SPECIAL REPORT

PERS 272 AN INVESTIGATION INTO COGNITIVE FLEXIBILITY AMONG EDUCATED BLACK AND WHITE GROUPS

NATIONAL INSTITUTE FOR PERSONNEL RESEARCH
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

C S I R Special Report PERS 272 (pp i - vii; 1 - 22)
UDC 159.923.435:371.212.8 (680)

Johannesburg, Republic of South Africa, March 1979

ISBN 0 7988 1182 C S I R Special Report PERS 272

Published by
National Institute for Personnel Research
Council for Scientific and Industrial Research
P O Box 10319
Johannesburg
2000
Republic of South Africa

March 1979

Printed in the Republic of South Africa by the
National Institute for Personnel Research

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ACKNOWLEDGEMENTS

Dr G.K. Nelson	:	Director, National Institute for Personnel Research
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Mr J.M. Verster	:	Head, Human Development Division, NIPR

The author wishes to express her indebtedness to the following for their co-operation:

Mrs E. Wood	:	Human Development Division, NIPR
Mr D. Crawford-Nutt	:	Department of Psychology, UNISA
Mr P. Moikangoe	:	Human Development Division, NIPR
Mr C. Chemel	:	Psychometrics Division, NIPR
Miss E.L. Botha	:	Human Development Division, NIPR
Mrs P. Minnaar	:	Human Development Division, NIPR

ABSTRACT

This study examines the differences in scores obtained by educated Black respondents and educated White respondents on tests of conceptual flexibility. These differences are then compared to the differences in scores obtained by the same respondents on tests of conceptual reasoning ability. As previous research had indicated the possibility of a difference in cognitive style between Black and White subjects, it was expected that significant differences would occur between these groups on tests of conceptual flexibility but not on tests of conceptual reasoning ability.

Significant differences occur between the groups on both the flexibility and the reasoning ability tests. These results may be partially due to inadequate sampling. Each sample (Black and White) consisted of a group of employees who had passed a stringent selection test, and a group of scholars in their Matric year. Too few employees were tested, and the groups of Black and White scholars could not be regarded as equivalent to one another. Problems were also experienced with clear differentiation of constructs and validity of tests. The findings from this study can therefore not be regarded as conclusive.

SAMEVATTING

Hierdie studie gaan verskille in tellings wat deur opgevoede Blanke en Swart proefpersone op toetse van konseptuele buigsaamheid behaal is, na. Hierdie verskille word dan vergelyk met verskille in die tellings wat deur dieselfde proefpersone op konseptuele redeneringstoetse behaal is. Aangesien vorige navorsing op die moontlikheid gedui het van 'n verskil in kognitiewe styl tussen Blanke en Swart proefpersone, was die verwagting dat betekenisvolle verskille tussen hierdie groepe op toetse van konseptuele buigsaamheid sou ontstaan, maar nie op toetse van konseptuele redeneringsvermoë nie.

Betekenisvolle verskille kom tussen die groepe voor op beide die buigsaamheids- en die redeneringstoetse. Hierdie uitslae mag deels aan 'n ontoereikende steekproef toe te skryf wees. Elke proefgroep (Swart en Blank) het bestaan uit 'n groep werknemers wat 'n streng keuringstoets duergekom het, en 'n groep skoliere in hul matriekjaar. Te min werknemers is getoets, en die groepe Swart en Blanke skoliere kon nie as ekwivalent aan mekaar beskou word nie. Probleme is met duidelike differensiasie van konstrukte ondervind, asook met die geldigheid van toetse. Die bevindings van hierdie studie kan dus nie as onweerlegbaar beskou word nie.

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1. INTRODUCTION

Rigidity and flexibility have, in the past, been studied almost exclusively as personality traits (Godsell 1976 pp 11 - 14). However, in the light of the current debate concerning the validity of trait theory (Mischel 1964, 1968; Endler 1973), and given the amorphous nature of a concept such as "a flexible personality" it was decided in this study of flexibility to work only in a small, clearly defined area of flexibility. Cognitive or conceptual flexibility seemed to be a suitably limited area, and one in which it would be possible to develop clear experimental definitions. Most important, it was hoped that study in this particular area would cast light on a subject of much concern today : the perceived differences in flexible behaviour between blacks and whites in an industrial setting.

There could be many reasons for these differences. The cause could lie in a background of rigid schooling for the blacks, with little opportunity for the development of independent thinking or behaviour. Or it could be related to the environment in which many black employees work, which does not allow for a display of initiative or assist the development of self-confidence. It could have something to do with the different opportunities and expectations of the individual in black and white societies. Some of these factors, or others not yet fully understood, might also contribute to differences in cognitive style - thinking and solving problems in different ways. This study examines the last possibility, that of a difference in cognitive style between blacks and whites, with the whites displaying more cognitive or conceptual flexibility than the blacks.

While much evidence is available concerning the effect of culture on cognition (Berry and Dasen, 1974; Tajfel 1969; Greenfield and Bruner, 1966), three studies in particular lead us to expect a possible cultural difference in the specific area of flexibility. The first is a study by Lovell written in 1955. Lovell compared the performance of two groups of British adolescents on various tests of intellectual ability. One group had a background of low stimulation, and the other group had a background of high stimulation. The term "stimulation" referred to both school and home environment, and reflected "inherited traits ... early upbringing and environment, cultural background, quality of teaching, and school atmosphere generally" (Lovell, 1955, p 208). While the low and high-stimulation groups were matched for general intelligence, and the low-stimulation group actually scored slightly better on verbal intelligence,

Lovell found a substantial difference between the groups on a factor called categorisation, strongly linked to mental flexibility, with the high-stimulation group obtaining better scores on this test.

Vernon (1972) supports Lovell's findings when he stresses the problems of education in developing countries, where schoolchildren may come from a background that is not academically oriented, and where classes are often very large. He suggests that "peripheral" skills such as spelling and arithmetic can be fairly successfully communicated in these circumstances, but that it is very difficult to develop "logical reasoning, flexibility of mind (and) ... initiative" (Vernon, 1972, p 231).

Lovell's and Vernon's comments would appear to have particular relevance to South Africa, and the differing degrees of stimulation and individual attention generally provided in black and white schools (Godsell, 1976, pp 28 - 29).

The third important article for this study is Kendall's (1974) report on "The development of an advanced version of the Form Series Test for use among literate black industrial workers". The Form Series Test is a series continuation test using size, colour, and shape as elements of the patterns. Kendall found, when studying responses to the test, that certain of his African subjects appeared to have difficulty in changing their *style* of problem-solving from the perceptual to the conceptual where such a change was required. This finding was in line with the work of other psychologists and anthropologists quoted by Kendall, and he suggested that "non-verbal rigidity as a feature in the structure of intellect of non-westerners should be seen as a future research priority for cross-cultural research" (Kendall, 1974, p 54).

For the purpose of this study, flexibility is defined as "the ability to change set when circumstances demand it" (see Godsell, 1976, p 14). Many ostensibly rigid responses to flexibility tests turn out, on further examination, to be the most efficient methods of solving a given problem (Luchins, 1951). The phrase "when circumstances demand it" has therefore been included in the definition to make it quite clear that it is not merely a *preference* for flexible or varied behaviour on the part of the subject which is being tested, but the *ability* to respond in a flexible fashion when such a response is called for.

Flexibility is, in this study, regarded as being an ability separate from conceptual reasoning ability.

2. AIMS AND HYPOTHESES

2.1 Aims

This study is designed to ascertain whether groups of educated black and white subjects differ more widely on tests which assess conceptual flexibility than they do on tests of conceptual reasoning ability.

The first task of the experimenter was therefore to select and/or develop a suitable battery of tests to measure conceptual flexibility and conceptual reasoning ability. Having prepared the tests, the next task was to administer them to samples of educated black and white subjects, and compare the results, looking particularly at the relationship between conceptual flexibility and conceptual reasoning ability scores within each group, as well as comparing scores across the groups.

2.2 Hypotheses

The first hypothesis concerns the expected difference in performance on flexibility tests between black and white subjects. It is anticipated, on the basis of the findings cited in the introduction, that there will be a difference in performance between the groups, with the whites achieving significantly higher scores than the blacks. The null hypothesis is formulated as follows :

H_1 : There is no difference in conceptual flexibility between blacks and whites.

The second hypothesis concerns the relationship between conceptual reasoning ability and conceptual flexibility. It is anticipated that the difference between the scores of blacks and whites on the flexibility tests will be larger than any difference that may occur between the two groups on the conceptual reasoning ability tests. The null hypothesis is formulated as follows :

H_2 : The difference in conceptual flexibility between black and white groups is the same as the difference in conceptual reasoning ability between the two groups.

3. EXPERIMENTAL DESIGN

3.1 Experimental Design

In order to test H_1, instruments had to be found which would measure conceptual flexibility as defined in section 1, and statistical tests for the significance of differences between black and white groups on these measures had to be carried out.

To test H_2, instruments had to be found which would measure reasoning ability in the same cognitive areas as those tapped by the flexibility tests. Obviously no direct comparison could be made between scores on different tests. In order to reject H_2, the conceptual flexibility tests should yield significant differences between black and white groups, while the conceptual reasoning tests should show no significant differences between the two groups.

In order to ensure that the instruments finally selected do, in fact, measure conceptual flexibility and conceptual reasoning ability as two separate variables, correlations will be calculated between the scores on the Progressive Matrices and scores on the other tests. If the variables are being measured separately, the Progressive Matrices score should correlate more highly with the conceptual ability version of a pair of tests (i.e. the Squares Test A and the Gottschaldt) than with the conceptual flexibility version (i.e. the Squares Test F and the Elements Test). The extent to which the conceptual ability version of a test correlates with the conceptual flexibility version will also need to be examined in this regard.

3.2 Test battery

Seven tests were used in the study. Of these, one was a buffer test which was used to acquaint subjects with testing procedures. Three tests were used to measure conceptual reasoning ability, and three to measure conceptual flexibility. Two tests from each of these groups were similar. That is, two variations of one test were drawn up, one variation measuring

reasoning ability and the other flexibility. In this manner two versions of a matches problem (Squares A and Squares F) and two versions of an embedded figures problem (the Gottschaldt test and the Elements test) were used.

In an attempt to limit the effect of language differences on the scores, tests making minimal demands on language proficiency were used.

3.2.1 The Spatial Orientation test is a test adapted by Crawford-Nutt (1976) to serve as an easy "buffer" test to familiarise subjects with testing procedures and increase their confidence. Subjects are required to examine a series of drawings of triangles which are all the same size and shape, but have different orientations. The subjects must determine which triangle in each set of drawings has been reversed instead of merely rotated. For the adapted version of the test each subject is given a cardboard triangle identical to the triangles in the drawings. The subjects can then manipulate these shapes to help them identify the reversed triangle, and should experience no difficulty in answering all test items correctly.

As this test was included solely as an introductory test, it was not scored.

3.2.2 The Standard Progressive Matrices was included in the battery as a measure of conceptual reasoning. It is a well-known test which was developed by G C Raven in 1936 as a test of "observation and clear thinking", and has often been used in a cross-cultural context (Irvine 1969). It is a pattern-completion test, with only one correct answer for each problem.

3.2.3 The Squares Test A is an adaptation of the squares test (Verster, 1975) along the lines of Guilford's Match Problems II, cited by French, Ekstrom and Price (1963). It is used in this battery as a figural test of reasoning ability. Both the number of lines to be removed from a printed pattern of squares, and the number of complete squares to be left in the pattern, are given. The subject is required to find only one correct solution to each problem.

3.2.4 The Squares Test F. This is an adaptation by Verster (1975) of a test called Match Problems V, described by French, Ekstrom and Price (1963) as a measure of figural adaptive flexibility. The subject is presented, in each item, with four identical printed patterns of squares. From each pattern he must remove the same number of lines, leaving behind a pattern of completed squares. Four different solutions must be presented for each item. In this study, 'different' means only 'non-identical'. Although French used elaborate criteria for assessing which different-seeming patterns did not, in fact, involve the application of a new principle, this method was not used here. The distinctions between old and new principles are sometimes rather abstruse, and were not regarded as being suitable for all the subjects in this study. Patterns of squares were carefully selected to ensure that it was not possible to use a single strategy to solve all four problems in an item. The test scores were weighted, so that subjects who completed four patterns in an item received ten points for that item, those completing three patterns received six points, two patterns three points and one pattern only one point. This system of marking was explained clearly to the subjects before the test was administered.

3.2.5 The Gottschaldt Figures Test was developed by the N I P R in 1956 using Gottschaldt's concepts concerning embedded figures. It is a measure of perceptual analysis or analytical reasoning. The subject is required to determine which of a series of simple figures is hidden or embedded in each of the complex patterns which constitute the test items. As only one figure is hidden in each complex pattern, only one answer can be provided for each item.

3.2.6 The Elements Test is an adaptation of the Common Elements Test developed by Schmidt (1970, 1971). In Schmidt's test, based on the Gottschaldt Figures Test, subjects must discover which hidden elements are common to pairs of complex patterns. The figures from his test have been used for this study, but have not been paired. Subjects are simply required to find the different simple elements hidden in each complex figure. This adaptation was made in order to produce a problem with several different solutions. Although only one simple figure is common to each pair of patterns in Schmidt's test, each complex pattern contains several simple figures. The scores in this test were not weighted, the subject receiving only one point for each figure correctly identified.

As the original Common Elements Test had not been drawn up with the intention of having each figure in every complex pattern identified, some ambiguous items were present in the adapted version. These were items in which figures which were fairly similar but not identical to the simple figures which had to be identified, were present. Most of these ambiguous items were identified by a group of judges and removed, bringing the test down from fifty to forty items. Some doubt remained, however, concerning the clarity of the remaining hidden elements. In order to control for possible different interpretations of some simple figures, two scores were obtained for each subject on this test. One score, the "strict" score, was obtained using only those elements which a further panel of three judges, all psychology graduates, had agreed were unambiguous. The other score, a "lenient" score, included items which this second panel of judges regarded as being ambiguous.

3.2.7 Random Sequences. The rationale behind the use of this measure is explained fully in Godsell 1976, pp 32 - 33. Briefly, it was included as a measure of flexibility, on the grounds that the more rigid subjects would tend to produce ordered, rather than random, sequences. The question of whether or not this measure taps the same problem-solving processes as the other tests will be dealt with in the discussion (p 19). The concept of randomness was explained to subjects in detail, with the aid of charts showing different random combinations of the letters of the alphabet. Subjects were then requested to write down random sequences of numbers, using only the digits 0 - 9. Six sequences were produced, subjects working on each sequence for one minute.

The sequences produced were then computer-scored, each sequence being scanned for different possible types of ordered sequence. The different computer scores were to be combined in order to produce a single score indicating degree of randomness.

3.3 Subjects

The sample consisted of four groups of male subjects : white scholars, black scholars, white employees and black employees. The scholars were all in Standard Ten, half-way through their final year of schooling. The employees were employed by a large computer firm. They had all gone through the same stringent selection procedure before being accepted by this organisation. Due to unexpected difficulties, numbers of employees finally tested were very much smaller than had originally

been anticipated. A description of the sample in terms of age and years of schooling appears in table 1. It is perhaps worth noting the greater heterogeneity of the black groups, both scholars and employees, with regard to age.

Table 1

Number, Age and Training of Subjects

Subjects	N	Age		Highest school standard passed		Years at University	
		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Black scholars	67	19,5	1,22	9	0	-	-
White scholars	71	17	0,78	9	0	-	-
Black employees	17	26,7	5,24	10	0	1,12	1,58
White employees	8	21,5	1,85	10	0	,63	1,19

3.4 Administration

All the instructions for the tests were given in English. Following work done by Crawford-Nutt (1976), instructions for all groups were modified to shift the emphasis from individual silent reading of instructions to visual charts presented and explained in detail by the tester. Before commencing the tests, all subjects had to complete examples which were checked by the testers and their assistants, who corrected and explained errors. The tests were administered in order of difficulty, except for the Random numbers exercise which was administered last to ensure that subjects were thoroughly familiar with testing procedures before attempting it. There were two sessions of testing, the first beginning with the buffer test and proceeding to the Progressive Matrices, Squares A and Squares F. The second session began with the Gottschaldt Figures and proceeded to the Elements Test and Random Sequences. The tests for conceptual flexibility were thus preceded by the matched form of reasoning ability tests for the squares and hidden figures tests.

Due to unanticipated unavailability of subjects on certain days, the order of testing had to be reversed for some of the subjects. Half of the sample of black and white scholars began their first testing session

with the Gottschaldt Figures test, and their second session with the buffer test.

Instructions were given to black schoolchildren by a black tester and white schoolchildren by a white tester. The testing of the employees, however, differed somewhat from that of the scholars in that the black employees were not willing to be tested separately from their white colleagues. The employees were therefore tested in small multiracial groups. As the testing of such multiracial groups will probably become increasingly common, it may be useful to set out in detail some of the problems experienced in this particular study.

It is generally argued (Pettigrew, 1964, p 116; Anastasi, 1968, p 572) that the best rapport is obtained between tester and testee when both come from the same cultural, racial and/or language group. When testing multiracial groups in the present study, two testers, one white and one black, were present, and the presentation of the instructions was divided between them. Neither tester appeared (on the purely subjective judgement of both testers) to have particularly good rapport with any group. While some subjects seemed indifferent to the race of the tester, others, from both racial groups, appeared slightly resentful of and uncooperative with a tester from a different racial group. Some of the white subjects seemed to become impatient with the detailed and visually-oriented instructions, and some of the blacks in mixed groups appeared reluctant to ask questions in the face of this impatience. Although these are all subjective impressions gained by the two testers, they do tie in with Crawford-Nutt's (1976) suggestion that black subjects respond better to a different type of instruction to that usually received by white subjects. Perhaps there is a need for more research to determine exactly what method of presentation is best for use with multiracial groups.

4. RESULTS

4.1 Descriptive Statistics

The mean, standard deviation, range and reliability of all tests except the Random Numbers are provided in tables 2A - 2E for all groups. Due to difficulty experienced in obtaining a single score for the Random Numbers exercise, this measure had to be excluded from statistical comparisons with the other tests. The results section therefore includes

only scores obtained on the five other tests : Progressive Matrices, Squares A, Squares F, Gottschaldt and Elements. For the Elements test, the strict score (see 3.2.6) is used throughout, as the correlation between the strict and lenient scores is at a level of ,98 or ,99 for all groups (see tables 3A - 3D).

The reliability of tests, obtained by the split-half method, appears to be satisfactory for all groups.

The significance of differences between the means will be discussed in section 4.3. It is perhaps important to note at this stage that the differences in scores between groups are affected not so much by differences in maximum score as by differences in minimum score. With the exception of the scores for the Gottschaldt figures test, the smallest range is consistently obtained by the white employees group, followed by the black employees. It was to be expected that these groups, which had passed through a strict selection test, would exhibit more homogeneous scores than the unselected groups of scholars. The range for these groups may also have been reduced by a "ceiling effect" for the first three tests, as so many scores clustered at or near the maximum possible score.

Inasmuch as the homogeneity and careful selection of the employee groups is reflected in high mean scores and restricted ranges, the heterogeneity of the scholars is indicated by an extensive range in scores, with the black scholars in particular obtaining some very low minimum scores, and some maximum scores which do not differ substantially from those obtained by other groups. This heterogeneity may well have had an effect on the patterns of scores obtained in this study, and will be examined again in the discussion.

Table 2A

Means, S Ds, Range and Reliability of scores on Progressive Matrices Test

	N	$\bar{X}$	S D	max. poss. score	max. score	min. score	range	reli-ability
White employees	8	56,1	2,7	60	60	53	7	0,67
Black employees	17	53,5	3,4	60	59	48	11	0,74
White scholars	71	51,2	4,5	60	60	37	23	0,82
Black scholars	+ 65	47,5	5,6	60	56	29	27	0,82

Table 2B

Means, S Ds, Range and Reliability of scores on Squares Test A

	N	$\bar{X}$	S D	max. poss. score	max. score	min. score	range	reli-ability
White employees	8	10,6	1,7	12	12	8	4	,86
Black employees	17	10,3	2	12	12	6	6	,87
White scholars	71	9,4	2,3	12	12	4	8	,76
Black scholars	+ 65	8,9	2,8	12	12	1	11	,73

Table 2C

Means, S Ds, Range and Reliability of scores on Squares Test F

	N	$\bar{X}$	S D	max. poss. score	max. score	min. score	range	reli-ability
White employees	8	107,5	17,7	120	120	72	48	0,86
Black employees	17	86,6	28,2	120	120	39	81	0,91
White scholars	71	81,2	28,3	120	120	14	106	0,89
Black scholars	+ 65	64,6	32,1	120	116	2	114	0,92

Table 2D

Means, S Ds, Range and Reliability of scores on the Gottschaldt Figures Test

	N	$\bar{X}$	S D	max. poss. score	max. score	min. score	range	reli-ability
White employees	8	25,6	7,7	45	40	18	22	0,98
Black employees	17	17,9	6,9	45	38	7	31	0,80
White scholars	71	19,1	6,4	45	36	8	28	0,83
Black scholars	†70	11,3	4,9	45	24	2	22	0,73

Table 2E

Means, S Ds, Range and Reliability of scores on the Elements Test

	N	$\bar{X}$	S D	max. poss. score	max. score	min. score	range	reli-ability
White employees	8	49,4	12,2	117	73	35	38	0,72
Black employees	17	55,9	13,3	117	81	28	53	0,94
White scholars	71	56,7	16,6	117	88	24	64	0,96
Black scholars	†70	42	14,3	117	76	10	66	0,90

† Differing N for black scholars due to some subjects being absent for one testing session.

4.2 Correlation matrices - examination of separation of conceptual flexibility and conceptual reasoning ability scores

The patterns of correlations shown in tables 3A - 3D are not clearly consistent. In the group of black scholars, the Progressive Matrices scores correlated highly with almost all other scores. This would indicate that for this group a 'g' factor was important in answering all the tests. Perhaps the heterogeneity of the group contributed to this : those scholars with a low g doing badly on all tests, and those with a high g doing relatively well on all tests. This may indicate that the relationship between conceptual flexibility and conceptual reasoning ability is similar to the relationship between creativity and intelligence outlined by Guilford (1968, pp 128 - 136). Guilford maintains that, although there is no correlation between creativity and intelligence, there is a clear relationship between the two constructs, with low divergent production ability occuring among low IQ-subjects, and both low and high divergent production among high IQ-subjects. That is, a certain level of intelligence is required before creative behaviour can occur, but a high level of intelligence is no guarantee of creativity.

Perhaps conceptual flexibility, too, can only be detected as a separate construct beyond a certain level of conceptual reasoning ability. Further studies should clarify this issue.

The correlations which are of particular interest are those between the Progressive Matrices scores and the scores on the other tests. Although the Progressive matrices scores show a somewhat higher correlation with the Squares test A than with the Squares test F, and with the Gottschaldt than with the Elements test, too much store cannot be laid by this because all correlations achieve significance.

The scores for the white scholars fall more into the anticipated pattern, as the correlation between the Progressive Matrices scores and the Gottschaldt scores (a conceptual ability measure) achieves significance, while the correlation between the Progressive Matrices and the Elements test (a measure of conceptual flexibility) does not achieve significance.
The pattern is not quite so clear with the Squares tests as the Progressive Matrices scores correlate significantly with scores for both the Squares test A and the Squares test F, although the correlation is somewhat higher with the Squares test A.

For the groups in this study which had been carefully selected i.e. the employee groups, very few significant correlations appear. This may be accounted for both by the small number of subjects in this category, and by the restricted range of the scores. For the black employees, as for the white scholars, the correlation between the scores on the Progressive Matrices and on the Gottschaldt achieves significance, while the correlation between the Progressive Matrices scores and the Elements scores is not significant. For this group the correlation between the Progressive Matrices scores and the Squares test A scores is marginally higher than that between Progressive Matrices and Squares test F. For the white employees, the correlation between scores on the Progressive Matrices and scores on the Gottschaldt is only marginally higher than that between the Progressive Matrices scores and the Elements test. The correlation between the Progressive Matrices scores and the Squares test F is, for this group only, higher than that between Progressive Matrices and the Squares test A. The correlation matrix for the white employees must, however, be interpreted with extreme caution because of the small number of subjects in this group.

For the white scholars and black employees, then, the two versions of the hidden figures appeared to be measuring constructs which could be differentiated from one another. For these groups, their scores on the Gottschaldt appeared to be influenced by the same conceptual reasoning factor as that which determined Progressive Matrices scores. Some of the correlation can probably be accounted for by the fact that both tests are figural; the Elements test is, however, also figural and scores on this test do not correlate significantly with Progressive Matrices scores.

The Squares tests do not appear to distinguish clearly between the two separate constructs, as the one correlation which is significant for all groups is that between the scores on the Squares test A and scores on the Squares test F. A possible explanation for this is that the effect of similar stimulus material in the two tests is so strong as to obliterate any variations caused by different answering strategies.

The correlation between the strict and lenient Elements scores is either ,98 or ,99 for all groups. This indicates that exclusion of ambiguous items would not have substantially altered the scores obtained by all subjects on the Elements test. In all the other tables and discussions in this report, therefore, only the strict total will be given for the Elements score.

Table 3A

Correlating test variables for black scholars (n = 65)

		1	2	3	4	5	6
1	Prog. matr.	1,00					
2	Squares test A	*0,38*	1,00				
3	Squares test F	*0,32*	*0,64*	1,00			
4	Gottschaldt	*0,25*	0,07	0,13	1,00		
5	Els. strict total	*0,33*	0,24	*0,30*	*0,41*	1,00	
6	Els. lenient total	*0,40*	*0,26*	*0,31*	*0,43*	*0,99*	1,00

Table 3B

Correlating test variables for white scholars (n = 71)

		1	2	3	4	5	6
1	Prog. matr.	1,00					
2	Squares test A	*0,50*	1,00				
3	Squares test F	*0,43*	*0,71*	1,00			
4	Gottschaldt	*0,36*	*0,37*	*0,33*	1,00		
5	Els. strict total	0,01	0,19	0,16	0,09	1,00	
6	Els. lenient total	0,01	0,17	0,14	0,08	*0,99*	1,00

Table 3C

Correlating test variables for black employees (n = 17)

		1	2	3	4	5	6
1	Prog. matr.	1,00					
2	Squares test A	-0,01	1,00				
3	Squares test F	-0,04	*0,60*	1,00			
4	Gottschaldt	*0,52*	0,29	0,29	1,00		
5	Els. strict total	0,33	-0,32	0,20	0,30	1,00	
6	Els. lenient total	0,29	-0,38	0,19	0,22	*0,98*	1,00

Table 3D

Correlating test variables for white employees (n = 8)

		1	2	3	4	5	6
1	Prog. matr.	1,00					
2	Squares test A	0,47	1,00				
3	Squares test F	0,66	*-0,93*	1,00			
4	Gottschaldt	-0,19	-0,55	-0,61	1,00		
5	Els. strict total	-0,21	-0,12	-0,08	-0,58	1,00	
6	Els. lenient total	-0,17	-0,22	-0,17	-0,51	*0,99*	1,00

Correlations given in italics are significant at $p \leq 0,05$.

4.3 Testing for significant differences in scores obtained by different groups

An analysis of variance was carried out, and for all the tests the differences between the groups were significant. Having obtained significant group differences on all tests, a further analysis was carried out to determine in what way the separate groups differed from one another.

The Bonferoni t-technique (Miller, 1966) was used as only four groups were involved, and every group was compared with every other group on every test. The results are summarised in table 4.

Table 4
Bonferoni t-comparison of groups

	Progress matrices	Squares A	Squares F	Gott-schaldt	Ele-ments
black scholars vs black employees	†b.e.>	†b.e.>	†b.e.>	†b.e.>	†b.e.>
black scholars vs white scholars	†w.s.>	†w.s.>	†w.s.>	†w.s.>	†w.s.>
black scholars vs white employees	†w.e.>	†w.e.>	†w.e.>	†w.e.>	w.e.>
black employees vs white scholars	†b.e.>	w.s.>	b.e.>	w.s.>	w.s.>
black employees vs white employees	w.e.>	w.e.>	w.e.>	†w.e.>	b.e.>
white scholars vs white employees	†w.e.>	w.e.>	w.e.>	†w.e.>	w.s.>

† indicates significance > indicates which of two groups being compared obtained the higher mean score.

Hypothesis 1 states that there is no difference in conceptual flexibility between black and white groups. A comparison of the scores obtained by black employees with those obtained by white employees provides some support for this, as scores only differ significantly on the Gottschaldt test. However, the scores of the black and white scholars differ significantly on every test. A possible reason for some of the differing patterns of scholars and employees is provided when we examine the relationship between the scores of the scholars and the employees. The black scholars differ significantly from the black employees on every test, indicating a large gap in performance between the two groups, while the white scholars differ significantly from the white employees only on the Progressive matrices and the Gottschaldt. The gap between the whites, therefore, does not appear to be as substantial as that between the blacks. This may indicate that a selection procedure such as that applied to the employees isolates, for the blacks, a group with a performance substantially different to that of scholars in their final year of school. For the whites such a marked difference does not appear to exist between a selected group and senior scholars.

It is also important to remember, when we are comparing means, that no proof of functional equivalence has been obtained for the tests used in this study (Poortinga and Foden, 1975). We have no certainty that the tests are interpreted in the same way by the different groups involved in this study, and therefore do not know whether their responses to the tests are in fact comparable.

We should be particularly cautious in the interpretation of table 4. Tables 3A - 3D have already indicated that the test instruments do not differentiate as clearly as they ought to between the different functions, and so we cannot expect a clear pattern of significant differences to emerge. Furthermore, the very small number of subjects in the employees' groups would tend to obscure possible significant differences which might have emerged with larger numbers in the same groups.

4.4 Examination of effects of order of administration

An analysis of variance was carried out to determine whether the differing orders of administration had had different effects on the different race groups. Although significant differences were found on all tests for the two orders of administration, the interaction between race and administration

was not significant on any test except the Elements Test. This may relate to the fact that scores on the Elements Test exhibited a unique pattern throughout, with white scholars obtaining a higher score than white employees, and the difference between white employees and black scholars being non-significant.

5. DISCUSSION AND CONCLUSION

The first question that arises when one begins to interpret the results of this study concerns the validity of the instruments used. This is not an easy question to answer, as there is as yet no clear external criterion against which a test of conceptual flexibility could be measured, nor has an analysis been undertaken of exactly what constitutes flexible behaviour in the workplace. Having defined conceptual flexibility very specifically, an attempt was made to construct/select instruments which complied with that definition, in that the subjects were obliged to find different ways of solving one problem.

However, no control was exercised over the degree to which test instruments may have measured factors other than conceptual flexibility on the one hand and conceptual reasoning ability on the other. In particular, no clarity was obtained at the beginning of the study regarding the anticipated relationship between flexibility and reasoning ability, although it was stated in the introduction that the two were regarded as separate constructs. The two factors may well both have been present in some of the tests which purported to measure only one or the other. It would not have been possible to do well on the "flexible" version of a test without having done well on the "reasoning ability" version, thus a measure of reasoning ability was certainly present in the flexibility measures. A certain measure of flexibility may also have been present in a reasoning ability test such as the Gottschaldt, where the subject is expected to be sufficiently field-independent to differentiate between figure and ground (Witkin and Berry 1975).

It is clear from the results (see tables 3A - 3D) that the instruments selected did not differentiate clearly between the constructs they were intended to measure for all tests and all groups. Mutual confounding of two constructs may provide a partial explanation. It would appear that merely altering the format of a test so that one version requires a single solution to each problem and a second version, several solutions, does not necessarily differentiate adequately between reasoning ability and

flexibility. Either the effect of the methodology will be so strong as to obliterate any variations caused by different answering strategies, as appears to have happened with the squares tests, or each test may include elements of the construct it is not supposed to be measuring, as with the hidden figures tests.

Gordon (in preparation) has obtained results using the Squares test F which tend to support these speculations. She used the test, along with other measures of spatial and reasoning ability, to study cognitive style and achievement in mathematics. It was found that a large proportion of the variance in Squares test F scores was due to reasoning and spatial ability. A discriminant analysis gave some indication of the presence of a potential flexibility factor, but no significant correlations were obtained. This finding lends weight to the suggestion that factors of reasoning and flexibility are both measured by this test. It appears to have potential, but requires further modification before it can be regarded as a pure measure of flexibility.

For a further study both of the constructs involved, (i.e. conceptual flexibility and conceptual reasoning ability) and their expected relationship with one another, will need to be clearly defined. Ideally, industry-related external criteria will also be defined, against which the validity of the instruments may be measured.

The unique configuration of scores obtained by the different groups on the Elements test has already been referred to. The inconsistencies of the scores obtained from this test in almost all of the statistical analyses carried out, must cast serious doubt on its usefulness in this context.

The random numbers exercise proved more difficult to score than had been anticipated, and the scores which were obtained were not very useful. It is possible that, despite the care taken with the instructions, the concept of randomness was not understood very well, in particular by the black scholars. For this test, subjects had to carry out a single task requiring a flexible approach, rather than solving different problems in a flexible fashion. This test may therefore have tapped a totally different domain of flexibility, and should not have been included along with the other problem-solving tests.

Having raised the question of the existence of different domains of flexibility, it is worth noting that low correlations between the flexibility tests may also have been due to the fact that each test tapped a different facet of the same construct. Just as one would not expect all the factors of creativity to demonstrate a high positive correlation with one another, so the different flexibility instruments may be tapping conceptual flexibility, but in areas that have little in common with one another. The same phenomenon may also be responsible for the low intercorrelations between the different conceptual reasoning scores.

The subjects selected also proved unsuitable for the topic under discussion. The differences in reasoning ability between the black and white scholars were too great to allow for any useful analysis of differences in flexibility scores. The numbers of the samples of employees were too small for any confidence to be placed in the patterns of significant differences in mean scores which emerged in these groups.

The only significant difference to emerge between the mean scores obtained by black and white employee groups is on the Gottschaldt test (a further indication that the Gottschaldt test and the Progressive Matrices test are measuring performance in different domains), but with a larger number of subjects significant differences may have appeared on other tests as well.

On the basis of the results in Table 4, hypothesis 1, that there is no significant difference in conceptual flexibility between black and white groups, must be rejected for the scholars but cannot be rejected for the employees.

Hypothesis 2, that the difference in conceptual flexibility between black and white groups is the same as the difference in conceptual reasoning ability between the two groups, cannot be rejected for either group.

This finding, however, by no means disproves the existence of a separate factor of flexibility which influences black responses in both testing situations and actual industrial environments. Because of all the drawbacks to this study which have been discussed, another study, using more carefully validated instruments and a large sample of industrial subjects, would need to be carried out.

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