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Reaction Times and Intelligence in Japanese Children

T. Shigehisa [a] & Richard Lynn [b]
[a] Tokyo Kasei-gakuin University , Japan
[b] University of Ulster , Coleraine, N. Ireland
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Reaction Times and Intelligence in Japanese Children

T. Shigehisa
Tokyo Kasei-gakuin University, Japan
Richard Lynn
University of Ulster, Coleraine, N. Ireland

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The hypothesis that reaction times are positively associated with intelligence was tested on 444 nine-year-old Japanese children. Intelligence was measured by the Raven's 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 variabilities. Factor analysis of the reaction time tasks indicated the presence of a general factor and three primary factors identifiable as movement times, simple reaction times, and complex reaction times. Of these, only complex reaction times showed significant associations with intelligence.

L'hypothèse que les temps de réaction sont positivement associés avec l'intelligence a été examinée sur 444 enfants japonais de neuf ans. L'intelligence a été déterminée par des Matrices Progressives Normales de Raven, et douze paramètres de temps de réaction ont été obtenus pour donner des mesures des temps de mouvement, des temps exacts de réaction (des temps de décision) différentiés, en des temps de réaction simples et complexes et des variabilités. L'analyse factorielle des tâches de temps de réaction a indiqué la présence d'un facteur général et de trois facteurs primaires identifiables à des temps de mouvement, des temps de réactions simples et des temps de réaction complexes. De ceux-ci, seulement les temps de réaction complexes ont montré des associations significatives avec l'intelligence.

INTRODUCTION

In the last decade or so a number of studies have been carried out in the U.S.A. on the relationship between reaction times and intelligence,

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Requests for reprints should be sent to R. Lynn, Dept. of Psychology, University of Ulster at Coleraine, Coleraine, Co. Londonderry BT52 1SA, Northern Ireland.

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e.g. Jensen (1982; 1987); Vernon (1983). Many of these studies have obtained significant positive correlations between the speed of reaction and IQs measured by standard tests, the magnitude of the correlations generally falling between 0.1 and 0.5. The theoretical interest of these results is that they suggest that the efficiency of information processing at the neurological level, picked up in reaction times, is a component of intelligence. It has been proposed by Jensen (1982) that the crucial neurological factor is speed of neural transmission, which would enter into the performance of both reaction time tasks and intelligence. Eysenck (1986) has proposed an alternative theory that accuracy of neural transmission is the critical variable.

This paper reports a study of the relation between reaction times and intelligence among children in Japan. There were two objectives of the study. Firstly, to determine whether the positive associations between reaction times and intelligence would be found in Japan. Secondly, to break reaction times down into components of movement times, reaction times proper (decision times) in simple and complex tasks, and variability, and to ascertain how these components are related to intelligence.

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METHOD

The subjects were 444 nine-year-old children attending primary schools in the Tokyo Metropolitan area. There were 223 boys, mean age 113.47 months, and 221 girls, mean age 113.38 months. The children were drawn from socially representative schools. Fathers' occupations were obtained and the percentages were matched to those in Japan as a whole derived from census returns. The percentages falling into three major categories were company employees 68.5% as compared with 65.9% in Japan; civil servants and public employees 15.6% as compared with 11.7% in Japan; and small shopkeepers, traders, and others 16% as compared with 22.4% in Japan.

All the children were given 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). 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 15 cm radius semicircle of eight plastic $\frac{3}{4}$ inch microswitch push-buttons, 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 & 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. At each of the sixteen 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 fifteen 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 fifteen 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 999 msec, and where the MT was less than 40 msec and greater than 999 msec, or, in the case of the odd man RT condition, 1999 msec.

The following measures were obtained from the reaction time trials: movement times; simple reaction times; choice (three bit) reaction times; odd man out reaction times; and the variability of reaction times as measured by the standard deviations. Medians were taken rather than means to minimise the effects of an occasional exceptionally fast or slow reaction time.

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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 mean medians and standard deviations for the reaction times and the second six variables are the mean medians and standard deviations for the movement times.

One of the objectives of the study was to determine whether the positive correlations between reaction times and intelligence obtained in American studies are also present in Japan. The correlations between the twelve reaction time parameters and 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 twelve-year-olds and those from a study of 191 Irish nine-year-olds obtained by Lynn and Wilson (1990). It will be seen that the results in the three studies are

TABLE 1
Means And Standard Deviations In 12 Reaction Time Parameters And Progressive Matrices

Reaction Times	*Mean*	*SD*
Median simple RT	348.1	55.0
Median choice RT	433.2	65.7
Median OMO RT	818.0	197.6
SD simple RT	103.1	27.7
SD choice RT	137.6	35.7
SD OMO RT	298.5	97.1
Median simple MT	218.3	71.7
Median choice MT	227.4	61.8
Median OMO MT	268.4	92.3
SD simple MT	63.3	27.7
SD choice MT	66.4	24.4
SD ONO MT	126.6	50.5
Progressive Matrices	41.7	7.6

broadly similar. In the Japanese results eleven out of the twelve correlations are negative (fast reaction times are represented by low scores and hence correlate negatively with high scores on the Progressive Matrices) and five are statistically significant. The complete correlation matrix is given in Table 3.

To determine what factors are present in the data the twelve reaction time

TABLE 2
Product Moment Correlations Of 12 Reaction Time Parameters

	Standard Progressive Matrices		
	Japanese	*American*	*Irish*
Median simple RT	−04	01	−03
Median choice RT	−07	−16	−14*
Median OMO RT	−17***	−17	−19**
SD simple RT	−07	−09	−08
SD choice RT	−10*	−22*	−16**
SD OMO RT	−20***	−15	−23***
Median simple MT	00	−17	−12*
Median choice MT	−01	−24*	−18**
Median OMO MT	−02	−33*	−20**
SD simple MT	−06	11	−08
SD choice MT	−08*	15	−16**
SD OMO MT	−08*	−07	−23***

Note: One, two and three asterisks denote statistical significance at the 5, 1 and 0.1% levels.

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TABLE 3
Correlation Matrix Of Reaction Time Parameters

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Median simple RT	—											
Median choice RT	64	—										
Median OMO RT	32	61	—									
SD simple RT	62	48	24	—								
SD choice RT	31	68	54	38	—							
SD OMO RT	21	46	83	22	50	—						
Median simple MT	49	26	12	34	13	07	—					
Median choice MT	43	28	13	33	14	08	89	—				
Median OMO MT	32	13	03	28	09	01	75	82	—			
SD simple MT	28	12	04	26	08	11	63	55	48	—		
SD choice MT	21	23	11	34	28	14	51	59	53	36	—	
SD OMO MT	−01	−13	−17	09	00	−08	27	28	56	25	26	—

Correlations of above 08 are statistically significant at the 5% level.

correlations were factored by principal axis analysis followed by varimax rotation. There were three factors with eigenvalues greater than unity accounting for 38.3%, 23.1%, and 9.2%, 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, simple reaction time and complex reaction time. On the complex reaction time factor the odd man out task has

TABLE 4
Factor Loadings On First Principal Axis Factor And On Three Varimax Factors

	General Factor	*Movement Time*	*Complex RT*	*Simple RT*
Median simple RT	67	24	14	81
Median choice RT	62	04	54	70
Median OMO RT	46	00	89	20
SD simple RT	57	24	18	59
SD choice RT	47	05	57	37
SD OMO RT	39	00	87	07
Median simple MT	80	84	03	32
Median choice MT	83	88	07	26
Median OMO MT	73	90	01	10
SD simple MT	53	58	−01	19
SD choice MT	58	58	16	16
SD OMO MT	24	47	−10	−11

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the highest loadings, being the most complex task, while the loadings of the choice reaction times are split about equally between the simple and complex reaction time factors.

The relation of the Progressive Matrices to the reaction time factors was examined by calculating correlations between subjects' factor scores on the three varimax factors and Progressive Matrices scores. The correlations were −0.01 for movement times; 0.00 for simple reaction times; and −0.19 for complex reaction times, (statistically significant at the 0.01% level). These results show that among these subjects it is only complex reaction times that have any significant association with psychometric intelligence as measured by the Progressive Matrices. For the first unrotated principal axis factor (rt g) the correlation between the factor scores and the Progressive Matrices was −0.08 (statistically significant at the 5% level).

In addition to the principal axis analysis the data were also analysed by Schmid-Leiman hierarchical analysis. The results of the Schmid-Leiman analysis are given in Table 5. The analysis produces a higher order general reaction time factor (on which simple and choice reaction times have the highest loadings) and three smaller factors: movement times (factor 1), complex reaction times (factor 2), and simple reaction times (factor 3). The correlations between the subjects' factor scores on the four Schmid-Leiman factors and the Progressive Matrices were −13** (general factor); −0.02 (movement times); −0.19*** (complex reaction times); and −0.02 (simple reaction times). Thus the Schmid-Leiman and varimax analyses produce closely similar results.

TABLE 5
Schmid–Leiman Analysis

	General Factor	*Movement Time*	*Complex RT*	*Simple RT*
Median simple RT	72	22	−02	−45
Median choice RT	85	04	27	−39
Median OMO RT	72	01	60	−06
SD simple RT	60	22	03	−32
SD choice RT	65	06	35	−18
SD OMO RT	62	02	61	02
Median simple MT	50	77	−02	−09
Median choice MT	50	81	02	−06
Median OMO MT	35	82	00	05
SD simple	30	53	−03	−05
SD choice MT	39	53	10	−02
SD OMO MT	−00	42	−05	12
% Variance	31.65	23.04	7.87	4.40

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The final analysis consists of the calculation of the multiple regression of the twelve reaction time parameters on the Progressive Matrices scores. The multiple correlation is +0.25, statistically significant at $P<0.01$. The multiple R^2 is 0.06 and the adjusted multiple R^2 is 0.04.

DISCUSSION

There are three points of interest in the results. Firstly, the study on Japanese children confirms the positive association between fast reaction times and intelligence obtained in studies in Germany, the U.S.A., and Ireland. The magnitude of the correlations is low. Nevertheless, eleven of the twelve reaction time parameters show the association, and five of these are statistically significant—and there can be no doubt about the overall statistical significance of the association.

Secondly, the factor analyses of the reaction time tasks indicated the presence of three factors identifiable as movement times, simple reaction times, and complex reaction times. The same three factors have been obtained in a study of Irish children (Lynn & Wilson, 1990). However, this factor structure differs from that obtained by Buckhalt and Jensen (1989) on 12-year-old American children. In this study reaction times factored into factors of movement time, reaction time, and variability represented by the standard deviations.

Thirdly, the more complex reaction times represented by the odd man out task have higher correlations with intelligence than the less complex reaction times and movement times. This is evident both from the correlations and from factor analysis of the reaction time parameters, which showed that only complex reaction times have a significant association with intelligence.

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