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REACTION TIMES AND INTELLIGENCE AMONG HONG KONG CHILDREN[1]

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Summary.—The hypothesis that reaction times are positively associated with intelligence was tested on 479 9-yr.-old Chinese Hong Kong children. Intelligence was measured by the Standard Progressive Matrices, and 12 reaction time parameters were obtained to give measures of movement times, reaction times proper (decision times), differentiated into simple and complex reaction times, and their variabilities. Factor analysis of the reaction time tasks indicated the presence of a general reaction time factor and three component factors identifiable as movement times, reaction times proper, and variabilities. All three components showed statistically significant associations with intelligence of approximately equal magnitudes.

About a quarter of a century ago it was shown by Roth (1964) that the speed of response in choice-reaction time tasks is positively associated with intelligence measured by psychometric tests. This discovery generated considerable interest because it suggests that the neurological basis of intelligence may lie in individual differences in the efficiency of information processing. It has been proposed by Eysenck (1982) that accuracy of neural transmission may be the crucial variable underlying the association. Jensen (1982) has proposed an alternative hypothesis that speed of neural transmission may be the critical variable.

So far as the empirical basis of the association between reaction times and intelligence is concerned, subsequent studies in general confirmed the positive association (Jensen & Munro, 1979; Jensen, 1982, 1987; Vernon, 1983; Frearson & Eysenck, 1986). More detailed analyses of the components of reaction time tasks has suggested that four processes are involved. These are (1) movement time, i.e., the time it takes to move the hand from one button to another; (2) simple reaction time, i.e., the decision time involved when one signal is presented; (3) choice reaction time, i.e., the decision time when two or more signals are presented; and (4) variability of reaction times over a number of trials, generally measured by the standard deviation.

Most of the work on the relation between reaction times and intelligence has been done on adults or adolescents. Among them it has generally been found that choice reaction times and variabilities have the stronger association with intelligence. The association of intelligence with movement

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times and simple reaction times has generally been weaker or nonexistent (Jensen, 1982).

The present paper reports a study of the relation between reaction times and intelligence among children in Hong Kong. There were two objectives of the study: firstly, to examine whether the positive associations between reaction times and intelligence found in western studies of adolescents and adults would be obtained among young Chinese children, and secondly, to divide reaction times into the components of movement times, reaction times proper (decision times) on simple and complex tasks, and variability, and to ascertain how these components are related to intelligence among young children.

Method

The subjects were 479 9-yr.-old Chinese children attending primary schools in Hong Kong. There were 239 boys, 240 girls; their mean age was 114.4 mo., with a standard deviation of 3.1. The children were drawn from socially representative schools serving a mix of middle- and working-class children. All the children were given the Raven's Standard Progressive Matrices as a measure of general intelligence. The reaction times were recorded with an apparatus similar to that described by Jensen and Munro (1979). This apparatus 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 semi-circle 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 computer. The subjects' data are recorded automatically on the working disk immediately after each trial. The apparatus measures reaction time (time between the onset of the stimulus light and release of the home button) and movement time (time between the release of the home button and depression of the response 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 three practice trials (further practice may be given if necessary). In the second condition choice reaction time was measured. All eight lights were employed. On each of the 16 trials (three 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 (six practice trials) were presented in two blocks of 15 trials with a rest of approximately 1 minute between them. On 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. In the first and second conditions trials were logged as errors where the RT was less than 170 msec. or greater than 999 msec. and 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 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. Medians were taken rather than means to minimise the effects of occasional exceptionally fast or slow reaction times.

RESULTS

Descriptive statistics giving means and standard deviations for all the reaction time measures and the Progressive Matrices are given in Table 1. The first six variables are the means and standard deviations for the reaction times and the second six variables are the means and standard deviations of the movement times.

TABLE 1
MEANS AND STANDARD DEVIATIONS OF 12 REACTION TIME PARAMETERS AND PROGRESSIVE MATRICES ($N = 479$)

Reaction Times	*M*	*SD*
M Simple RT	347.3	53.8
M Choice RT	413.0	50.7
M Odd-Man-Out RT	749.8	158.5
SD Simple RT	95.8	28.8
SD Choice RT	112.5	27.0
SD Odd-Man-Out RT	251.4	86.8
M Simple MT	252.1	75.1
M Choice MT	250.9	64.9
M Odd-Man-Out MT	302.5	90.5
SD Simple MT	63.9	26.6
SD Choice MT	62.1	22.9
SD Odd-Man-Out MT	132.7	44.1
Progressive Matrices	47.0	5.4

One of the objectives of the study was to ascertain whether the positive correlations between reaction times and intelligence obtained in American studies are also present in Hong Kong. The correlations between each of the

TABLE 2

PRODUCT-MOMENT CORRELATIONS BETWEEN EACH OF 12 REACTION TIME PARAMETERS AND RAVEN'S STANDARD PROGRESSIVE MATRICES IN PRESENT STUDY AND IN BUCKHALT AND JENSEN'S (1989) STUDY

Reaction Times	Correlations With Progressive Matrices	
	Present Study	Buckhalt and Jensen
M Simple RT	-.19‡	.01
M Choice RT	-.19‡	-.16
M Odd-Man-Out RT	-.20‡	-.17
SD Simple RT	-.14‡	-.09
SD Choice RT	-.15‡	-.22*
SD Odd-Man-Out RT	-.17‡	-.15
M Simple MT	-.20‡	-.17
M Choice MT	-.18‡	-.24*
M Odd-Man-Out MT	-.14‡	-.33*
SD Simple MT	-.11†	.11
SD Choice MT	-.10*	.15
SD Odd-Man-Out MT	-.03	-.07
n	479	78

*$p = .05$. †$p = .01$. ‡$p = .10$.

12 reaction-time parameters and scores on the Standard Progressive Matrices are shown in Column 1 of Table 2. Also shown for comparative purposes are the correlations obtained by Buckhalt and Jensen (1989) on 78 American 12-yr.-olds. It will be seen that the results in the two studies are broadly similar insofar as the general trend of the correlations is negative in both studies. Fast reaction times are represented by low scores and hence correlate negatively with high scores on the Progressive Matrices. The complete correlation matrix is given in Table 3.

TABLE 3

CORRELATION MATRIX FOR 12 REACTION TIME PARAMETERS ($N = 479$)

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. *M* Simple RT												
2. *M* Choice RT	.68											
3. *M* Odd-Man-Out RT	.33	.53										
4. *SD* Simple RT	.49	.38	.16									
5. *SD* Choice RT	.23	.41	.18	.58								
6. *SD* Odd-Man-Out RT	.18	.31	.76	.30	.35							
7. *M* Simple MT	.50	.41	.13	.27	.14	.01						
8. *M* Choice MT	.45	.68	.15	.24	.12	.02	.86					
9. *M* Odd-Man-Out MT	.31	.22	-.01	.10	-.01	-.12	.71	.84				
10. *SD* Simple MT	.27	.18	.00	.46	.17	.15	.60	.47	.36			
11. *SD* Choice MT	.17	.18	.00	.50	.49	.19	.41	.48	.37	.41		
12. *SD* Odd-Man-Out MT	.03	-.09	-.25	.08	.06	-.17	.13	.16	.43	.14	.26	

To examine what factors are present in the data the 12 reaction time correlations were factored by principal axis analysis followed by varimax rotation. There were three factors with eigenvalues greater than unity accounting for 36.8, 19.9 and 13.2% of the variance, respectively. Table 4 shows the loadings of the reaction time parameters on the general factor and the three varimax factors. It will be seen that there is a fairly strong general factor on which all the reaction time variables have appreciable loadings. This may be considered a general reaction time factor. The three varimax factors are identifiable as movement time, variabilities, and complex reaction time. The first factor is movement time, with high loadings of the three movement time measures (.85, .94 and .87). The second factor is reaction time standard deviations or variability, with high loadings of the standard deviations of both the reaction times and movement times (.70, .73, .62, .72), although the standard deviations of the odd-man-out task do not load highly on this factor. The third factor is complex reaction time, with high loadings for choice reaction time and odd-man-out reaction time (.63 and .91).

TABLE 4
FACTOR ANALYSIS OF REACTION TIME PARAMETERS SHOWING LOADINGS ON FIRST PRINCIPAL AXIS FACTOR AND THREE VARIMAX FACTORS

Variables	General Factor	Varimax Factors		
		1	2	3
Mean Simple RT	.61	.04	.23	.44
Mean Choice RT	.59	.33	.24	.63
Mean Odd-Man-Out RT	.33	.05	−.01	.91
SD Simple RT	.59	.13	.70	.25
SD Choice RT	.48	−.04	.73	.24
SD Odd-Man-Out RT	.29	−.12	.28	.65
Mean Simple MT	.80	.85	.23	.10
Mean Choice MT	.83	.94	.17	.11
Mean Odd-Man-Out MT	.65	.87	.07	−.12
SD Simple MT	.65	.40	.62	−.04
SD Choice MT	.64	.33	.72	−.07
SD Odd-Man-Out MT	.17	.25	.16	−.31

The relation of the Progressive Matrices to the reaction time factors was examined by calculating correlations between subjects' factor scores on the general factor and each of the three varimax factors and Progressive Matrices scores. The correlations for the four factor scores were −.24 (for the general factor), −.16 (movement time factor), −.12 (variability factor), and −.19 (complex reaction time factor). All three components of reaction times contribute about equally to psychometric intelligence as measured by the Progressive Matrices. The pattern of results suggests that each of the reaction time parameters may measure a different feature of the efficiency of neurological information processing. This can be checked by calculating the multiple correlation between the 12 reaction time parameters and Progressive Matrices scores. The multiple correlation is 0.29, which is significantly higher than any of the individual correlations between the reaction time parameters and intelligence shown in Table 2 and confirms the interpretation that all of the reaction time parameters (except for the variability of movement times on the odd-man-out task) are associated with psychometric intelligence.

Discussion

There are three principal points of interest in the results. Firstly, they confirm on this large sample of young Hong Kong children the existence of positive correlations between speed of reaction and psychometric intelligence. Eleven of the 12 reaction time parameters show statistically significant correlations with psychometric intelligence measured by Raven's Standard Progressive Matrices. The only exception is variability of movement time in the odd-man-out task, for which the correlations fall between .10 and .20.

Most of the studies reported hitherto have been on quite small numbers of subjects so the low correlations do not reach statistical significance. The large number of children tested in the present study establishes beyond doubt that the correlations between reaction times and intelligence are statistically significant although they are quite low.

Secondly, the factor analysis shows that reaction times can be separated into three components consisting of movement times, reaction times proper or decision times, and variabilities. The same factor structure was obtained by Buckhalt and Jensen (1989) on American 12-yr.-olds. Thirdly, all three components of reaction times are approximately equally associated with psychometric intelligence. There was no tendency for the more complex reaction times or the variabilities to show higher correlations with intelligence than the movement times or the simple reaction times. This result differs from outcomes of a number of previous studies of older children and adults which work has shown more complex reaction times and variabilities were more highly correlated with intelligence than the simpler reaction times. In this respect there is a contrast between the general trend of the correlations in the present study and those hitherto reported. Typical of previous results are those obtained in the Jensen and Buckhalt (1989) study, shown for comparative purposes in Table 2, where the choice and odd-man-out reaction times tend to show higher correlations with intelligence than the simple reaction and movement times. It has been suggested by Jensen (1982) that there is an age effect in the relation of reaction times to intelligence such that movement times are related to intelligence among young children but that this relationship disappears among older children and adults. The present results suggest that this may be correct, but more systematic studies of age trends are required to establish such an age difference.

REFERENCES

BUCKHALT, J. A., & JENSEN, A. R. (1989) The British Ability Scales speed of information-processing subtest: what does it measure? *Brit. J. educ. Psychol.*, 59, 100-107.

EYSENCK, H. J. (1982) Introduction. In H. J. Eysenck (Ed.), *A model for intelligence.* Berlin: Springer-Verlag.

FREARSON, W., & EYSENCK, H. J. (1986) Intelligence, reaction time and the "odd man out" R. T. paradigm. *Person. & indiv. Diff.*, 7, 807-818.

JENSEN, A. R. (1982) Reaction time and psychometric g. In H. J. Eysenck (Ed.), *A model for intelligence.* Berlin: Springer-Verlag.

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

JENSEN, A. R., & MUNRO, E. (1979) Reaction time, movement time and intelligence. *Intelligence*, 3, 121-126.

ROTH, E. (1964) Die Geschwindigkeit der Verarbeitung von Information und ihr Zusammenhang mit Intelligenz *Zeit. exp. angew. Psychol.*, 11, 616-622.

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

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