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REACTION TIMES AND INTELLIGENCE IN CHINESE AND BRITISH CHILDREN [1]

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Summary.—239 British and 118 Chinese Hong Kong nine-year-old children, each representative for intelligence of Britain and Hong Kong, were tested on the Standard Progressive Matrices and on reaction times. The reaction time apparatus measured simple and complex reaction times proper (i.e., decision times), movement times, and variabilities. The results showed that all the reaction time measures were associated with intelligence and that Hong Kong children had a higher mean IQ and faster reaction times than British children. This suggests that the difference in mean IQ between Hong Kong and British children has a neurological basis. However, the British children showed faster movement times and lower variabilities, contrary to expectation. This suggests independent neurological processes may underlie reaction times, movement times, and variabilities.

Several studies have found that the mean IQ of Chinese children in Hong Kong is higher than that of Caucasian children in Britain and the United States. In this paper we address the question of whether Chinese Hong Kong children also have faster reaction times than Caucasian children. The interest of this question is that reaction times have been found to be associated with IQs and have been proposed as measures of the basic neurological processes underlying intelligence, which can be identified as the accuracy or speed of the neurological transmission of information in the nervous system (Eysenck, 1982; Jensen, 1982). Hence data on the reaction times of Hong Kong children should show whether their high intelligence is explicable in terms of basic cognitive processes measured by reaction times, or alternatively, whether explanations have to be sought elsewhere, e.g., possibly in test bias in favour of Chinese children, in training in cognitive skills by parents, in schools, or other factors.

The major study showing a high mean IQ in Chinese children in Hong Kong is by Lynn, Pagliari, and Chan (1988). This paper reports results for standardizations of Raven's Standard Progressive Matrices in Hong Kong on 13,822 children in 1968 and 4,500 children in 1982. The two samples obtained mean IQs of 103.4 and 109.8 in relation to British means of 100. A study of 376 Chinese Hong Kong 9-yr.-olds tested on Cattell's Culture Fair Test gave a mean IQ of 104.5 (Lynn, Hampson, & Lee, 1988). In a further study, 4,858 Chinese Hong Kong 6-yr.-olds tested with the Coloured

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Progressive Matrices in the years 1981-84 yielded a mean IQ of 116 (Chan & Lynn, 1988). The reason for this high figure is probably that the Coloured Progressive Matrices has a visuospatial component, on which Oriental children appear to be particularly strong (Lynn, 1987).

The literature on the association between intelligence and reaction times is reviewed by Jensen (1982) and Eysenck (1982). Reaction times have been broken down into five components. These are 'movement times,' i.e., the time taken to move the hand from one button to another; 'simple reaction times,' involving the decision time taken to respond to a single stimulus; 'choice reaction times,' involving decision times where more than one stimulus is presented; 'the odd-man-out' task of Frearson and Eysenck (1986) where three lights are presented and the subject has to react to the light which is more distant from the other two; and the 'variability of reaction times' as measured by the standard deviation of a number of reactions. In general, it has been found that movement times and simple reaction times have lower correlations with intelligence than choice reaction times, the odd-man-out task, and variabilities (Jensen, 1982; Frearson & Eysenck, 1986).

In the study to be reported, Chinese children in Hong Kong were tested on all five of these reaction time parameters and also on Raven's Standard Progressive Matrices. The same tests were given to a comparison group of British children. The objective of the study was to assess whether the Chinese children would display faster times on one or more of the components of the reaction time tasks.

Method

Subjects

The British sample consisted of 239 9-yr.-old children tested with Raven's Standard Progressive Matrices and on reaction times, in 1988. The sample consisted of 110 boys and 129 girls whose mean age was 113.3 mo. ($SD = 3.4$). The sample was drawn from socially mixed primary schools from various locations in the United Kingdom. The mean Progressive Matrices raw score of the sample was 36.1 ($SD = 9.6$).

The 1979 50th percentile on the Progressive Matrices corresponds to a raw score of 35 (Raven, 1981) and the mean raw score of the present sample corresponds to the 56th percentile on the 1979 restandardization of the Progressive Matrices on British children and hence to an IQ of 102 (6 percentile points are approximately equivalent to 2 IQ points). The mean of the sample then was fractionally higher than that of the British children as of 1979. This can be attributed to a small secular increase in intelligence over the decade from the 1979 British standardization of the Progressive Matrices to the testing of the sample in 1988. The rate of increase in the mean of the

Progressive Matrices among British children has been approximately 2 IQ points a decade (Lynn & Hampson, 1986) and hence the mean IQ of 102 of the present sample should be closely representative of British children as of 1988.

The Hong Kong sample consisted of 118 Chinese 9-yr.-old children (67 girls and 51 boys) tested in 1988, with a mean age of 113.9 mo. (*SD* 6.7), and drawn from socially mixed primary schools. As with the British sample, it is important to establish that this sample was representative of Chinese Hong Kong children for intelligence. The mean of the sample on the Progressive Matrices was 41.9 ($SD = 3.1$). The Progressive Matrices test was standardized on 4,500 Chinese Hong Kong children in 1982 and the mean score for 9½-yr.-olds was 40 (Lynn, Pagliari, & Chan, 1988). Intelligence has been increasing in Hong Kong, as elsewhere, and the rate of increase over the period 1968-82 has been 6 raw score points. Projecting this increase forward for 1982-88, children in 1988 should have gained a further 2.5 raw score points, bringing the 1982 mean of 40 up to 42.5. The mean of the sample was, as noted, 41.9 and is thus approximately representative of Chinese Hong Kong children as of 1988.

Procedure

Both the British and the Chinese Hong Kong children were tested on reaction times with identical apparatus and procedures. Reaction times were recorded with an apparatus similar to that described by Jensen and Munro (1979). It consists of a flat black metal box with a top side pitched at a 20° angle. On the top surface of the box is a 15-cm. radius semicircle of 8 plastic, ¾-in. 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 (RT, time between the onset of a stimulus light and release of the home button) and movement time (MT, 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 & 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 one minute between them. In each of the trials, three of the eight buttons illuminated simultaneously, and the subjects were asked to press the button which was furthest away from the other two (i.e., the odd-man-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. On the first and second conditions, trials were logged as errors if the RT was less than 170 msec. or greater than 999 msec. or where the MT was less than 40 msec. and greater than 999 msec. In the third condition, trials were logged as errors where the RT was less than 170 msec. or greater than 1999 msec., or where the MT was less than 40 msec. or greater than 999 msec.

The following five 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.

Results

The Chinese Hong Kong and British children differ on the Progressive Matrices by 5.80 raw score points. The mean of the standard deviation of the two samples is 6.35, hence the Hong Kong mean exceeds that of the British by 0.91 standard deviation units.

In both samples the reaction time parameters are negatively correlated with Progressive Matrices scores. Table 1 gives these Pearson correlations for both samples and for the two samples combined. The correlations are all negative because fast reaction times are expressed as low milliseconds and these were correlated with high scores on the Progressive Matrices. In both samples the correlations lie between –.06 and –.34 and are of about the same magnitude as those found by other investigators such as Buckhalt and Jensen (1989). Although the correlations are relatively low, they are consistently negative and the pattern of results as a whole clearly confirms previous work showing a positive relationship between fast reaction times and intelligence.

In the British data, the correlations between the Progressive Matrices and choice and odd-man-out reaction times are a little higher than between Progressive Matrices and simple reaction times, as has typically been found in previous studies, and hence when simple reaction times are subtracted from choice and odd-man-out reaction times, the residuals are significantly associated with the Progressive Matrices [*r*s = −.14 ($p = .05$) and −.22 ($p < .01$)]. However, in the Hong Kong data these relationships do not hold up. Here the odd-man-out correlations with the Progressive Matrices are somewhat lower than the simple and choice reaction times.

TABLE 1
PRODUCT-MOMENT CORRELATIONS OF REACTION TIME PARAMETERS WITH STANDARD PROGRESSIVE MATRICES FOR HONG KONG AND BRITISH CHILDREN AND COMBINED SAMPLES

Reaction Time Measures	Correlations With Progressive Matrices		
	Hong Kong	British	Combined Samples
Simple Reaction Time	−.18*	−.25‡	−.23‡
Simple Movement Time	−.20*	−.20‡	−.20‡
Simple Reaction Time—*SD*	−.24†	−.06	−.15*
Simple Movement Time—*SD*	−.19*	−.12*	−.15*
Choice Reaction Time	−.23†	−.34‡	−.31‡
Choice Movement Time	−.21†	−.26‡	−.24‡
Choice Reaction Time—*SD*	−.29‡	−.09	−.18‡
Choice Movement Time—*SD*	−.23†	−.13*	−.17‡
Odd-Man-Out Reaction Time	−.13	−.29‡	−.25‡
Odd-Man-Out Movement Time	−.16*	−.25‡	−.22‡
Odd-Man-Out Reaction Time—*SD*	−.15	−.27‡	−.24‡
Odd-Man-Out Movement Time—*SD*	−.08	−.17‡	−.15*
Choice RT Minus Simple RT	−.02	−.14*	−.12*
Odd-Man-Out RT Minus Simple RT	−.07	−.22‡	−.18‡

*$p = .05$. †$p = .01$. ‡$p = .001$.

Table 2 presents descriptive statistics for the two samples giving means in milliseconds and standard deviations for the reaction time parameters. Also shown in the right-hand column of the table are the differences between the Hong Kong and British means expressed in standard deviation units. Positive values of the differences show a Hong Kong advantage and minus signs a British advantage. The last two rows in the table give choice reaction times minus simple reaction times and odd-man-out reaction times minus simple reaction times.

The Chinese Hong Kong children obtained a higher mean than the British children on the Progressive Matrices, and the hypotheses are therefore that they should also show faster reaction times and movement times and that their advantage on the choice and odd-man-out tasks should be greater than on the simple reaction times.

The data set out in Table 2 show that this is the case for reaction times but not for movement times. On reaction times the Hong Kong children are fractionally but not significantly faster on the simple reaction times (by 0.16 *SD* units), but they are substantially and significantly faster on the choice and odd-man-out reaction times (by 0.87 and 0.61 *SD* units, respectively).

The Chinese Hong Kong children are also faster when their simple reaction times are subtracted from their choice and odd-man-out times (by 0.89 and 0.60 *SD* units, respectively).

The remaining results are contrary to expectation. The Chinese Hong Kong children's movement times are significantly slower than those of the British children on the simple and odd-man-out tasks (0.50 and 0.25 *SD*s, respectively). Also, the Chinese Hong Kong children's variabilities are consistently greater than those of the British children.

TABLE 2
MEANS AND STANDARD DEVIATIONS OF HONG KONG AND BRITISH CHILDREN ON REACTION TIME PARAMETERS (MSEC.), AND HONG KONG-BRITISH DIFFERENCES EXPRESSED IN STANDARD DEVIATION UNITS

Reaction Time Measures	Hong Kong		British		Difference
	M	*SD*	*M*	*SD*	
Simple Reaction Time	360.6	68.1	371.2	63.7	0.16
Simple Movement Time	272.9	89.9	236.2	64.7	-0.50*
Simple Reaction Time—*SD*	98.6	34.3	89.8	39.8	-0.25*
Simple Movement Time—*SD*	67.7	31.9	52.3	28.2	-0.52*
Choice Reaction Time	422.6	56.1	480.1	70.9	0.87*
Choice Movement Time	267.1	73.8	261.0	75.7	-0.08
Choice Reaction Time—*SD*	114.5	30.2	110.4	33.7	-0.12
Choice Movement Time—*SD*	65.3	25.4	55.9	25.2	-0.37*
Odd-Man-Out Reaction Time	787.4	172.1	897.8	184.8	0.61*
Odd-Man-Out Movement Time	323.2	102.2	296.7	108.6	-0.25*
Odd-Man-Out Reaction Time—*SD*	269.4	100.6	285.0	97.8	0.16
Odd-Man-Out Movement Time—*SD*	136.3	48.0	110.1	47.5	-0.55*
Choice RT Minus Simple RT	61.9	46.4	108.8	55.9	0.89*
Odd-Man-Out RT Minus Simple RT	426.8	156.8	526.6	172.9	0.60*

*$p = .05$ (*t* test).

The hypothesis that it would be useful to subtract simple reaction times from choice and odd-man-out reaction times to obtain better measures of pure decision times was tested by calculating the correlation between these derived measures and the Progressive Matrices. The correlations are given in the last two rows of Table 1. It will be seen that they are zero in the Hong Kong sample and add nothing to the primary measures of simple, choice, and odd-man-out reaction times in the British and combined samples. The hypothesis is disconfirmed, and these two measures have therefore been dropped from further analyses.

It is an interesting question whether the processes which are responsible for the Hong Kong-British differences on the reaction time parameters are a function of the degree to which the reaction time parameters are associated with intelligence. To ascertain the answer to this question, the correlation was calculated between the differences in the reaction time parameters and the correlations of the reaction time parameters with the Progressive Matrices for the combined sample, given in Table 1, Column 3.

It may be objected that the correlations for the combined groups will necessarily reflect the mean differences between the groups in each variable and are thereby spuriously inflated. To overcome this objection, we have calculated the RT–IQ correlations for the combined group with group membership partialed out. This was done by obtaining the square of each r, multiplying each r^2 by its N, obtaining the mean of the two products, dividing by the combined Ns, and taking the square root. After these adjustments, Spearman's rank-order correlation, *rho*, was −0.86, statistically significant at $p<.01$.

TABLE 3

Pearson Correlation Matrix of 12 Reaction-time (RT) Parameters: Hong Kong Children in Bottom Left Diagonal, British Children in Top Right

Variables	1	2	3	4	5	6	7	8	9	10	11	12
						British Children						
1. Simple RT		42	42	07	66	31	10	00	35	20	16	-02
2. Simple MT	58		05	21	35	84	−14	14	19	72	-03	11
3. Simple RT—*SD*	49	31		22	24	02	53	19	10	00	26	07
4. Simple MT—*SD*	34	65	50		11	20	25	29	-02	19	11	16
5. Choice RT	74	34	46	15		28	25	08	58	17	29	-07
6. Choice MT	55	84	27	50	47		−16	27	17	85	02	16
7. Choice RT—*SD*	25	11	68	36	45	15		41	15	-08	39	12
8. Choice MT—*SD*	24	44	58	64	24	49	49		00	33	15	25
9. Odd-Man-Out RT	91	13	24	08	52	15	18	02		01	64	-17
10. Odd-Man-Out MT	37	67	10	29	27	85	-07	34	00		-03	38
11. Odd-Man-Out RT—*SD*	27	00	41	19	34	07	34	20	79	-07		13
12. Odd-Man-Out MT—*SD*	12	16	05	01	01	29	00	30	-15	51	-05	
						Hong Kong Children						

Note.—Decimal points omitted.

We consider now the factor structure of the reaction time parameters in the two samples. The correlation matrices are given in Table 3. The matrices were factored by principal axis analysis which showed a general factor accounting for 39.3% of the variance in the Hong Kong sample and 28.8% of the variance in the British sample. In addition, there were three further factors with eigenvalues above unity in both samples but the fourth factor was only fractionally greater than unity. Hence varimax rotations for three- and four-factor solutions were carried out. The three-factor rotations provided the better solutions in both samples and are shown in Table 4, together with the general factor. In both samples, the first varimax factor is movement times, as shown by the high loadings of movement times on the simple, choice, and odd-man-out tasks. Factor 2 is reaction times and Factor 3 is reaction time variabilities. The three factors of movement times, reaction times, and variabilities are the same as those obtained by Buckhalt and Jensen (1989) for American 12-yr.-olds. As an index of factor similarity, congruence coefficients were calculated; values were 0.94, 0.98, 0.95, and 0.90 for the four factors shown in Table 4.

TABLE 4
FACTOR ANALYSES OF REACTION-TIME (RT) PARAMETERS IN HONG KONG AND BRITISH SAMPLES

Reaction Time Measures	First Principal Factor		Varimax Factors					
			RT		MT		RT—*SD*	
	Hong Kong	British	Hong Kong	British	Hong Kong	British	Hong Kong	British
Simple RT	.71	.55	.56	.62	.47	.27	.23	.04
Simple MT	.76	.79	.16	.25	.80	.84	.25	.01
Simple RT—*SD*	.66	.28	.33	.34	.10	-.07	.76	.46
Simple MT—*SD*	.63	.29	.07	.04	.39	.17	.57	.39
Choice RT	.64	.60	.65	.78	.28	.20	.24	.06
Choice MT	.83	.84	.21	.15	.93	.93	.19	.09
Choice RT—*SD*	.50	.19	.25	.30	-.08	-.29	.76	.78
Choice MT—*SD*	.68	.34	-.02	-.02	.36	.20	.78	.58
Odd-Man-Out RT	.40	.41	.92	.76	-.06	.02	.00	-.05
Odd-Man-Out MT	.60	.75	.02	-.04	.90	.89	.00	.25
Odd-Man-Out RT—*SD*	.37	.27	.67	.50	-.15	.12	.26	.29
Odd-Man-Out MT—*SD*	.22	.20	-.13	-.17	.37	.22	.06	.36

To examine the association of the reaction time factors with the Progressive Matrices, subjects' Progressive Matrices scores were correlated with their factor scores on the general factor and the three varimax factors. The results are shown in Table 5. It can be seen that in both samples the general reaction time factor has the highest correlations with scores on the Progressive Matrices. Of the three varimax factors, in both samples reaction times have higher correlations with the Progressive Matrices than either movement times or variabilities.

TABLE 5
PEARSON CORRELATIONS BETWEEN FACTOR SCORES AND PROGRESSIVE MATRICES IN HONG KONG AND BRITISH SAMPLES

Measure	Correlation With Progressive Matrices	
	Hong Kong	British
General Factor	-.30‡	-.37‡
Movement Times	-.14	-.22‡
Reaction Times	-.25†	-.31‡
Variabilities	-.15*	-.13*

*$p = .05$. †$p = .01$. ‡$p = .001$.

The final analysis treats all 12 reaction time parameters as measures of different components of information processing efficiency and calculates the multiple regression of the 12 parameters with the Progressive Matrices scores as the dependent variable. The resulting multiple correlation was 0.36 for the Hong Kong sample, indicating that the 12 reaction time parameters account for 13% of the variance in the Progressive Matrices. For the British sample the multiple correlation was 0.51, which accounts for 26% of the Progressive Matrices' variance.

Discussion

The results for reaction times proper (decision times) are according to expectation. The Hong Kong children obtain a higher mean on the Progressive Matrices than the British. They also have faster reaction times on the simple, choice, and odd-man-out tasks, although on the simple task the difference is not statistically significant. Speed of reaction is associated with Progressive Matrices scores in both samples, confirming the results of a number of previous studies. The Hong Kong-British difference on the Progressive Matrices is 0.91 of a standard deviation, while the differences on the choice and odd-man-out tasks are of approximately the same magnitude at 0.87 and 0.61 standard deviations. These results support the hypothesis that the Hong Kong-British difference on intelligence, as measured by the Progressive Matrices, is largely a function of differences in cognitive processing ability, as measured by choice and odd-man-out reaction times.

The general interest of the results is that they suggest that the high means obtained by Chinese Hong Kong children on intelligence tests are explicable in terms of a high level of the neural efficiency of the brain, as measured by the reaction time tasks. This tells against an explanation of the high intelligence test means of Chinese Hong Kong children in terms of possibly superior teaching and training in cognitive skills by parents and schools. The high means of the Chinese Hong Kong children on the reaction time tests may suggest high genotypic intelligence but it is possible that nutritional or other environmental factors affecting the neurological development of the brain could be involved. Whatever the reason for the fast reaction times of Chinese Hong Kong children, the results suggest that it has a biological rather than a social basis.

While these results seem straightforward, the results for movement times and for variabilities are more problematical. In both the Hong Kong and British samples, movement times and variabilities are negatively associated with Progressive Matrices scores, as has been found in other studies. Since the Chinese Hong Kong children score higher on the Progressive Matrices, they would be expected to show faster movement times and lower variabilities. Yet this is not the case. Contrary to this expectation, the Chinese Hong Kong children show slower movement times and greater variabilities. The pattern of results suggests a neurologically independent process of reaction times, movement times, and variabilities which some factors, possibly nutritional, bring into positive correlation within the Hong Kong and British samples but which do not operate between the samples. An alternative hypothesis might refer to differences in the strategies adopted by Chinese and British children. Clearly, further research is required to elucidate these anomalies.

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