1. INSTRUCTIONS ...

2. CONSULTATION ...

3. LEADER EMERGING ...

4. COMPLETION ...

LEADERLESS GROUP TEST ...

B.

1. A Consideration of the application of the Bus-Route Test to P.U.T.C.O. (Public Utility Transport Corporation - a transport company running a large fleet of busses for Africans and employing a big African staff). The test was applied to the following 8 groups:

   1. A new Intake Group
   2. A Clerical Group
   3. A supervisory Group
   4. A Group of Drivers
   5. A Driving Instructors Group
   6. A Group of candidate drivers
   7. A Group of Ticket Inspectors
   8. A mixed groups of clericals, drivers and supervisors.

None of these groups finished the test, although all groups were given a minimum of 30 minutes on the model. The mixed group continued to argue for 1 hour without arriving at a satisfactory solution. The Supervisory group held a theoretical argument for 35 minuted before positioning a single bus-stop sign, and although allowed to carry on for 1 hour and 36 minutes they were still unsatisfied with their bus-route and began repositioning bus-stops when the test was terminated.

2. Understanding the test instructions:

All groups understood the instructions without any difficulty. A number of subjects, however, asked questions of the tester immediately the test commenced. The questions asked were always about the same two problems, namely:

1. "Where must we start our bus-route and where must we finish it?"

2. "How many bus-routes must we make?"

Both of these questions were countered with a shrug of the shoulders and the answer: "You men are the owners of the bus company, not me. You know best." This answer always had the desired effect of making the subjects realise that all responsibility for planning rested with them and they immediately went ahead without further questioning.

The instructions regarding the use of traffic signs only after the completion of the bus route, were included after it was noticed that without such instruction the group tended to split into two, one group concentrating on bus-stops and the other on traffic-signs.

3. Differences of approach to the problem:

Observation of the groups tested revealed three basic approaches to the problem:

1. The Haphazard Approach:

this happened when one member of the group positioned a bus-stop and began working on a route without consulting the others, the rest of the group eventually joining in. This type of approach usually ended in chaos and argument, resulting in some type of compromise or in a complete alteration of the bus-route.

2. The Positioning of Termini Approach:

an approach adopted by groups composed of more intelligent subjects. The problem being tackled from a holistic viewpoint after some usually very illuminating theoretical arguments among subjects. The layout in such cases was considered as a whole, the most suitable termini chosen and the route joining them planned.

3. The Main and Feeder-Route Approach:

such an approach usually started in the haphazard way but was rescued before utter confusion resulted by the "true leader" who made a compromise between the existing bad position and a feeder-bus system attached to the main route, to cover the neglected townships.

In their approach to the task it was observed that the majority of subjects to overcome abstract thi[illegible] gave names to all the townships, to the [illegible] railway-station and to [illegible].

It is interesting to note that bus drivers attempted whenever possible to cut down on the number of sharp turns they had to make because of the difficulty of manoeuvring busses round such roads. They also insisted that all bus-stops be on level stretches or on down-grades to eliminate "overshooting" the stop. They realised the safety offered by rail-bridges and tended to select longer routes in order to miss the level-crossings.

The Supervisory and Clerical Groups stressed the economic aspects. Many of their arguments centred around such topics as: the competition with the railway, the most convenient stops for factory workers "who are always tired", and the consideration of safety precautions when planning a bus-stop for children "because if any kids are killed we may have to pay damages".

4. Intra Group Relations:

As leadership in this test does not require any physical exertion - physical dominance by reason of strength seldom occurred. Intelligence, an ability to evoke cooperation, tact, a thorough understanding of the problem and being able to

deal effectively with criticism, were far more important than being physically active, strong and agile.

In the groups observed a tactful suggestion and an intelligent response in a "debating society atmosphere", was more frequent than the heavy handed leadership found on the Mines Leadership Tests. This, however, is probably due as much to the more sophisticated type of subjects, as to the test situation. This is [illegible] for as many of the candidates [illegible] posts in secondary industry are selected from the long service older staff members, physical handicaps due to age are eliminated.

On a number of occasions there were heated arguments, one group actually splitting up into two opposing factions, which were eventually drawn together by a compromise solution from the true leader.

It was noticed that groups composed of intelligent subjects considered the problem longer before taking any action, while the less intelligent groups tended to act and think and argue at the same time.

5. The Tests usefulness for Secondary Industrial Leadership selection:

The following points emerged on the basis of observations made on the various groups tested, involving some 50 odd subjects:

1. The subjects fully understood the test instructions and the test appeared to have enough face validity to motivate the groups to action.
2. No subject took exception in having to undergo the test and co-operation with the tester was excellent.

N.I.P.R. RESEARCH PROJECT P.U.T.C.

R A T I N G F O R M

Co. No. .....

0 1 2 3 4 5

(1) Ability to express his ideas

(2) Quality of contricutions made

(3) Attempted dominance over group

(4) Deference received from group

(5) Effective criticism of others

(6) Ability to support own contentions and deal with criticism of others

(7) Amount of particupation

(8) Calmness and self-control (ease)

(9) Pleasentness of manner

(10) Ability to stick to the point.

COMMENTS:

0 = Very poor

1 = Poor

2 = Low average

3 = High average

4 = Very good

5 = Superior

3. In 5 of the 8 groups tested the subjects became so immersed in the problem that the tester after instructing them to "Stop now please" a couple of times, had to step between the subjects and the test in order to end their discussion and argument.

4. In all groups tested a leader emerged although a number of leaders were rated as unsatisfactory:

		+4	+3	+2	+1	0	-1	-2	-3	-4
1.	Supervisory Group			1	2	3				
2.	Clerical Group				1	2	3			
3.	New Intake					2		3		
4.	Mixed Group				2	1		3		
5.	Ticket Inspectors					1	1			2
6.	Driving candidates					1		2		3
7.	Driving Instructors			1		2		3		
8.	Drivers				2	1	3			
				2	7	13	7	11		5
				LEADERS			NON-LEADERS			

5. The test situation tends to promote the tactful, calm, intelligent, organising type of leadership required by secondary industrial supervisors who deal with urbanised and educated Africans; and although dominance is an important aspect of the leadership situation, in the present set-up it requires a close integration with the above mentioned factors if the leadership is to prove successful.

6. This test layout tends to provide the "dominant but dim" leaders with enough "rope to hang themselves", and when exposed they soon break down under criticism from the rest of the group.

7. The test does not require these more sophisticated

Africans to do any undignified acrobatics, nor does it soil their clothes (very many of them being dressed in suits) and consequently, it in no way developed a wrong set among the subjects.

APPENDIX : I

1. Statistics formulae.

WILCOXON TWO SAMPLE TEST:

A non-parametric test of the hypothesis that two populations are identical against the alternate hypothesis that [illegible]

Example:

1. Find the number of times each y is greater than an x.

   e.g. y = 2, 3, 7, 8

   x = 1, 2, 6, 7, 9

   Start with the smallest x; there are 4 y's greater. Take the next lowest x - ignore the tie with the smallest y, this leaves 3 y's greater. There are 2 y's greater than the next x, 6. The second last x has a tie and only one y greater. There are no y's greater than the last x. Therefore the number of y's greater than an x is:

   $$u = 4 + 3 + 2 + 1 + 0 = 10$$

2. Compute $\sigma_u^2 = \frac{m.n(m+n+1)}{12}$ ..where m = number of x's, here 5.
   n = number of y's, here 4.

   in the case above $\sigma_u^2 = \frac{5.4.10}{12} = 16.67$

   Compute $E(u) = \frac{m.n}{2}$; for this example E(u) = 10

3. Find the value of $r = \frac{u - E(u)}{\sigma_u}$

   in the case above $r = \frac{10 - 10}{\sqrt{16.67}} = 0$

4. Look up r in a table of the Cumulative Normal Distribution, (see Table II, page 93: Hald's "Statistical Tables and Formulae") and write down the corresponding probability.

5. Multiply the P obtained by 100, and then subtract from 100. For example, if a P = .9929, the answer will be:

   100 - 99.29 = .71%

DISCRIMINANT FUNCTION:

1. Obtain the sums, sums of squares and cross-products for all tests.

2. Compute the differences between [illegible] Mechanical and Non-mechanical Groups.

3. Multiply these differences [illegible]

[illegible] number in smaller group.

4. Obtain regression coefficients by following equations: (in this particular instance the "compact method" was used)

$$a\Sigma x_1^2 + b\Sigma x_1 x_2 + c\Sigma x_1 x_3 + \ldots\ldots + m\Sigma x_1 = \frac{N_1 N_2}{N_1 + N_2}\left\{\bar{x}_{1M} - \bar{x}_{1NM}\right\}$$

$$a\Sigma x_1 x_2 + b\Sigma x_2^2 + c\Sigma x_3^2 + \ldots\ldots + m\Sigma x_2 = \frac{N_1 N_2}{N_1 + N_2}\left\{\bar{x}_{2M} - \bar{x}_{2NM}\right\}$$

$$a\Sigma x_1 x_3 + b\Sigma x_2 x_3 + c\Sigma x_3^2 + \ldots\ldots + m\Sigma x_3 = \frac{N_1 N_2}{N_1 + N_2}\left\{\bar{x}_{3M} - \bar{x}_{3NM}\right\}$$

and so on .....

$$a\Sigma x_1 + b\Sigma x_2 + c\Sigma x_3 + \ldots\ldots + m(N_1 + N_2) = 0$$

5. Find sums of squares accounted for by fitting the coefficient from:

$$D = a.\frac{N_1 N_2}{N_1 + N_2}\left\{\bar{x}_{1M} - \bar{x}_{1NM}\right\} + b.\frac{N_1 N_2}{N_1 + N_2}\left\{\bar{x}_{2M} - \bar{x}_{2NM}\right\} + c.\frac{N_1 N_2}{N_1 + N_2}\left\{\bar{x}_{3M} - \bar{x}_{3NM}\right\} + \ldots$$

6. Compute the Multiple R.

$$R = \sqrt{\frac{D}{\frac{N_1 N_2}{N_1 + N_2}}}$$

7. Complete the following table:

SUMS OF SQUARES.	ν	MEAN SQ. = $\frac{\text{SUM OF SQS.}}{\nu}$	RATIO.
D	Number of tests	$\frac{D}{\text{N. of tests}} = A$	$\frac{A}{B}$ or $\frac{B}{A}$
$\frac{N_1 N_2}{N_1 + N_2} - D$	$N_1 - N_2 - 1 - (\text{n. of tests})$	$\frac{\text{Sum of Sqs.}}{\nu} = B$	
$\frac{N_1 N_2}{N_1 + N_2}$	$N_1 - N_2 - 1$		

8. Compute the battery scores for each individual and compile the frequency distributions of these scores for the Mech. and Non-mech. Groups.

ANALYSIS OF COVARIANCE:

The formulae employed for controlling the influence of education alone, or age alone.

1. The following quantities are required:

$$\Sigma x^2,\ \Sigma y^2,\ \Sigma xy,\ \Sigma x,\ \Sigma y,$$

for each group separately, and for both groups combined. (x is the education score, or the age score; y is the test score)

2. Compute the following:

i) $\Sigma x_1 y_1 - N_1(\frac{\Sigma x_1}{N_1})(\frac{\Sigma y_1}{N_1}) = A_1, A_2$

$\Sigma x_1^2 - N_1(\frac{\Sigma y_1}{N_1})^2 = B_1, B_2$ for each group separately.

$\Sigma y_1^2 - N_1(\frac{\Sigma y_1}{N_1})^2 = C_1, C_2$

ii) $\Sigma xy - N(\frac{\Sigma x}{N})(\frac{\Sigma y}{N}) = A$

$\Sigma x^2 - N(\frac{\Sigma x}{N})^2 = B$ for both groups combined.

$\Sigma y^2 - N(\frac{\Sigma y}{N})^2 = C$

3. Complete the following table:

	X SUM OF SQUARES	Y SUM OF SQUARES	XY SUM OF SQUARES	REGRESSION COEFFICIENTS	RESIDUAL SUMS OF SQUARES.
Between groups	β (by subtraction)	γ (by subtraction)	α (by subtraction)	$b_m = \frac{\alpha}{\beta}$	δ (by subtraction)
Within groups	B_1+B_2	C_1+C_2	A_1+A_2	$b_a = \frac{A_1+A_2}{B_1+B_2}$	$C_1+C_2-\frac{(A_1+A_2)^2}{B_1+B_2}$
Total:	B	C	A	$b_t = \frac{A}{B}$	$C - \frac{A^2}{B}$

p = Number of groups (2 in this case)

N = Total number of individuals.

b_t = the regression of y and x when both groups are combined.

b_a = the pooled regression of y on x within groups, (i.e. eliminating differences due to real differences between group means).

b_m = the regression of y on x of the group means

$\left\{C_1+C_2-\frac{(A_1+A_2)^2}{B_1+B_2}\right\}\frac{1}{N-P-1}$ is the best estimate of the variance of the random fluctuations of test scores about the mean score for each educational class.

4/.....

4. Apply the following tests:

i. To test for the existence of a regression of y on x;
Apply the F test to the ratio of

$$\frac{(A_1+A_2)^2}{B_1+B_2}$$

and $$C_1+C_2 - \frac{(A_1+A_2)^2}{B_1+B_2} \quad \frac{1}{N-P-1}$$

with 1 and N-P-1 degrees of freedom respectively.

This tests whether the sum of squares accounted for by fitting b_a (i.e. with differences due to real differences between group means eliminated) is significantly different from the sum of squares due to deviations from the regression line.

ii. To test whether there are significant differences between group means of y after they have been corrected for the regression of y on x;
Apply the F test to the ratio of

$$\frac{\delta}{P-1}$$

and $$C_1+C_2 - \frac{(A_1+A_2)^2}{B_1+B_2} \quad \frac{1}{N-P-1}$$

with P-1 and N-P-1 degrees of freedom respectively.

This tests whether the variance of the deviationsof the group means from the regression line b_m and the difference between b_a and b_m are significantly different from the variance of random fluctuations.

ANALYSIS OF COVARIANCE.

Computation for removing the effects of both Age and Education.

The "within groups" and "overall" regression coefficients are computed and from them the sum of squares accounted for by each set is found. The residual sums of squares, "within groups" and "overall" are found by deduction, and the difference between these residuals is tested against the "within groups" residual by the usual F test.

The following quantities are required:

FOR EACH TEST SEPARATELY

ΣE_T, ΣA_T, ΣEA_T, ΣT_T — for both groups combined.
ΣE_T^2, ΣA_T^2, N_T, ΣAT_T, ΣET_T, ΣT_T^2
and
ΣE_M, ΣE_{NM}, ΣA_M, ΣA_{NM}, N_M, N_{NM} — for each group separately.
ΣT_M, ΣT_N

where
ΣE = sum of Education squares
ΣE^2 = sum of squared Education scores
ΣA = sum of Age scores.
ΣEA = sum of Age x Education cross-products
N = numberof individuals
ΣT = sum of test scores

Subscripts M, NM and T stand for "Mech.", "Non-Mech.", and "Mech. + Non-Mech." respectively.

1. Compute:

$$x_1 = \Sigma E_T^2 - \left(\frac{\Sigma E_M}{N_M}\right)^2 - \frac{(\Sigma E_{NM})^2}{N_{NM}}$$

$$y_1 = \Sigma A_T^2 - \frac{(\Sigma A_M)^2}{N_M} - \frac{(\Sigma A_{NM})^2}{N_{NM}}$$

$$xy_1 = \Sigma EA_T - \frac{(\Sigma E_M)(\Sigma A_M)}{N_M} - \frac{(\Sigma E_{NM})(\Sigma A_{NM})}{N_{NM}}$$

and

$$x_T = \Sigma E_T^2 - \frac{(\Sigma E_T)^2}{N_T}$$

$$y_T = \Sigma A_T^2 - \frac{(\Sigma A_T)^2}{N_T}$$

$$xy_T = \Sigma EA_T - \frac{(\Sigma E_T)(\Sigma A_T)}{N_T}$$

2. Invert the following matrices:

$$\begin{bmatrix} x_i & xy_i \\ xy_i & y_i \end{bmatrix} \quad \text{and} \quad \begin{bmatrix} x_T & xy_T \\ xy_T & y_T \end{bmatrix}$$

The inverses are:

(a) "within groups"

$$\begin{bmatrix} \frac{y_i}{\Delta_i} & \frac{-xy_i}{\Delta_i} \\ \frac{-xy_i}{\Delta_i} & \frac{x_i}{\Delta_i} \end{bmatrix} \quad \text{where } \Delta_i = x_i y_i - (xy_i)^2$$

and

(b) "overall"

$$\begin{bmatrix} \frac{y_T}{\Delta_T} & \frac{-xy_T}{\Delta_T} \\ \frac{-xy_T}{\Delta_T} & \frac{x_T}{\Delta_T} \end{bmatrix} \quad \text{where } \Delta_T = x_T y_T - (xy_T)^2$$

3. The regression coefficients are given by the following:

(a) "within groups"

Education:

$$\bar{E} = \frac{Y_i}{\Delta_i}\left\{\Sigma ET_T - \frac{(\Sigma E_M)(\Sigma T_M)}{N_M} - \frac{(\Sigma E_{NM})(\Sigma T_{NM})}{N_{NM}}\right\} + \frac{-xy_i}{\Delta_i}\left\{\Sigma AT_T - \frac{(\Sigma A_M)(\Sigma T_M)}{N_M} - \frac{(\Sigma A_{NM})(\Sigma T_{NM})}{N_{NM}}\right\}$$

$$= \frac{y_i}{\Delta_i}\,\alpha_i + \frac{-xy_i}{\Delta_i}\,\beta_i$$

Age:

$$\bar{A} = \frac{-xy_i}{\Delta_i}\left\{\Sigma ET_T - \frac{(\Sigma E_M)(\Sigma T_M)}{N_M} - \frac{(\Sigma E_{NM})(\Sigma T_{NM})}{N_{NM}}\right\} + \frac{x_i}{\Delta_i}\left\{\Sigma AT_T - \frac{(\Sigma A_M)(\Sigma T_M)}{N_M} - \frac{(\Sigma A_{NM})(\Sigma T_{NM})}{N_{NM}}\right\}$$

$$= \frac{-xy_i}{\Delta_i}\,\alpha_i + \frac{x_i}{\Delta_i}\,\beta_i$$

(b)/.....

(b) "Overall"

Education:

$$\overline{E}_T = \frac{x_T}{\Delta_T}\left\{\Sigma ET_T - \frac{(\Sigma E_T)(\Sigma T_T)}{N_T}\right\} + \frac{-xy_T}{\Delta_T}\left\{\Sigma AT_T - \frac{(\Sigma A_T)(\Sigma T_T)}{N_T}\right\}$$

$$= \frac{y_T}{\Delta_T}.\alpha_T + \frac{-xy_T}{\Delta_T}.\beta_T$$

Age:

$$\overline{A}_T = \frac{-xy_T}{\Delta_T}\left\{\Sigma ET_T - \frac{(\Sigma E_T)(\Sigma T_T)}{N_T}\right\} + \frac{x_T}{\Delta_T}\left\{\Sigma AT_T - \frac{(\Sigma A_T)(\Sigma T_T)}{N_T}\right\}$$

$$= \frac{-xy_T}{\Delta_T}.\alpha_T + \frac{x_T}{\Delta_T}.\beta_T$$

4. The sums of squares accounted for by the regression equations are:

(a) "within groups"

$$S_1 = \overline{E}_1 a_1 + \overline{A}_1 \beta_1$$

(b) "overall"

$$S_T = \overline{E}_T a_T + \overline{A}_T \beta_T$$

5. The "residual sum of squares" are computed from:

(a) "within groups"

$$\left\{\Sigma T_T^2 - \frac{(\Sigma T_M)^2}{N_M} - \frac{(\Sigma T_{NM})^2}{N_{NM}}\right\} - S_1 = R_1$$

(b) "overall"

$$\left\{\Sigma T_T - \frac{(\Sigma T_T)^2}{N_T}\right\} - S_T = R_T$$

6. The "between groups residual" is computed from:

$$R_B = R_T - R_1$$

7. And the test whether the two groups still differ significantly after removing the effects of differences in age and education distributions is:

$$\frac{R_B}{1} \times \frac{N - 4}{R_1}$$

which is compared with the figure given in the F table with 1 and N-4 degrees of freedom.

ANALYSIS OF COVARIANCE.

1. To test the usefulness of including a coefficient for age after first taking account of education, take the difference between the "within groups residual" in the table with education alone - given in the Covariance Analysis on Education -, and R_1 - given in the last Covariance calculations.

   Let this difference be D_1

   Then test the ratio

$$\frac{D_1}{1} \times \frac{N - 4}{R_1}$$

   with the F tables with 1 and N-4 degrees of freedom.

ANALYSIS OF COVARIANCE.

To test the usefulness of including a coefficient for "job experience" after first accounting for the influence of age and education.

1. Carry out a pivotal condensation to obtain the test regression weights.

2. Multiply each set of weights by the corresponding criterion correlation. Call the results R_S^2, R_T^2, R_K^2 (subscripts S, T and K stand for Screws Test, Tripod Test and Kohs Blocks Test respectively).

3. Compute the "residual mean square" from:

$$\frac{1 - R_S^2}{N-4}$$

4. To obtain the regression weights for Age and Education alone, compute:

$$\Delta = 1 - r_{EA}^2 ,$$

and the matrix $\begin{bmatrix} \frac{1}{\Delta} & \frac{-r_{EA}}{\Delta} \\ \frac{-r_{EA}}{\Delta} & 1 \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} \\ C_{12} & C_{22} \end{bmatrix}$

5. Carry out the matrix multiplications:

$$\begin{bmatrix} C_{11} & C_{12} \\ C_{12} & C_{22} \end{bmatrix} \times \begin{bmatrix} r_{ES} & r_{ET} & r_{EK} \\ r & r & r \end{bmatrix} = \begin{bmatrix} \beta_{ES} & \beta_{ET} & \beta_{EK} \\ \beta_{AS} & \beta_{AT} & \beta_{AK} \end{bmatrix}$$

Each column represents the β weights for one of the tests on Education and Age alone.

6. Compute the sum of squares accounted for by fitting Education and Age.

$$R_S'^2 = \beta_{ES} r_{ES} + \beta_{AS} r_{AS}$$

$$R_T'^2 = \beta_{ET} r_{ET} + \beta_{AT} r_{AT}$$

$$R_K'^2 = \beta_{EK} r_{EK} + \beta_{AK} r_{AK}$$

7. To test whether the inclusion of job experience as an additional variable makes a significant reduction in the residual sum of squares, i.e.: a significant reduction in the scatter of the observed values about the predicted values, compute:

$$\frac{R_S^2 - R_S'^2}{1} \times \frac{N - 4}{1 - R_S^2} = F_{JE_S}$$

and look up in the F tables with 1 and N-4 degrees of freedom.

ANALYSIS OF COVARIANCE.

Computation for controlling the effects of both Age and Education in the Job Experience groups.

The "within groups" and "overall" regression coefficients are computed and from them the sum of squares accounted for by each set is found. The residual sum of squares, "within groups" and "overall" are found by deduction, and the difference between these residuals is tested against the "within groups" residual by the usual F test.

1. The following quantities are required:

FOR EACH TEST SEPARATELY

ΣE_T, ΣA_T, ΣEA_T, ΣT_T for both groups combined.

ΣE^2_T, ΣA^2_T, N_T, ΣAT_T, ΣET_T, ΣT^2_T

and

ΣE_I, ΣE_{II}, ΣE_{III}, ΣA_I, ΣA_{II}, ΣA_{III}, N_I, N_{II}, N_{III} for each group separately.

ΣT_I, ΣT_{II}, ΣT_{III}

where

ΣE = sum of Education scores
ΣE^2 = sum of squared Education scores
ΣA = sum of Age scores
ΣEA = sum of AgexEducation cross-products
N = number of individuals
ΣT = sum of test scores.

Subscripts I, II and III, and T stand for Job Experience Group I, Job Experience Group II and Job Experience Group III, and Job Experience Group I + Group II + Group III respectively.

Group I: Subjects with long present job experience and long industrial experience, i.e.: a stay of 10 years or more in the Urban Areas and 4 years or more in the present job.

Group II: Subjects with short present job experience and long industrial experience, i.e.: a stay of less than 1 year in the present job but more than 10 years in the Urban Areas.

Group III: Subjects with short present job experience and short industrial experience, i.e.: a stay of less than 1 year in the present job and less than 4 years in the Urban Areas.

2/.....

2. Compute:

$$x_i = \Sigma E_T^2 - \frac{(\Sigma E_I)^2}{N_I} - \frac{(\Sigma E_{II})^2}{N_{II}} - \frac{(\Sigma E_{III})^2}{N_{III}}$$

$$y_i = \Sigma A_T^2 - \frac{(\Sigma A_I)^2}{N_I} - \frac{(\Sigma A_{II})^2}{N_{II}} - \frac{(\Sigma A_{III})^2}{N_{III}}$$

$$xy_i = \Sigma EA_T - \frac{(\Sigma E_I)(\Sigma A_I)}{N_I} - \frac{(\Sigma E_{II})(\Sigma A_{II})}{N_{II}} - \frac{(\Sigma E_{III})(\Sigma A_{III})}{N_{III}}$$

and

$$x_T = \Sigma E^2 - \frac{(\Sigma E_T)^2}{}$$

$$y_T = \Sigma A_T^2 - \frac{(\Sigma A_T)^2}{N_T}$$

$$xy_T = \Sigma EA_T - \frac{(\Sigma E_T)(\Sigma A_T)}{N_T}$$

3. Invert the following matrices:

$$\begin{bmatrix} x_i & xy_i \\ xy_i & y_i \end{bmatrix} \quad \text{and} \quad \begin{bmatrix} x_T & xy_T \\ xy_T & y_T \end{bmatrix}$$

The inverses are:

(a) "within group"

$$\begin{bmatrix} \frac{y_i}{\Delta_i} & \frac{-xy_i}{\Delta_i} \\ \frac{-xy_i}{\Delta_i} & \frac{x_i}{\Delta_i} \end{bmatrix}$$

where $\Delta_i = x_i y_i - (xy_i)^2$

and

(b) "overall"

$$\begin{bmatrix} \frac{y_T}{\Delta_T} & \frac{-xy_T}{\Delta_T} \\ \frac{-xy_T}{\Delta_T} & \frac{x_T}{\Delta_T} \end{bmatrix}$$

where $\Delta_T = x_T y_T - (xy_T)^2$

4/.....

4. the regression coefficients are given by the following:

(a) "within groups"

Education.

$$\bar{E}_1 = \frac{y_1}{\Delta_1}\left\{\Sigma ET_T - \frac{(\Sigma E_I)(\Sigma T_I)}{N_I} - \frac{(\Sigma E_{II})(\Sigma T_{II})}{N_{II}} - \frac{(\Sigma E_{III})(\Sigma T_{III})}{N_{III}}\right\}$$

$$+ \frac{-xy_1}{\Delta_1}\left\{\Sigma AT_T - \frac{(\Sigma A_I)(\Sigma T_I)}{N_I} - \frac{(\Sigma A_{II})(\Sigma T_{II})}{N_{II}} - \frac{(\Sigma A_{III})(\Sigma T_{III})}{N_{III}}\right\}$$

$$= \frac{y_1}{\Delta_1}\alpha + \frac{-xy_1}{\Delta}\beta$$

Age.

$$\bar{A}_1 = \frac{-xy_1}{\Delta_1}\left\{\Sigma ET_T - \frac{(\Sigma E_I)(\Sigma T_I)}{N_I} - \frac{(\Sigma E_{II})(\Sigma T_{II})}{N_{II}} - \frac{(\Sigma E_{III})(\Sigma T_{III})}{N_{III}}\right\}$$

$$+ \frac{x_1}{\Delta_1}\left\{\Sigma AT_T - \frac{(\Sigma A_I)(\Sigma T_I)}{N_I} - \frac{(\Sigma A_{II})(\Sigma T_{II})}{N_{II}} - \frac{(\Sigma A_{III})(\Sigma T_{III})}{N_{III}}\right\}$$

$$= \frac{-xy_1}{\Delta_1}\alpha + \frac{x_1}{\Delta_1}\beta$$

(b) "overall"

Education.

$$\bar{E}_T = \frac{y_T}{\Delta_T}\left\{\Sigma ET_T - \frac{(\Sigma E_T)(\Sigma T_T)}{N_T}\right\} + \frac{-xy_T}{\Delta_T}\left\{\Sigma AT_T - \frac{(\Sigma A_T)(\Sigma T_T)}{N_T}\right\}$$

$$= \frac{y_T}{\Delta_T}\alpha_T + \frac{-xy_T}{T}\beta_T$$

Age.

$$\bar{A}_T = \frac{-xy_T}{\Delta_T}\left\{\Sigma ET_T - \frac{(\Sigma E_T)(\Sigma T_T)}{N_T}\right\} + \frac{x_T}{\Delta_T}\left\{\Sigma AT_T - \frac{(\Sigma A_T)(\Sigma T_T)}{N_T}\right\}$$

$$= \frac{-xy_T}{\Delta_T}\alpha + \frac{x_T}{\Delta_T}\beta$$

5/.....

5. the sums of squares accounted for by the regression equation are:

   (a) "within groups".

   $$S_i = \bar{E}_i \alpha_i + \bar{A}_i \beta_i$$

   (b) "overall"

   $$S_T = \bar{E}_T \alpha_T + \bar{A}_T \beta_T$$

6. The "residual" sum of squares is computed from:

   (a) "within groups"

   $$\left\{ \Sigma T_T^2 - \frac{(\Sigma T_I)^2}{N_I} - \frac{(\Sigma T_{II})^2}{N_{II}} - \frac{(\Sigma T_{III})^2}{N_{III}} \right\} - S_i = R_i$$

   (b) "overall"

   $$\left\{ \Sigma T_T^2 - \frac{(\Sigma T_T)^2}{N_T} \right\} - S_T = R_T$$

7. The "between groups" residual is computed from:

   $$R_B = R_T - R_i$$

8. To test whether the two groups still differ significantly after removing the effects of differences in age and education distributions is:

   $$\frac{R_B}{2} \times \frac{N - 5}{R_i}$$

   which is compared with the figure given in the F table with 1 and N-4 degrees of freedom.

References:

A. General:

1. COLUMBIA INDUSTRIAL REPORTS (1951): Series No. 1, "Frontiers of Personnel Administration."

2. JAQUES, E. (1951): "The Changing Culture of a Factory." Tavistock Publications, Ltd.

3. KATZ, D. (1949): "Morale and Motivation in Industry." The Survey Research Centre, University of Michigan.

4. MORRIS, B.S. (1949): "Community Studies and Community Education in Relation to Social Change." A paper read to the Annual General Meeting of the British Psychological Society, Bristol.

5. NATIONAL INSTITUTE FOR PERSONNEL RESEARCH (1950) "Aptitude Tests for Native Labour on the Witwatersrand Gold Mines - Part II: Description of Tests and Testing Procedures." Report on investigation H 16/35 carried out on behalf of the Transvaal Chamber of Mines.

6. SEASHORE, S.E. (1954): "Group Cohesiveness in the Industrial Work Group." The Survey Research Centre, University of Michigan.

B. Job Analysis Theory:

7. COHEN, L. (1948): "More Reliable Job Evaluation" Personnel Psychology, Vol. 1, No. 4.

8. FERGUSON, L.W. (1948): "A Brief Description of a Reliable Criterion of Job Performance." Journal of Psychology, Vol. 25.

9. GHISELLI, E.E. & BROWN, C.W. (1948): "Personnel and Industrial Psychology." McGraw - Hill Book Coy. Inc.

10. HEYEL, C. (1949): "The Foreman's Handbook." McGraw - Hill Book Coy. Inc.

11. LAWSHE, C.H. (1953): "Psychology of Industrial Relations." McGraw - Hill Book Coy. Inc.

12. MILLER, D.C. & FORM, W.H. (1951): "Industrial Sociology - an introduction to the Sociology of Work Relations." New York, Harper and Brothers.

13. SHARTLE, C.F. (1946): "Occupational Information." Prentice - Hall.

14. TIFFIN, J. (1951): "Industrial Psychology". London, George Allen and Unwin, Ltd.

C. African Studies:

15. BARRETT, A.L. (1953): "The Character of the Native In South Africa." Optima, Vol. 3, No. 3.

16. BIESHEUVEL, S. (1949): "Psychological Tests and Their Application to Non-European Peoples." The Year Book of Education. London, Evans Brothers, Ltd.

17. CAROTHERS, J.C. (1953): "The African Mind in Health and Disease - A study in Ethnopsychiatry." Geneva, World Health Organisation.

18. HELLMAN, E. (1949): "Handbook on Race Relations in South Africa." Oxford University Press.

19. HELLMAN, E. (1953): "Sellgoods - A Socialogical Survey of An African Commercial Labour Force." South Africa, Institute of Race Relations.

20. MALAN, DR. D.F. (Sept.25, 1951): "South Africa's Rapid Industrial Development." the text of a speech delivered by the Prime Minister at the opening of the annual congress of the South African Federated Chamber of Industries. Published by the Director, State Information, Pretoria.

21. NGCOBO, S.B. (1954): "The Response of Africans To Industrial Employment." Race Relations Journal, Vol. XXI: No. 1.

22. OFFICAL YEAR BOOK of the Union of South Africa, No. 25, 1949. Government Printer, Pretoria.

23. RHEINALLT JONES, J.D. (1952): "The Native's Roll in the Economic Development of Africa." Optima, Vol. 2 No. 3, September.

24. RODSETH, F. (1954): "The Economic Motive for Native Migration to the Towns." Optima, Vol. 4, No. 1, March.

25. UNION DEPT. OF NATIVE AFFAIRS (1952): "Industrial Revolution in South Africa - Its Impact on European and Native Life." A fact paper - Director of State Information Office, Private Bag, Pretoria, South Africa.

26. VAN DER HORST, SHEILA T. (1953): "The Native in South Africa's Industrial Revolution." Optima, Vol. 3, No. 2, June.

D. Testing Theory:

27. LAWSHE, C.H. (1948): "Principles of Personnel Testing." McGraw - Hill Book Company, New York.

28. SUPER, DONALD E. (1949): "Appraising Vocational Fitness by Means of Psychological Tests." Harper Brothers, New York.

29. THORNDIKE, ROBERT L. (1949): "Personnel Selection - Test and Measurement Techniques." John Wiley and Sons. Inc., New York.

30. VINCENT, D.F. (1954): "Age and Test Performance." An occasional paper of the Institute of Industrial Psychology.

E. Statistical Theory:

31. BABINGTON SMITH, B. (1951): "On Some Difficulties Encountered in the Use of Factorial Designs and Analysis of Variance With Psychological Experiments." The British Journal of Psychology (General Section) Vol. XLII, Part 3, August.

32. BROWNLEE, K.A. (1949): "Industrial Experimentation." A Monograph published by the Directorate of Royal Ordinance Factories (Explosives), Ministry of Supply. Fourth Edition. His Majesty's Stationary Office: London.

33. DAVIS, OWEN L. (1954): "The Design and Analysis of Industrial Experiments." Published for Imperial Chemical Industries Limited by Oliver and Boyd: London WC1.

34. FISHER, R.A. (1941): "Statistical Methods for Research Workers." Oliver and Boyd, Eight Edition.

35. HAGOOD, M.J. AND PRICE D.O. (1952): "Statistics for Socialogists" Henry Holt and Company, New York. Revised Edition.

36. KENDALL M.G. (1945): "The Advanced Theory of Statistics." Vol. 1. Charles Griffin and Company Limited, Drury Lane.

37. KENDALL, M.G. (1950): "The Statistical Approach" - Inangural Lecture given at the London School of Economics on January 7, 1950. Printed in "Economica" May 1950.

38. McNEMAR, QUINN (1949): "Psychological Statistics" John Wiley and Sons, Inc., New York.

39. MORONEY, M.J. (1953): "Facts from Figures." Penguin Books Limited, Harmondsworth, Middlesex. Second edition.

F. Leadership Theory:

40. FLEISHMAN, EDWIN A. (1951): "A study of the Leadership Role of the Foreman in an Industrial Situation - With Special Implications for Leadership Training." Published by the Personnel Research Board, Ohio State University; Columbus, Ohio.

41. HEYNS, ROGER W. (1952): "Conference Leadership Which Stimulates Teamwork." - Michigan Business Review, Vol. IX, No. 6, November.

42. KAHN, R.L. (1952): "The Human Factor Underlying Industrial Productivity." - Michigan Business Review, Vol. IX, No. 6, November.

43. LIKERT, R. (1952): "Findings of Research on Management and Leadership." Published in the Proceedings, Pacific Coast Gas Association, Vol. 43.

44. SHARTLE, C.L. (1951): "Leader Behaviour in Jobs." - Occupations, December, Vol. XXX, No. 3.

45. STOGDILL, RALPH M. (1950): "Leadership, Membership and Organisation." Psychological Bullitin, Vol. 47, No. 1, January.

SUMMARY OF RESEARCH.

1. In 1946 at the request of the Transvaal Chamber of Mines and Associated Mining Companies, the National Institute for Personnel Research devised a battery of nine tests to classify African Mine labour into broad occupational groups.

2. The General Adaptability Test Battery constructed for this purpose proved a most satisfactory classificatory device for mine labour.

3. The present study considers the use of this battery for African selection in a new field - namely, for secondary industrial selection.

4. Great differences in age and education exist within the African secondary industrial population so the influence of these factors on test performance was also studied.

5. The tests were applied to two samples:
   a) an industrial sample of 1000 subjects
   b) a school sample of 2000 subjects.

6. The industrial sample was classified on the basis of a job analysis criterion into:
   a) Mechanical workers
   b) Non-Mechanical workers.

7. Results show that as a group Mechanical workers do significantly better on the tests than Non-Mechanical workers.

8. A considerable overlap on all test scores exists between the two groups however.

9. The test battery has a 61% discriminative ability between these two groups in secondary industry.

10. Education exerts a significant influence on test scores.

11. In seven of the tests education is not the main differentiating factor between the test scores of the two groups of workers.

12. The battery functions to some extent as a test of educational achievement.

13. Age exerts a significant influence on test scores.

14. On none of the tests is age the main differentiating factor between the two groups of workers.

15. The better educated worker does better on the tests, the older worker does worse on the tests.

16. Length of job experience exerts a significant influence on test scores.

17. As a group boys do better on the tests than girls.

18. Seven of the nine tests differentiate significantly between the sexes.

PHOTOGRAPHIC SEQUENCE OF THE MAIN JOBS AND JOB FAMILIES:

1. STORAGE
2. STORE ROOM-MATERIALS CNT.
3. UNBOXING " "
4. JIG MAKING -EXP. BAY
5. WELDING A JIG " "
6. SPOT WELDING- BODY JIG BAY
7. WELDING FLOOR " "
8. WELDING BODY " "
9. FILE WIPING -BODY LINE
10. DISCING " "
11. ROUTING - BODY LINE
12. TINNING " "
13. MELTING LEAD " "
14. LEAD WIPING " "
15. DOOR FITTING-DR. FITTING SEC.
16. PAINT SHOP
17. UPHOLSTERY - UPHOL. DEPT.
18. SEAT PULLING- " "
19. HEADLINING -TRIM LINE
20. ARMRESTS " "
21. SPEEDO CABLE- ELECTR. LINE
22. PANEL WIRING- " "
23. MOUNTING BODY- BDY. MT. LINE
24. ENGINE FITTING - ENGINE LINE
25. " " " "
26. WHEELS TO CHASSIS-CHS. LINE
27. ENGINE " "
28. CHASSIS READY " "
29. FINAL FINISH
30. RAMP

NATIONAL MOTOR ASSEMBLIES (pty) ltd.

Mae Riddle