Research Finding PERS-381 1985

Factors related to mechanical aptitude in Blacks II: Empirical study

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RGN·HSRC

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Pretoria
Human Sciences Research Council
1985

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National Institute for Personnel Research
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ISBN 0 7969 0291 7

Printed by Express Kopie

ACKNOWLEDGEMENTS

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OPSOMMING

Hiérdie verslag volg op PERS 380, wat 'n literatuuroorsig is van intelligensiestruktuur en die aard van meganiese aanleg by Blankes en Suid-Afrikaanse Swartes.

In hierdie verslag, word die empiriese studie aangebied en bespreek.

Die studie was daarop gemik om:

(i) die faktorstruktuur van toetse wat teoreties met meganiese aanleg verband hou, te ondersoek;

(ii) die mate te bepaal waartoe biografiese en belangstellingsveranderlikes gebruik kan word om prestasie op die hoofdimensies van meganiese vermoë, soos bepaal deur die faktorstruktuur, te voorspel.

Die steekproef het bestaan uit 75 geselekteerde Swart manlike tegniese applikante met 'n Standerd 8 tot 10 onderwyspeil. Vier faktore is onttrek: Ruimte, Analitiese Redenering, Konseptuele Redenering en Meganiese Redenering. Die Ruimte-Faktor het beduidend gekorreleer met Meganiese Redenering, maar nie met die ander faktore nie. Biografiese en belangstellingsveranderlikes het nie konsekwent met die ander faktore verband gehou nie. Beduidende voorspellers is gevind vir 'n faktor wat verband hou met formele onderwys, met opvoeding en verstedeliking wat 'n belangrike rol speel. Voorspellers vir die ander faktore was nie so duidelik omlyn nie.

SUMMARY

This report follows from PERS 380 which reviews the literature bearing on the structure of intelligence and the nature of mechanical aptitude of Whites and of South African Blacks.

In this report, the empirical study is presented and discussed.

The study was aimed at:

(i) investigating the factor structure of tests theoretically related to mechanical aptitude;

(ii) determining the extent to which biographical and interest variables may be used to predict performance on the major dimensions of mechanical ability as determined by the factor structure.

The sample consisted of 75 selected Black male technical applicants with a Standard 8 to 10 level of education. Four factors were extracted: Space, Analytic Reasoning, Conceptual Reasoning, and Mechanical Reasoning. The Space factor correlated significantly with Mechanical Reasoning, but did not correlate with the other factors. Biographical and interest variables were not consistently related to the factors. Significant predictors were obtained for a factor related to formal schooling, with education and urbanization playing a major role. Predictors for the other factors were not so clearly defined.

CHAPTER 1

INTRODUCTION

1.1 Statement of problem

Whereas many studies have been conducted investigating mechanical aptitude in Whites, no clear model has been formulated. Certain abilities, however, have been shown to be relevant for the development of mechanical skills in Whites. There has been a paucity of research, however, into the mechanical aptitude of Blacks. The main thrust of investigations into the intellectual structure of Blacks in Southern Africa has focussed on relatively uneducated Blacks performing relatively uncomplicated mechanical tasks. The aim of the present study is to broaden the informational base about the mechanical aptitude of relatively highly educated Blacks. This will be done in two stages. First by conducting an exploratory factor analysis to investigate the factor structure of a group of tests which are theoretically related to mechanical aptitude in Whites, and assessing whether similar factors are extracted with a Black sample. Second, by investigating the relationship between biographical and interest variables and the major dimensions of mechanical ability to assess whether various components of the socio-cultural environment of a modern technologically orientated culture, - industrial experience, urbanization, education, hobbies and interests - exert direct effects on the development of intellect in general and on the skills which constitute the major dimensions of mechanical aptitude in Blacks in particular. In this way it is hoped that a contribution will be made to knowledge of the important area of mechanical aptitude in Blacks by the establishment of some guidelines, albeit tentative ones, for identifying and developing the relevant skills in Blacks which are essential for coping with Western technology.

1.2 Aims

As the research is essentially exploratory in nature, aims rather than hypotheses have been formulated. The following are the specific aims of the investigation.

1.2.1 Aim 1

To determine the factor structure of a group of tests theoretically related to mechanical aptitude in Whites, on a sample of Black males.

Rationale for Aim 1

Although no clear model of mechanical aptitude exists for Whites, certain components have been shown to be relevant to the development of mechanical skills in Whites. Bowd (1973) has shown that mechanical aptitude is a construct which has been developed within a technologically sophisticated environment. It is, thus, suggested that factors similar to those which are related to mechanical aptitude in Whites, may emerge in a relatively highly educated Black sample.

1.2.2 Aim 2

To determine the extent to which biographical and interest variables of a sample of Black males may be used to predict performance on the major dimensions of mechanical ability as determined by the factor analyses.

Rationale for Aim 2

The factor structure of intellect and ability levels of Blacks has been shown to be affected by exposure to Western culture (Biesheuvel, 1959; Grant, 1969; Kendall, 1971, 1980) and levels of education (Grant & Schepers, 1969), leading to marked differences across groups (Grant, 1970a; Irvine, 1969a).

Thus biographical inventories (Botha, 1976; Bowd, 1973; Paterson, Elliott, Anderson, Toops & Heidbreder, 1930; Sorensen, 1966) and interest inventories (Kemp, 1980; Möller, 1965; Paterson et al., 1930; Thurstone, 1950) suggested mechanical ability. The influence of biographical variables on spatial perception, one of the primary components of mechanical ability, has also been demonstrated (Dickinson, 1980; Hudson, 1960; Kemp, 1980; Kilbride & Robbins, 1967, 1968; McFie, 1961; Mundy-Castle, 1966; Serpell, 1979). A relationship between the biographical and interest variables of the present sample and performance on the tests loading on the major dimensions of mechanical ability was, therefore, suggested.

CHAPTER 2

METHOD

2.1 Sample

The initial sample consisted of 252 Black male applicants applying for training as technicians. Of the 252 applicants, 144 were selected for an interview on the basis of test results. Because norms were unavailable, norms were calculated from the total sample, and a stanine of four was used as a cut-off point. Of the eight initial tests, a person selected for an interview had to obtain a stanine of four or above on six of the tests, provided that these included the three spatial tests and the two tests of verbal and abstract reasoning. Sixty-seven were recommended, 51 were recommended with reservation, and 26 were not recommended. The final selected sub-sample consisted of 75 applicants who were selected for training as technicians.

A demographic description of the sample by means of percentages and respondent group is contained in Table 1.

TABLE 1

Demographic description of sample by percentages and respondent group.

Characteristic	Total sample (n=252)	Selected sample (n=75)
Age:		
Under 18	0,4	0,0
18 - 20	23,0	13,3
21 - 23	44,5	48,0
24 - 26	23,8	29,4
27 - 29	8,0	9,3
over 29	0,4	0,0
Level of education:		
Std 8	34,5	10,7
Std 9	16,7	17,3
Std 10	35,7	52,0
post-school training	13,1	20,0
Background:		
rural	22,9	17,3
urban	77,1	82,7
Subjects taken at school:		
maths	92,1	92,0
science	69,4	78,4
practical	4,7	8,2

2.2 Measuring instruments

2.2.1 Cognitive tests

2.2.1.1 Intermediate Mental Alertness

This is a sub-test of the Intermediate Battery (Wilcocks, 1973) and is a measure of general intelligence and the ability to apply previously gained knowledge to new situations (Visser, 1978). According to Lätti and Verster (1975) knowledge obtained through traditional Western educational systems is a prerequisite for solution of the items. The 30 items of this sub-test include reasoning in terms of verbal analogies, numerical and letter series, and classification of common elements. The test has a high verbal component (Wilcocks, 1973). The time limit is 30 minutes, and the test has a multiple choice format. Visser (1978) reported that the Intermediate Mental Alertness, which has been standarized for Whites with 9 to 12 years of schooling shows a better reliability and yields a more normal distribution than the High Level Mental Alertness (Lombard, 1975), as far as Black first-year university students are concerned, and is thus a more appropriate test for Blacks at that level. Erwee (1981) has confirmed this and Hall (1978, 1980) has demonstrated that the Intermediate Mental Alertness test may be used successfully with Black matriculants.

Mean, standard deviation, and reliability estimate

The mean, standard deviation, and reliability estimate of the Mental Alertness test are contained in Table 2.

TABLE 2

Mean, standard deviation, and reliability estimate of the Mental Alertness test

			Reliability	
n	Mean	*SD*	KR 21	Tucker correction
507[a]	16,57	4,81	0,703	0,814

[a] Black first-year male and female university students at the University of Fort Hare, tested in 1977 and 1978 (Visser, 1978).

Validation of the Mental Alertness

According to Visser (1977), as Mental Alertness is a test of general reasoning ability, dependent on formal learning, scores usually correlate significantly with school results. Thus Hall (1979) found that scores on Mental Alertness correlated significantly ($\underline{n}$ = 66, $\underline{r}$ = 0,40, $\underline{p}$ = 0,01) with matriculation results for a group of Black medical technology applicants, and Visser (1978) found a significant correlation ($\underline{n}$ = 50, $\underline{r}$ = 0,39, $\underline{p}$ = 0,001) with end of year results in the Science courses at first-year university level.

2.2.1.2 Technical Reading Comprehension

This is a sub-test of the General Science Test (A/107) (1970) of the NIPR which is a measure of the ability to read, absorb and synthesize technical and scientific material. The test consists of 10 paragraphs containing information of a technical and scientific nature. Each paragraph is followed by a number of multiple choice questions or statements about the paragraph which the testee must answer. There are 30 questions and the testing time is 35 minutes. The test requires a thorough understanding of the concepts of the paragraphs. Transformation of the information is necessary, requiring synthesizing and paraphrasing abilities, all within the context of a language medium. It is thus not wholly dependent on school background (Hall, 1979).

Mean, standard deviation, and reliability estimate

The mean, standard deviation, and reliability estimate of the Technical Reading Comprehension test are contained in Table 3.

TABLE 3

Mean, standard deviation, and reliability estimate of the Technical Reading Comprehension test

			Reliability	
n	Mean	SD	KR 21	Tucker correction
75[a]	15,58	3,95	0,640	0,820

[a] Black matriculated male and female applicants for medical technology training, tested in 1978 (Hall, 1979).

Validation of Technical Reading Comprehension

Hall (1979) reported that the Technical Reading Comprehension test correlated significantly ($p < 0,01$) with all school results for a sample of Black applicants for medical technology. This was particularly noticeable with matriculation results ($r = 0,54$, $p < 0,01$), mathematics marks ($r = 0,51$, $p < 0,01$), and science marks ($r = 0,66$, $p < 0,01$). According to Hall (1979) these results tend to confirm the usefulness of the test as a predictor of success in technical studies for those who have not included science in their matriculation curricula.

2.2.1.3 Blox

This test was designed to measure the ability to perform manipulations of three-dimensional visual images, and to understand the nature of the arrangement of the elements contained within a visual stimulus pattern, and is thus essentially a measure of the spatial-relations and orientation factor (Michael, Guilford, Fruchter and Zimmerman, 1957). On each page of the question booklet, five sets of cubes are presented, containing between two to six blocks per set. The blocks are arranged together in different ways and the testee has to identify from a number of possible answers which alternative set of blocks, seen from a different perspective, corresponds to the question item. There are 45 test items to be answered in 30 minutes.

Mean, standard deviation, and reliability estimate

The mean, standard deviation, and reliability estimate of the Blox test are contained in Table 4.

TABLE 4

Mean, standard deviation, and reliability estimate of the Blox test

			Reliability	
n	Mean	SD	KR 21	Tucker correction
131[a]	19,94	6,42	0,747	0,840

[a] Black first-year male and female university students at the University of Fort Hare, tested in 1977 and 1978 (Visser, 1978).

Validation of the Blox

Mauvis (1979) found a significant correlation ($n = 66$, $r = 0{,}56$, $p < 0{,}005$) between scores on the Blox test and end of the the year results for Black and White first-year engineering students at the University of Rhodesia. J.M. Taylor (1980) and S. Taylor (1981) reported similar results for engineering students at the University of the Witwatersrand, thus indicating the usefulness of the Blox in predicting spatial perception ability.

2.2.1.4 F Test

This test is part of the original General Aptitude Test Battery (GATB) (United States Employment Service, 1967). The test consists of a series of exercises containing a stimulus figure and five drawings of two-dimensional geometric figures made up of a number of smaller parts. The testee must select which of the alternative figures has the same parts as the stimulus figure, with the parts however being either rearranged or re-oriented. The test does not utilize depth cues and thus does not require three-dimensional visualization.

This is a highly speeded test, requiring the testee to answer 49 questions in 7 minutes.

Mean, standard deviation, and reliability estimate

The mean, standard deviation, and reliability estimate of the F Test are contained in Table 5.

TABLE 5

Mean, standard deviation, and reliability estimate of the F Test

			Reliability	
n	Mean	SD	KR 21	Tucker correction
197[a]	17,6	7,4	0,795	0,871

[a] Mainly White, predominantly male, first-year engineering students at the University of the Witwatersrand, tested in 1979 (J.M. Taylor, 1980).

Validation of the F Test

The F Test is a test of two-dimensional spatial ability, and hence scores should correlate with other spatial tests and with the ability to interpret technical drawings. J.M. Taylor (1980) found that scores on the F Test correlated significantly with examination results in Engineering Analysis and Design for first-year engineering students (n = 102, r = 0,53, $p < 0,01$), and with scores on the Blox (n = 93, r = 0,51, $p < 0,01$). Epstein (in press) found that scores on the F Test increased significantly after a remedial course in depth perception.

2.2.1.5 H Test

This is a sub-test of the GATB (United States Employment Service, 1967). The test measures the ability to think visually about geometric forms, and to comprehend the two-dimensional representation of three-dimensional objects, as well as the ability to recognise the relationships resulting from movement of objects in space. The H Test is thus essentially a measure of the visualization factor (Michael et al., 1957).

The test consists of a series of exercises containing a stimulus figure and four drawings of three-dimensional objects. The stimulus figure is pictured as a flat piece of metal which is to be mentally bent and/or rolled. Lines indicate where the stimulus figure is to be bent. The testee indicates which one of the four drawings of the three-dimensional objects can be made from the stimulus figure.

This is a highly speeded test, requiring the testee to answer 49 items in 8 minutes. The original time limit of 6 minutes was changed to 8 minutes, as it had been found in pilot studies that the test appeared to be too difficult for Blacks with the distribution of scores tending to be positively skewed. When more time was given, it was observed that the distribution of scores tended to be more normal.

Mean, standard deviation, and reliability estimate

The mean, standard deviation, and reliability estimate of the H Test are contained in Table 6.

TABLE 6

Mean, standard deviation, and reliability estimate of the H Test

			Reliability	
n	Mean	SD	KR 21	Tucker correction
232[a]	24,0	6,4	0,780	0,865

[a] Mainly White, predominantly male, first-year engineering students at the University of the Witwatersrand, tested in 1979 (J.M. Taylor, 1980).

TABLE 7

Mean, standard deviation, and reliability estimate of the Figure Classification Test

			Reliability	
n	Mean	SD	KR 21	Tucker correction
145[a]	16,74	6,92	0,820	0,860

[a] Black first-year male and female university students at the University of Fort Hare, tested in 1977 and 1978 (Visser, 1978).

These figures refer to the original 36-item Figure Classification Test of the NIPR, designed to assess conceptual reasoning of Blacks with 7 to 9 years of education. The reliabilities indicate that the test is suitable for Blacks per se. The High-Level version was developed by Werbeloff and Taylor (1982) to measure the conceptual reasoning of more highly educated Blacks. The test was used in this study on an experimental basis, and thus no reliability or validity data for the High-Level version were available at the time.

2.2.1.7 Mechanical Comprehension

The Mechanical Comprehension test (A3/1) was developed from the Bennet Test of Mechanical Comprehension Form AA (Bennet, 1940) at the NIPR (Griffiths, 1968). The test is designed to assess the comprehension of the nature, operation and effects of various physical principles. The items are based on the contents of the science course syllabus used in secondary schools, the majority of items being drawn from applied mechanics and general physics. Each item consists of an illustration, a brief clarifying comment where necessary, and a question with three possible answers. There are 42 items to be answered in 35 minutes.

Mean, standard deviation, and reliability estimate

The mean, standard deviation, and reliability estimate of the Mechanical Comprehension test are contained in Table 8.

TABLE 8

Mean, standard deviation, and reliability estimate of the Mechanical Comprehension test

			Reliability	
n	Mean	SD	KR 21	Tucker correction
92[a]	16,82	4,08	0,402	0,617

[a] Black first-year male and female university students at the University of Fort Hare, tested in 1977 and 1978 (Visser, 1978).

Validation of Mechanical Comprehension

Visser (1978) noted that as the mechanical problems are presented in pictorial form, the test is also a form of perceptual reasoning, and she found that the test correlated significantly (n = 92, r = 0,32, p = 0,01), with the Blox; with Mental Alertness (n = 89, r = 0,40, p = 0,01), with Arithmetic Problems (n = 89, r = 0,34, p = 0,01), and with a test of abstract reasoning (n = 92, r = 0,35, p = 0,01), which probably indicates that the test is not pure.

As far as can be ascertained, there are no validity data available for Mechanical Comprehension for Blacks. Hoek and De Jager (1978) however, indicated that it correlated significantly (n = 42, r = 0,37, p = 0,05) with a drawing course for White apprentice instrument makers.

2.2.1.8 Gottschaldt Embedded Figures Test

The Gottschaldt Embedded Figures Test (GEFT) is an embedded figures test designed to measure analytic perceptual ability. The test consists of complex figures, each of which contains one of five simple key figures. The testee has to identify the key figure embedded in each complex figure. This requires the ability to extract the embedded figure without being distracted by the background. There are 45 items to be answered in 20 minutes. The GEFT is a measure of Thurstone's (1944, 1949) flexibility of closure, and has been found to be associated with both field articulation and spatial skills (Witkin et al., 1962), and with analytic thinking (Pemberton, 1952).

Mean, standard deviation, and reliability estimate

The mean, standard deviation, and reliability estimate of the Gottschaldt Embedded Figures Test are contained in Table 9.

TABLE 9

Mean, standard deviation, and reliability estimate of the Gottschaldt Embedded Figures Test

			Reliability	
n	Mean	SD	KR 21	Tucker correction
81[a]	12,62	5,86	0,784	0,884

[a] Black matriculated male applicants for technical training, tested in 1980.

Validation of the Gottschaldt Embedded Figures Test

No validation data of the GEFT could be found for Blacks. Since the GEFT is a test of analytic, perceptual ability, scores usually correlate with spatial tests (Vernon, 1972). Thus, for a sample of White chargehands, Lewis (1980) found that the GEFT correlated significantly (n = 70, r =0,37, p = 0,05) with the ability to interpret technical drawings, and with scores on the Blox test (n = 70, r = 0,52, p = 0,05).

2.2.1.9 Arithmetic Reasoning

The Arithmetic Reasoning test measures the ability to reason arithmetically within an arithmetical context. The test requires the subject to determine the value of unknown digits. The numerical calculations involved are relatively simple. Crucial to effective performance on the test is the use of the rules of arithmetic in a strategic manner. The solution of all items involves more than one logical step; each step involves the application of one or other arithmetic rule. As Arithmetic Reasoning has a novel format which is unlikely to bear any resemblance to arithmetic tasks which the subject has encountered before, the test measures the subject's grasp of the essential rules and strategies of arithmetic. An individual whose arithmetic skills do not extend beyond the parrot-like reproduction of standard arithmetic procedures will have great difficulty with the test. There are 19 items to be answered in 20 minutes.

Mean, standard deviation, and reliability estimate

The mean, standard deviation, and reliability estimate of the Arithmetic Reasoning test are contained in Table 10.

TABLE 10

Mean, standard deviation, and reliability estimate of the Arithmetic Reasoning test

			Reliability	
n	Mean	SD	KR 21	Tucker correction
92[a]	9,28	5,25	0,874	0,934

[a] Black matric scholars tested in 1980.

No validity data are available, and the test was thus used in this study on an experimental basis.

2.2.2 Apparatus tests

2.2.2.1 Fault-Finding Test

The Fault-Finding Test was designed to assess the ability to diagnose and correct mechanical faults, one of the most important characteristics of a mechanic (Skawran, Van der Reis, & Moore, 1967). The apparatus consists of a mechanical instrument designed to incorporate a number of mechanical principles. Ten different faults, which vary in degree of difficulty, can be set up for the testee to find and to correct. The faults can all be corrected by hand. The test does not resemble any familiar mechanical instrument, such as a pump or a clock, thus individuals with practical experience should have little advantage over persons with no experience. Fundamental to the scoring system is the tester's assessment of whether the testee is reasoning mechanically or whether he is relying on trial-and-error methods. (For details of the scoring system, see Skawran et al., 1967)

Reliability of the Fault-Finding Test

The reliability of the test, based on a sample of White applicants for mechanical jobs (n = 542) was reported by Skawran et al (1967) to be 0,66. No inter- and intra-rater reliabilities were reported. Although Bennett (1970) noted that the subjectivity of rating systems, on which the scoring system of the Fault-Finding Test is based, is a disadvantage, careful training and the introduction of guidelines can result in raters marking consistently to a common standard.

Validity of the Fault-Finding Test

On a sample of successful White applicants for mechanical positions (n = 39), Skawran et al. (1967) demonstrated a significant correlation (r = 0,28, p = 0,01) between the Fault-Finding Test and a criterion of on-the-job effectiveness, suggesting that the test is assessing practical mechanical ability. Skawran et al. (1967) also reported significant relationships between scores on the test and knowledge of general scientific principles (n = 95, r = 0,34, p < 0,01); and between scores on the test and the person's ability to understand scientific reading material (n = 96, r = 0,27, p < 0,01). No validity data for Blacks are available and the test was used on an experimental basis.

2.2.2.2 The Poppelreuter

This is a mechanical ability apparatus test based on the Poppelreuter Test and redesigned by the National Institute for Personnel Research. The test measures comprehension of elementary mechanical principles (Lätti & Verster, 1975). The apparatus consists of a board on which a mechanical structure is mounted. The testee has one minute to examine it and to understand the principle on which it works. He then has to dismantle it and arrange the pieces in a pre-arranged manner on another board. The test task is mainly the reconstruction of the apparatus. There is a 15 minute time limit, and the scoring is objective. Skawran et al. (1967) observed that, as the testee has to reconstruct what he has previously seen, the test has a memory component and tends to assess reproductive mechanical intelligence. Verwey (1964) found that the test had high loadings on a practical/manual factor for English (0,53) and Afrikaans (0,56) mine apprentices.

No validity or reliability data are available and the test was used in this study on an experimental basis.

2.2.2.3 O'Connor Finger Dexterity

The O'Connor Finger Dexterity was designed to assess finger dexterity, particularly with reference to instrument assembly work. The subject is required to pick up three small metal pins at a time from a shallow tray of pins with the preferred hand, and place them three at a time into a small hole on a metal plate. The metal plate has 100 holes, arranged in 10 rows of 10 each. The score is the number of pins placed during one five minute trial. Super (1949) noted that finger dexterity is likely to be related to success on the job when people with approximately equal technical experience are being compared.

Mean, standard deviation, and reliability estimate

The mean, standard deviation, and reliability estimate of the O'Connor Finger Dexterity test are contained in Table 11.

TABLE 11

Mean, standard deviation, and reliability estimate of the O'Connor Finger Dexterity test

n	Mean	SD	Test-Retest Reliability
200[a]	266,0	19,0	0,76

[a] White basic trainee airmen tested in 1954.

As far as can be ascertained, there are no South African validation data.

2.2.3 Vocational interest inventory

The rationale behind the Rothwell-Miller Interest Blank is that people hold stereotyped conceptions of occupations and base their choice of occupation on them (K.M. Miller, 1968). The inventory consists of nine blocks in which each of 12 occupational stereotypes is represented and the subjects have to rank the occupations in each block according to their preferences. The categories with the lower scores indicate the preferred occupational field. The 12 categories include occupations in the following fields: outdoor (for example, archeologist); mechanical (for example, engineer); computational (for example, computer programmer); scientific (for example, chemist); persuasive (for example, salesman); aesthetic (for example, artist); literary (for example, novelist); musical (for example, singer); social service (for example, social worker); clerical (for example, postal clerk); practical (for example, carpenter); and medical (for example, doctor).

There are separate forms of the Rothwell-Miller Blank for males and females. There is no time limit and it takes approximately 15 to 20 minutes to complete. Although originally developed in Australia and modified by K.M. Miller (1968) for use in England, the suitability of the Rothwell-Miller Interest Blank for Black matriculants has been established (Breger, 1976; Shannon, 1975). The Rothwell-Miller Interest Blank was originally designed as an adjunct to an interview (K.M. Miller, 1968), and the responses are normally discussed with the testee. In this study, the responses were not verified in this way before they were statistically analysed. It has, however, been established (Erwee, 1981; Shannon, 1975) that this procedure can be used fairly reliably when results of Black groups are analyzed.

Reliability of the Rothwell-Miller Interest Blank

Shannon (1975) analysed the consistency of each subject's responses to the 12 interest categories of the Rothwell-Miller Interest Blank to assess whether the subject had reacted consistently in ranking the interest categories rather than randomly according to preferences for individual occupations. Using Kendall's coefficient of concordance, she found that of the 88 subjects, the responses of nine were not significantly consistent, three were significant at the 5% level, and 76 were significant at the 1% level. Thus 87% of her sample were to some extent systematic in their preferences for careers that were homogeneous in terms of interest fields. Shannon (1975) does not, however, report the coefficients of concordance obtained. In addition, she noted a wide spread between highest and lowest summed category scores. This reveals a consistent reaction to each category, rather than random ratings which tend to produce scores clustering around the median.

Validation of the Rothwell-Miller Interest Blank

Visser (1978) found a significant relationship ($p = 0,05$) between measured interest on the Rothwell-Miller Interest Blank (K.M. Miller, 1968) and choice of university career. She demonstrated that Arts students tend to rate Literary and Social Service categories more highly than either the Commerce or the Science group; Science students tend to prefer Scientific and Medical categories; and Commerce students tend to prefer Computational and Clerical categories. She does not report the exact validity coefficients obtained.

2.3 Procedure

2.3.1 Testing

The initial sample was tested at four testing sessions. The tests were administered in the same order at all the testing sessions by a Black test administrator, and there were adequate numbers of invigilators from the NIPR, both Black and White, present. Precautions were taken to cut disturbances down to a minimum. Many testees, however, arrived late and others left early, which accounts for some differences in the number of testees completing particular tests.

The original battery consisted of eight tests, the Rothwell-Miller Interest Blank, and a biographical questionnaire. The Rothwell-Miller Interest Blank and the biographical questionnaire were administered first, and the tests were administered in the following order: Mental Alertness, Mechanical Comprehension, F Test, H Test, Figure Classification Test-High Level. Blox, Technical Reading Comprehension, and Arithmetic Reasoning. Considerations of time prevented the Gottschaldt Embedded Figures Test from being administered at the testing session, and it was administered to the selected group of trainees at the end of their training. It was not economically feasible to administer the apparatus tests to the whole group of applicants, and thus the Fault Finding Test, the Poppelreuter, and the O'Connor Finger Dexterity were administered to the selected group of trainees three months after their training commenced.

All the tests were administered and scored by NIPR personnel. Analyses of the data were carried out by personnel of the Computer Division at the NIPR.

2.3.2 Statistical techniques employed

2.3.2.1 Factor analysis

To determine the factor structure of the test battery, the matrix of intercorrelations obtained from the battery of 12 tests was subjected to Kaiser's Second Generation Little Jiffy (Kaiser & Rice, 1974) factor analysis. This is a non-iterative procedure, with squared multiple correlations being used for the initial estimates of communality. The number of factors extracted was determined in accordance with Kaiser's Little Jiffy Mark IV criterion (Kaiser & Rice, 1974). The factor matrix was rotated to positive manifold by the Direct Quartimin Method (Jennrich & Sampson, 1966) which is an oblique rotation.

2.3.2.2 Multiple regression analyses

To determine whether biographical and interest variables were significantly related to the major dimensions of mechanical ability as determined by the factor structure, a multiple regression analysis technique was used.

The regression model fitted to the data is:

$$y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots . + \beta_p x_p + \varepsilon$$

(Dixon & Jennrich, 1981, p. 252)

The predicted value y for each case is:

$$\hat{y} = \alpha + \hat{\beta}_1 x_1 + \hat{\beta}_2 x_2 + \ldots . + \hat{\beta}_p x_p$$

Where:

y = predicted value for the dependent variable y

α = intercept of the regression line

β_i = regression coefficient

x_i = scores of the independent variables

To indicate that an estimate of the parameter is made, the ^ symbol is used.

The method adopted for including independent variables in the regression equation was the forward stepwise inclusion. This procedure enters variables into the regression equation according to the amount of variance of the dependent variable accounted for by the independent variable in a descending order of contribution. At each step the variable with the highest F-to-enter value is included in the equation. As this was an exploratory study, a variable was included if its contribution was significant at $p < 0,1$ (F-to-enter = 3,0) and removed if, after some other inclusions, its contribution fell below this level.

Four new variables were created as independent variables: 'Space', 'Analytic Reasoning', 'Conceptual Reasoning', and 'Mechanical Reasoning', corresponding to each of the four factors obtained in the factor analysis. The new variables comprised the summed standard scores of the tests which had loadings greater than or equal to 0,30 on each factor.

2.3.3 Coding

Most of the biographical variables were nominal data. As numbers assigned to categories of a nominal scale have neither order nor unit of measurement, they need to be converted into dummy variables before they can be treated as scores and included in a regression equation (Chattergee & Price, 1977).

2.3.3.1 Independent variables included in the biographical category

With the exception of the age variable, all biographical variables were nominal data. The variable 'Hobby', 'Educational level', 'Background', 'Subject taken at school', 'Subject preference' and 'Previous job experience', were all converted into dummy variables. The variable 'Previous job experience' was categorised according to the various Rothwell-Miller Interest Blank interest categories. The description of the dummy variables is contained in Table 12. Dummy variables with only a small number of cases were omitted from the regression analyses because it was believed they would distort the findings.

TABLE 12

Description of dummy variables

Nominal variable	Dummy variable	No of cases
Educational level	Standard eight	8
	Standard nine	13
	Standard ten[a]	54
Subject preference	English	4
	Afrikaans#	1
	Mathematics	44
	Science	12
	Biology	9
	Accounting#	2
	Economics#	1
	Practical#	1
	History#	1
Subject taken at school	Maths	69
	Science	58
	Biology	45
	Practical	6
Hobby	Sport	57
	Chess	9
	Music	11
	Reading	11
	Photography#	1
	Movies and television	9
	Practical	6

TABLE 12 (continued)

Nominal variable	Dummy variable	No of cases
Background	Urban	62
	Rural	13
Previous job experience	None	34
	Outdoor	9
	Mechanical	26
	Computational	18
	Scientific#	2
	Persuasive	3
	Aesthetic#	0
	Literary#	0
	Musical#	0
	Social Service	3
	Clerical	16
	Practical	4
	Medical#	1

[a] Includes testees with post-school training.

Omitted from regression analyses due to small number of cases.

2.3.3.2 Independent variables included in the interest category

The variables included in the Interest category were the rankings obtained for the 12 Rothwell-Miller Interest Blank categories. It should be noted that as a high ranking indicates a low interest, the sign of the beta coefficient in the multiple regression equation will be changed to the opposite direction.

CHAPTER 3

RESULTS

The results of the study are reported in this chapter without comment or discussion. The relevance of the findings is discussed in Chapter 4 of the report.

3.1 Descriptive statistics of the tests

The means, standard deviations, coefficients of skewness and kurtosis, ranges, and reliability estimates of the tests are contained in Table 13.

TABLE 13

Means, standard deviations, coefficients of skewness and kurtosis, ranges, and reliability estimates of the tests

Test	Mean	SD	Skewness	Kurtosis	Range				Reliability	
					Minimum		Maximum			Tucker's
					poss.	obs.	poss.	obs.	KR 21	correction
Mental Alertness	16,20	4,17	0,57	0,20	0	7	30	29	0,59	0,74
Mechanical Comprehension	16,80	3,85	0,77	0,51	0	9	42	29	0,33	0,57
F Test	17,21	4,41	-0,24	0,10	0	6	49	27	0,44	0,65
H Test	18,61	4,86	0,07	-0,54	0	6	49	29	0,52	0,70
Figure Classification Test	15,29	4,16	-0,91	0,70	0	2	24	21	0,71	0,83
Blox	25,88	5,49	-0,27	-0,47	0	12	45	37	0,65	0,78
Technical Reading Comprehension	10,13	3,76	0,33	-0,37	0	2	30	20	0,54	0,73
Arithmetic Reasoning[a]	9,91	5,61	0,03	-1,27	0	0	19	19	0,90	0,95
Poppelreuter	21,07	9,58	-0,20	-0,92	0	0	35	35	0,94	0,97
Gottschaldt Embedded Figures Test[b]	12,94	5,76	0,96	0,18	0	4	45	29	0,74	0,85
Fault Finding Test[c]	26,45	7,47	0,50	-0,16	10	11	50	45		
O'Connor Finger Dexterity[c]	270,51	18,27	-0,34	-0,77	0	231	300	300		

[a] *n* = 68
[b] *n* = 64
[c] Due to the nature of these tests, reliability estimates of internal consistency could not be calculated.

3.2 Factor analysis

3.2.1 Matrix of intercorrelations

The battery of 12 tests was intercorrelated, together with age and education, using Pearson's product moment correlation technique. Significance testing is two-tailed. The matrix of intercorrelations is contained in Table 14.

TABLE 14

Matrix of intercorrelations
(n = 75)

Tests	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Mental Alertness	1,00													
2 Mechanical Comprehension	0,25*	1,00												
3 F Test	0,02	0,07	1,00											
4 H Test	0,10	0,22*	0,45***	1,00										
5 Figure Classification Test	0,50***	0,06	-0,01	0,02	1,00									
6 Blox	0,02	0,14	0,34***	0,42***	0,12	1,00								
7 Technical Reading Comprehension	0,40***	0,26*	0,02	0,00	0,11	-0,12	1,00							
8 Arithmetic Reasoning[a]	0,49***	0,17	0,16	0,13	0,29**	0,07	0,38***	1,00						
9 Poppelreuter	0,21*	0,16	0,25*	0,29**	0,02	0,24*	0,10	0,12	1,00					
10 Gottschaldt[b] Embedded Figures Test	0,31***	0,33***	0,36***	0,37***	0,07	0,28**	0,41***	0,33***	0,33***	1,00				
11 Fault Finding Test	0,03	0,31***	0,08	0,29**	-0,08	0,19	0,07	0,02	0,27*	0,18	1,00			
12 O'Connor Finger Dexterity	0,09	-0,07	0,21*	0,10	-0,16	0,14	-0,04	-0,11	0,10	-0,01	0,10	1,00		
13 Age	-0,13	-0,17	-0,13	-0,17	-0,17	-0,11	-0,15	-0,17	0,11	-0,25*	0,16	-0,19	1,00	
14 Education	0,21*	0,24*	0,12	0,22	0,26*	0,15	0,06	0,24*	0,18	0,29**	0,10	0,05	-0,14	1,00

[a] n = 68

[b] n = 64

*p < 0.05

**p < 0,01

***p < 0,005

In an exploratory factor analysis, the matrix of intercorrelations was subjected to Kaiser's Second Generation Little Jiffy (Kaiser & Rice, 1974) factor analysis. This is a non-iterative procedure, with squared multiple correlations being used for the initial estimates of communality.

The number of factors which were extracted was determined in accordance with Kaiser's Little Jiffy Mark IV criterion (Kaiser & Rice, 1974). Four factors appeared to be significant according to Kaiser's (1958) decision rule.

3.2.2 Matrix of residuals

The matrix of residuals is contained in Table 15.

TABLE 15

Matrix of residuals[a]

Tests	1	2	3	4	5	6	7	8	9	10	11	12
1 Mental Alertness	-											
2 Mechanical Comprehension	0,06	-										
3 F Test	-0,05	-0,03	-									
4 H Test	0,02	0,06	0,16	-								
5 Figure Classification Test	0,19	-0,02	-0,01	0,01	-							
6 Blox	-0,04	0,03	-0,09	0,14	0,09	-						
7 Technical Reading Comprehension	0,09	0,08	-0,02	-0,04	-0,04	-0,11	-					
8 Arithmetic Reasoning	0,13	0,01	0,09	-0,06	0,07	0,02	0,11	-				
9 Poppelreuter	0,07	0,00	0,05	0,06	-0,03	0,06	-0,01	-0,01	-			
10 Gottschaldt Embedded Figures Test	-0,05	0,09	0,11	0,09	-0,04	0,08	0,16	0,06	0,08	-		
11 Fault Finding Test	-0,01	0,17	-0,05	0,10	-0,06	0,05	0,01	-0,01	0,12	0,01	-	
12 O'Connor Finger Dexterity	0,12	-0,08	0,10	0,00	-0,12	0,05	0,00	-0,09	0,05	-0,06	0,06	-

[a] Distribution of the absolute value of the residuals

.1 = 52

.1 to .2 = 14

.2 = 0

Inspection of the matrix of residuals (Table 14) indicates that the majority of the residuals lie below 0.1, thus confirming the Kaiser's criterion that four factors account for most of the common variance of the tests.

3.2.3 Rotated factor matrix

The factor matrix was rotated to positive manifold by means of the Direct Quartimin method (Jennrich & Sampson, 1966). The rotated factor matrix is contained in Table 16.

TABLE 16

Rotated factor matrix, communalities, and uniquenesses

Test	I	II	III	IV	h2	u2
Mental Alertness	-0,01	0,29	0,46	0,04	0,45	0,55
Mechanical Comprehension	-0,05	0,16	0,04	0,36	0,19	0,81
F Test	0,51	0,09	0,00	0,03	0,29	0,71
H Test	0,38	-0,04	0,06	0,28	0,33	0,67
Figure Classification Test	-0,05	-0,02	0,54	-0,05	0,27	0,73
Blox	0,36	-0,15	0,14	0,19	0,25	0,75
Technical Reading Comprehension	-0,06	0,50	0,04	0,06	0,30	0,70
Arithmetic Reasoning	0,06	0,36	0,28	-0,04	0,31	0,69
Poppelreuter	0,21	0,08	0,06	0,23	0,18	0,82
Gottschaldt Embedded Figures Test	0,27	0,38	0,05	0,21	0,40	0,60
Fault Finding Test	0,02	-0,02	-0,06	0,39	0,15	0,85
O'Connor Finger Dexterity	0,24	-0,01	-0,04	-0,04	0,05	0,95
Eigen Value	3,02	2,00	1,22	1,05		

Note. Tests with loadings ≥ 0,30 are underlined

3.2.4 Factor correlations

The factor correlations for the rotated factors are contained in Table 17.

TABLE 17

Factor correlations for rotated factors

Factor	I	II	III	IV
I	1,00			
II	0,00	1,00		
III	0,05	0,52	1,00	
IV	0,51	0,35	0,20	1,00

3.3 Rothwell-Miller Interest Blank descriptive statistics

The descriptive statistics for rankings of choices of Rothwell-Miller Interest Blank categories are presented in Table 18.

TABLE 18

Descriptive statistics for rankings of Rothwell-Miller Interest Blank categories[a]

(*n* = 75)

Category	Mean	*SD*	Skewness	Kurtosis
Outdoor	9,69	1,85	-1,20	1,46
Mechanical	3,27	2,74	1,18	0,36
Computational	4,81	2,51	0,77	0,41
Scientific	2,91	2,09	1,93	4,26
Persuasive	7,57	2,80	-0,60	-0,49
Aesthetic	5,84	2,71	0,23	-0,65
Literary	6,27	2,73	0,16	-0,77
Musical	9,70	2,04	-0,81	0,46
Social Service	7,03	2,44	-0,03	-0,17
Clerical	7,58	2,97	-0,24	-0,85
Practical	9,20	3,04	-0,87	-0,44
Medical	3,49	2,17	-0,98	0,50

a Maximum possible score = 12
Low score indicates a high preference.

3.4 Biographical and interest variables related to mechanical aptitude

To determine whether biographical and interest variables were significantly related to the major dimensions of mechanical ability as determined by the factor structure, a multiple regression analysis technique was used.

The summary tables of the analyses of variance and the multiple regression analyses are contained in Tables 19 to 26.

3.4.1 Summary tables of Factor I: Space

Analysis of variance

The analysis of variance conducted with Space as a criterion is contained in Table 19.

TABLE 19

Analysis of variance [a] conducted with Space as criterion and biographical variables and Rothwell-Miller Interest Blank ratings as independent variables

	SS	df	MS	F
Regression	15,51	6	2,58	6,10*
Residual	28,40	67	0,42	

[a] n = 75

*p < 0,005

Multiple regression

The summary table of the multiple regression analysis conducted with Space as a criterion is contained in Table 20.

TABLE 20

Summary of multiple regression analysis[a] conducted with Space as criterion and biographical variables and Rothwell-Miller Interest Blank ratings as independent variables. (Multiple $\underline{R} = 0{,}59$; $\hat{\alpha} = -1{,}19$)

Variable	beta coeff.	Standard error of coeff.	F-to-remove
Preference for science	0,73	0,21	11,70***
Standard ten	0,36	0,17	4,39*
Previous persuasive job	0,82	0,23	12,19***
Previous clerical job	0,66	0,17	15,70***
Movies and television	-0,66	0,24	7,33**
Social Service Interest	-0,07	0,03	4,79*

[a]$\underline{n} = 75$

*$\underline{p} < 0{,}05$

**$\underline{p} < 0{,}01$

***$\underline{p} < 0{,}005$

3.4.2 Summary tables of Factor II: Analytic Reasoning

Analysis of variance

The analysis of variance conducted with Analytic Reasoning as a criterion is contained in Table 21.

TABLE 21

Analysis of variance [a] conducted with Analytic Reasoning as criterion and biographical variables and Rothwell-Miller Interest Blank ratings as independent variables

	SS	df	MS	F
Regression	21,74	7	3,11	8,79*
Residual	23,33	66	0,35	

[a] n = 75

*p < 0,005

Multiple regression

The summary table of the multiple regression analysis conducted with Analytic Reasoning as criterion is contained in Table 22.

TABLE 22

Summary of multiple regression analysis[a] conducted with Analytic Reasoning as criterion and biographical variables and Rothwell-Miller Interest Blank [b,c] ratings as independent variables (Multiple $\underline{R}$ = 0,69; $\hat{\alpha}$ = -4,73)

Variable	beta coeff.	Standard error of coeff.	F-to-remove
Urban	0,56	0,19	8,46***
Preference for English	-0,33	0,32	8,55***
Standard ten	0,58	0,17	12,00***
Maths	0,72	0,26	7,61**
Biology	0,43	0,16	7,14**
Literary Interest	0,09	0,03	11,67***
Musical Interest	-0,13	0,03	14,09***

[a]$\underline{n}$ = 75

*$\underline{p}$ < 0,05

**$\underline{p}$ < 0,01

***$\underline{p}$ < 0,005

3.4.3 Summary tables of Factor III: Conceptual Reasoning

Analysis of variance

The analysis of variance conducted with Conceptual Reasoning as criterion is contained in Table 23.

TABLE 23

Analysis of variance [a] conducted with Conceptual Reasoning as criterion and biographical variables and Rothwell-Miller Interest Blank ratings as independent variables

	SS	df	MS	F
Regression	19,21	6	3,20	6,31*
Residual	33,97	67	0,51	

[a]n = 75

*p < 0,005

Multiple regression

The summary table of the multiple regression analysis conducted with Conceptual Reasoning as criterion is contained in Table 24.

TABLE 24

Summary of multiple regression analysis[a] conducted with Conceptual Reasoning as criterion and biographical variables and Rothwell-Miller Interest Blank ratings as independent variables (Multiple R = 0,60; $\hat{\alpha}$ = -0,92)

Variable	beta coeff.	Standard error of coeff.	F-to-remove
Preference for English	0,80	0,38	4,50*
Standard ten	0,52	0,19	7,39**
Sport	0,58	0,26	5,16*
Scientific Interest	0,09	0,04	4,46*
Aesthetic Interest	-0,11	0,03	12,76***

[a]n = 75

*p < 0,05

**p < 0,01

***p < 0,005

3.4.4 Summary tables of Factor IV: Mechanical Reasoning

Analysis of variance

The analysis of variance conducted with Mechanical Reasoning as criterion is contained in Table 25.

TABLE 25

Analysis of variance [a] conducted with Mechanical Reasoning as criterion and biographical variables and Rothwell-Miller Interest Blank ratings as independent variables

	SS	df	MS	F
Regression	11,15	3	3,72	7,12*
Residual	36,52	70	0,52	

[a] n = 75

* p < 0,005

Multiple regression

The summary table of the multiple regression analysis conducted with Mechanical Reasoning as criterion is contained in Table 26.

TABLE 26

Summary of multiple regression analysis[a] conducted with Mechanical Reasoning as criterion and biographical variables and Rothwell-Miller Interest Blank ratings as independent variables (Multiple R = 0,48; $\hat{\alpha}$ = -0,06)

Variable	beta coeff.	Standard error of coeff.	F-to-remove
Preference for English	0,76	0,38	4,12*
Preference for science	0,73	0,23	10,08***
Standard nine	-0,59	0,22	6,94*

[a] n = 75

*p < 0,05

**p < 0,01

***p < 0,005

CHAPTER 4

DISCUSSION

4.1 Factor analysis

Aim 1: To determine the factor structure of a group of tests theoretically related to mechanical aptitude in Whites, on a sample of Black males.

4.1.1 Distribution of test scores

It can be seen from Table 13 that the observed ranges of the tests show sufficient spread in the scores. Inspection of the skewness indicates that apart from Mechanical Comprehension and the Gottschaldt Embedded Figures Test which are positively skewed and thus appear to be somewhat difficult, and the Figure Classification Test which is somewhat negatively skewed and thus appears to be rather easy, most of the tests are of an appropriate level of difficulty. Many of the means and standard deviations of the test scores of the sample are similar to those obtained in the standardization samples (see Chapter 2, Tables 2 to 11).

Note that the tests were standardized on groups at matriculation or first-year University level and the present sample had an educational range of Standard 8 to 10 (see Table 1). The relatively high score of the sample may be attributed to the selection procedure. Furthermore, Spence (1982) has shown that a group with Standard 7 to 10 educational range scored significantly lower on the Mental Alertness and Figure Classification Tests than the standardization samples. However, the mean level of education (Standard 8) of her sample was lower than that of the present sample (Standard 10) and a large proportion were over 30 years of age. As T. Taylor (1977) has reported a negative correlation between age and scores on the Figure Classification Test, these two points could, according to Spence (1982) account for the difficulties which the members of her sample experienced.

The present sample, however, seemed to find the Figure Classification Test rather easy (see Table 13) which could indicate that it was a rather more urbanized sample than that reported by Spence (1982) and Visser (1978), particularly as 82,7% of the present sample purported to be urbanized. Numerous writers (Grant, 1972; Kendall, 1977; T. Taylor, 1977; Werbeloff & Taylor, 1982) have indicated that conceptual reasoning is related to urbanization and T. Taylor (1977) and Kendall (1977) have pointed out that the ability to think conceptually is essential for functioning in a western technological society. The degree of urbanization of the present sample is not surprising considering that they were a selected group who were mechanically orientated.

4.1.2 Reliabilities

An inspection of Table 13 indicates that, in general, the reliabilities of the tests in the battery are not very high, and are, with the exception of Arithmetic Reasoning ($\underline{r}_{tt}$ = 0,90), all lower than the KR 21 reliabilities reported for the standardization samples. It should be noted, however, that the Figure Classification Test ($\underline{r}_{tt}$ = 0,71), Gottschaldt Embedded Figures Test ($\underline{r}_{tt}$ = 0,74), and Poppelreuter ($\underline{r}_{tt}$ = 0,94), which were used on an experimental basis in this study, had KR 21 reliabilities of a more acceptable order. Notwithstanding that KR 21, which is a measure of internal consistency (Kuder & Richardson, 1937) gives, at best, only a lower bound estimate of the KR 20 reliability (Kuder & Richardson, 1937; Horst, 1953), the reliabilities of the other tests fall far short of the minimal 0,75 level of reliability at which test constructors aim (Werbeloff & Taylor, 1982). Reliability, however, is affected by the homogeneity of the sample (Nunnally, 1967) and, as this is a relatively selected group, this could tend to depress the reliability values.

Considering that the reliabilities of speeded tests are often spuriously high (Schepers, 1974), the KR 21 reliability estimates of the F Test (0,44; 0,65 with the Tucker correction) and the H Test (0,52; 0,70 with the Tucker correction) are surprisingly low and this is rather difficult to interpret. Although the tests are highly speeded, it is also likely that they have a power component. This may be particularly so where Blacks are concerned, as Schepers (1974) has pointed out that speed is not normally stressed with Black developing groups.

The very low KR 21 reliability estimate ($\underline{r}_{tt}$ = 0,33) of Mechanical Comprehension may be due partly to the test being multi-dimensional, in which case the KR 21 value, as a measure of internal consistency would thus be low. Nunnally (1967), however, has pointed out that guessing tends to decrease reliability. Thus in view of Schepers' (1974) comment that lower educated groups have a tendency to guess, and in view of the fact that as there are only three alternative choices per item which gives testees a 33% chance of guessing correctly, a more disturbing aspect may be that the low reliability may also be due to guesswork on the part of the present sample.

The low reliabilities which have been obtained may be an indication that these tests are not suitable in their present form for Blacks.

4.1.3 Correlations of the tests

From the matrix of intercorrelations (Table 14), it may be seen that whereas many of the tests correlate positively with one another, the degree of correlation is not great, the highest positive correlation ($\underline{r}$ = 0,50; $\underline{p} < 0,005$) being between Mental Alertness and the Figure Classification Test.

From Table 14 it may be noted that whereas only the Gottschaldt Embedded Figures Test correlates significantly ($\underline{r}$ = -0,25, $\underline{p} < 0,05$) with age, most of the obtained correlations with age are negative. Thus, although the significant negative correlation between age and the Figure Classification Test which T. Taylor (1977) reported has not been obtained, the correlation ($\underline{r}$ = -0,17) is in the right direction. He ascribed this negative correlation of age with the Figure Classification Test as being a measure of Cattell's (1971) fluid intelligence ('g_f'), which is known to decline with age. It is interesting to note that the two mechanical apparatus tests, the Poppelreuter and the Fault Finding Test, are the only tests to correlate positively with age. This could be ascribed to their being related to experience.

Education correlates significantly (*r* = 0,29) with the Gottschaldt Embedded Figures Test at the 1% level of significance, and with Mental Alertness (*r* = 0,21), Mechanical Comprehension (*r* = 0,24), H Test (*r* = 0,22), Figure Classification Test (*r* = 0,26) and Arithmetic Reasoning (*r* = 0,24), at the 5% level. Although these findings tend to confirm the results of numerous researchers who have shown that education facilitates performance in ability tests (Crawford-Nutt, 1977a, 1977b; Grant, 1969; Mauer, 1974; McFie, 1961; Schepers, 1974; Silvey, 1963; T. Taylor, 1977), it should be borne in mind that a 5% level of significance may not be particularly meaningful.

The mean level of education of the present sample, however, is Standard 10, with only a few individuals in Standard 8 or 9. As the correlation between two variables generally increases with increase in standard deviation of the variables, the restricted range of the education variable may result in the lower correlations obtained.

4.1.4 Matrix of residuals

Inspection of the matrix of residuals (Table 15) indicates that when four factors have been extracted, the residual correlations tend to become very small. This confirms Kaiser's (1958) criterion that four factors account for most of the common variance of the tests. There are, however, a number of residuals which are not as small as desired. Muller & Browne (1972) have noted that an application of Kaiser's (1958) criterion sometimes results in an underestimation of the number of factors and thus perhaps five factors would have accounted for more of the common variance. Harman (1967), however, has stated that a certain amount of subjective judgement is often necessary if psychological meaningfulness is to be obtained, and hence with only twelve tests in the battery, it would not be possible to interpret the factors adequately if five factors had been extracted.

4.1.5 Interpretation of the factors

Interpretation of each factor has been based primarily upon the tests with high loadings; that is, with loadings above 0,30. Interpretation of loadings between 0,20 and 0,30 are rather more tentative, and loadings below 0,20 have not been interpreted. It should be borne in mind that an oblique rotation was performed. Although the factor loadings are not very high, Botzum (1951) has indicated that factor loadings for oblique solutions are lower than for orthogonal rotations. It is thus possible that, had an orthogonal rotation been performed, higher loadings might have been obtained.

4.1.5.1 Factor I

An inspection of the rotated factor matrix (Table 16) indicates that Factor I is best defined by the following tests: F Test (0,51), H Test (0,38), and Blox (0,36) with smaller loadings on the Gottschaldt Embedded Figures Test (0,27), O'Connor Finger Dexterity (0,24), and the Poppelreuter (0,21).

The three highest loadings on this factor stamp it unmistakably as a Space factor, as they are all standard spatial tests : the F Test measuring two-dimensional spatial representation, the Blox measuring SR-O, and the H Test measuring Vz.

The extraction of a spatial factor accounting for 15,75% of the variance instead of a reasoning factor as the first factor is rather unusual. This could possibly be attributed to the similarity of format of the three tests loading highest on the factor; the F Test, the H Test, and the Blox are all tests containing diagrams from which the testee has to make a choice, whereas the other tests in the battery have very different formats. This aspect could tend to strengthen the factor.

The loading of the Gottschaldt Embedded Figures Test (0,27) on this factor is in line with reported findings that tests of field articulation correlate with spatial tests (Dawson, 1967a, 1967b; Gardner, Jackson, & Messick, 1960; Vernon, 1972; Witkin, Dyk, Faterson, Goodenough, & Karp, 1962). MacFarlane Smith (1964) pointed out that the crucial component of the space factor is the capacity to perceive and hold in mind the structure and properties of a form or figure grasped as a whole. This appears to be very similar to the concept of field articulation (Gardner et al. 1960; Gruenfeld & MacEachron, 1975) where the poor performer is unable to pick out and articulate the relevant figure.

While the loading of the O'Connor Finger Dexterity (0,24) on this factor may at first seem rather surprising, the loading may not have occurred by chance. The O'Connor Finger Dexterity involves the ability to co-ordinate finger movements while picking up the three small pins, and to perform fine manipulations while inserting the pins in the holes under speeded conditions (Fleishman, 1954). This would involve spatial orientation of the testee with relation to the pins and the holes, which brings to mind Thurstone's (1949) S_1 factor. This interpretation is strengthened by the results of Chapman (1948) who, in analyzing the MacQuarrie Test, found a correlation of 0,68 between the factors he identified as spatial and motor. The highest loading of his spatial factor was given by Dotting, which requires skill similar to that required by the O'Connor Finger Dexterity. Pemberton (1952) also reported a test similar to Dotting to have a loading (0,28) on a space factor. Fleishman and Hempel (1954b) have indicated that different factors are involved at different stages of a learning task, and both De Wet (1967) and Biesheuvel (1979) have shown that in early trials with psycho-motor tests, non-motor factors, which are probably spatial and verbal, predominate. Perhaps in the present sample, it is the spatial component which is operative in the O'Connor Finger Dexterity. Indeed, Fleishman (1957) has shown that the influence of spatial ability in motor test performance may decline with practice.

Many researchers have pointed to the high degree of specificity of psychomotor tests (Biesheuvel, 1949; De Wet, 1967; Fleishman & Hempel, 1954a; Vernon & Parry, 1949; Wolfle, 1940) which is borne out by the low communality ($\underline{h}^2$ = 0,05) of the O'Connor Finger Dexterity in this study. The test clearly has little in common with any of the other factors.

Although Skawran et al. (1967) asserted that the Poppelreuter is essentially two-dimensional, it has spatial visualization connotations as the testee has to understand and visualize the relationships of the various gears and wheels to each other. The testee also needs to keep in mind the whole structure while visualizing how the various parts will fit together. The supposition that the Poppelreuter has a visualization aspect appears to be confirmed by the fact that its highest correlation is with the H Test (r = 0,29, p < 0,01).

The negligible loading of Mechanical Comprehension on Factor I is rather surprising, as it clearly has quite a few spatial items, and numerous writers (Ekvall, 1969; Guilford, Fruchter, & Zimmerman, 1952; Guilford & Zimmerman, 1947; Patterson, 1956; Super & Crites, 1962; Thurstone, 1949) have demonstrated that mechanical comprehension tests have spatial, particularly visualization, components. Ekvall (1969) particularly has stressed that the spatial factor generally carries the most weight in factor studies of the test. In view of these findings, and in view of the low reliability of Mechanical Comprehension, it is likely that the test is not measuring what it should be measuring, and may thus not be suitable for Blacks. This supposition will be discussed later in more detail (see section 4.1.5.4).

In view of the spatial (figural) context within which the Figure Classification Test is embedded, it is interesting to note that the test does not load on the spatial factor, nor does it correlate with any of the three main spatial tests. These results are in contrast with those of Werbeloff and Taylor (1982), who obtained significant correlations between the Figure Classification Test and Blox for a matriculated sample of Black sugar workers (n = 72; r = 0,4, p < 0,05), and for a sample of first year Black Technikon students (n = 199, r = 0,35, p < 0,05), which they attributed to the spatial and reasoning components common to the tests. A possible reason for this lack of correlation will be discussed later (see section 4.1.5.5).

Only one spatial factor was extracted. Although many writers (Guilford & Lacy, 1947; McGee, 1979, 1982; Michael et al., 1957; and Thurstone, 1949) have pointed to the separation of SR-O from Vz, many of them have difficulty in differentiating the two (Carroll & Maxwell, 1979; Harris, 1981; MacFarlane-Smith, 1964; Mandler & Stein, 1977; McGee, 1979, 1982; Michael et al, 1957; Myers, 1958; Patterson, 1956; Vandenberg, 1975; Zimmerman, 1954a, 1954b) and others (Borich & Bauman, 1972; Goldberg & Meredith, 1975; Horn, 1972; Karlins, Scheurkoff, & Kaplan, 1969; Michael et al., 1957; Roff, 1952; Thurstone, 1949, 1950, 1951), have indicated that factors of SR-O and Vz are correlated. Zimmerman (1953) has suggested that the two factors represent levels of complexity of essentially the same dimension. It is possible that because of the relative lack of experience of Blacks in the Western technologically orientated culture and lack of environmental support, their spatial structures have not yet crystallized and developed along the continuum, and are thus relatively undifferentiated. In this regard, Ferguson (1954, 1956) has stressed the role of cultural demands in fostering the differentiation of intellect. As the Blacks become more integrated into a technologically sophisticated environment, with its concomitant demands on the development of specific skills, it is likely that spatial abilities would become more differentiated. This interpretation is strengthened by the fact that the F Test, which could represent the lowest level of complexity as it assesses two-dimensional rather than three-dimensional depth perception, has the highest loading (0,51) on the Space factor. However, it should be borne in mind that there are few suitable tests available for testing Blacks at this level, and had more tests been included in the battery, it is possible that the separation between SR-O and Vz, which Ballentine (1982) obtained, would have been confirmed.

4.1.5.2 Factor II

Factor II is best defined by the following tests: Technical Reading Comprehension (0,50); Gottschaldt Embedded Figures Test (0,38) and Arithmetic Reasoning (0,36) with a smaller loading on Mental Alertness (0,29).

Tests which are high on this factor all appear to require analytic thinking and the processing of information in a series of logical steps. In all cases, application of previous knowledge is involved.

This factor is interesting as the four tests are presented in different contexts. Technical Reading Comprehension is embedded in a language context; the Gottschaldt Embedded Figures Test is figural (spatial); Arithmetic Reasoning is numerical; and Mental Alertness is mainly verbal with a numerical component to a lesser degree. This indicates that the activity represented by Factor II transcends the immediate presentation of the problem and thus renders it more powerful.

This factor is, to a certain extent, similar to Grant and Schepers (1969) 'perceptual analysis' factor, in which the reproduction of a given pattern is required, together with synthesis and analysis. However, Grant and Schepers' (1969) study used performance tests, whereas the tests loading on this factor are all pencil-and-paper tests.

Technical Reading Comprehension requires the ability to read and absorb the given information, to analyze the problem, and then to process, synthesize, and transform the information. This is clearly an analytic task which has to be performed in a series of steps.

The Gottschaldt Embedded Figures Test requires the ability to find a given figure in a distracting complex field. What seems to be required is flexible thinking and freedom from Gestaltbindung. In the test, one has to analyze the Gestalt formed by the large figure in order to find the smaller given figure. Pemberton (1952) has indicated that flexibility of closure (C_2) of which the Gottschaldt Embedded Figure Test is a measure, represents a generalized analytic orientation. In this regard, it is interesting to note that a number of writers (Arbuthnot & Gruenfeld, 1969; Barrett & Bass, 1972; Gruenfeld & MacEachron, 1975; Holtzman, Swartz & Thorpe, 1971; S. Levy, 1969; Zytowski, Mills & Paepe, 1969) have indicated that people who are more field articulate tend to pursue mechanical or similar occupations, which require analytic cognitive skills. Connolly and Bruner (1974) state that the skills required to cope with technology include "the capacity for combining information in a fashion that permits one to use flexibility; to go beyond the information given; to draw inferences ... and to connect and probe for connection" (p. 4). They view the acquisition of these skills as being essential to cope with existing realities, and they call this "operative intelligence - knowing how rather than simply knowing that" (Connolly & Bruner, 1974, p. 3).

Arithmetic Reasoning requires the ability to manipulate symbols according to the four basic rules of arithmetic. The test is thus dependent to a large extent on formal schooling as the person needs to apply his previously gained knowledge in arithmetical concepts. The information must also be analyzed and processed sequentially. T. Taylor (Note 1) has indicated that the solution to the problem involves more than one logical step. It is interesting to note that during the testing the invigilators noticed that many of the testees appeared to experience numerous problems in understanding what was required of them. As the test has a novel format, it is likely that some of the testees were not able to adapt to an unfamiliar task. Erwee (1981) has pointed out that teaching in the Black schools emphasizes rote learning, and Vernon (1967) has suggested that rote learning tends to inhibit flexible problem-solving strategies.

The somewhat low loading (0,29) of Mental Alertness on this factor is rather surprising as it is basically an analytic task. The key for the solution of the items in Mental Alertness lies upon discovering and analyzing the relationship among parts. In letter and number series, the testee needs to discover the principle upon which the items are built; in analogies, the relationship between the parts needs to be analyzed. In all cases, well established concepts of number and letter are required. The test is thus dependent to a large extent on formal schooling, which Visser (1977) has noted. Like Arithmetic Reasoning, many of the items require several successive reasoning steps, each step being dependent on the previous step.

One of the reasons for the low loading of Mental Alertness on this factor may be ascribed to its high verbal component. It has to be borne in mind that notwithstanding English or Afrikaans being the medium of education for Blacks, their mother-tongue is usually an entirely different language. Werbeloff and Taylor (1982) have pointed out that, as the processing of verbal material forms an important component of the task contained in Mental Alertness, Blacks, whose home language is not English or Afrikaans, might experience difficulty in understanding what is required of them in certain items. They further point out that verbal reasoning tasks would be more difficult for those whose home language is not the language of the test, for the subject either has to translate the material into his own language before performing logico-verbal manipulation or perform the manipulations in a second or third language. In this regard, Bowd (1973) has suggested that differences in test performance between White and Indian samples were mediated to a large extent by facility in English.

Because no verbal factor has been extracted and because the tests loading highest on Factor III all have fairly lengthy written instructions, it is possible that the Conceptual Reasoning factor also contains some verbal variance.

4.1.5.3 Factor III

Factor III is best defined by the Figure Classification Test (0,54) and Mental Alertness (0,46) with a lower loading on Arithmetic Reasoning (0,28). Tests which are high on this factor require flexible thinking and the ability to approach a new task with an open mind.

Although, as can be seen from Table 17, Factors II and III are correlated (r = 0,52) and may be considered to be of a similar kind, they are nevertheless sufficiently different to require separate interpretation. Factor II requires analytic ability, where previous knowledge is either given or assumed, whereas Factor III appears to refer mainly to a conceptual hypothetico-deductive mode.

Factor III, like Factor II, transcends the immediate test content: Figure Classification Test is spatial, Mental Alertness is verbal and numerical, and Arithmetic Reasoning is numerical.

The processes underlying the Figure Classification Test are complex and imply a complicated, dynamic system. Not only analysis and synthesis are required, but their interplay seems to be a basic characteristic of conceptual reasoning. Fundamental to the task is that hypotheses must be formulated and verified (Werbeloff & Taylor, 1982), while T. Taylor (1977) stressed that no preliminary training or knowledge is required. Grant (1972) has commented that the essential nature of conceptual reasoning is that the subject does not approach the problem with the concepts underlying the task already learned, but he has to derive the concepts while doing the test. This is the essential difference between the Figure Classification Test and the usual inductive tests. Grant (1972) added that, in the latter case, it is taken for granted that the subjects have well formulated concepts of letter and number. However, as discussed previously (see section 4.1.5.2), the likelihood exists that this may not always apply where Blacks are concerned.

There is little information available on the way Blacks solve problems, and it appears likely that they find Mental Alertness more of a conceptual hypothetico-deductive task than an analytic task. In this regard, numerous writers (Bruner, Goodnow, & Austin, 1956; French, 1965; Pemberton, 1952) have indicated that people use different problem-solving strategies in approaching tasks. It has been pointed out (Kendall, 1974, 1977; Werbeloff & Taylor, 1982) that Blacks tend to adopt different problem-solving strategies from those used by the Whites on conceptual reasoning tests, which Kendall (1977) ascribed to temperamental and attitudinal factors. It may be highly likely that they would also adopt a different approach to solving the items of the Mental Alertness test. Further, Crawford-Nutt (1977a) has indicated that the rationale of tests can change with changing educational levels as higher education facilitates a shift in problem-solving modes. He attributed this to increasing cognitive differentiation. The tests would not thus be measuring the same thing for all people (French, 1965) and this would consequently affect the factor loadings and possibly account for the loading of the Mental Alertness on Factors II and III. If, as Irvine (1969) has noted, factor loadings approach Western patterns as the groups become more acculturated, it is likely that Mental Alertness would then load more highly on Factor II.

The loading of Arithmetic Reasoning on Factor II and III may be due to a similar reason. T. Taylor (Note 1) has pointed out that conceptual reasoning may be related more to urbanization than to formal schooling, whereas Arithmetic Reasoning is dependent to a certain extent on formal schooling as well-established arithmetical concepts are required. However, it seems that part of the variance accounted for by the test is due to hypothesis formulation. It is likely that the novel format of the test might have caused the sample to resort to additional hypothesis formulating strategies in attempts to solve the items. Dreyer (1974) has demonstrated that when African primary-school children are faced with arithmetic tasks which are not based on counting activities, they tend to resort to ill-defined strategies, and Okonji (1971) and Siann (1972) have shown that familiarity with the task affects performance. It is thus likely that the present sample resorted partly to a conceptual-hypothetico-deductive mode when faced with a test which had a novel format and thus did not conform to the usual arithmetical task with which they were familiar.

4.1.5.4 Factor IV

From Table 16 it may be ascertained that Factor IV is best defined by the Fault-Finding Test (0,39) and Mechanical Comprehension (0,36) with smaller loadings on the H Test (0,28); Poppelreuter (0,23) and the Gottschaldt Embedded Figures Test (0,21).

This factor is rather more difficult to interpret as there are no really well-defined marker tests. The tests loading highest on this factor all seem to require mechanical reasoning, knowledge, and experience; although whether it is merely mechanical knowledge and experience, or whether there is a specific reasoning component involved is difficult to assess.

Although Skawran et al. (1967) have asserted that the Fault-Finding Test is, to a large extent, independent of mechanical training, those who are familiar with, or have had experience in tinkering with mechanical devices would have a clearer understanding of the underlying principles involved. Thus, while knowledge can partly be disregarded as a source of variation, experience of manipulating mechanical parts can be assumed on reasonable grounds to influence the scores to an appreciable degree.

The fact that the test has no loading in Factor II is at first glance rather surprising, as it would seem reasonable that a reasoning component would be present as the testee has to analyze the problem in order to trace the faults. Thurstone (1949) has stressed that reasoning is an important component of mechanical aptitude as it is necessary to understand the nature of the mechanism, and to trace successive displacements. It is thus possible that this factor is tapping a mechanical reasoning component which is distinct from the other reasoning factors.

The loading of Mechanical Comprehension on Factor IV only is rather surprising in view of the fact that numerous writers (Ekvall, 1969; French, 1951; Fruchter, 1952a; Guilford, 1948; Guilford & Lacy, 1947; Guilford & Zimmerman, 1947; Patterson, 1956; Super & Crites, 1962; Thurstone, 1949, 1950, 1951) have stressed that mechanical comprehension tests of the Bennett type are not pure. Whereas the loading on Factor IV is to be expected, loadings on Space and Analytic Reasoning factors should have occurred, particularly as Visser (1978) found that Mechanical Comprehension correlated significantly ($\underline{p} < 0{,}01$) with spatial and reasoning tests for a sample of Black university students. It can be ascertained from Table 16, however, that Mechanical Comprehension has a rather low communality ($\underline{h}^2 = 0{,}19$), thus indicating that it does not share much variance with the other variables. Indeed, the only other factor on which it loads is Factor II (0,16) which, considering there are numerous reasoning items, is a somewhat low loading.

A disturbing possibility exists in that when Mechanical Comprehension was adapted by Griffiths (1968), various changes were made which did not conform to the original aims of the test. There are many items which relate to elementary physics rather than to intuitive understanding of mechanical problems. In view of the relative lack of experience in mechanical matters which most Blacks have, it is thus likely that the test is more of an achievement test in formally taught principles of physics rather than a test which taps mechanical intuition and experience, which may be an explanation for Visser's (1978) findings. If this is so, the loading of the test on Factor IV would relate to the more formal type of mechanical knowledge rather than to mechanical reasoning and insight. In view of these anomalous factor loadings, and in view of the low reliability of the test, serious doubts may be raised as to the suitability of the test for Blacks in its present form, and may indeed raise some doubts about the suitability of the test for Whites. Both Sorensen (1966) and Ekvall (1969) stress that the better mechanics are those who do not rely on formally taught principles, but rather on everyday mechanical experience.

The loading of the H Test, which is a measure of visualization (Vz) on this factor, can be accounted for if one examines the role of visualization in the development of mechanical ability. Skawran et al. (1967) have stressed that three-dimensional comprehension is one of the prime requisites of a mechanical task, and Thurstone (1949) has asserted that the ability to visualize a flexible configuration is essential for the development of mechanical skills. This link between visualization and mechanical insight is strengthened by the correlation of the H Test with the Fault-Finding Test (r = 0,29, p < 0,01) and with the Poppelreuter (r = 0,29, p < 0,01). It is interesting to note that whereas the F Test correlates with the Poppelreuter (r = 0,25, p < 0,05), it does not correlate with the Fault-Finding Test (r = 0,08). It is thus likely that the higher loading of the Fault-Finding Test compared with the Poppelreuter in this factor may be attributed to the three-dimensional character of the Fault-Finding Test being more characteristic of mechanical tasks. This tends to confirm Skawran et al.'s (1967) assertion that it is this feature which differentiates the Fault-Finding Test and the Poppelreuter.

The visualization component of mechanical aptitude has been reported consistently by previous researchers (Friedman & Detter, 1975; Friedman & Ivens, 1967; Theologus, Romashko, & Fleishman, 1970; Thurstone, 1949, 1950, 1951; Tyler, 1965) regarding mechanical aptitude in Whites, and in Bowd's (1973) cross-cultural study, the spatial tests loaded on the same factor as the mechanical tests.

The loading on this factor of the Gottschaldt Embedded Figures Test (a measure of Thurstone's, 1949, C_2) is in accord with Thurstone's (1949, 1950, 1951) results. He obtained saturation of C_2 in his criterion measurement of Mechanical Comprehension (r = 0,50).

Factors II and IV are correlated (r = 0,35), which is an indication that some relationship between analytic reasoning and mechanical insight exists, as Thurstone (1949, 1950, 1951) has suggested. However, the relationship in this case appears to be rather tenuous, and Factor IV appears to be tapping knowledge, experience, and mechanical reasoning.

The Poppelreuter has rather low loadings in both Factors I (0,21) and IV (0,23), and also has a rather low communality (h^2 = 0,18). As the testee is shown the apparatus first and is then allowed to dismantle it, the relatively low loading on Factor IV may be attributed to Skawran et al.'s (1967) assertion that the test is less dependent on mechanical insight and more dependent on memory and reproductive thinking. From Table 14 it may be ascertained that whereas the Poppelreuter correlates with Mental Alertness (r = 0,21, $p < 0,05$), the Fault-Finding Test has negligible correlation (r = 0,03) with Mental Alertness. This tends to confirm Skawran et al.'s (1967) assertion, and is possibly an indication that the subjects may be using reasoning methods other than mechanical insight based on experience to complete the Poppelreuter.

4.1.5.5 Correlation of factors

From Table 17, it may be ascertained that Factors I and IV are highly correlated (0,51), which is to be expected, considering that spatial factors play an important role in mechanical aptitude (Botha, 1976, 1978; Estes, 1942; Harrell, 1940; Guilford et al, 1952; Guilford & Zimmerman, 1947; Guilford & Lacy, 1947; Zimmerman, 1953; Staff, Personnel Research Section, 1945; Thurstone, 1949, 1950, 1951; Verwey, 1964) and there is thus a clear interaction between spatial ability and mechanical ability. Ekvall (1969) has pointed out that a good spatial ability will make it easier for an individual to understand and to handle mechanical problems, which, in turn, will tend to strengthen interest in mechanical matters, which should consequently improve his ability to solve the problems in spatial tasks. In the present sample, it is thus likely that spatial ability makes a greater contribution to the solution of problems of mechanical tasks than general reasoning. Ekvall (1969) came to a similar conclusion regarding a sample of White male technical applicants in Sweden. Thus, in view of the background factors which are thought to contribute to depth perception, and in view of the relationship between spatial depth perception and mechanical skills, it is likely that the relatively impoverished pictorial background and general lack of exposure to mechanical toys and objects which is characteristic of the growing Black child's environment, will militate against the development of mechanical skills.

From Table 17 it may be seen that there is no correlation between the spatial factor and the two reasoning factors. Although the separation of spatial factors from factors of general reasoning has been reported consistently in other studies in Africa (Ballentine, 1982; Grant, 1969, 1970, 1972; Irvine, 1969; Kendall, 1977; MacArthur, 1968), it should be noted that the majority of the reports were based on orthogonal rotations and thus no factor correlations were reported. In Grant's (1972) study, all the tests loaded on a spatial factor, which led Grant (1972) to hypothesize that had an oblique rotation been performed on the data, spatial and conceptual reasoning factors would have been correlated to the extent of 0,60. Similarly, Bowd (1973), in his cross-cultural study on mechanical aptitude, obtained a general reasoning factor which was fairly stable across all the groups on which the spatial tests loaded. The total lack of correlation between the spatial and reasoning factors in the present sample is therefore somewhat surprising, and may be attributed partly to the fact that this sample was not a random, but a relatively select one, and hence less heterogeneous. Vernon (1972) has indicated that correlation of spatial tests with intelligence is lowered in selected groups.

Various researchers (Deregowski, 1980; Ekstrom, French, & Harman, 1976; Gregory, 1970; Turvey, 1978) have suggested an information processing and problem-solving approach to spatial depth perception which would imply a possible link between spatial perception and analytic thinking. Gordon (1979) has indicated that many spatial tests may be solved spatially or by reasoning. The observed lack of relationship between the spatial and the reasoning factors in the present sample may indicate that the subjects do not adopt a problem-solving or analytic approach toward depth perception. This lack of correlation between the space and the two reasoning factors appears to be corraborative evidence for Kemp's (1980) suggestion that there may be basic problem-solving activities which have not been adequately developed with respect to Blacks. He hypothesized that difficulties which Blacks tend to experience in understanding two-dimensional diagrams may be related to difficulties in processing and integrating other novel information, and that there may be a common education, cultural or environmental deficiency.

These findings of a four-factor structure of mechanical aptitude appear to be in direct contrast to Murray's (1956) simplistic structure, and to be more closely related to the studies reported by Grant (1969, 1970a, 1972), Kendall (1971, 1980), Irvine (1969) and Ballentine (1982).

The obtained four factors do, in fact, conform to a large extent to the research findings regarding the factor structure of mechanical aptitude in Whites (Ekvall, 1969; French, 1951; Thurstone, 1949, 1950, 1951; Vernon, 1950, 1961). The results appear to bear out the theory of Ferguson (1954, 1956) regarding the role of culture and education on the differentiation of ability, and strengthen Bowd's (1973) hypothesis that cultural environments influence ability structure.

4.2 Biographical and interest variables related to mechanical aptitude

Aim 2 : To determine the extent to which biographical and interest variables of a sample of Black males may be used to predict performance on the major dimensions of mechanical ability as determined by the factor structure.

4.2.1 Vocational preferences

It must be borne in mind that a low score in the Rothwell-Miller Interest Blank indicates a preference for a particular occupational grouping, whereas a high score indicates a dislike.

From Table 18 it can be seen that the Scientific (first choice), Mechanical (second choice) and Medical (third choice) were the three interest categories most strongly favoured, with the Practical (tenth choice), Outdoor (eleventh choice) and Musical (twelfth choice) categories being the three least preferred. The observed ranking of the Mechanical category is in contrast to the findings generally reported in the literature where it has been reported consistently as being among the least preferred occupational categories of the Blacks. (Breger, 1976; Cloete, 1981; Erwee, 1981; Hall, 1978, 1980; Shannon, 1975; Spence, 1982; Tunmer, 1972; Visser, 1978). It is to be expected, however, that the present sample would tend to rate Scientific and Mechanical categories favourably, as Super and Crites (1962) have noted that it is logical that applicants for mechanical training would have interests compatible with their career choice. However, the possibility exists that, as the Rothwell-Miller Interest Blank was administered as part of a selection battery, a certain amount of 'subjectivity' and 'faking' was involved, particularly in view of the low rankings which were given to the related Outdoor and Practical occupations. The low ranking of these two categories, while in line with general trends reported in the literature (Breger, 1976; Cloete, 1981; Erwee, 1981; Hall, 1978, 1980; Shannon, 1975; Spence, 1982; Tunmer, 1972; Visser, 1978) is somewhat disturbing in view of the practical aspects which a mechanical job connotes. The low ranking may be attributed to a status factor which tends to influence occupational choices. Both Visser (1978) and Mojafela (1980) have indicated that a dislike for outdoor and blue-collar occupations should be interpreted in terms of the low status accorded to these categories in the Black community.

In this regard, it is interesting to note that the strong preference for the Social Service categories, which Blacks have indicated in previous studies (Breger, 1976; Cloete, 1981; Erwee, 1981; Hall, 1978, 1980; Shannon, 1975; Tunmer, 1972; Spence, 1982; Visser, 1978) and which is usually attributed to a status factor and a need to be of service to the community, was not observed in this sample. According to Godsell (1982) this need to be of service is internalized in the Black value system as a central value which prescribes their behaviour towards others. The preference for Mechanical and Scientific categories and the relatively low preference for Social Service observed, may indicate that, whereas the belief that Blacks are 'people' rather than 'thing' orientated, generally holds (Bayer, 1972; Cloete, 1981), the present sample, being interested in being selected for a technical job, were more 'thing' than 'people' orientated. Cloete (1981), however, postulated that Blacks may not be specifically 'thing' orientated, but, having previously been excluded from technical occupations, they exhibit a corresponding lack of interest. This is in agreement with others (Biesheuvel, 1974; Cloete, 1981; Crites, 1969; Picou & Campbell, 1975) who have postulated that the vocational choices of Blacks are influenced by additional factors than those which influence the choices of Whites. They ascribed this to the variety of racially discriminatory practices which tend to operate in the labour market which would narrow the vocational choice of Blacks. The report of the Wiehahn Commission of Inquiry (Bendix, 1979) and the Industrial Conciliation Amendment Act of 1979 have, however, ensured that the vast majority of job restriction legislations have been rescinded. According to Biesheuvel (1974), these restrictions were particularly prevalent in the technical fields. It will thus take time for Blacks in this sphere to become 'visible'. Both Sewell and Martin (1976) and Cloete (1981) have attributed the lack of interest of Blacks to the lack of both 'visibility' and positive role models.

Because of this and because of the lack of guidance facilities prevalent in Black schools (Spence, 1982), there may be only a limited amount of vocational information available as to what a technical job entails. A number of writers (Cloete, 1981; Erwee, 1981; Hall, 1978, 1980; Mojafela, 1980; Shannon, 1975; Spence, 1982; Visser, 1978) have noted that Blacks may not be able to evaluate occupations realistically if they have had no previous exposure to them. The present sample might thus have aspired to the technical field because of the prestige which surrounds the technical and computer business world, without being able to assess realistically what the job would entail. This may have implications regarding their motivation and tenure in mechanical jobs.

In this regard, it should be noted that during the testing sessions, the invigilators noted that there were many requests for help in completing the Rothwell-Miller Interest Blank, as the testees did not have clear ideas about many of the occupations. Erwee (1981) and Spence (1982) have reported similar problems. It is thus possible that the results of the present sample do not reflect the testees' aspirations accurately.

It should be borne in mind, however, that the Rothwell-Miller Interest Blank was used in the present study without recourse to an interview. Although it has been shown (Erwee, 1981; Hall, 1978, 1980; Shannon, 1975; Visser, 1978) that it might be used fairly reliably for Blacks in this manner, it was designed by K.M. Miller (1968) to be an adjunct to an interview, where anomalies and ambiguities could be clarified.

In the light of the aforegoing, it seems that the occupational choices of the present sample may reflect the findings of previous research and be rather unrealistic, and that the Rothwell-Miller Interest Blank should be used with caution in Black samples.

4.2.2 Factors related to mechanical aptitude

4.2.2.1 Variables related to Factor I : Space

From Table 20 it can be ascertained that the most significant predictors for the Space factor are 'preference for science', 'previous persuasive job', and 'previous clerical job', all at the 0,005 level of significance. Whereas the variable 'movies and television' is significant at the 1% level, it should be noted from Table 20 that the beta coefficient is negative, and hence the relationship between them is inverse. Having a 'standard ten' education and a 'Social Service Interest', are significant at the 5% level. These variables together account for 35% of the variance of the Space factor (Multiple $\underline{R}$ = 0,59).

Support for the relationship between 'preference for science' and Space is provided by Vernon (1972) who found that adolescent boys whose leisure time activities included scientific hobbies performed significantly better on spatial tests. It is possible that those who profess an interest in science have had some previous exposure to technical material and diagrams.

There is no clear explanation for the observed relationship between 'previous persuasive job', 'previous clerical job' and Space, and the reasons for their appearance in the regression analysis are not immediately apparent. They may, however, merely relate to having some proper job experience and training. Without further details, it is not possible to interpret these results further, and they may be due to certain peculiarities in the sample.

The appearance of 'Social Service Interest' in the regression analysis may be interpreted as an indication that people who have high spatial abilities tend to veer away from social service activities, and it appears likely that they invest their capacities in a different direction.

The relationship between the variable 'standard ten' and Space can be readily explained, as the level of formal and informal education has been shown to be related to spatial depth perception (Dickinson, 1980; Hudson, 1960; Kilbride & Robbins, 1968; McFie, 1961; Mundy-Castle, 1966; Serpell, 1979).

Hudson (1960), however, has stressed that it is the level of informal rather than formal education which is the critical variable. He attributed this to the fact that because Western culture is book-learned and characterized by dependence on the written word and on pictorial material, characteristic perceptual habits have become the norm for groups professing Western culture. Support for Hudson's (1960) contention is given by Grant (1969) who reported no correlation between formal education and his spatial factor.

If informal education is the critical variable, it would be expected that such hobby variables as 'reading', 'movies and television' and 'practical' would appear in the regression equation. Thus Newcombe (1982) attributed the development of spatial ability to experiential 'masculine' activities such as playing with puzzles, building toys and models, and engaging in large motor activities. However, while 'movies and television' is the only one of these variables to appear in the regression equation, it bore a negative relationship to the Space criterion, which may be an indication that those who enjoy watching films and television do not have highly developed spatial abilities. The reasons for this are uncertain, particularly as Selden (1971) has commented on the positive effects of films and television in shaping depth perception. It is possible, however, that those who spend a great deal of their leisure time watching movies and television are more passively orientated, and do not involve themselves in the more practical kinds of experiences which would shape depth perception.

The expected contribution of 'practical' hobbies to the spatial visualization abilities of Blacks reported by Kemp (1980) also failed to appear in the regression equation. However, it should be noted that whereas little research has been done with regard to Blacks, research in the area of hobbies and interests related to the development of spatial skills in Whites has been equivocal. Newcombe (1982) attributed a possible reason for this to self-selection. People with high spatial ability may choose (or be chosen) to engage in activities which utilize these strengths, rather than the strengths being developed by the activities.

In the light of the important role which level of acculturation plays in facilitating the development of spatial skills (Deregowski, 1970; Hudson, 1960, 1962, 1967; Omari and MacGinitie, 1974), it is also rather surprising to note that urbanization does not contribute to the regression equation. As the majority of the sample (82,7%) are from an urban background, it is likely, however, that the restriction in range would tend to reduce the effect of any possible relationship.

The possible reasons for the lack of clear predictors to the development of spatial ability for Blacks will be discussed more fully later in relation to the development of mechanical skill (see section 4.2.3).

4.2.2.2 Variables related to Factor II : Analytic Reasoning

From Table 22 it may be ascertained that most of the predictors in the multiple regression equation for the Analytic Reasoning factor are highly significant ($p < 0{,}005$). They are: 'urban', 'standard ten', and 'Literary Interest'; and 'preference for English' and 'Musical Interest', which have negative beta coefficients. 'Maths' and 'Biology' are significant at the 1% level. These variables together account for 48% of the variance (Multiple $R = 0{,}69$).

The importance of an urban background for the fostering of Analytic Reasoning is to be expected, and is in line with previous research in which analytic thinking has been shown to be related to acculturation and to be relevant to functioning in a Western technological environment (Baran, 1970; Du Preez, 1968; Okonji, 1969). In this regard Peluffo (1967, p. 195) has noted that "an under-developed milieu does not stimulate a dynamic reasoning", while Latouche and Dormeau (1956) have attributed the good results obtained in the case of urban candidates to a highly developed environment rather than to individual differences.

The negative contribution of a 'preference for English' to the regression equation is surprising, particularly as Silvey (1963) has noted that language plays an important role in mental development by its capacity to initiate and reinforce curiosity and to "orient ... [one] ... to analytic rather than descriptive concepts" (p. 18). Silvey's contention would appear to be borne out by the positive contribution to the re ression equation of having a 'Literary Interest' ($p < 0{,}05$). One possible reason to account for this anomaly is that having a 'preference for English' does not necessarily reflect a concomitant 'proficiency in English', and that the two are, in fact, unrelated.

The paramount role of formal education in facilitating performance on ability tests has clearly been pointed out by numerous writers (Biesheuvel, 1956; Crawford-Nutt, 1977a, 1977b; Grant, 1969; Mauer, 1974; McFie, 1961; Schepers, 1974; Silvey, 1963; T. Taylor, 1977). This increase in test performance has been attributed to increasing psychological differentiation (Burt, 1954; Crawford-Nutt, 1977a, 1977b; Grant, 1969; Hudson, Roberts, Van Heerden & Mbau, 1962; Irvine, 1962, 1963, 1969; McFie, 1954, 1961). It would be expected therefore, that those with higher levels of education would have more highly developed problem-solving and analytical abilities. Ekvall (1969) has indicated that school training improves the ability to solve verbal intelligence tests. Although the tests loading highest on this factor are not directly related to formal schooling, they are dependent on it to a certain extent. Thus Hall (1979) has shown that the Technical Reading Comprehension correlated significantly ($p < 0{,}01$) with all school results and, in particular, with matriculation results ($r = 0{,}54$, $p < 0{,}01$).

It is also quite understandable on logical grounds that analytic reasoning may be related more to scientific interests than to language interests, and thus the significant contributions to the regression equation of 'mathematics' and 'biology' as school subjects is quite explicable. Mathematics is clearly an analytic subject, and Ekvall (1969) has pointed out that mathematical ability demands more comprehension of basic principles than other subjects in which rote learning is possible to a greater degree. A preference for mathematics would thus appear to be commensurate with a problem-solving ability. Hall (1979), for example, found that Technical Reading Comprehension, which had the highest loading on the Analytic Reasoning factor (0,50), correlated significantly with school mathematics ($r = 0{,}51$, $p =$ 0,01) for a sample of Black students.

The negative contribution to the regression equation of 'Musical Interest' is quite understandable, as those who are interested in the more artistic field generally tend not to be interested in scientific and analytic pursuits.

4.2.2.3 Variables related to Factor III : Conceptual Reasoning

From Table 24 it may be ascertained that the most significant predictor for Conceptual Reasoning is 'Aesthetic Interest' (p < 0,005), which makes a negative contribution to the regression equation. Having a 'standard ten' education is significant at the 1% level. 'Preference for English', 'sport' as a hobby, and 'Scientific Interest' are significant at the 5% level. These variables together account for 36% of the variance (multiple R = 0,60).

It appears that those whose abstract reasoning abilities are well developed are not particularly interested in occupations in the artistic field. A similar result was reported by Erwee (1981), who suggested that as students develop proficiency in certain areas, they seem to realize which careers should be avoided because they demand skills that the student has not developed.

Formal education and urbanization have been shown to be the media through which Blacks acquire conceptual strategies (Brimble, 1963; Crawford-Nutt, 1977a, 1977b; Erwee, 1981; Evans, 1973; Jah[illegible]a, 1956; Kendall, 1974, 1977; Okonji, 1971; Pick, 1980; Reuning, 1972; Schmidt, 1960; Spence, 1982; T. Taylor, 1977; Vernon, 1967; Werbeloff & Taylor, 1982), and thus the contribution of a 'standard ten' education is quite explicable. Kendall (1977) and T. Taylor (1977) attributed the important influence of formal education on conceptual reasoning to its being one of the strongest and most direct agents of acculturation, which in turn tends to influence intellectual adaptability to Western technological society. The more highly educated Blacks would thus be more familiar with Western concepts.

In the light of the research mentioned above and, in particular, in light of Grant's (1969) finding that urbanization increased the mean performance of conceptual reasoning, it is somewhat surprising to note that in the present sample, urbanization is not a factor in the regression equation. As mentioned previously, the restriction in the range, however, would tend to reduce the effect of a possible relationship.

That a 'preference for English' makes a significant contribution to the regression equation tends to confirm Bowd's (1973) finding that test performance is mediated by a facility in English. Silvey (1963) has stressed the effects of verbal skills on intelligence and has pointed out that:

> In the African setting it may be that a pupil who is proficient in English language not only has a means of understanding better the content of what he is taught, but also has access to a language which is more flexible and capable of a wider range of function than his vernacular ... it may allow him a greater sensitivity to the notions of differentiation and abstraction. (Silvey, 1963, p. 18)

People who are interested in science would most likely have a flexible approach to problem-solving, and it is flexible thinking which Kendall (1977) regarded as being the moderating variable which mediates the shift from perceptual to conceptual reasoning strategies. Further, T. Taylor (1977) has noted that science is rich in formal concepts.

The reason for the contribution of 'sport' as a hobby to the regression equation for Conceptual Reasoning may appear at first glance to be rather inexplicable. If it is remembered, however, that soccer is generally regarded as the favourite sport of Black males, the reasons perhaps become clearer. Soccer is a game requiring a great deal of strategy with regard to the placing of the ball and the players, and in the actual game playing itself. It would be expected that those who expend a great deal of time playing soccer have had practice in planning strategies and in formulating and testing the resultant hypotheses.

4.2.2.4 <u>Variables related to Factor IV : Mechanical Reasoning</u>

From Table 26 it can be seen that 'preference for science' is the most significant predictor for Mechanical Reasoning ($p < 0,005$). 'Preference for English' and having a 'standard nine' education are significant at the 5% level, with 'standard nine' having a negative beta coefficient, and hence a negative relationship with the criterion. The variables together account for only 23% of the variance (Multiple $R = 0,48$).

The best predictor of Mechanical Reasoning is 'preference for science'. In the light of the obtained correlation ($r = 0,51$) between Space and Mechanical Reasoning factors, it is interesting to note that a 'preference for science' is the most significant predictor ($p < 0,005$) in both cases. Botha (1976, 1978) also reported that a 'preference for science' was one of the biographical items which discriminated between 'high' and 'low' mechanical aptitude in Blacks. Although this outcome is in general agreement with the literature, certain anomalies are apparent. Thurstone (1950, 1951) found that his 'high' mechanical aptitude group rated themselves as having high Mechanical and Scientific interests. Whereas a 'preference for science' would appear to be commensurate with scientific interests, 'Scientific' and 'Mechanical' interests did not appear in the regression analyses, although they were rated the two most preferred occupations by the whole group (see Table 18). Thus, in contrast to Thurstone (1950, 1951), it does not appear that a relationship exists between Scientific and Mechanical interests and Mechanical Reasoning. Another disturbing possibility exists, however, particularly in view of the low ranking which the sample gave to the Practical interest category. This pertains to the unrealistic nature of vocational aspirations of Blacks in Africa (Biesheuvel, 1962; Breger, 1976; Cloete, 1981; Erwee, 1981; Hall, 1978, 1980; Mojafela, 1980; Obanya, 1978; Shannon, 1975; Spence, 1982; Tunmer, 1972; Visser, 1978). It may also be an indication that the Rothwell-Miller Interest Blank is somewhat transparent, which renders it open to faking.

The role of the variable 'preference for English' ($p < 0,05$), which makes a positive contribution to Mechanical Reasoning, may be attributed to the important role which verbal skills play in fostering intellectual curiosity (Silvey, 1963).

The reason for the negative relationship between having a 'standard nine' education and Mechanical Reasoning is not immediately apparent, and may be due to peculiarities of the sample.

These results would appear to be somewhat surprising as there is a particularly noticeable lack of certain predictors pertaining to hobbies and related biographical variables which have been shown generally to contribute toward mechanical aptitude. Thus, such variables as 'previous mechanical job', 'practical' and 'reading' hobbies, 'urban', and 'practical' subject taken at school would be expected to play some role. Whereas 13,5% of the sample had some previous job experience in the mechanical field, however, it is likely that it entailed relatively low-level mechanical tasks, which did not foster mechanical reasoning.

Ekvall (1969) commented that an interest in mechanical activities concerns, to a large extent, reading about and working with mechanical devices during leisure time, and these activities would be an indirect measure of mechanical knowledge and experience. Other researchers (Fruchter, 1952b; Guilford & Lacy, 1947; Henry, 1965; Kemp, 1980; Mottram, 1977; Paterson et al., 1930; Pendelbury & Hardman, 1967; Ross, 1962; Sorensen, 1966) concur. However, it should be noted that with the exception of Kemp's (1980) sample, in which he found that Black students who did well on tests of mechanical reasoning had technical interests and related experiences, all the studies refer to Whites.

4.2.3 Summary

It is not surprising that no clear model for mechanical aptitude in Blacks has crystallised. Ogbu (1981) has stated that "competence is the ability to perform a culturally specified task" (p. 414); and

Bowd (1973) has suggested that mechanical aptitude is a construct which has developed within a technologically sophisticated culture. The modern technological framework is modelled on competence in Whites. Thus, whereas a relatively large Multiple $\underline{R}$ (0,69) accounting for 48% of the variance has been obtained for Analytic Reasoning, with most of the predictors being highly significant ($\underline{p} < 0,005$), the percentage of the variance explained for Conceptual Reasoning (36%), Space (35%), and Mechanical Reasoning (23%), is lower, with few highly significant predictors.

Analytic Reasoning is related to formal education and is thus very much a part of the repertoire of skills which Blacks utilize in their everyday lives, and it is thus likely that biographical variables related to it will be found. Both formal education and urbanization were thus highly significant predictors ($\underline{p} < 0,005$). Conceptual Reasoning, Space, and Mechanical Reasoning, however, may not play such a vital role in the day to day experiences of Blacks, although they are necessary for effective functioning in the Western technological culture. Berry (1966) and Deregowski (1980) have attributed the highly developed spatial skills and mechanical aptitude of the Eskimos to these being necessary for the survival of the Eskimos.

Mechanical aptitude thus appears to be culture-bound and whereas there are certain common components, the factorial composition tends to differ across groups. Bowd (1973) ascribed the differences in the development and patterning of abilities as being due to observed inequalities of opportunity. The effect of these cultural influences is in accord with Ferguson's (1954, 1956) theories that the demands of the culture shape the skills necessary to function effectively in that culture.

According to Connolly and Bruner (1974), ghetto Blacks do not have the operative intelligence for managing modern technology. They attributed this to inadequate childhood experiences which tends to restrict intellectual curiosity. While this may be a rather damning indictment of American ghetto Blacks, and may not apply in the South African context, it may be an indication that a home and educational system which militates against competence may not foster the development of clear predictors of mechanical aptitude.

It is thus possible that the White, middle-class home, with its electrical gadgets, books, television and, possibly, micro-computer, would contribute to the development of mechanical skills, but that the poverty and relative deprivation characteristic of the majority of Black homes would not provide a supportive environment which could foster the kind of activities which would give clear predictors of any possible relationships. It is also possible that the hobbies and interests listed by the sample in the present study were not well defined in the sense of being abiding and consuming interests, but were merely marked in terms of a passing interest, social desirability, or in the context of a selection procedure.

The unrealistic vocational aspirations and lack of relevant vocational knowledge have been discussed. Sewell and Martin (1976) attributed the lack of interest in the technical and scientific field of American Blacks to their reluctance to choose occupations where Blacks are not clearly visible. Cloete (1981) has indicated a similar lack of positive Black role models in the technical fields existing in Southern Africa. Another factor which militates against socialization of interests and hobbies which are thought to be related to the development of mechanical skills may be the lack of a father figure to give a role model for the more male orientated technical tasks. Gordon (1983) has pointed to the high divorce rate resulting in the large proportion of female heads of household prevalent in Black homes. She has also shown that primary school success with respect to Blacks is related to the presence of a father, and this may be particularly relevant as far as the development of mechanical aptitude is concerned.

Furthermore, numerous writers ("Black prospects remain dim", 1981; De Lange, 1981; Geber & Newman, 1980; Morris, 1980) have attested to the shortcomings of a school system which is based on a western model of education which may not be relevant to Blacks. The Black school system, which has little to offer in the way of learning by doing, or practical experiments, and which tends rather to focus on rote learning, also could be responsible for the lack of well-defined skill and interests in its pupils.

CHAPTER 5

CONCLUSION

The investigation into factors related to mechanical aptitude in Blacks has yielded a number of interesting results.

5.1 Major findings of the study

The finding of a four-factor structure of mechanical aptitude appears to bear out the results obtained by other researchers (Ballentine, 1982; Grant, 1969; Grant & Schepers, 1969; Irvine, 1969; Kendall, 1971, 1980) with regard to the complexity of the structure of intellect of Blacks, and to refute the concept of a general practical intelligence and the simplistic structure postulated by Murray (1956).

Whereas the obtained factors of Space, Analytic Reasoning, Conceptual Reasoning, and Mechanical Reasoning appear to conform largely to research findings regarding factors related to mechanical aptitude for Whites (Ekvall, 1969; French, 1951; Thurstone, 1949, 1950, 1951; Vernon, 1950, 1961), it is apparent that there are cross-cultural differences with regard to the way Blacks process information which may have affected the construct validity of the tests.

The obtained correlation between the spatial and mechanical factors confirms previous research regarding the inter-relationship between spatial depth perception and mechanical aptitude. It is possibly an indication that the difficulties which Blacks are thought to experience with mechanical tasks are related to difficulties which they experience with depth perception. These difficulties and differences may be due to educational, cultural or environmental causes.

There was little evidence, however, in the present study to provide clear-cut indications of biographical variables which would be predictive of factors related to mechanical aptitude. Many of the expected predictors such as education and urbanization failed to play consistent roles, and others such as previous mechanical experience and mechanical hobbies were not predictive.

The clearest picture emerged with relation to Analytic Reasoning, with most of the predictors, including education and urbanization being highly significant ($p < 0,005$). It is not surprising that significant predictors for the factor related to formal schooling and application of knowledge would emerge, as education has been shown to have significant effects on the development of abilities important for functioning in a Western culture.

The picture was not so clear, however, with regard to the factors of Space, Conceptual Reasoning and Mechanical Reasoning, with lower Multiple R's and fewer highly significant predictors being obtained. Thus predictors for skills peripheral to the everyday existence of Blacks were not so clearly defined. These results are an indication that the relative deprivation characteristic of many of the homes of Blacks, and a school system which does not appear to foster scientific curiosity, may lead to few Blacks having well-defined skills or interests relevant to the development of mechanical aptitude. In this regard it should be noted that a 'preference for science' as a school subject was a significant predictor ($p < 0,005$) for both Space and Mechanical Reasoning factors. It is possible that those who enjoy science have some previous exposure to technical material and are thus more familiar with technology. It is thus likely that as Blacks are incorporated into the mainstream of technological society, so that it becomes an integral part of their everyday life experience, they will become more involved in activities which may foster the development of relevant mechanical skills.

The results appear to confirm Ferguson's (1954, 1956) theory regarding the influence which culture and education have on the differentiation of ability, and to be in agreement with Bowd's (1973) contention that mechanical aptitude is influenced by the cultural environment.

5.2 Limitations of the study

There were a few limitations in the study which may have influenced the results obtained. Consequently the results should be accepted with some reservations.

5.2.1 Sample

The relatively small sample (n = 75) places a certain limitation on the generalizability of the results. Further, as the sample was rather select, restriction in range may possibly have affected the correlations between the variables. Whereas results from the initial larger sample would possibly have been more generalizable, restrictions of time and money were such that only eight tests were administered to the total sample. As three tests are needed to determine a factor adequately, these results from the larger sample could not be utilized in a factor analysis.

5.2.2 Measuring instruments

5.2.2.1 Cognitive tests

Although the results obtained from the cognitive tests were generally of an appropriate level of difficulty, their reliabilities were generally far lower than those commonly reported for White samples. Whereas the lower reliabilities may in part be due to a restriction in range, they are an indication that many of the tests may not be suitable for Blacks in their present form. Poor reliabilities are an indication that the results should be interpreted with caution. The distinct possibility exists that future researchers, using more reliable tests, may obtain results somewhat different from those observed in the present study.

5.2.2.2 Apparatus tests

The three apparatus tests (Poppelreuter, Fault-Finding Test and the O'Connor Finger Dexterity) were not administered as part of the original selection battery as it was not economically feasible to test all the candidates on the apparatus tests. They were thus administered to the selected sample a few months after training had begun. The possibility exists, therefore, that the intervening training raised the scores on these tests. Whereas an increase in score should not affect the factor loadings, it is possible that the training might have led to the crystallization of their mechanical skills which could conceivably have affected the loadings. Accordingly, future researchers should ensure that the apparatus tests are administered before training begins.

5.2.2.3 Vocational interest inventory

As the Rothwell-Miller Interest Blank was completed in a selection context, it is possible that the observed preference for Scientific and Mechanical interests may have been due to a certain amount of faking. It is thus possible that results closer to those reported in other studies may have been obtained in different circumstances.

It should also be borne in mind that difficulties were experienced by the sample in completing the questionnaires. Many did not understand the instructions. Many of the job categories were outside the experience and knowledge of the average Sowetan Black. An additional point which may have confounded the results pertains to the difficulty in separating out vocational interests from the status factor. As the desire for status plays an important role in the career choices of Blacks, attention should be given to rearranging the categories in order to eliminate or isolate the status factor.

It is thus possible that many of the anomalous findings regarding interests in the prediction of mechanical aptitude may be due to inherent difficulties with the Rothwell-Miller Interest Blank and the results should be interpreted with caution.

These results are an indication that the Rothwell-Miller Interest Blank may not be a suitable instrument for Blacks in its present form, and that some thought should be given to developing a version which may have more utility.

5.2.3 Biographical information

Due to the small sample size, many variables, which might have been predictors, had to be omitted from the regression analyses because of the small number of cases in their cells. Had a larger sample been available, it is likely that this potentially valuable information would not have been lost. It is possible that the findings of the study would have been enhanced had more detailed biographical information been available. Thus the precise identification of length of urban residence, amount of industrial experience and the relevant skill level, current occupational status and actual school marks, might have provided additional information. However, as the testing was done as part of a large selection exercise, much of the relevant information could not be verified.

Other biographical information which might have been informative relates to ascertaining the socio-economic status, and the presence or absence of a father figure. It might then have been possible to explore the relationships between biographical variables and test performance more fully.

5.3 Implications of the present study

The results of the present study are an indication that the structure of mechanical aptitude of Blacks is multi-factorial. Attention should thus be focussed on investigating and clarifying the relationship between the various components of mechanical aptitude which may elucidate some of the findings obtained in the present study. It would perhaps be fruitful for future researchers to explore in more detail the relationship between the spatial and mechanical reasoning factors, and between the spatial and reasoning factors. By setting up a model, it may be possible to establish whether mechanical aptitude is influenced directly or indirectly through spatial skills.

The factor correlations and the anomalous loadings of some of the tests are an indication that the relationships between test performance and information processing and problem-solving need to be explored. This would serve to focus greater attention on the underlying cognitive processes which result in level of performance.

Although most of the tests used in the present study appeared to be of an appropriate level of difficulty, the reliabilities certainly were lower than those commonly reported for White samples, which is an indication that the tests used may not be suitable in their present form for Blacks. It is also apparent that the construct validity of some of the tests may not be the same for Blacks and for Whites. It cannot be assumed, therefore, that a test necessarily measures the same intellectual ability when administered to people of differing races with differing levels of education. In view of the indiscriminate manner with which local and overseas psychological tests are often administered and interpreted, these findings are important.

The paucity of standardized tests available for Blacks at higher levels of education has already been noted. Thus, in order to explore the structure of mechanical aptitude of more highly educated Blacks more fully, the range of tests needs to be broadened quite considerably. Serious attention should thus be given to the development of tests which are reliable and valid for Blacks, and which do not place them at any disadvantage.

The results obtained from the Mechanical Comprehension Test are particularly disturbing, as it appears to have serious limitations as a test of mechanical insight. The test seems to be more of an achievement test in elementary physics than a test of mechanical reasoning. Furthermore, the presence of only three answer choices per item and the anomalous factor loadings of the test lend strength to the supposition that it is unsuitable for Blacks in its present form. In view of the importance of mechanical reasoning as a predictor, serious attention should be given to developing a mechanical reasoning test which is both more reliable and valid.

The lack of predictors for many of the factors is an indication that Blacks may be prevented from developing their full potential of skills required for effective functioning in the Western technologically orientated culture as a result of the relative deprivation of the socio-economic and cultural environment in which they grow up. This may be ascribed not only to the lack of both informal and formal education, but may also relate to their values and aspirations. The predilection of Blacks for being of service to the community has been noted (Godsell, 1982) as has the unrealistic nature of their vocational aspirations. Results obtained from the present study are an indication that Blacks may have little conception of what a mechanical job entails. This may have serious implications regarding their motivation and long-term tenure in mechanical jobs. Research aimed at clarifying the work values and career aspirations of Blacks with regard to the technical field is clearly indicated, as is the dissemination of accurate vocational information.

Heyneman and Loxley (1983), in a recent World Bank study, have shown that poor family background can be overcome by the quality of the schools and the teachers to which the children are exposed, and Verster (1983) has pointed to the important role of community development in fostering informal education. Urgent attention should be given to: upgrading the quality of schooling and teachers; establishing hobby centres; providing language and communication training; providing accurate vocational guidance in the schools, and to the establishment of bridging education programmes for tertiary education. Whereas many programmes have been initiated, it is imperative that they should not be undertaken on an ad hoc basis.

The question arises, given that the relevant mechanical skills may not have been fostered in young Blacks, whether increased intervention and training, resulting in a familiarity with technology, can overcome these disadvantages and effect long-term changes in their factor structure. Longitudinal research aimed at examining and clarifying the long-term effects of these interventions may provide the answer to this important question.

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ISBN 0 7969 0291 7

1380/85/12