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REACTION TIMES AND INTELLIGENCE: A COMPARISON OF JAPANESE AND BRITISH CHILDREN

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Summary. Japanese and British 9-year-old children were compared on the standard progressive matrices and twelve reaction time parameters providing measures of simple and complex decision times, movement times and variabilities. The mean of the Japanese children on the progressive matrices exceeded that of the British children by 0·65 SD units and on the decision times component of reaction times by 0·50 SD units, suggesting that the high Japanese mean on psychometric intelligence is largely explicable in terms of the more efficient processing of information at the neurological level. Japanese children also showed faster movement times but, contrary to expectation, had greater variabilities than British children.

Introduction

There have been several reports that the mean IQ of children in Japan is higher than that of Caucasian (white) children in the United States and Britain. These reports are based principally on the Japanese standardisations of the Wechsler tests and of the Columbia mental maturity scale (Lynn, 1987; Misawa *et al.*, 1984). There is, in addition, a contrary finding of no overall differences on a battery of diverse tests between Japanese and American children (Stevenson *et al.*, 1985). One of the problems is that Japanese children appear to have a distinctive pattern of abilities consisting of strong visuospatial abilities and weaker verbal abilities (Lynn, 1987). Hence, when their mean IQ is expressed as a single figure, its value will depend on the mix of visuospatial and verbal abilities which contribute to the overall mean IQ.

The present paper reports a study designed to clarify some of these problems in two regards. Firstly, it presents data on the performance of Japanese children on Raven's standard progressive matrices. This is a non-verbal reasoning test which is not biased towards either visuospatial or verbal ability and is widely considered to be among the best tests of Spearman's g, the general ability factor underlying all cognitive abilities (Jensen, 1980).

Secondly, the study reports a comparison of Japanese and British children on reaction times. The interest of this comparison lies in a number of reports of a positive association between reaction times and intelligence (Jensen, 1982). These positive associations have been interpreted as arising because reaction times provide a measure of the efficiency of the nervous system in the analysis and transmission of information (Jensen, 1982; Eysenck, 1982). Hence a normative study of the performance of Japanese and British children on reaction times should reveal whether a difference is present at the level of neurological information processing capacity.

In studies of the relation between reaction times and intelligence, five measures of reaction times have frequently been recorded. These are: simple reaction times, the time taken to react to the stimulus by taking the finger off the home button; movement times, the time taken to move the finger from the home to the off button; choice reaction time, the time taken to react where two or more stimuli are presented and alternative responses are required; the more complex odd man out task devised by Frearson & Eysenck (1986) in which three lights are presented, two of which are closer together and the subject has to identify and react to the third and more distant stimulus; and the variabilities of reaction times measured by the standard deviations. All five measures of reaction times were measured in this study.

Two further reaction time measures were obtained: the choice reaction time minus the simple reaction time, and the odd man out reaction time minus the simple reaction time. The reason for taking these measures was that all reaction times probably have both a sensory-motor component and a speed of information processing component, and it should be possible to remove the sensory-motor component from the choice and odd man out times by subtracting the simple reaction times.

Method

The subjects consisted of 9-year-old children in Britain and Japan obtained from socially mixed primary schools. The children were tested in 1988. The numbers consisted of 444 Japanese children and 239 British children. The mean age of the Japanese children was 113·4 monnths and of the British children 113·3 months. In both countries the children were given the progressive matrices and tested on reaction times, as described below.

In order to establish that the children were representative of their respective populations the following procedures were employed. The British children were obtained from state primary schools from various urban and rural locations. Their mean progressive matrices raw score was 36·1 (SD 9·6). The progressive matrices was standardised on a representative sample of British children in 1979 and the mean raw score of 9·5-year-olds was 35. Thus the present sample's raw score exceeded that of the 1979 standardisation sample by 1·1. This corresponds to the 56th percentile and to a mean IQ of approximately 102. It is well known that mean IQs have been increasing over the last half century, and in Britain the rate of increase of the progressive matrices has been approximately two IQ points per decade (Lynn & Hampson, 1986). Hence in the years between the 1979 standardisation and the testing of the present sample in 1988 the mean IQ of British children should have increased to approximately 102. This would make the present sample exactly representative of British children for intelligence.

In the case of the Japanese children, the progressive matrices has not been standardised in Japan and it is therefore not possible to ascertain what mean score a representative sample of Japanese children would obtain. Hence the children were obtained from economically and socially representative public primary schools, which are attended by approximately 99% of Japanese children. In addition, the socioeconomic status of the Japanese children's families was compared to that of the Japanese population given in census returns. The percentages falling into the 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 shop-keepers, traders and others 16·0%, as compared with 22·4% in Japan.

The three Japanese census categories are rather broad and are not ranked in a socioeconomic hierarchy like those in Britain and the United States. This limits their value as a standard against which to match a sample. Nevertheless, the figures are given to show that the occupational status of the sample's families conforms broadly to that of the census categories. The Japanese children obtained a mean of 41·7 (SD 7·6) on the progressive matrices.

All the children were tested for reaction times with an apparatus similar to that described by Jensen & 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 $\frac{3}{4}$-in 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 (preceded by 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 & Eysenck (1986). Thirty odd man out trials (preceded by six practice trials) were presented in two blocks of fifteen trials with a rest of approximately 1 min 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 farthest away from the other two (i.e. the odd man out). After the third condition another sixteen 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 reaction time was less than 170 msec or greater than 999 msec, and where the movement time was less than 40 msec and greater than 999 msec or, in the case of the odd man out reaction time condition, 1999 msec.

The following measures were obtained from the reaction time trials: movement times, simple reaction time, choice (three-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 for the performance of the Japanese and British children on the reaction time parameters are given in Table 1. This gives the means and standard deviations for the two samples expressed in msec and the difference between the two means expressed in standard deviation units. The Japanese children are consistently faster than the British children in all reaction times and movement times, but they also show greater variability.

The correlations between the reaction times and the progressive matrices are shown in Table 2. The correlations are consistently negative, i.e. fast reaction times are associated with higher matrices scores. Among the British children the correlations are nearly all statistically significant. Among the Japanese children the correlations are lower and only four are statistically significant. It is clear that there is a difference between the two populations with regard to the magnitude of the correlations. Nevertheless, the overall pattern of negative correlations is consistent among the Japanese children, except for the zero correlation for simple movement time. The

Table 1. Means and SD of Japanese and British children on reaction time parameters, and Japanese–British differences in SD units

	Japan		Britain		
Reaction times	Mean	SD	Mean	SD	Difference
Simple reaction	348·1	55·0	371·2	63·7	0·40***
Simple movement	218·3	71·7	236·2	64·7	0·26***
Simple reaction—SD	103·1	27·7	89·8	34·8	−0·44***
Simple movement—SD	63·3	29·0	52·3	28·2	−0·38***
Choice reaction	433·2	65·7	480·1	70·9	0·69***
Choice movement	227·4	61·8	261·0	75·7	0·50***
Choice reaction—SD	137·6	35·7	110·4	33·7	−0·78***
Choice movement—SD	66·4	24·4	55·9	25·2	−0·43***
Omo reaction	818·0	197·6	897·8	184·8	0·41***
Omo movement	268·4	92·3	296·7	108·6	0·29***
Omo reaction—SD	298·5	97·1	285·0	97·8	−0·14*
Omo movement—SD	126·6	50·5	110·1	47·5	−0·33***
Choice–simple reaction time	85·1	52·0	108·8	55·9	0·44***
Omo–simple reaction time	469·9	187·1	526·6	172·9	0·31**

*, **, ***: significant at the 5%, 1% and 0·1% levels respectively, tested by Mann–Whitney tests.

Table 2. Product moment correlations of reaction time parameters with standard progressive matrices in Japanese and British children (decimal points omitted)

Reaction times	Correlations with progressive matrices	
	Japan	Britain
Simple reaction	−04	−25***
Simple movement	00	−20***
Simple reaction—SD	−07	−06
Simple movement—SD	−06	−12*
Choice reaction	−07	−34***
Choice movement	−01	−26***
Choice reaction—SD	−10*	−09
Choice movement—SD	−08	−13*
Omo reaction	−17***	−29***
Omo movement	−02	−25***
Omo reaction—SD	−20***	−27***
Omo movement—SD	−08	−17**
Choice–simple reaction time	−04	−14*
Omo–simple reaction time	−17***	−22***

Significance: as Table 1.

probability of there being no positive correlations among the Japanese children can be tested by the binomial theorem, which shows that such a result would be obtained by chance on one occasion in 4096. It is therefore considered that although the Japanese correlations are low they show consistency with the British and with previous results, indicating a negative relationship between reaction time speeds and intelligence.

The last two rows in Tables 1 and 2 give choice and odd man out reaction times from which simple reaction times have been subtracted. These figures are given as a test of the hypothesis that the decision-making process in the choice and odd man out task might be measured more accurately by removal of the more elementary process involved in simple reaction times. However, these figures do not increase the Japanese–British differences or show greater correlations with the progressive matrices. This hypothesis therefore fails to receive support and these figures have been omitted in further analyses.

The data were analysed to determine whether the magnitudes of the Japanese–British differences on the twelve reaction time parameters were a function of the degree to which these parameters were measures of psychometric intelligence as measured by the progressive matrices. The interest of this question arises from Jensen's (1985) data showing that black–white differences on various intelligence tests are a function of the degree to which the tests are measures of Spearman's g. Does the same principle hold for the Japanese–British differences in reaction times? To answer this question the Japanese–British differences (Table 1) were correlated with the

Table 3. Correlation matrix of twelve reaction time parameters (decimal points omitted) in Japanese (bottom left diagonal) and British (top right diagonal) children

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	49	—	05	21	35	84	−14	14	19	72	−03	11
3. Simple reaction time—SD	62	34	—	22	24	02	53	19	10	00	26	07
4. Simple movement time—SD	28	63	26	—	11	20	25	29	−02	19	11	16
5. Choice reaction time	64	26	48	12	—	28	25	08	58	17	29	−07
6. Choice movement time	43	89	33	55	28	—	−16	27	17	85	02	16
7. Choice reaction time—SD	31	13	38	08	68	14	—	41	15	−08	39	12
8. Choice movement time—SD	21	51	34	36	23	59	28	—	00	33	15	25
9. Omo reaction time	32	12	24	04	61	13	54	12	—	01	64	−17
10. Omo movement time	32	75	28	48	13	83	09	51	03	—	−03	38
11. Omo reaction time—SD	21	07	22	01	46	08	50	14	83	01	—	13
12. Omo movement time—SD	−01	27	09	25	−13	28	00	26	−17	56	−09	—

correlations with the progressive matrices (column 3, Table 2). The resulting correlation is 0·30 and is not statistically significant.

In order to ascertain the factor structure of the reaction times in the two samples, both sets of data were analysed by principal axis analysis followed by varimax rotation. The correlation matrices are shown in Table 3 and the results of the factor analyses in Table 4. The Japanese data showed three significant factors with eigenvalues greater than unity. The British data showed a marginal fourth factor, but the three-factor rotation gave a better solution, preserves consistency with the Japanese analysis and is shown in Table 4.

The factor analyses show that in both samples there is a general factor which accounts for 38·3% of the variance in the Japanese data and 28·8% of the variance in

Table 4. Factor analysis of the reaction time parameters in Japanese and British samples (decimal points omitted)

	First principal component		Varimax factors					
Reaction times	Japanese	British	Japanese	British	Japanese	British	Japanese	British
Simple reaction	67	55	24	27	14	62	81	04
Simple movement	81	79	84	84	03	25	32	01
Simple reaction—SD	57	28	24	−07	18	34	59	46
Simple movement—SD	53	29	58	17	−01	04	19	39
Choice reaction	62	60	04	20	54	78	70	06
Choice movement	83	84	88	93	08	15	26	09
Choice reaction—SD	47	19	05	−29	57	30	37	78
Choice movement—SD	58	34	58	20	16	−02	16	58
Omo reaction	46	41	−01	02	89	76	20	−05
Omo movement	73	75	90	89	01	−04	10	25
Omo reaction—SD	39	27	01	12	87	50	07	29
Omo movement—SD	24	20	47	22	−10	−17	−11	36

the British data. The first factor is movement time in both samples. The second factor is odd man out reaction time and variability in the Japanese sample and reaction times in the British sample. The third factor is simple and choice reaction times in the Japanese sample and the variabilities of reaction and movement times in the British sample.

The final analyses consider how much of the variance in the progressive matrices can be explained by the twelve reaction time parameters in the two samples by calculating the multiple regression of the reaction times on the progressive matrices. The multiple correlations are 0·51 in the British sample and 0·25 in the Japanese sample, statistically significant at the $p < 0{\cdot}001\%$ and $p < 0{\cdot}01\%$ levels respectively, and accounting for 26% and 6% of the variance respectively.

Discussion

There are four principal findings of interest in the study. Firstly, the Japanese children obtained a higher mean score on the progressive matrices than the British children. The difference between the two means was 5·6 and the average of the two standard deviations was 8·6. Thus the mean of the Japanese children exceeded that of the British by 0·65 of a standard deviation, equivalent to ten IQ points.

The most comparable study is that by Misawa *et al.* (1984) based on the Japanese standardisation of the Columbia mental maturity scale. This is a non-verbal reasoning test rather similar to the progressive matrices. In relation to American norms and mean of 100, the Japanese standardisation sample obtained a mean IQ of 113. This figure can be adjusted downwards by removing blacks from the American standardisation sample and allowing for the time interval between the American and the Japanese standardisations. These adjustments, the details of which are given in Lynn (1987), give an adjusted Japanese mean of 107·5. The Japanese mean of 110 in relation to British children obtained in the present study is reasonably close to this figure, although it has to be noted that the number of children in the present study is quite small and the sample may not be precisely representative of Japanese children.

Secondly, in both samples fast reaction times and low variabilities were consistently associated with psychometric intelligence although the correlations were quite low, particularly in the Japanese.

Thirdly, one of the principal objectives of the study was to determine whether the Japanese–British difference in intelligence was also present on reaction times. The results showed that it was, and that on reaction times proper (decision times) the Japanese means exceeded the British by 0·40, 0·69 and 0·41 standard deviations for simple, choice and odd man out reaction times respectively, giving an average of 0·50. This is only fractionally less than the Japanese advantage on the progressive matrices and indicates that the most of the Japanese advantage in tests of psychometric intelligence is reducible to an advantage on the elementary cognitive processes involved in reaction time tasks. This in turn suggests that the Japanese advantage on psychometric intelligence may be explicable in terms of the hypothesis that the neurological basis of intelligence lies in the speed or accuracy of information processing. The Japanese children also had faster movement times than the British children, consistent with their higher progressive matrices means.

Fourthly, the variabilities of the Japanese children were consistently greater than those of the British. This is an unexpected result, since high variabilities have generally been found to be negatively associated with psychometric intelligence and this was confirmed in the present study on both samples. The expectation would have been that the Japanese children would have shown lower variabilities than the British. It is not easy to see how this paradoxical result can be explained.

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