Social Behavior and Personality, 1990, **18**(2), 299-308.

DOI 10.2224/sbp.1990.18.2.299

BLACK-WHITE DIFFERENCES IN REACTION TIMES AND INTELLIGENCE

RICHARD LYNN
MANDA HOLMSHAW
University of Ulster, Coleraine, Northern Ireland and Pretoria, South Africa

350 black South African 9-year-old children were compared with 239 white British children on the Standard Progressive Matrices and 12 reaction time tests giving measures of decision times, movement times and variabilities in tasks of varying complexity. The black children obtained a mean IQ of approximately 65. They also had slower decision times and greater variabilities than the white children, but they had faster movement times. The magnitude of the white advantage on decision times was 0.68 of a standard deviation, about one-third of the white advantage on the Progressive Matrices. The result suggests that around one-third of the white advantage on intelligence tests may lie in faster information processing capacity.

In recent years a number of studies have reported positive correlations between intelligence as measured by standard intelligence tests and reaction times (Jensen, 1982; Eysenck, 1982; Vernon, 1983). The theoretical explanation advanced for these correlations is that reaction times measure the neurological efficiency of the brain and that this also expresses itself in the performance of intelligence tests, thereby bringing the two into positive correlation.

This discovery has some potential for the problem of black-white differences in intelligence. It has become well established through numerous studies in the United States that blacks obtain lower mean IQs than whites (Shuey, 1966; Jensen, 1972; Loehlin, Lindzey and Spuhler, 1975). More recently it has been found that this is also the case in Britain (Scarr, Caparulo, Ferdman, Tower, and Caplan, 1983; Mackintosh and Mascie-Taylor, 1985). There is no general agreement on the reason for this difference. Some have argued that genetic differences are probably involved (Jensen, 1972; Loehlin, Lindzey and

Spuhler, 1975; Vernon, 1979). Others maintain that environmental factors are solely responsible (Flynn, 1980; Scarr, 1984; Rose, Kamin, and Lawontin, 1984). The principal environmental factors advanced to explain the difference are that the tests are biased in favor of whites and that blacks are disadvantaged by prejudice, discrimination and low socioeconomic status.

The present paper reports a study on the question of whether the black-white differences in intelligence are also present in reaction times. The interest of this question lies in the work showing that reaction times are associated with intelligence and the theory advanced by several workers in this field that reaction times provide a measure of the neurological efficiency of the brain (Jensen, 1982; Eysenck, 1982; Vernon, 1983). If the black-white differences in intelligence are also present in reaction times, it can be inferred that the causes of the differences lie at the neurological level. Alternatively if there are no black-white differences in reaction times, it can be inferred that the causes of the differences lie at the social level and result from such factors as test bias, prejudice and discrimination. A third possibility is that black-white differences in reaction times might be present but of lesser magnitude than those in intelligence tests. Such a result would indicate that both neurological and social factors contribute to the differences in intelligence.

A further question investigated is whether any black-white differences that may exist in reaction times may be related to the complexity of the reaction time tasks. Reaction time tasks can be broken down into movement times, simple reaction times involving the decision time taken in responding to a single stimulus, and complex reaction times involving discrimination between several stimuli. There is some evidence that the more complex reaction times are more highly correlated with intelligence (Jensen, 1982). It might therefore be expected that if black-white differences in reaction times exist they would be greater for complex than for simple reaction times. The study to be reported presents evidence on this question.

METHOD

The subjects consisted of 9-year-old black children in South Africa and white children in Britain tested in 1988. In both countries the children were obtained from socially representative state primary schools. There were 350 black children consisting of 196 boys and 154 girls with a mean age of 113.5 months, *SD* = 3.4. The British children numbered 239 and consisted of 110 boys and 129 girls with a mean age of 113.3 months, *SD* = 3.5. Thus the British children were on average younger than the South African children by 0.2 of a month or about 5 days, which can be considered negligible, and the standard deviations of the two samples are virtually identical.

It is useful to establish that both samples of children were representative of their respective populations. This can be done from their scores on Raven's Standard Progressive Matrices, which was administered to both samples. The mean raw score of the black children on the test was 12.7, *SD* 4.5. this corresponds to the first percentile on the norms of the 1979 British standardisation (Raven, 1981), and the first percentile corresponds to a mean IQ of 65. This may seem a low figure but it is approximately representative of blacks in South Africa. In a recent study by Owen (1989) approximately 1,000 black and white 16-year-olds in South African schools were tested with the Junior Aptitude Test (an omnibus intelligence test of reasoning, verbal comprehension, visuospatial and memory abilities) and Raven's Standard Progressive Matrices. On the Junior Aptitude Test the black-white difference was 2.1 standard deviations, equivalent to a mean black IQ of 68.5. On the Progressive Matrices the black mean was 27.6, equivalent to the 1.5 percentile on the British 1979 standardization norms and an IQ of 67. These results indicate that the mean of the 9-year-olds in the present study is about right for black children in South Africa.

The British children obtained a mean of 36.1, *SD* 9.6, on the Progressive Matrices. This is equivalent to the 56th percentile on the 1979 British standardization norms and an IQ of 102. The British means on the Progressive Matrices have been increasing by approximately 2 IQ points per decade during the last half century (Lynn and Hampson, 1986), so if this increase is projected forward from 1979 to 1988, the mean of the British sample in the study should be precisely representative of British children as of 1988.

In both South Africa and Britain the children were tested on reaction times using the apparatus similar to that described by Jensen and Munro (1979). It consists of a flat black metal box with the top side pitched at a 20° angle. On the top surface of the box is a 15cm radius semicircle of 8 plastic ¾ inch microswitch pushbuttons which are lit from underneath. At the centre of the semicircle, nearest the subject, is a black "home" button. Pressing the home button activates each trial, which is programmed and timed by an Apricot microcomputer. Subjects' data are recorded automatically on the working disk immediately after each trial. The apparatus measures reaction time (time between the onset of a stimulus light and release of the home button) and movement time (time between the release of the home button and depression of the stimulus button). The consistency of response for reaction time and movement time is also measured as the standard deviation of responses across trials (Buckhalt and Jensen 1989). Three conditions were employed in the reaction time experiment. In the first condition simple reaction time was measured. Only one of the lights was employed and the others were masked. Sixteen trials were given, preceded by 3 practice trials (further practice may be given if necessary). In the second condition choice reaction

time was measured. All eight lights were employed. At each of the 16 trials (3 practice trials) one of the lights came on at random. The third condition involved the use of the "Odd Man Out" paradigm, which was introduced by Frearson and Eysenck (1986). Thirty odd man out trials (6 practice trials) were presented in two blocks of 15 trials with a rest of approximately 1 minute between them. In each of the trials, three of the eight buttons illuminated simultaneously and te subjects were asked to press the button which was furthest away from the other two (i.e. the odd men out). After the third condition another 16 trials of the second condition were given. When errors occurred due to the subjects
pressing the wrong button, the trials were repeated at the end of the block of trials in that condition. If errors recurred on repetition the trial was repeated until the correct response was made. Trials were logged as errors where the RT was less than 170 msec or greater than (1999 msec in the third condition), and where the MT was less than 40 msec and greater than 999 msec.

The following measures were obtained from the reaction time trials: movement times; simple reaction time; choice (3 bit) reaction time; odd-man-out reaction time; and the variability of reaction times as measured by the standard deviations. Each subject's medians were taken rather than means to minimise the effects of occasional exceptionally fast or slow reaction times. The medians were averaged to give means for the sample.

RESULTS

Descriptive statistics giving means (in milliseconds) and standard deviations for the reaction time parameters for the black and white children are shown in Table 1. Also shown in the right hand column are the black-white differences expressed in standard deviation units. The last two rows in the table give data for choice and odd man out reaction times less simple reaction times. These data are presented to test the hypothesis that the cognitive processes involved in choice and odd man out reaction times might be measured more accurately if the processes involved in simple reaction times were removed. However, these two readings do not show either greater black-white differences or higher correlations with the Progressive Matrices (shown in Table 2). Hence the hypothesis has to be rejected and these data are not considered further.

The black-white differences show that whites obtain significantly faster reaction times in the simple and odd man out tasks and non significantly faster times in the choice task. Blacks show significantly faster movement times in the choice and odd man out tasks. For the simple movement time task the movement times are virtually identical. Blacks show significantly greater variabilities on all tasks.

TABLE 1: MEANS AND STANDARD DEVIATIONS OF SOUTH AFRICAN BLACK AND BRITISH WHITE CHILDREN ON REACTION TIME PARAMETERS, AND BLACK-WHITE DIFFERENCES EXPRESSED IN STANDARD DEVIATION UNITS

	Blacks		**Whites**		**Difference**
Reaction Times	***Mean***	***SD***	***Mean***	***SD***	***SD Units***
Simple reaction time	298.0	68.6	371.2	63.7	-0.90*
Simple movement time	235.9	44.8	236.2	64.7	0.01
Simple reaction time-*SD*	128.9	32.4	89.8	34.8	-1.17*
Simple movement time-*SD*	68.7	26.6	52.3	28.2	-0.60*
Choice reaction time	488.8	75.5	480.1	70.9	-0.12
Choice movement time	236.1	38.3	261.0	75.7	0.47*
Choice reaction time-*SD*	155.4	27.5	110.4	33.7	-1.50*
Choice movement time-*SD*	70.4	22.4	55.9	25.2	-0.62*
Omo reaction time	924.0	215.4	897.8	184.8	-0.38*
Omo movement time	255.7	66.9	296.7	108.6	0.49*
Omo reaction time-*SD*	332.1	95.9	285.0	97.8	-0.49*
Omo movement time-*SD*	119.0	50.0	110.1	47.5	-0.18*
Choice-simple rt	90.8	55.8	108.8	55.9	0.32*
Omo-simple rt	526.0	200.5	526.6	172.9	0.00

Asterisks denote statistically significant differences at the 5 percent level tested by t tests

Table 2 shows the correlations between the 12 reaction time parameters and the Progressive Matrices for blacks and whites and for the combined samples, weighted by sample size. It will be seen that in the white sample all the correlations are negative and all but two are statistically significant, confirming previous results of an association between fast reaction times and intelligence (the correlations are negative because fast reaction times are expressed as low scores in milliseconds). Among the black sample the correlations are also predominantly negative and six of them are statistically significant. In general the South African correlations are a little lower than the British, possibly because the Progressive Matrices variance is smaller (the standard deviation is 4.5 as against 9.6 in the British sample). It is curious that in the South African sample the movement times are significantly correlated with the Progressive Matrices but the reaction times proper (decision times) do not show this correlation.

In order to ascertain the factor structure of the 12 reaction time parameters in the two samples, both sets of data were analyzed by principal axis analysis followed by varimax rotation. The correlation matrices for the two samples are shown in Table 3. Principal axis analysis showed three significant factors in the black sample. The white sample produced a marginal fourth factor, but three factors were used in the varimax rotation to keep the analyses comparable in the two samples.

TABLE 2: PRODUCT MOMENT CORRELATIONS OF REACTION TIME PARAMETERS WITH STANDARD PROGRESSIVE MATRICES AMONG BLACK AND WHITE CHILDREN (DECIMAL POINTS OMITTED).

	Correlations with Progressive Matrices		
Reaction Times	**Blacks**	**Whites**	**Combined Sample**
Simple reaction time	-01	-25***	-11*
Simple movement time	-12**	-20***	-15**
Simple reaction time-*SD*	-11*	-06	-09
Simple movement time-*SD*	-08	-12*	-10*
Choice reaction time	01	-34***	-14**
Choice movement time	-15**	-26***	-20***
Choice reaction time-*SD*	02	-09	-02
Choice movement time-*SD*	-18***	-13*	-16**
Omo reaction time	05	-29***	-09
Omo movement time	-17***	-25***	-21***
Omo reaction time-*SD*	08	-27***	-07
Omo movement time-*SD*	-13**	-17**	-15**
Choice-simple rt	02	-14*	-05
Omo-simple rt	06	-22***	-05

1, 2 and 3 asterisks denote statistically significant at the 5, 1 and 0.1 percent levels respectively

TABLE 3: CORRELATIONS MATRIX OF REACTION TIME PARAMETERS FOR BLACKS (BOTTOB LEFT DIAGONAL) AND WHITES (TOP RIGHT DIAGONAL); DECIMAL POINTS OMITTED

	Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1.	Simple reaction time	–	42	42	07	66	31	10	00	35	20	16	-02
2.	Simple movement time	20	–	05	21	35	84	-14	14	19	72	-03	11
3.	Simple reaction time-*SD*	63	16	–	22	24	02	53	19	10	00	26	07
4.	Simple movement time-*SD*	01	30	02	–	11	20	25	29	-02	19	11	16
5.	Choice reaction time	70	18	56	04	–	28	25	08	58	17	29	-07
6.	Choice movement time	11	82	06	28	04	–	-16	27	17	85	02	16
7.	Choice reaction time-*SD*	50	17	43	10	74	05	–	41	15	-08	39	12
8.	Choice movement time-*SD*	01	26	01	23	-01	37	06	–	00	33	15	25
9.	Omo reaction time	37	15	31	08	62	10	56	07	–	01	64	-17
10.	Omo movement time	03	54	01	26	-02	68	04	31	03	–	03	38
11.	Omo reaction time-*SD*	25	08	26	12	45	04	44	08	84	09	–	13
12.	Omo movement time-*SD*	-12	18	-04	22	-16	29	-06	18	-15	60	-02	–

TABLE 4: FACTOR ANALYSIS OF THE REACTION TIME PARAMETERS IN BLACK AND WHITE SAMPLES (DECIMAL POINTS OMITTED)

			Varimax Factors					
	First Principal Factor		I		II		III	
Reaction Times	**Blacks**	**Whites**	**Blacks**	**Whites**	**Blacks**	**Whites**	**Blacks**	**Whites**
Simple reaction time	69	55	02	27	83	62	07	04
Simple movement time	41	79	74	84	25	25	-01	01
Simple reaction time-*SD*	57	28	02	-07	67	34	10	46
Simple movement time-*SD*	17	29	37	17	01	04	10	39
Choice reaction time	84	60	-03	20	83	78	37	06
Choice movement time	33	84	89	93	12	15	-04	09
Choice reaction time-*SD*	71	19	04	-29	61	30	39	78
Choice movement time-*SD*	15	34	40	20	-01	-02	07	58
Omo reaction time	80	41	05	02	36	76	88	-05
Omo movement time	23	75	82	89	-02	-04	01	25
Omo reaction time-*SD*	66	27	08	12	20	50	85	29
Omo movement time-*SD*	-01	20	47	22	-15	-17	-06	36

Table 4 shows the loadings of the reaction time parameters on the first principal factor and the three varimax factors. It will be seen that in both samples the reaction time parameters are fairly highly loaded on the first principal factor except for the three movement time standard deviations. The varimax rotations show a first factor consisting of movement times, a second factor consisting of simple and choice reaction times and standard deviations and a third factor consisting of odd-man-out reaction time and standard deviation. It can be seen by inspection that the factor structure is similar in both samples.

It is an interesting question whether the black-white differences in the 12 reaction time parameters are a function of differences in Spearman's g. It has been argued by Jensen (1985) that black-white differences in cognitive performance are largely g differences. The question is whether this thesis applies to the 12 parameters of the reaction time tasks. In order to answer this question we can take the correlations of the 12 reaction time parameters with the Progressive Matrices as an index of the degree to which they are measures of Spearman's g, and we can then examine whether these correlations are positively associated with the magnitude of the black-white differences on the reaction time parameters. The correlation has been calculated using the correlations between the reaction time parameters and the Progressive Matrices on the combined samples, given in column 3 of Table 2. The correlation is 0.87 and is statistically significant at the 5 percent level. The direction of the correlation indicates that the reaction time parameters on which blacks have the greatest advantage (movement times in the choice and odd-man-out tasks) are those which have the highest association with the Progressive Matrices. This is a paradoxical result, since it would be expected that the reaction time parameters most highly associated with the Progressive Matrices would be those on which whites would have the greatest advantage.

It is possible that each of the 12 reaction time parameters measures a different component of information processing capacity and therefore that the complete battery will predict Progressive Matrices scores better than any individual measure. This can be tested by multiple regression. The resulting multiple correlations are 0.29 for the black sample and 0.51 for the white, both of which are statistically significant at the 0.1 percent level and greater than any of the individual correlations shown in Table 2.

DISCUSSION

There are three significant features of the results. Firstly, in the white sample the speed of reaction times and movement times are significantly correlated with intelligence at about the same magnitude of around 0.2 as found in American studies such as that of Buckhalt and Jensen (1989). However, these associations are not so clear cut in the black sample, in which movement times and the variabilities are significantly associated with intelligence, but the three reaction times proper (decision times) do not show the correlation. There is no apparent explanation for this discrepancy.

Secondly, when the black-white differences are considered there is a contrast between performance on reaction times and movement times. Whites are significantly faster on simple and odd-man-out reaction times and show lower variabilities on all the tasks. This is as would be expected, because fast reaction times and low variabilities are associated with intelligence, and the whites have a higher mean IQ. However, the movement times present a paradox. Fast movement times are associated with high intelligence, both in the present data and in the results of Buckhalt and Jensen (1989). Yet blacks have significantly faster movement times in the choice and odd-man-out tasks. The faster movement times and slower reaction times of the black children suggests that the two components of reaction times must involve different neurological processes.

Thirdly, while the white children show significantly faster reaction times and lower variabilities, the magnitude of this advantage in standard deviation units is not so great as their advantage on the Progressive Matrices.

On the means and variabilities of the 6 reaction times proper (decision times), the white advantage lies between 0.12 and 1.50 standard deviations and averages 0.68 suggesting a white advantage in basic information processing capacity of approximately two-thirds of a standard deviation. The white advantage on the Progressive Matrices is a little over two standard deviations, most of which must be attributed to some source other than information processing capacity.

REFERENCES

Buckhalt, J. A. and Jensen, A. R. (1989). The British Ability Scales speed of information processing subtest: what does it measure? *British Journal of Educational Psychology*. **59**, 100-107.

Eysenck, H. J. (1982). Introduction. In H. J. Eysenck (ed.) A *Model for Intelligence.* Berlin: Springer-Verlag.

Flynn, J. R. (1980). *Race, IQ and Jensen.* London: Routledge Kegan Paul.

Frearson, W. and Eysenck, H. J. (1986). Intelligence, reaction time and the "oddman-out R. T. Paradigm. *Personality and Individual Differences,* **7**, 6, 807-818.

Jensen, A. R. (1972). Genetics and Education, London: Methuen.

Jensen, A. R. (1982). Reaction Time and Psychometric g. In A *Model for Intelligence.* In H. J. Eysenck (ed.), Berlin: Springer-Verlag.

Jensen, A. R. (1985). The nature of the black-white difference on various psychometric tests: Spearman's hypothesis. *The Behavioural Brain Sciences*, **8**, 193-263.

Jensen, A. R. (1987). Process differences and individual differences in some cognitive tasks. *Intelligence*, **11**, 107-136.

Jensen, A. R. and Munro, E. (1979). Reaction time, movement time and intelligence. *Intelligence,* **3**, 121-126.

Loehlin, J. C., Lindzey, G. and Spuhler, J. N. (1975). *Race differences in intelligence.* San Francisco: W.H. Freeman.

Mackintosh, N. J. and Mascie-Taylor, C. G. N. (1985) The IQ question. In *Education for* All (The Swann Report) Cmnd paper 9453. London: HMSO.

Rose, S. Kamin, L. & Lewontin, R. (1984). *Not in Our Genes.* Slough: Penguin.

Scarr, S., Caparulo, B. K., Ferdman, B. M., Turner, R. B. and Caplan, J. (1983). Developmental status and school achievements of minority and non-minority children from birth to 18 years in a British Midlands town. *British Journal of Developmental Psychology,* **1**, 31-48.

Lynn, R. and Hampson, S. (1986). The rise of national intelligence: evidence from Britain, Japan and the United States. *Personality and Individual Differences*, **7**, 23-32.

Owen, K. (1989). *Test and item bias: the suitability of the Junior Aptitude Tests as a common battery for white, Indian and black pupils in Standard 7.* Pretoria: Human Sciences Research Council.

Raven, J. (1981). *Manual for Raven's Progressive Matrices and Mill Hill Vocabulary Scales.* London: H. K. Lewis.

Shuey, A. M (1966). *The testing of Negro Intelligence*. New York: Social Science Press.

Vernon, P. A (1983). Speed of information processing and general intelligence, *Intelligence*, **7**, 53-70.

Vernon, P (1979). *Intelligence: Heredity and Environment.* San Francisco: W. H. Freeman.

Requests for reprints should be addressed to:

RICHARD LYNN
Professor Psychology
University of Ulster at Coleraine
Coleraine
Co. Londerderry BT521SA
Northern Ireland