9	.63*	.08	.18	-.06	-.28
10	.27	.18	.24	.57*	-.13
11	.11	.85*	.22	-.08	-.06
12	-.05	.64*	.05	.18	-.18
13	.84*	.21	.02	.18	-.06
14	.12	.09	.04	.56*	.02
15	.69*	.12	.20	.10	-.09
16	.05	.40	-.02	.27	-.68*
17	.32	.07	.69*	.06	-.16
18	.19	.81*	.14	.09	.02
19	.76*	.10	-.05	.18	.08
20	.44	.11	.54	.12	-.44
21	.25	-.08	-.02	.59*	.14
22	.64*	.01	.22	.14	-.10
23	.08	.32	.69	.34	-.13
24	.29	.24	.00	.62	-.30
25	.67*	.04	.27	.23	-.26
26	.62*	.28	.27	.35	.19
27	.67*	.20	.23	.11	-.09
28	.20	.69*	.03	.06	-.16
29	.80*	.07	.33	-.06	-.03
30	.65*	-.01	.11	.59*	-.10
31	.04	.64	.08	.34	-.08
32	.41	.20	.67*	.17	-.02
33	.81*	.03	.19	.08	-.17
34	.06	.48	.26	.12	-.61*
35	.60*	.25	.19	.15	-.25
36	.41	.62	.20	.17	.11
37	.71*	.16	.19	.33	.20
38	.22	-.04	.90*	.05	-.09
39	.14	.45	.28	.03	-.47
40	.46	.52*	.27	.13	-.24
41	.67*	.12	-.14	.20	-.24
42	.37	.24	.78*	.08	.19
43	.38	.18	.39	.17	-.35
44	.77*	.26	.25	.19	.07

Item	Factors I	II	III	IV	V
45	-.19	.18	.22	.58*	-.33
46	.68*	.20	.20	.16	.29
47	.42	.24	.46	.47	.04
48	.28	.38	.51*	.32	-.02
49	.43	.07	.24	.38	.02

Loadings > .5 are marked with an asterisk.

See Appendix I for the items.

Factor I appears to represent general programming ability, Factor II programming style, i.e. the writing of clear straightforward programs. Factor III has items loading highly on it which reflect efficiency in getting a program working, Factor IV may be described as sensitivity or adaptability to the demands of the programming environment. Factor V is associated with documentation and, it should be noted, has a large number of negative loadings.

(e) The items defining the first four factors were further refined by item analyses in which a total is calculated from a set of items loading highly on a factor. Items with low correlations with the total are dropped from the set while non-members with high correlations are brought in.

The intercorrelation matrix for the second sample for the sub-criteria in their final form is:

	Total Criterion	Pro-gramming Ability	Style	Effi-ciency	Sensi-tivity
Total Criterion	1.0				
Programming	.88	1.0			
Style	.73	.43*	1.0		
Efficiency	.84	.73*	.53*	1.0	
Sensitivity	.78	.57*	.51*	.57*	1.0

(N = 32)

Note: Correlations significant at the 5% level are marked by an *

The subdivision of the New Criterion was not applied to the Third sample as no useful correlations with test scores had been obtained in the second sample. (See the following table).

(f) Correlations between test scores and sub-criteria for 2nd sample:

	M.A.	Gottschaldt	Pattern Relations	Concept Attainment
Programming ability	.10	-.06	-.37*	-.34
Style	.18	.02	-.20	-.04
Efficiency	.16	.07	-.55*	-.24
Sensitivity	.06	-.24	-.13	-.08

(N = 32)

2. Biographical data for 2nd and 3rd Samples

	2nd Sample		
	Education#	Total Experience	Age
N	25	25	27
Mean	2.3	2.2 yrs	24.9 yrs
Standard deviation	.8	2.1	4.5

	3rd Sample		
	Education#	Total Experience	Age
N	38	38	38
Mean	.7	1.4 yrs	31.1 yrs
Standard deviation	.5	2.0	7.6

Code for educational levels 0 = below matric, 1 = matric, 2 = post matric, 3 = university.

Correlations between new criteria and biographical data

Second Sample

	New Criterion	Education	Total Experience	Age
New Criterion	1.00			
Education	-.13	1.00		
Total Experience	.51*	-.03	1.00	
Age	.64*	0.0	.70*	1.00
(N = 25)				

Third Sample

	New Criterion	Education	Total Experience	Age
New Criterion	1.00			
Education	-.27	1.00		
Total Experience	.22	-.04	1.00	
Age	.31	-.37*	.50*	1.00
(N = 38)				

In the second sample criterion schedule scores were highly correlated with age and experience. This is to be expected as raters were not asked to discount experience when making their assessments, but it can also be the result of stringent on-the-job selection. The negative correlation between Criterion Score and education in both samples is interesting. It may reflect a generally lower educational level in the more youthful part of the Labour Force when computers were first introduced, or it may indicate that on-the-job selection in programming favours less highly educated staff.

3. Relations between criteria and test scores for 2nd and 3rd Samples

Note:

(a) For tests (i) to (v) the Norm Groups are matriculants except (iii) where they are 1st year engineering students. The Norm Groups for the Interest Questionnaire are Std. 9 and 10 High School Students and 1st year University Students.

(b) In cases where the standard deviations differ significantly, Welch's form of the "t" test in which approximate degrees of freedom are computed is applied (8).

(c) "Not significant" means not significant at 5% level, "highly significant" means significant beyond 1% level.

(i) Mental Alertness

			Norm Groups	
	2nd Sample	3rd Sample	Eng.	Afr.
N	32	38	116	161
Mean	33.7	27.0	23.9	22.5
Standard deviation	3.1	5.9	5.7	5.9
Correlation with new criterion	.16	.19	-	-
Correlation with old criterion	.40*	-	-	-

Test of difference between sample means:

2nd sample v Eng. Norm Group:
t = 12.86, df = 98.98, highly significant

3rd sample v Afr. Norm Group:
t = 4.23, df = 197, highly significant

Both samples are superior to the Norm Groups on this test.

(ii) Gottschaldt

	2nd Sample	3rd Sample	Norm Groups Eng.	Norm Groups Afr.
N	32	38	116	161
Mean	33.9	18.9	25.3	25.5
Standard deviation	6.3	7.1	8.9	9.1
Correlation with new criterion	-.11	-.01	-	-
Correlation with old criterion	-.14	-	-	-

Test of difference between sample means:

2nd sample v Eng. Norm Group:
t = 6.20, df = 73.09, highly significant

3rd sample v Afr. Norm Group:
t = 4.91, df = 73.50, highly significant

The 3rd sample scores are lower than the Norm Group.

(iii) Pattern Relations

	2nd Sample	3rd Sample	Norm Groups Eng.	Norm Groups Afr.
N	32	38	-	276
Mean	16.2	11.3	-	14.9
Standard deviation	4.0	4.7	-	4.8
Correlation with new criterion	-.40*	.02	-	-
Correlation with old criterion	-.26	-	-	-

Test of difference between sample means:

2nd sample v Afr. Norm Group:
t = 1.47, df = 306, not significant

3rd sample v Afr. Norm Group:
t = 4.35, df = 312, high significant

Note that the 3rd sample scores are lower than the Norm Group.

(iv) Concept Attainment

			Norm Groups	
	2nd Sample	3rd Sample	Eng.	Afr.
N	32	38	-	-
Mean	51.3	42.2	-	-
Standard deviation	16.8	14.0	-	-
Correlation with new criterion	- .26	- .11	-	-
Correlation with old criterion	- .12	-	-	-

(v) Temperament Questionnaire

			Norm Groups	
	2nd Sample	3rd Sample	Eng.	Afr.
N	32	-	262	371
Mean	14.1	-	13.3	13.5
Standard deviation	5.2	-	5.2	4.9
Correlation with new criterion	.22	-	-	-
Correlation with old criterion	.14	-	-	-

Test of difference between sample means:

2nd sample v Eng. Norm Group:
$t = .82$, $df = 292$, not significant

(vi) Interest Questionnaire

A. (Adventure)

	2nd Sample	3rd Sample	Norm Groups Eng.	Norm Groups Afr.
N	32	38	1744	1299
Mean	5.5	9.3	10.1	10.5
Standard deviation	3.9	4.7	4.3	4.4
Correlation with new criterion	.13	- .24	-	-
Correlation with old criterion	.03	-	-	-

Test of difference between sample means:

2nd sample v Eng. Norm Group:
t = 6.01, df = 1774, highly significant

3rd sample v Afr. Norm Group:
t = 1.65, df = 1335, not significant

Both samples have lower means than the Norm Groups.

B. (Outdoor Interests)

	2nd Sample	3rd Sample	Norm Groups Eng.	Norm Groups Afr.
N	32	38	1744	1299
Mean	6.3	8.4	6.8	8.3
Standard deviation	4.0	4.5	4.0	3.7
Correlation with new criterion	- .21	- .10	-	-
Correlation with old criterion	- .16	-	-	-

Test of difference between sample means:

2nd sample v Eng. Norm Group:
t = .70, df = 1774, not significant

3rd sample v Afr. Norm Group:
t = .14, df = 40.56, not sifnificant.

C. (Clerical)

	2nd Sample	3rd Sample	Norm Groups Eng.	Norm Groups Afr.
N	32	38	1744	1299
Mean	7.9	12.2	7.7	8.1
Standard deviation	3.5	2.8	4.3	4.1
Correlation with new criterion	.17	-.24	-	-
Correlation with old criterion	.25	-	-	-

Test of difference between sample means:

2nd sample v Eng. Norm Group:
t = .26, df = 1774, not significant

3rd sample v Afr. Norm Group:
t = 8.76, df = 4404, highly significant.

Note: The results for the 3rd sample are probably due to members originally being transferred from other clerical branches to programming.

K. (Fine Arts and Music)

	2nd Sample	3rd Sample	Norm Groups Eng.	Norm Groups Afr.
N	32	38	1744	1299
Mean	11.7	7.0	6.3	5.8
Standard deviation	2.8	4.4	4.2	4.5
Correlation with new criterion	-.30	.10	-	-
Correlation with old criterion	-.23	-	-	-

Test of difference between sample means:

2nd sample v Eng. Norm Group:
t = 10.69, df = 35.78, highly significant

3rd sample v Afr. Norm Group:
t = 1.62, df = 1335, not significant

Both samples have higher means than the Norm Groups.

N. (Natural Science)

	2nd Sample	3rd Sample	Norm Groups Eng.	Norm Groups Afr.
N	32	38	1744	1299
Mean	7.9	7.4	7.1	7.5
Standard deviation	3.0	3.7	3.8	4.3
Correlation with new criterion	.17	.06	-	-
Correlation with old criterion	.21	-	-	-

Test of difference between sample means:

2nd sample v Eng. Norm Group:
t = 1.18, df = 1744, not significant

3rd sample v Afr. Norm Group:
t = .14, df = 1335, not significant

O. (Persuasion)

	2nd Sample	3rd Sample	Norm Groups Eng.	Norm Groups Afr.
N	32	38	1744	1299
Mean	6.2	7.6	7.0	7.5
Standard deviation	3.5	4.3	4.4	4.6
Correlation with new criterion	.17	.03	-	-
Correlation with old criterion	.25	-	-	-

Test of difference between sample means:

2nd sample v Eng. Norm Group:
t = 1.02, df = 1774, not significant

3rd sample v. Afr. Norm Group:
t = .13, df = 1335, not significant

S. (Social Science)

	2nd Sample	3rd Sample	Norm Groups Eng.	Afr.
N	32	38	1744	1299
Mean	10.5	9.6	8.0	7.9
Standard deviations	2.7	3.2	3.7	3.9
Correlation with new criterion	- .18	- .18	-	-
Correlation with old criterion	- .08	-	-	-

Test of difference between sample means:

2nd sample v Eng. Norm Group:
$t = 5.15$, $df = 35.31$, highly significant

3rd sample v Afr. Norm Group:
$t = 2.66$, $df = 1335$, highly significant

Both samples have higher means than the Norm Groups.

T. (Technical)

	2nd Sample	3rd Sample	Norm Groups Eng.	Afr.
N	32	38	1744	1299
Mean	8.9	11.4	9.3	8.7
Standard deviation	4.3	3.8	4.9	5.2
Correlation with new criterion	.28	.15	-	-
Correlation with old criterion	.09	-	-	-

Test of difference between sample means:

2nd sample v Eng. Norm Group:
$t = .46$, $df = 1774$, not significant

3rd sample v Afr. Norm Group:
$t = 4.26$, $df = 43.39$, highly significant

U. (Altruistic)

	2nd Sample	3rd Sample	Norm Groups Eng.	Norm Groups Afr.
N	32	38	1744	1299
Mean	9.5	10.6	7.2	8.5
Standard deviation	4.2	4.2	4.6	4.7
Correlation with new criterion	.02	- .13	-	-
Correlation with old criterion	- .05	-	-	-

Test of differences between sample means:

2nd sample v Eng. Norm Group:
t = 2.81, df = 1774, highly significant

3rd sample v Afr. Norm Group:
t = 2.72, df = 1335, highly significant

Both samples have higher means than the Norm Groups.

V. (Verbal)

	2nd Sample	3rd Sample	Norm Groups Eng.	Norm Groups Afr.
N	32	38	1744	1299
Mean	12.3	9.7	7.8	7.6
Standard deviation	3.7	4.2	4.9	5.3
Correlation with new criterion	- .17	- .07	-	-
Correlation with old criterion	- .05	-	-	-

Test of difference between sample means:

2nd sample v Eng. Norm Group:
t = 6.77, df = 35.16, highly significant

3rd sample v Afr. Norm Group:
t = 3.01, df = 42.72, highly significant

Both samples have higher means than the Norm Groups.

W. (Mathematical)

	2nd Sample	3rd Sample	Norm Groups Eng.	Norm Groups Afr.
N	32	38	1744	1299
Mean	13.7	12.7	9.5	9.0
Standard deviation	3.0	4.8	6.6	6.7
Correlation with new criterion	-.04	.13	-	-
Correlation with old criterion	.11	-	-	-

Test of difference between sample means:

2nd sample v Eng. Norm Group:
t = 7.59, df = 39.12, highly significant

3rd sample v Afr. Norm Group:
t = 4.62, df = 43.57, highly significant

Both samples have markedly higher means than the Norm Groups, but this may be due to a tendency to prefer applicants with good mathematics symbols.

4. Possible Influence of Education and Sex on Validity

(a) The Second Sample

(i) The correlation of .51 between the new criterion score and experience suggests a possible reason for the lack of correlation between test and criterion scores. Experienced staff, who would tend to receive higher scores on the criterion schedule, are necessarily older and there is commonly a negative correlation between test score and age. However, in this case the correlations between test scores and experience were generally low:-

Total Experience v	Mental Alertness	0.0
	Gottschaldt	-.01
	Pattern Relations	-.38*
	Concept Attainment	-.18

(N = 32)

Partialling out experience from the criterion test correlations

	Original Correlation	Correlation with Experience partialled out
New Criterion v		
Mental Alertness	.16	.19
Gottschaldt	-.11	-.12
Pattern Relations	-.40*	-.26
Concept Attainment	-.26	-.19

(N = 32)

There is no appreciable improvement in validities.

(ii) The second sample was hetereogeneous with regard to sex and educational level. Its composition is shown in the following table:

	Non-graduates	Graduates	Total
Males	50%	50%	14
Females	46%	54%	11
Total	13	12	25

Note:

Biographical information was available for only 25 of the 32 cases.

Scores on criterion and tests for the subgroups were as follows:

(a) New Criterion Schedule

	Graduates	Non-graduates	Males	Females
N	13	10	18	14
Mean	185.2	194.5	183.4	181.9
Standard deviation	23.7	24.4	33.0	26.6

Difference between sample means:

graduates v non-graduates:
t = .92, df = 21, not significant

males v females:
t = .14, df = 30, not significant

(b) Mental Alertness

	Graduates	Non-graduates	Males	Females
N	13	10	18	14
Mean	34.6	33.0	33.5	34.0
Standard deviation	2.7	3.6	3.1	3.3
Correlation with new criterion	.55*	.42	.14	.22

Difference between sample means:

graduates v non-graduates:
t = 1.22, df = 21, not significant

males v females:
t = .44, df = 30, not significant

(c) Gottschaldt

	Graduates	Non-graduates	Males	Females
N	13	10	18	14
Mean	35.2	30.5	33.7	34.2
Standard deviation	5.3	7.4	5.9	6.9
Correlation with new criterion	.03	.42	-.05	-.18

Difference between sample means:

graduates v non-graduates:
t = 1.78, df = 21, not significant

males v females:
t = .22, df = 30, not significant

(d) Pattern Relations

	Graduates	Non-graduates	Males	Females
N	13	10	18	14
Mean	15.5	16.1	15.9	16.5
Standard deviation	3.4	4.6	4.0	4.2
Correlation with new criterion	- .17	- .77*	- .25	- .63*

Difference between sample means:

graduates v non-graduates:
t = .36, df = 21, not significant

males v females:
t = .41, df = 30, not significant

(e) Concept Attainment

	Graduates	Non-graduates	Males	Females
N	13	10	18	14
Mean	54.2	51.3	44.9	59.5
Standard deviation	10.2	20.7	18.8	9.1
Correlation with new criterion	- .16	- .30	- .19	- .61*

Difference between sample means:

graduates v non-graduates:
t = .41, df = 21, not significant

males v females:
t = 2.89, df = 30, highly significant.

Only the sex difference on Concept Attainment is significant. Note that graduates and females tend to have lower scores on the criterion but do better on the tests. The correlation between sex and education is however only -.11 (sex is coded 1 = male, 2 = female).

The intercorrelation matrix for the new criterion, tests and biographical variables is shown below:

	Criterion	M.A.	G.	P.R.	C.A.	Total Exp.	Sex	Education	Age
Criterion	1.0								
M.A.	.36	1.0							
G.	.18	.03	1.0						
P.R.	-.21	-.10	-.16	1.0					
C.A.	-.17	.15	.07	-.02	1.0				
Total Exp.	.62*	.18	.10	-.38	-.11	1.0			
Sex	-.04	-.06	-.01	.14	.36	.13	1.0		
Education	-.13	.27	.32	-.30	.17	.01	-.11	1.0	
Age	.64*	.20	.32	-.45*	-.28	.72*	-.37	.11	1.0

(N = 25)

The test criterion correlations after partialling out biographical factors are:

	Original	Eliminating Sex	Eliminating Education	Eliminating Age
Criterion v M.A.	.36	.36	.41*	.31
v Gottschaldt	.18	.18	.24	-.03
v P.R.	-.21	-.21	-.26	.11
v C.A.	-.17	-.17	-.15	.01

(N = 25)

When the negative correlation of criterion scores with educational level is eliminated the correlation between the criterion score and the mental alertness score becomes significant. In no other case does eliminating biographical factors produce a significant correlation.

The low test-criterion correlations could be due to:

(a) the unsuitability of the criterion. The correlation of .60 between the criterion and the firm's own assessments of the members of the sample appears to discount this.

(b) the unsuitability of the tests. The significant differences between the mean scores for the programmer samples and the unselected populations used for normalising the tests contradict this.

(c) the effect of factors such as sex, age, education and experience. Partialling out the effects of these factors makes no appreciable difference.

(d) the effect of restriction of range through on-the-job selection. Restriction is evident if the approximate ranges i.e. 2 standard deviations above and below the mean of the second sample and the English Norm Group are compared.

	M.A.	Gottschaldt	Pattern Relations
2nd Sample	27.5 - 39.9	21.3 - 46.5	8.2 - 24.2
Norm Group	12.5 - 39.8	7.5 - 43.1	5.3 - 24.5

Restriction in this case is more severe than in the first sample where the range of scores for M.A. was 19.4 - 40.6 (Steyn (4)). The effect of restriction of range is to greatly reduce correlations between scores of tests correlated with whatever factors were responsible for the restriction, and the criterion.

(b) The Third Sample

Restriction of range appears only in the case of Mental Alertness in the third sample.

	M.A.	Gottschaldt	Pattern Relations
3rd Sample	15.2 - 39.8	4.9 - 32.9	1.9 - 20.7
Norm Sample	10.7 - 34.3	7.3 - 43.7	5.3 - 24.5

The lower scores on the Gottschaldt and Pattern Relations tests are probably due to the effects of age and the lower educational levels.

There are no significant correlations between tests and the criterion, but the criterion is positively correlated with age and negatively with educational level and there is a significant negative correlation between age and educational level. In other words older staff who generally have a lower educational level have received higher ratings on the criterion, possibly because of their position and experience. Mental Alertness scores are positively correlated with educational level and negatively correlated with age, both correlations being significant at the 5% level.

	Criterion	M.A.	G.	P.R.	C.A.	Total Exp.	Sex	Education	Age
Criterion	1.0								
M.A.	.17	1.0							
G.	-.04	.15	1.0						
P.R.	0.0	.27	.17	1.0					
C.A.	-.11	.44*	-.04	.22	1.0				
Total Exp.	.05	-.19	.07	.14	-.27	1.0			
Sex	0.0	0.0	0.0	0.0	0.0	0.0	1.0		
Education	-.29	.51*	.26	.15	.36*	-.09	0.0	1.0	
Age	.30	-.33*	-.11	-.30	-.51*	.30	0.0	-.36*	1.0

(N = 36)

The partial correlation between the criterion and Mental Alertness eliminating the influence of education is .39 which is significant. If the influence of age is also eliminated the correlation rises to .44. The effects of these factors are in the same direction for the other tests but none of the partial correlations reach significance as the following table shows:

	Original Correlation	Eliminating Education	Eliminating Age
Criterion v M.A.	.17	.39*	.30
v Gottschaldt	-.04	.04	0.0
v P.R.	0.0	.05	.10
v C.A.	-.11	0.0	-.04

(N = 36)

(c) Second and Third Samples Combined

If the second and third samples are combined the effects of restriction of range are much reduced and two of the criterion test correlations reach significance.

Correlation with the Criterion	
Mental Alertness	.41*
Gottschaldt	.35*
Pattern Relations	.11
Concept Attainment	.02

(N = 61)

The correlations between biographical factors, tests and the criterion are:-

	Criterion	M.A.	G.	P.R.	C.A.	Total Exp.	Sex	Education	Age
Criterion	1.0								
M.A.	.41*	1.0							
G.	.35*	.49*	1.0						
P.R.	.11	.35*	.32*	1.0					
C.A.	.02	.44*	.23	.22	1.0				
Total Exp.	-.16	-.39*	-.30*	-.10	-.30*	1.0			
Sex	.24	.31*	.42*	.29*	.36*	-.26*	1.0		
Education	.22	.63*	.69*	.26*	.38*	-.38*	.39*	1.0	
Age	.12	-.42*	-.31*	-.45*	-.49*	.41*	-.37*	-.42*	1.0

(N = 61)

The partial correlations between the criterion and test scores eliminating the biographical factors are as follows:

	Original Correlation	Eliminating Sex	Eliminating Education	Eliminating Age
Criterion v M.A.	.41*	.36*	.36*	.51*
v Gottschaldt	.35*	.28*	.28*	.41*
v P.R.	.11	.04	.06	.19
v C.A.	.02	-.07	-.07	.09

(N = 61)

If age is partialled out the correlations between the Criterion and the Mental Alertness and the Gottschaldt tests rise to .51 and .43 respectively. If education is partialled out as well, they fall to .43 and .30. All these correlations are significant.

The influence of education and age is reinforced owing to a strong negative correlation.

Their individual effects are indicated by the following partial correlations:

	Original Correlation	After Eliminating Age
Education v Criterion	.22	.30*
v Mental Alertness	.63*	.55*
v Gottschaldt	.69*	.65*
v Pattern Relations	.26*	.09
v Concept Attainment	.38*	.22

	Original Correlation	After Eliminating Education
Age v Criterion	.12	.24
v Mental Alertness	-.42*	-.22
v Gottschaldt	-.31*	-.03
v Pattern Relations	-.45*	-.39*
v Concept Attainment	-.49*	-.39*

The multiple correlation between the criterion and the battery score formed of various combinations of tests is shown below:

Tests	Multiple Correlation
Mental Alertness + Gottschaldt + Pattern Relations + Concept Attainment	.26
Mental Alertness + Gottschaldt	.43
Ditto, eliminating education	.44
Ditto, eliminating age	.50
Ditto, eliminating age and education	.55

5. Conclusion

From the above it appears that the best prediction is obtained when the battery is composed only of the Mental Alertness and the Gottschaldt tests. However, the retention of all four tests for the follow-up stage is recommended. The reason for retaining the Pattern Relations and Concept Attainment tests is that both second and third samples have undergone a fairly severe on-the-job selection on the abilities these tests measure, and there are sound psychological reasons for expecting better of such tests when applied to an applicant sample.

In practice the battery will be administered to applicants mainly of the same age and the criterion will, in the follow-up stage, be administered after a fixed period of experience, namely less than 1 year, so that the factors of age and experience should not need taking into account.

The influence of education requires further study in the follow-up validation, as well as the anomalous role of the Gottschaldt test which correlates significantly with the criterion in the combined sample but in which the 3rd sample has a lower mean than its corresponding Norm Group.

VI. THE APPLICATION OF THE N I P R PREFERENCE ANALYSIS QUESTIONNAIRE

Although most overseas studies into the selection of computer personnel have concentrated on the use of tests of ability, see Van der Merwe (5) pages 3-16, there has been some work investigating the interest patterns of computer personnel. The most noteworthy research in this field was done by Perry and Cannon who developed a programmer key for the Strong Vocational Interest Blank (S.V.I.B.). They found that an interest in problem- and puzzle-solving activities is the most striking characteristic of programmers. They also have a combination of applied scientific and administrative interests involving technological applications rather than theory. "Generally speaking, computer programmers are different from other professional men in their greater interest in problem solving, mathematics and mechanical pursuits and their lesser interest in people, especially activities involving close personal interaction. (see Van der Merwe (5) p.14).

The interest key constructed by Cannon and Perry resembled those of earlier researchers, but differed from them in the marked differences found between the interests of business and scientific programmers. At a later stage, a female programmer key was developed for the S.V.I.B. Female programmers were found to differ from male programmers in their interest patterns, but also from females in general.

It is known that successful occupational adjustment and job satisfaction are related to the involvement of basic interest patterns in the chosen occupation, so these approaches appeared to hold promise. It was consequently decided to include the recently developed NIPR Preference Analysis Questionnaire (PAQ) in the battery of tests administered to the subjects involved in the present study.

The PAQ is a questionnaire made up of items of the following kind:

"Work on a mathematical problem", "Read an anthology of poems", "Test various parts of a radio". Each item is answered on a three point scale, the points representing respectively dislike for an activity, a neutral attitude towards an activity and liking for an activity. The questionnaire covers 11 interest areas for men and 13 for women. The answer sheet is scored by means of separate keys, one for each interest area. The strength of the interest displayed in each interest area is assessed in terms of that displayed by a norm group. At present, the only norms available are those based on 3,043 students and matriculation scholars. Approximately twenty minutes are required for the administration of the questionnaire and a similar length of time to score each set of answers.

The results obtained from the administration of the PAQ to the present sample proved to be disappointing. Fairly large differences between the programmer/systems analyst group and the norm group were obtained on six of the PAQ scales. These were:

Adventure	(2nd sample, low),
Fine Arts	(2nd sample, high),
Social Science	(both samples, high),
Altruistic	(both samples, high),
Technical	(3rd sample, high),
Verbal	(both samples, high),
Mathematical	(both samples, high).

It is interesting to note that Cannon and Perry report high aesthetic interests for male scientific programmers and a strong interest in mathematics, together with lack of interest in people for female programmers. To an extent the results of the present study support these findings. Other findings reported by Cannon and Perry relating to high and low interest areas are, however, not confirmed and were at times contradicted. But, in view of the differences between the instruments used, this is not surprising.

Although differences between the programmer and the norm groups were observed, differences were also observed between the sub-groups comprising the programmer group. At times these differences were large. Furthermore in all interests except mathematics, the differences between the programmer and the norm groups could be accounted for by variation in age, experience and language-group affiliation.

The following factors are thought to be responsible for the failure of the PAQ to discriminate satisfactorily between the two groups:

(a) the hetereogeneous composition of the programmer group;

(b) the failure to control potential sources of difference such as age, experience, language group affiliation. It must be noted, however, that the difficulty experienced in obtaining a sufficiently large sample for the programmer group meant that it was not possible to control these factors.

It was finally recognised that the inclusion of the PAQ would contribute but little to the predictive power of the test battery, and the cost in terms of increased administration time did not warrant its use. In this regard it is interesting to note that research workers other than Cannon and Perry conclude that while the Strong Vocational Interest Blank contains elements related to the career success of computer programmers, the relationship is not strong enough to be of value for selection.

VII. THE NATURE OF THE FINAL BATTERY AND ITS LIMITATIONS

Van der Merwe (5) concludes that systems analyst and programmer job types are related: both involve the organization, integration and conceptualization of information. The difference between them lies in the kind and scope of the information which has to be dealt with, the systems analyst dealing with a broader field of far less clearly defined problems than the programmer. The difference in intellectual functioning is a quantitative one.

It seems clear, therefore, that a primary factor to be considered in selection procedures is one which relates to the essential nature of these jobs. "In both cases the work process involves the formulating of objectives, at first the overall objective of an assignment, then sub-objectives to achieve the overall goal. Eventually each step has to be identified and defined in its functional relationship to the overall objective. This 'solution' structure is in turn translated into a computer processable form". (Ibid. p.59). Thus the crux of the matter seems to involve intellectual functioning essentially of an abstract logical nature and at a fairly high level. It is thought that this is what is meant by what various investigators have called "reasoning ability".

It was suggested by Van der Merwe that the selection procedures should aim at simulating the problem-solving aspect of programming i.e. "should require the structuring of a number of steps to achieve a given objective and the reformulating of this structure in terms of very specific restrictions" (Ibid. p.59). In addition to this central cognitive factor, non-cognitive factors such as interests, and personality factors including "... motivation, the ability to establish interpersonal relationships with others[1], ability to persevere under stress, accuracy, a flair for detail ..." (Ibid. p.60) appear to be important. Which of these factors is measured by the tests finally included in the battery?

High Level Mental Alertness Test

This test is a test of general intelligence which was specifically designed to measure individual differences in pre-selected sophisticated samples which have had formal schooling for no less than twelve years.

It is a power test consisting of 42 items which cover a wide array of specific sub-abilities generally known as intelligence. It contains items dealing with the ability to decode certain stimuli, the ability to grasp logical relationships between sets of number and letter series and other aspects of logical thinking. Although the item content is diverse, the internal consistency of the instrument has been demonstrated to be in excess of .90 which confirms that the test is measuring a single broad domain.

Pattern Relations Test

This test contains 30 items in the form of 3x3 matrices of figures. The last figure is not contained in the matrix and has to be chosen from six items provided at the bottom of the matrix. The task of the testee is to discover the rule which relates the 8

---

[1] in this context, "interpersonal relations" refers not to close interpersonal contact requiring a real interest in people, but rather to an ability to co-operate with peers and outsiders in order to get the work done.

figures to one another and to indicate the item which completes the logical pattern. The ability to find a general rule from specific stimuli is called Inductive Reasoning.

The test was originally standardized on a group of post-graduate research workers of the C.S.I.R. It had a reliability of 0.87. It was subsequently reapplied to a group of first-year engineering students and again showed a high degree of variance and internal consistency.

The test is in essence a more difficult version of the Raven's Progressive Matrices, an internationally acknowledged test of inductive reasoning ability.

Concept Attainment Test

This instrument is based on the rationale of C. Maag and was specifically designed to measure high level problem solving ability. It is designed in such a way that the correct answer can only be obtained by following a strategy of thinking which is optimally logical. Another component of the test measures the ability to synthesize information into a logically meaningful whole.

The stimulus material is presented in the form of 32 line drawings which may differ in any of five specified ways. Two of the figures are uniquely determined by a combination of 4 of the attributes, 4 are determined by a combination of 3 of the attributes whilst 8 figures share any 2 of the attributes. The testee is given a particular model and requested to identify the seven other drawings which share two unspecified attributes with this model. He has to select any other object and ask whether that object contains the two characteristics. He is given feedback on whether the choice was a false or a true one. Provided that a logical strategy is followed, a testee should arrive at a correct solution within a maximum of 4 steps.

The format of the test is quite unique. Permanent record of the strategy followed by the testee is left on the answer sheet because he has to erase aluminium foil opposite the number of the object he is dealing with in order to receive feedback on its attributes.

The test contains ten different problems.

Gottschaldt Figures Test

This test, containing 45 items, measures the ability to think analytically. The stimulus material consists of a complex drawing in which a simple figure is hidden or embedded. The analytical person is capable of breaking down the problem into its logically constituent parts without being unduly disturbed by the binding Gestalt (or whole) of the complex figure.

This test is also used to assess important personality variates. The analytical person generalises this ability over the entirety of his experience and is capable of functioning autonomously in almost all situations. He is capable of structuring ambiguous situations into clearly definable, articulated parts and to reconcile these articulated parts with his inner frame of reference. It must be noted, though, that while this test covers this area, its measurement is not pure.

Thus, intelligence, the ability to think logically and analytically, inductive reasoning and the ability to solve problems are the main factors assessed by the battery. Only one personality variable, the ability to function autonomously under varying conditions, is assessed, and that not purely.

In being restricted almost exclusively to the area of cognitive functioning, the present battery resembles tests developed overseas. It is, however, thought to be superior to these tests, for two main reasons: First, the central intellectual function involved in programming and systems analysis, as determined by job analysis, is replicated in the Concept Attainment Test. This test has had its validity for the present task demonstrated (see Steyn (4)). Its inclusion in the present battery is unique. Second, each test which is included in the present battery is highly reliable, something which cannot always readily be said about tests aimed at this area and developed abroad. A further advantage is that all the tests are either South African in origin, or have been modified and standardized to suit South African conditions. They are all, of course, available in both official languages.

Interest areas and personality factors are, however, not covered, which is recognised as a defect. These areas are notoriously difficult to measure: the instruments available are time consuming, not always easy to score, depend fairly heavily on psychological interpretation for their assessment and tend to have lower reliabilities than cognitive tests. Furthermore, in some areas (e.g. motivation) no really satisfactory instrument has yet been produced, either in South Africa or elsewhere. Nevertheless, attempts were made to cover these areas, represented by the inclusion of the Temperament Questionnaire (Steyn (4), p.24-26) and the Preference Analysis (reported on in an earlier section of the present report). Neither of these two instruments, however, proved to have predictive validity in the present context.

It is thought that the final battery represents an improvement on ones previously available, and its use should result in improved selection, even if non-cognitive factors are not taken into account in the selection process. Non-cognitive factors, nevertheless, remain important, both in the selection of novices and in promotion of programmers to systems analysts. The motivation of novices to enter a career in programming/systems analysis is most important and should be carefully assessed in an interview. The interests listed by Van der Merwe ((5) p.14) can serve as a useful guide in helping to assess whether motivation is realistic or not. The differences between scientific and business programmers cited by Cannon and Perry are also relevant here (Ibid p.15). In considering programmers for promotion to systems analysts, the greater scope of the latter job and the lack of clarity with regard to the formulation of problems to be investigated must be remembered. A systems analyst must be more capable of functioning autonomously than a programmer, must have self-confidence and be capable of developing a broad overview of things. It is recommended, therefore, that the battery be supplemented by interviews and that promotion of programmer to systems analyst be based on regular assessments of merit in terms of the factors suggested above.

Good selection methods, however, are only the beginning. In order to utilize recruits most effectively, it is essential that job demands be stated precisely and clearly, that training be more clearly related to them than is the case at present and that careful consideration be given to organizing the work so that the most profitable use is made of available skills. "Training curricula, in particular, are affected (by this lack of clarity) and do not appear to contribute greatly to the training of computer personnel". Van der Merwe (5), p. 57.

The opening chapters of this report forecast an acute future shortage of manpower in the industry. In Appendix III there is an indication of the sources that will have to be tapped for it describes the employment of manpower, older and of a lower educational level than is currently regarded as acceptable. But, satisfactory results will only be obtained from this grade of labour if there are better methods of selection, and as is apparent from the description, careful training and a well-planned organization of the work so that skilled staff are relieved of routine coding and testing.

The information collected in the course of the project and the greatly varying results obtained for the three samples, which are a reflection of differences in organization and selection and training policies, suggest a requirement for greater flexibility in the use of the test results. While the constituent tests and method of administration remain unchanged, individual firms may find it necessary to use the test scores in ways most suited to their particular requirements.

VIII. RECOMMENDED TEST BATTERY AND THE CONDITIONS GOVERNING ITS USE

1. Recommended Test Battery

Primarily for the selection of Programmers but may be used for Systems Analysts.

(a) Pattern Relations Test:
measures abilities associated with the finding of general concepts fitting sets of data, that is, the ability to grasp specific relationships between objects.

(b) High Level Mental Alertness:
measures general intelligence.

(c) Gottschaldt Figures Test:
measures ability to reason analytically and to some extent the ability to function autonomously in an unstructured situation.

(d) Concept Attainment Test:
ability to develop logical systems of reasoning in solving complex problems i.e. the testee has to develop and apply a strategy of thought.

The battery score will consist of the sum of the unweighted raw scores of the individual tests. This implies a weighting system which gives more weight to Gottschaldt and Mental Alertness than to Pattern Relations and twice as much weight to Concept Attainment.

The cut-off for programmers on the battery score is at 77 which will exclude the lower 10% of the combined second and third samples. The cut-off for systems analysts is at 130 which includes the top 1/3 of the combined sample.

No allowance need be made for level of education, experience, age or sex of the testee.

Subjects should not be retested on the battery as test scores will be inflated by test familiarity.

The battery will require $3\frac{1}{2}$ hours for administration. The tests should be administered in the following order:-

Concept Attainment

Gottschaldt

Mental Alertness

Pattern Relations

It is recommended that 1 test administrator and 1 invigilator be employed for every 10 testees.

2. Conditions under which the battery may be used and procedures to be followed

(a) Firms wishing to use the battery must have a letter from the Computer Society authorising the NIPR to make the battery available to them.

(b)1. Firms must nominate a member of staff who is registered with NIPR as a "B" level user, or who has a bachelors degree in psychology with psychology III, to be responsible for the security and administration of the battery. Should this member of staff leave the firm another must be nominated to take over responsibility for the battery. To comply with the requirements of the Psychological Association, if the Society establishes a central testing unit or in the case where a firm nominates a psychological consultant, the battery must be in the charge of a registered "C" level user. The NIPR must be notified of the names and qualifications of all staff as nominated and retains the right not to accept any nomination.

(b) 2. The registered user may train lower grade staff to handle routine administration, but he must be responsible for the security and the administration of the tests, and be available for dealing with any problems that may arise in connection with the battery. He must also be responsible for reviewing and interpreting test results.

(c) The person nominated must, if required by the NIPR, attend a course of training at the NIPR in the administration of the battery and attain a satisfactory standard. The length of training depends on the sophistication of the trainee and may vary from 2 days to 2 weeks.

(d) The NIPR will make the test materials required for the battery available at a 25% discount for as long as the battery developed under present project remains in use.

(e) Test materials and results are to be treated as highly confidential and are to be kept in a place of security under the control of the nominee of the firm who has been accepted by the NIPR. The battery must be applied in accordance with the general and specific principles and practices of test administration pertaining to the battery.

The conditions set out in "Test User Categories and Conditions of Sale" must be observed.

(f) The battery must be used exclusively for programmer or systems analyst selection, and the tests, the battery or the testing procedure may not be modified in any way.

(g) The N I P R retains the right to recall the battery from and to refuse to supply test materials to any firm which is not observing the foregoing conditions. The Society is to be informed of such cases.

(h) The N I P R retains ownership and copyright over the individual tests making up the battery and the right to sell these tests to other parties. The Computer Society has ownership and copyright over the material derived from the project. The N I P R however, has the right to use the data collected for the project for the purposes of research and the right to publish the results of such research provided it does not prejudice the interests of the Computer Society in the battery.

(i) Subject to the aforementioned conditions the Society is free to make the battery available to whomsoever it pleases and to make whatever charges it sees fit.

IX. RECOMMENDATIONS FOR THE FOLLOW-UP STAGE

1. The test battery and the biographical schedule should be administered to all applicants.

2. Applicants should be selected on the basis of the cut-offs recommended in chapter VIII.

3. The test answer sheets used by applicants and completed biographical schedules should be forwarded to a person nominated by the Computer Society. This person will extract whatever information is required by the Society and will forward the answer sheets and biographical schedules to the head of the Psychometric Division at the N I P R.

4. After a period of one year the criterion schedule should be completed for each applicant tested on the battery and thereafter appointed as a programmer. Should an appointee leave the firm or cease to do programming before a year, he should be rated on the criterion schedule at the time he leaves the position.

5. Completed criterion schedules are to be handled as in paragraph 3 above.

6. Any enquiry relating to the battery will in the first place be referred to the Computer Society who will decide how it is to be dealt with.

7. When sufficient i.e. between 100 and 200 criterion schedules have accumulated the NIPR will undertake a revalidation of the test battery. Consideration will also be given to the sequential screening of applicants so that the full battery need be applied to only a small proportion of applicants.

REFERENCES

1. Education and Training for the use of Computers. NDMF Survey Report, Johannesburg, 1968.

2. "Computers in South Africa." STATS Vol. 5, 1968, p. 869-873.

3. "The Computer" STATS Vol. 6, 1970, p. 1114.

4. Steyn, D.W. Computer Programmers - A Preliminary Criterion and Validation Study. NIPR Report C/Pers 168, Johannesburg, June 1969.

5. Van der Merwe, Operator, Programmer and Systems Analyst Job Demands: A Description and Analysis. NIPR Report C/Pers 163, Johannesburg, October 1968.

6. Harvey, G.A. Skilled Manpower Requirements for Automation in South Africa. Third National Conference, South African Council for Automation and Computation, Pretoria, October 1969.

7. Data supplied by V. Marting and Associates Ltd., Johannesburg.

8. Kendall, M.G. & A. Stuart. Advanced Theory of Statistics. Vol. 2, Page 146.

APPENDIX I

CRITERION SCHEDULE

NATIONAL INSTITUTE FOR PERSONNEL RESEARCH

Computer Programmer Evaluation Schedule

Confidential: This material must not be shown to unauthorized persons or used without permission of the National Institute for Personnel Research.

Ratee:

Name: . . . .

Designation: . . . .

Programming Experience in current organization:

. . . . years . . . . months

Programming Experience in previous organization(s):

. . . . years . . . . . . months

Rater:

Name: . . . .

Designation: . . . .

Programming Experience: . . . . years . . . . months

Date: . . . .

Length of time for which rater has observed ratee:

. . . . years . . . . . . months

1. Does he understand specifications for new programs quickly?

1 2 3 4 5

Very slowly — Very quickly

2. Do other programmers ask his advice on programming problems?

1 2 3 4 5

Very seldom — Very frequently

3. Are the labels on his flow charts clear?

1 2 3 4 5

Very confusing — Very clear

4. Does he use testing techniques, such as dumps or traces, wastefully?

1 2 3 4 5

Very frequently — Very seldom

5. How well does he overcome unforeseen obstacles when pushed for time?

1 2 3 4 5

Very ineffeciently — Very well

6. How good is his knowledge of <u>new</u> programming techniques?

1 2 3 4 5

Very poor — Very good

7. Do his programs require excessive running times?

1 2 3 4 5

Very frequently — Very seldom

8. Does he think the logic out carefully before starting to write a program?

1 2 3 4 5

Very seldom — Consistently

9. Would you ask him to adapt a program written for a different machine?

1 2 3 4 5

Very reluctantly — With confidence

10. How quickly does he notice important omissions from a program specification?

1 2 3 4 5

Very slowly Immediately

11. Are his programs easy to read?

1 2 3 4 5

Very difficult Very easy

12. Does he use correct but obscure logic?

1 2 3 4 5

Very frequently Very seldom

13. Has he a good knowledge of the Master programs controlling the operation of the computer?

1 2 3 4 5

Very poor Very good

14. Is he co-operative when asked to work overtime?

1 2 3 4 5

Very unco-operative Very co-operative

15. Would you give him an assignment requiring sophisticated programming?

1 2 3 4 5

Very reluctantly With confidence

16. How often does he violate installation standards for documentation without reason?

1 2 3 4 5

Very frequently Very seldom

17. Rate the accuracy of his coding.

1 2 3 4 5

Very inaccurate Very accurate

18. Do other programmers find it difficult to understand the logic of his programs?

1 2 3 4 5

Very frequently | Very occasionally

19. Do you give him programs with tight deadlines?

1 2 3 4 5

Very seldom | Very frequently

20. Does it take him long to utilize new programming facilities?

1 2 3 4 5

Very long time | Very short time

21. Have there been occasions when he has misunderstood what has been required of a program?

1 2 3 4 5

Very frequently | Never

22. Is he quick at determining the causes of error conditions?

1 2 3 4 5

Very slow | Very quick

23. How often, after he has modified a program, does the number of test runs indicate a lack of care in making the changes?

1 2 3 4 5

Very frequently | Very seldom

24. Does he make efficient use of subroutines or segments in long programs?

1 2 3 4 5

Very seldom | Very frequently

25. How good is his knowledge of coding techniques?

1 2 3 4 5

Very poor | Very good

26. Would you ask him to prepare program specifications?

1 2 3 4 5

Never | Very frequently

27. How many assignments can he handle at once?

1 2 3 4 5

A very limited number | Far more than average

28. Does he use comments freely to make his programs easier to follow?

1 2 3 4 5

Very seldom | Always

29. Would you ask him to adapt a complicated program written by someone else?

1 2 3 4 5

Very reluctantly | With confidence

30. If he strikes a difficult problem in his program does he lose interest and expect others to solve it?

1 2 3 4 5

Very frequently | Very seldom

31. Are his programs needlessly complex?

1 2 3 4 5

Very often | Very seldom

32. Do errors in his programs that should have been found during testing appear after the program is in use?

1 2 3 4 5

Very frequently | Very seldom

33. Would you refer programming problems to him?

1 2 3 4 5

Very occasionally | Very frequently

34. Do his programs fail to conform to the standard system conventions of the installation?

1 2 3 4 5

Very often | Very seldom

35. How much difficulty does he have in understanding technical manuals?

1 2 3 4 5

Very great difficulty | No difficulty

36. Do you think he would be good at training new programmers?

1 2 3 4 5

Very poor | Very good

37. If time was short and some program was giving trouble would you ask him to correct it?

1 2 3 4 5

Very reluctantly | With confidence

38. How many compilations or assemblies does he normally require to remove syntax errors from his programs?

1 2 3 4 5

Far more than average | Far fewer than average

39. Do you ever have to criticize him for poor documentation?

1 2 3 4 5

Very frequently | Very seldom

40. Would you consider his programs good models for beginners?

1 2 3 4 5

Very poor | Very good

41. Does he ever, usefully, suggest that new programs or subroutines are needed?

1 2 3 4 5

Very seldom | Very frequently

42. How many test runs does he usually need to get a program working?

1 2 3 4 5

Far more than average — Far fewer than average

43. Does he panic when things go wrong in a tight schedule?

1 2 3 4 5

Very often — Very seldom

44. How well do you think he would design a suite of programs for a multistage operation?

1 2 3 4 5

Very inadequately — Very well

45. Are his operating instructions referred back because of obscurities?

1 2 3 4 5

Very frequently — Very seldom

46. Is he versatile in that he can use several different programming languages?

1 2 3 4 5

Not at all versatile — Very versatile

47. Does he notice it if there are discrepancies in program specifications?

1 2 3 4 5

Very seldom — Almost invariably

48. In general, how would you rate the logic of his programs?

1 2 3 4 5

Very poor — Very good

49. Is he flexible in adapting his programming methods to meet varied requirements?

1 2 3 4 5

Very inflexible — Very flexible

APPENDIX II

BIOGRAPHICAL SCHEDULE

SOUTH AFRICAN COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

NATIONAL INSTITUTE FOR PERSONNEL RESEARCH

BIOGRAPHICAL INVENTORY

CODE NUMBER: ....

TODAY'S DATE: ....

DESIGNATION: ....

If you have ever done any aptitude or personnel selection tests before, state date, place and reason for testing.

....

....

....

....

A. GENERAL

Nationality: . . . .

Age: . . . .

Date of Birth: . . . .

Sex: . . . .

Home Language: . . . .

Single, engaged, married, widowed, divorced or separated:

. . . .

If married, number of children and other dependants (excluding spouse)

. . . .

B. EDUCATION AND TRAINING

1. In the table below list all the subjects you studied in your final year at school.

Subject	Average % obtained during the year	Symbol or percentage obtained in final examination
. . . .	. . . .	. . . .
. . . .	. . . .	. . . .
. . . .	. . . .	. . . .
. . . .	. . . .	. . . .
. . . .	. . . .	. . . .
. . . .	. . . .	. . . .
. . . .	. . . .	. . . .
. . . .	. . . .	. . . .
. . . .	. . . .	. . . .
. . . .	. . . .	. . . .

2. What is the highest standard you passed at school? ....

(a) What class pass did you obtain? ....
(i.e. 1st class, 2nd class, A or B stream)

(b) Date of examination: ....

(c) Name of school: ....

3. Which standard(s) did you fail at school? ....

4. Write down type of school which you attended (Academic, Commercial, Technical, Agriculture): ....

5. In the table below give details of post-school training (i.e. University, Technical College, etc.)

Name of Institution	Years attended		Course taken B.A., A.T.C. U.E.D. etc.	Full time, Extra mural, Correspondence	Degrees, Diplomas, etc. obtained
	From	To			
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....

6. In the table below, list all the subjects taken for any post-school training.

Subject Indicate e.g. Psychology I, Maths II	Faculty or Branch	Year of qualifying	Number of attempts
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....

7. What career did you intend following when you left full-time school?

....

....

....

8. What alternative careers have you seriously considered/ are you still seriously considering?

....

....

....

9. As far as your career is concerned, what sort of job do you think you will be doing in five years' time?

. . . .

. . . .

In ten years' time?

. . . .

. . . .

In twenty years' time?

. . . .

. . . .

10. In the table below indicate your proficiency as

1 = Good
2 = Average
3 = Not so good

Language	Reading	Writing	Speaking
English	. . . .	. . . .	. . . .
Afrikaans	. . . .	. . . .	. . . .
Other (specify)	. . . .	. . . .	. . . .

C. OCCUPATIONAL HISTORY

1. In the table below list in chronological order the jobs you have held, placing your present position last.

Job Title	Name of Firm	Length of Service		Reason for leaving
		From	To	
....	....	......	......	....
....	....	......	......	....
....	....	......	......	....
....	....	......	......	....
....	....	......	......	....
....	....	......	......	....

2. Give details of any special knowledge and/or experience you have acquired in any field.

....

....

....

3. Give details of any special knowledge and/or experience you have acquired in each of your previous jobs that is of value in your present job.

Job Title	Knowledge and/or experience relevant to present job	Motivate
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....

4. Considering your experience, education and special training and interest, for which specific fields of your profession do you consider yourself best suited. State reasons.

Field	Reason
1.	....
2.	....
3.	....

D. SPORT AND HOBBIES

1. Do you actively participate in sport? Yes/No

2. Name (a) The games at which you are best:

. . . .

(b) The games you enjoy most:

. . . .

3. Below are a number of sports and physical activities.

Write 0 - if you never participate(d) in it
1 - if you participate(d) from time to time
2 - if you participate(d) regularly

	At school	Now		At school	Now
Angling			Life-saving		
Athletics			Motor boating		
Badminton			Mountaineering		
Baseball			Netball		
Basketball			Riding		
Boxing			Rowing		
Cricket			Rugby		
Cycling			Shooting		
Fencing			Skin-Diving		
Golf			Snooker		
Gymnastics			Soccer		
Hockey			Squash		
Hunting			Surfing		
Ice-skating			Swimming		
Judo			Tennis		
Jukskei			Walking		
Karate			Wrestling		
Other (specify)			Yachting		

4. How do you normally spend your free time and what are your hobbies?

. . . .

. . . .

. . . .

5. Do (did) you belong to any societies or clubs? If so, give details.

. . . .

. . . .

. . . .

6. Give the names of a few books that you have read lately.

1. . . . .

2. . . . .

3. . . . .

7. Write down the names of newspapers and magazines which you read regularly.

. . . .

. . . .

. . . .

Give any other information that you think is relevant.

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

APPENDIX III

A MORE DETAILED STUDY OF THE JOBS IN THE ORGANIZATION FROM WHICH THE THIRD SAMPLE WAS DRAWN

THIRD SAMPLE PROGRAMMER JOBS COMPARED WITH PROGRAMMER JOBS FOUND IN COMMERCIAL CONCERNS

1. Introduction

A short study was made in February 1970 to determine whether the content and demands of the third sample programmer jobs are similar to those of programmer jobs found in industry, as described in a previous report (5).

2. Reasons for the Investigation

The third sample had characteristics not shared by either the first or second samples and the test results contrasted oddly with those of the other samples.

(a) Whereas industry employs programmers with at least a matriculation certificate and preferably a degree and prefers relatively young persons (e.g. the second sample consisted of 48% matriculants and 52% graduates and had a mean age of 25), the third sample consisted of a large number of non-matriculants (37%) and only a few graduates (5%) and a relatively large number of programmers older than 30 were employed.

(b) The results for the third sample were much poorer than those of either first or second samples. The scores on the selection battery for the third sample showed virtually no overlap with the results for the second sample, as the highest scores of the former overlapped only with the lowest scores of the latter.

When the statistical analysis was carried out, it was also found that the third sample did not show the same pattern of intercorrelations as the second sample, e.g. a correlation of .44 was found between M.A.* scores and C.A.* scores for the third sample whereas the second sample showed a negligible correlation between these scores.

The third sample also showed a significant correlation between education and M.A. (.49) and between education and C.A. (.40), whereas the second sample showed negligible correlations between education and these tests. This could mean that as the standard of education is relatively low in the third sample, the C.A. test tends to measure intelligence rather than logical reasoning.

A possible explanation for the successful employment of programmers with such markedly different educational levels from the rest of the industry is that programmer job demands in the organization from which the third sample was drawn were dissimilar to those found in industry. The present short study was undertaken to investigate this.

3. Progress

The Organization is subdivided into two divisions "A" and "B" each of which has its own data processing department.

The superintendents of the two data processing departments of the Organization and three programmers (one from department "A" and two from department "B") were interviewed during 17-19 February, 1970.

---

* M.A. = Mental Alertness test
C.A. = Concept Attainment test

During the interviews with the superintendents information was obtained concerning organization and task allocation policies, methods of on-the-job training, and the nature of the computer applications required of their staff.

The programmers were interviewed to obtain more detailed information about the job content and job demands. As in the past, the NIPR Job Description method was applied, with particular emphasis on the Decision-factor, or Key-factor. To shorten this somewhat lengthy method, the interviews were conducted along the following lines:

(a) Programmers were asked to outline briefly what their jobs involved. This outline served as a basis for discussing differences existing between their jobs and programmer jobs in industry.

(b) Job summaries of the commercial programmer and systems analyst jobs were inspected and similarities and differences with those in the Organization were noted.

(c) Examples of decisions made by each interviewee in his job were obtained.

4. Findings

Factors which could affect the job content and demands on programmers in the third sample are discussed below. Similar or dissimilar situations existing in industry are indicated.

4.1 Task delineation

The Data Processing Departments (D.P.Ds.) have similar organizational structures:

(a) These departments are divided into a number of sections, each section being responsible for a particular type of computer application (e.g. department "A" has the following sections: payroll administration, freight charges, stores control, PERT, and department "B" has a real time processing section to implement their new "package" system and a batch processing section to maintain temporarily their old system). This approach is similar to that used in the firm from which the second sample was drawn where different sections were responsible for commercial programming, mining applications and so forth.

(b) No systems analysts per se exist and the tasks of senior and intermediate programmers involve both systems analysis and programming. This approach is similar to that used by smaller commercial concerns, in that more than one functional area is assigned to an employee. Task delineation for a particular computer application follows the same pattern found in industry, namely collaboration in a team, where the size of the team depends on the complexity and scope of the application. A relatively simple job may require no more than one programmer responsible for analysis and programming. A large and complex system (e.g. computerization of the whole administrative system), which may include various inter-related systems, would require a team consisting of a number of senior programmers, junior programmers and coders.

An able programmer is appointed as project leader, but often a number of senior programmers collaborate in designing a system, discussing problems, task allocation and pooling experience and ideas.

4.2 Training and Personnel Development

Training and personnel development practices differ rather markedly in the two D.P.Ds.:

(a) D.P.D. "A"

The formal programmer training course offered by the Computer Supplier is supplemented by placing junior programmers as understudies to senior programmers. The seniors assign small jobs to their understudies, assisting them with any problem they may experience and gradually increase the scope complexity of assignments. It requires about one year for these junior programmers to make an independent contribution.

Job advancement is stringently prescribed in department "A" and depends essentially on years of service (experience). This D.P.D., maintains that the more experienced programmers (in terms of years of experience) are in fact the better programmers.

(b) D.P.D. "B"

A rather unique on-the-job training procedure is followed by this department. It includes both group and individual tuition, closely aligned to on-the-job development. This procedure, briefly discussed below, appears to be relatively successful, as the department claims that its programmers are able to make individual contributions six months after entering the programming field.

Beginners are enrolled at formal programming courses offered by the computer supplier. On completion, this training is supplemented by after-hours lectures, given by D.P.D. personnel, to reinforce knowledge of the most important and useful code statements and the practical application of the coding language.

Individual on-the-job development is carried out by first requiring all trainee programmers to write a standard program for which a solution exists. Their performance is evaluated and problem areas are identified and discussed It is considered of great importance for beginners to gain confidence and to this end work assignments are carefully graded, gradually becoming more complex and demanding. For the same reason programmers with little formal education (i.e. no more than Std. VIII) are at first given assignments where they can use previous experience in the Organisation (e.g. to write a program to supplement an administrative procedure of which they have had previous experience). Later they are given assignments in areas of which they have had little or no prior experience.

(c) The Organisation compared with Industry

Programmers and systems analysts interviewed during a previous study (5) stressed the importance of on-the-job training, especially with regard to the application of the principles taught during formal courses. Many expressed the opinion that formal training curriculae do not contribute much to the training of programmers. Both departments expressed similar views, and as indicated above department "B" in particular supplements formal training with its own relatively successful training programme.

On-the-job training methods in industry generally follow the same pattern as in department "A" namely, placing beginner programmmers as understudies to more senior programmers. Commercial programmers interviewed expressed the opinion that a programmer needs about one to two years before he is able to make an independent contribution.

4.3 Nature of Computer Applications required by the Organisation

The responsibilities of the D.P.Ds are essentially similar and are discussed below. To start off with, however, certain organizational peculiarities which D.P.D. "A" has to contend with, should be mentioned. This arises primarily from the manner in which Division "A" is administered, namely, each of its departments functions independently, virtually as an autonomous unit and practically no contact between departments exists. When these individual administrative systems are computerized, it is often found that the processing of certain information is duplicated (e.g. information required by the PAYE system, such as number of children, is also required by the Medical Fund system). These conditions have to be taken into consideration when writing programs in order to link the independent systems into more economical and efficient single systems.

Another unique aspect is the fact that part of the administration is subject to law, not to "company" policy or "company" rules and regulations. This gives rise to exceedingly complicated and involved processing (e.g. the Pension Fund System), demanding a careful investigation of the confusing array of laws to determine priorities and implications (i.e. all possible combinations of situations for which the program system would have to cater).

The responsibilities of the two D.P.Ds. are summarized below:

(a) D.P.D. "A"

The D.P.D. is responsible for

(i) the investigation of all administrative systems with a view to possible computerization where such a step would streamline the functioning of its division, and,

(ii) maintenance of existing computer systems to ensure their continued efficient functioning.

At present the following is involved: the computerization of general accounting proceedings affecting various depts (e.g. payroll, expenditures), PERT applications (required by large scale future developments), operating procedures, an annual equipment census, forecasting of revenue for planning purposes, a masterfile of staff records, etc. and maintenance of existing programs and applications (e.g. Pension System).

(b) D.P.D. "B"

The D.P.D. is responsible for

(i) the investigation of present and future data processing needs of the division in order to tailor the purchased master system to organizational needs, and,

(ii) the maintenance of computer systems in use (batch processing) to ensure continued efficient functioning.

At present

(i) involves the investigation of existing clerical systems to effect the most viable data processing applications, i.e. to produce as economically as possible the information required by the different departments. Two aspects mainly are involved, viz. the control of operational messages and various administrative messages (e.g. accounts rendered); etc., and a record keeping system of transactions for future operations.

From the above discussion it can be seen that electronic data processing applications required by the Organization are essentially similar to commercial programming applications in industry.

4.4 <u>Programmer jobs in the Organisation compared to Programmer jobs in Industry</u>

The data collected during this short study indicate that the Organisation's programmer jobs in terms of job demands occupy a position midway between the "average" programmer and "average" systems analyst jobs found in industry and described in a previous report (5). The comparative definitions of the commercial programmer and systems analyst jobs are reproduced below, as well as an indication of the situation for the Organisation's programmers.

4.4.1 Definitions of the Job Demands of Commercial Programmers and the Organisation's Programmers and Commercial Systems Analysts

(a) Commercial Programmer	(b) The Organisation's Programmer	(c) Commercial Systems Analyst
Formal education to matriculation level, preferably a commercially oriented course (including Arithmetic, Costing, Secretarial Practice, etc.), as well as training in basic programming principles (e.g. introduction to computer functioning) and/or a programming language. Appropriate experience with administrative systems (e.g. as a clerk in an accounting department) as well as experience and on-the-job training in the application of programming theory to solve a given problem (± 2 years).	Similar education and experimental requirements as for "Commercial Programmer", but in practice lower are accepted.	Academic qualifications up to the level of a B-degree (degree depends on field of specialization, e.g. a B.Comm. degree for commercial systems) or qualifications such as a C.A., C.I.S., etc. In addition training in programming is required and experience in the application of theoretical and technical knowledge in the computer field to develop an approach typified by problem-orientation rather than solution-orientation (i.e. to perceive and conceptualize a problem in terms of needs and to "fit" it to a computer, treating the solution as incidental).
Converts outline of computer programs (which form a system or part of a system) to statements in a code language which can be processed by a computer, yielding the prescribed results.	Consults with user departments to obtain relevant factual information, applies specialized knowledge and experience of computer applications to conceptualize the objectives of the system, to organize the factual information and to define "sub-objectives" in terms of processing units (e.g. programs) where required. Converts outline of computer programs (which form a system or part of a system) to statements in a code language which can be processed by a computer, yielding the prescribed results.	Renders a service to own or outside organizations as an authority, evaluating needs for computerized data-processing systems, designing and implementing such systems. Consults with prospective users, selecting relevant factual information, applying specialized knowledge and experience of computer applications to conceptualize objectives of the system, to organize the factual information and to define "sub-objectives" in terms of processing units (e.g. programs) required. In addition concerned with the standardization of programming methods and techniques to ensure the optimal effectiveness of programs and to improve control.

(a) Commercial Programmer	(b) The Organisation's Programmer	(c) Commercial Systems Analyst
Decisions based on cues which are direct, though often abstract and subtle. In some cases it requires a critical evaluation and independent interpretation of given facts and concepts, based on specialized technical knowledge and general appreciation of the broader context to which an assignment relates. Solutions are often virtually "prescribed" as a result of experience in the application of programming principles and techniques, which enables recall of a "best" solution and immediate discounting of other alternatives, though these could be many. These "prescribed" solutions are often the result of a process of growth terminating in insight and appreciation of the use of programming techniques.	Decisions involve the selection of the essential situational aspects of a problem to establish the needs of the user (i.e. to conceptualize the problem in terms of the system of objectives). Collects, organizes and evaluates factual information about the operation of the manual administrative system in the user department and its relationship to other departments in the Organisation to design a computer oriented system that would answer the established needs. "Programmer" decisions apply in so far as programming is also required of job incumbents.	Decisions based on cues which are indirect, abstract and have often to be formulated by incumbent on the bases of specialized technical knowledge of the computer field, broad background knowledge of the subject field for which the system is required, prior experience, user's available personnel. Decisions revolve around the selection of the essential situational aspects of a problem to establish the needs of the user (i.e. to conceptualize the problem in terms of the system objective). Collects, organizes and evaluates factual information pertaining to the operation of the existing manual administration system in user organization to design a computer oriented system which would answer established needs and to plan, organize and co-ordinate the implementation of the system.
A measure of independence in "solving processing sequence, as many different approaches to any one problem are possible and the effectiveness of different solutions is difficult and costly to determine."	As for "Commercial Programming".	Decisions affect long-term functioning of user organization, and have implications for user's economic development. Requires a flexible approach, an appreciation for subtle implications of installing a computerized system, and using the advantages of such a system to the best effect, playing down disadvantages.

(a) Commercial Programmer

Controls are many and direct:
Detailed control is exercised in that records are kept of e.g. the number of compilation and testing runs required, running time of the completed program, overall time required for producing a working program (writing and testing) etc. Less detailed control is exercised in that only the overall program design (in terms of sub-objectives) and the correctness of computer processed results are checked. Computer exerts a direct check on the program, as it requires strict adherence to prescribed codes and programming principles.
A measure of indirect control through discussions with colleagues, systems analysts, in some cases the user, and experts employed by the computer supplier.

(b) The Organisation's Programmer

Direct controls are exercised by the user departments in that a proposed program or system design must conform to their information requirements. The computer exerts a direct check on a program, as it requires strict adherence to prescribed codes and programming principles. Indirect control in the form of discussions with colleagues, user department.

(c) Commercial Systems Analyst

A measure of direct control only in that analyst submits proposed design for computerized system and implementation schedule for acceptance by user.

4.5 Additional Findings

During the interviews with representatives from the Organization's data processing personnel, the following points were raised and merit serious consideration in any attempt to evaluate the third sample's results on the selection battery.

(a) Programmers in the organisation with no formal education beyond Std. VIII, were all forced to leave school for domestic and/or financial reasons.

(b) A factor which might have affected the sample's performance on the test battery, is that the testees appear to have had difficulty hearing instructions, particularly during introduction to the C.A. Test.

(c) The D.P.Ds are service divisions not dependent on outside contracts. It is therefore likely that pressure of work is not as great as in the case of the second sample where deadlines have to be stringently observed.

5. Conclusions

The findings of this short study indicate that there is no real difference between the Organisation's programmer job demands and the job demands identified for commercial programmers during a previous study (5). A tentative evaluation of the implications of the findings of the present study is given below:

5.1 As indicated earlier, (Section 2(a)), the third sample was markedly different from the commercial programmer samples. In the light of the findings of the present study, it seems reasonable to accept that the Organisation's employees with relatively low educational qualifications (Std. VIII) have a much higher potential. However, even though this may be true, it does not necessarily follow that these people would make as good programmers as individuals with higher educational qualifications as the Organisation claims they do. The only reasonable explanation for this situation is that on-the-job training in the organisation is particularly successful.

It was recommended in an earlier report (5) that training requirements and training practices in the data processing field should be investigated in addition to selection procedures. The findings of the present study offer some additional support for this recommendation. It may in the long run prove to be more effective to base the selection of programmers on the results of a work-oriented training programme.

5.2 The NIPR Programmer Selection Battery was compiled after considerable investigation of programmer job demands. The full value of this battery can only be determined when follow-up data becomes available in a year or two. As the results of the third sample were taken into consideration when the cut-off point for the combined score on the battery was determined, it seems reasonable to wait for follow-up data before re-evaluating the tests included in the battery.

To conclude, then, it is recommended that the selection battery for programmers is evaluated only when sufficient follow-up information is available, and that serious consideration is given to establishing the effect of work-oriented training on programmer performance.