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THE INTELLIGENCE OF THE MONGOLOIDS: A PSYCHOMETRIC, EVOLUTIONARY AND NEUROLOGICAL THEORY

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Summary—This paper presents a theory of the intelligence of the Mongoloids consisting of three linked sub-theories. The first concerns the psychometric features of Mongoloid intelligence and proposes that Mongoloids are characterised by high general intelligence (Spearman's g), high visuospatial abilities and low verbal abilities. Mongoloid abilities also display slow maturation in infancy and early childhood. It is proposed that this pattern of abilities cannot be explained in environmental terms and should be regarded as substantially genetically programmed. The second sub-theory presents an evolutionary explanation for this pattern of abilities in Mongoloids, whereby it is proposed that the extreme cold of the ice ages acted as a selection pressure for increases in Spearman's g and the visuospatial abilities. The low verbal abilities and slow maturation rates are interpreted as by-products of these adaptations. The third sub-theory presents a neurological model for the Mongoloid brain in which it is proposed that cortex devoted to the visuospatial abilities was expanded at the expense of the cortex devoted to the verbal abilities. The implication that there exists a negative correlation between the visuospatial abilities and the verbal abilities is considered in the concluding part of the paper and shown to be correct.

INTRODUCTION

During the last two decades there has been a considerable amount of serious work on the problem of racial differences in intelligence. Nevertheless, this work has been characterised by four weaknesses. Firstly, the data on which the rival environmental and genetic theories have been built have consisted largely, although not entirely, on differences in mean IQ between blacks and whites (hereafter Negroids and Caucasoids) in the United States. Secondly, these differences have been expressed largely, although again not entirely, as differences in a single overall IQ rather than as differences in patterns of narrower abilities. Thirdly, if there are genetic differences between races, these must have arisen through differential selection pressures operating in the course of evolution to produce the observed differences in intelligence. A complete genetic theory should provide an explanation concerning the nature of these differential selection pressures and show how they have brought about the differences in intelligence between the races; and yet no such explanation has been proposed. Fourthly, if differential selection pressures for intelligence have indeed been present, they must have resulted in different neurological structures or functions in the brain of the respective races, and here too no theory of the nature of these neurological structures has been proposed.

It is our objective in this paper to advance this field of inquiry in all four of these respects. The paper is concerned primarily with the intelligence of the Mongoloids because the intelligence of this major race has been a relatively neglected issue and the intelligence of the Mongoloids provides a considerable extension of the data base from which theories of racial differences in intelligence can be constructed. The scope of the arguments presented in the paper is now briefly sketched. In Part 1 a fairly extensive account is given of the intelligence of the Mongoloids. We shall see that Mongoloids in Japan and in the United States, and to some degree in other states of the Far East, have a distinctive type of intelligence, consisting most notably of high general intelligence (Spearman's g), and a low verbal–high visuospatial pattern of abilities. In Part 2 we consider environmental theories of the Mongoloid–Caucasoid differences and conclude that it is not possible to construct an environmental theory capable of explaining the data. Part 3 considers the alternative genetic theory of Mongoloid intelligence. Part 4 presents an evolutionary theory to explain the principal features of the abilities of the Mongoloids. Part 5 presents a neurological theory of the different brain structures in Mongoloids and Caucasoids. Part 6 deals with a problem which arises during the exposition of the theory, namely that during the course of the evolution of the hominids there must have developed a negative association between the verbal and visuospatial abilities, and psychometric evidence is presented to show that this is the case. Part 7 concludes the paper with a summary of the principal propositions of the theory.

I. THE INTELLIGENCE OF MONGOLOIDS

The Mongoloid peoples are those whose original habitat was North East Asia, north of the Himalayas and east of the Urals (Bodmer and Cavalli-Sforza, 1976). Their distinctive physiognomy evolved as adaptations to conditions in this part of the world. For practical purposes the Mongoloids are largely the Chinese and Japanese, and we start with a review and synthesis of the intelligence of these peoples in Japan, the United States and the three Far East nations of Hong Kong, Singapore and Taiwan.

The intelligence of different populations is often expressed as a single mean IQ. The single IQ is itself an average of tests of a variety of verbal, reasoning, spatial, perceptual, memory and other cognitive abilities, and in many cases it expresses adequately the mean cognitive ability of a population. For instance, both male–female differences and Caucasoid–Negroid differences are quite well represented by a single IQ, although there are in addition more subtle differences such as the well known tendency of males towards superiority on visuospatial tasks and of females towards superiority in immediate verbal memory and word fluency (Maccoby and Jacklin, 1974; Jensen and Reynolds, 1983).

In the case of Mongoloids, however, a single IQ does not capture at all adequately the significant features of their intelligence. The intelligence of Mongoloids differs from that of Caucasoids more in the pattern or profile of their abilities than in the overall IQ. To describe adequately the Mongoloid pattern of abilities it is necessary to express them in terms of a more complex model of intelligence. For this purpose we use the Burt–Vernon hierarchical model, first proposed by Burt (1949) and Vernon (1950) and the paradigm for the structure of intelligence that commands general acceptance among leading contemporary students in this field (see, e.g. Eysenck, 1979; Vernon, 1979; Jensen, 1980; Undheim, 1981; Gustafsson, 1984).

The hierarchical model consists firstly of a general factor identified as general intelligence or Spearman's g. This factor embraces all cognitive abilities and is responsible for their positive intercorrelation, as Spearman (1904) originally proposed. The purest measure of Spearman's g consists of abstract reasoning tests such as Raven's Progressive Matrices (e.g. Jensen, 1980; Gustafsson, 1984). Spearman's g may well be represented neurologically by the overall size of the brain or its general neural efficiency in the analysis and storage of information, as proposed by Eysenck (1982).

At the second level in the hierarchical model, Spearman's g is divided into two group factors. These were originally designated by the British factorists the *verbal–educational* (v–ed) and the *spatial–mechanical* (k–m) factors. This nomenclature has not received universal acceptance and is for various reasons unsatisfactory. We prefer the terms verbal and visuospatial abilities. In neurological terms these two groups of abilities are, broadly, localised in the left and right cerebral hemispheres and the significance of this fact will be discussed more fully in Part 5 of this paper when we consider the neurology of the Mongoloid brain.

At the third level of the hierarchical model are found a number of primary abilities. Six of these primary abilities were originally conceptualised by Thurstone (1938). Over the last half century their number has grown and there are now some thirty in the combined lists given by Cattell (1971) and Ekstrom, French and Harman (1976). These primaries are of two kinds. Firstly, many of them are finer components of the broad verbal and visuospatial group factors. Thus the verbal group factor can be split down into the primaries of verbal comprehension (vocabulary etc.) number ability (mental arithmetic), long term verbal memory (verbal fluency), and immediate verbal memory (digit span). Similarly, the visuospatial group factors can be split down into primaries of spatial visualisation (maze tests), spatial orientation (tests of rotating three dimensional shapes), drawing ability and flexibility of closure (the Embedded Figures Test).

In addition there are further primary abilities which do not belong to either of the verbal or visuospatial groups. These include abstract reasoning, the closest measure available of Spearman's g, the musical primaries, ideational fluency and other miscellaneous primaries. The most sophisticated recent factorial work on the hierarchical model of abilities is that carried out by the Swedish factorists Undheim (1981) and Gustafsson (1984), whose refined version of the Burt–Vernon model is followed in this paper.

The remainder of this part of the paper is concerned with the quantification of the intelligence of the Mongoloids in terms of the hierarchical model. We shall see that the Mongoloids are superior to the Caucasoids with regard to Spearman's g, the visuospatial group factor, and the visuospatial primaries, but inferior to Caucasoids with regard to the verbal group factor and the verbal primaries. This pattern of abilities is shown in turn for Mongoloids in Japan, in the United States and, to some degree, in South East Asia. It is also seen that Mongoloids tend to develop more slowly in infancy and early childhood than Caucasoids.

1. THE INTELLIGENCE OF THE JAPANESE: THREE DEFINITIVE STUDIES

The intelligence of the Japanese is best considered first in terms of three definitive studies, from which values for the principal Japanese abilities can be calculated. A number of other studies, to be reviewed in the next section, can then be assimilated into this structure. The three definitive studies are the Japanese standardisations of the American McCarthy Scales of Children's Abilities, covering the age range $2\frac{1}{2}$–$8\frac{1}{2}$ years; the Wechsler Preschool and Primary Scale of Intelligence, covering the age range 4–6 years; and the Wechsler Intelligence Scale for Children-Revised, covering the age range 6–16 years. Full details of the Japanese standardisations of these three tests and the calculation of Japanese values for general intelligence, the verbal and visuospatial group factors and a number of primary abilities are given in Lynn and Hampson (1986a, b and c). What is given here and shown in Table 1 is a summary of these values given in these three studies.

Before discussing the details of these Japanese abilities, several points need to be made. Firstly, all the values are calculated as mean IQs for Japanese children set in relation to means of 100 and standard deviations of 15 for American Caucasoid children. This has entailed statistical adjustments to remove the effects of Negroids on the means of the American standardisation samples. Secondly, all Japanese IQs are adjusted for differences in dates between the standardisations in Japan and the United States. The Japanese standardisations were carried out later than the American, and mean population IQs have shown secular increases in both countries (Lynn and Hampson, 1986d). Hence to compare Japanese and American means for any given year the Japanese means need to be reduced to allow for the later dates of the standardisations in Japan. These two adjustments to the values for Japanese IQs are designated "race and time adjusted" in subsequent discussions of the calculations of Japanese abilities. Thirdly, indices of factor comparison show that the tests are measuring the same factors in the two populations. Fourthly, the Japanese and American values for Spearman's g and the verbal and visuospatial group factors are derived from factor scores for these three abilities. The primary abilities, however, are calculated directly from individual tests. Fifthly, some of the values for the WISC-R in Table 1 differ in detail from those given in Lynn and Hampson (1986c) because of the correction of small errors in the earlier publication.

We consider now the principal features of interest in the abilities of Japanese children displayed in Table 1.

1. The values for Spearman's g are set out in Column 1. They show that Japanese children score lower than American Caucasoids over the age range $2\frac{1}{2}$–$5\frac{1}{2}$ years; between 6–8 years they score about the same; from 9 years upwards Japanese children score slightly higher. The Japanese superiority from the age of 9 years upwards is not statistically significant for individual years, but it is significant for the 9–16 year age group considered as a whole because of the larger numbers when the years are aggregated. There is clearly a significant age trend in Japanese children such that from lower values of Spearman's g amongst the youngest groups aged $2\frac{1}{2}$–$5\frac{1}{2}$, they first draw level with American children between the ages of 6–8 years, and finally overtake them from the age of 9 years onwards.

2. It will be noted that these age trends in Japanese abilities are also present for all the other abilities shown in Table 1. In every case there is a rising trend from low values among $2\frac{1}{2}$–3 year olds to higher values among older age groups. There are two possible interpretations for these rising

Table 1. Mean IQs of Japanese children in relation to American Caucasoid means of 100 and standard deviations of 15. Source: Lynn and Hampson, 1986a, b and c

				Verbal primaries				Visuospatial primaries		Other primaries			
Age	Spearman's g	Verbal GF	Visuospatial GF	Comprehension	Fluency	Immediate memory	Number	Spatial	Drawing	Inductive reasoning	Musical rhythm	Perceptual speed	Test
2½	94.4	92.8	97.0	91.8	92.4	89.8	94.6	92.8	99.0	102.6	99.1	—	McCarthy
3	94.1	92.5	96.5	90.4	91.5	92.4	91.9	95.1	99.4	98.5	94.6	—	McCarthy
3½	96.6	94.7	99.5	93.3	93.5	92.5	93.0	96.6	103.0	100.0	101.8	—	McCarthy
4	95.9	93.1	99.6	89.5	96.6	92.1	93.6	102.1	102.0	100.2	104.1	—	McCarthy
4½	97.1	93.8	101.6	89.5	98.8	92.5	94.3	104.4	105.3	99.6	100.7	—	McCarthy
5	97.2	92.6	103.7	86.4	97.6	87.9	93.0	101.5	112.8	100.5	103.9	—	McCarthy
5½	98.7	93.8	105.7	90.1	98.7	98.2	96.3	108.7	113.7	102.3	103.3	—	McCarthy
6½	101.2	97.1	107.2	97.3	102.6	93.7	97.3	106.5	119.4	100.8	105.3	—	McCarthy
7½	98.5	93.9	104.5	94.3	96.7	93.0	100.5	108.0	108.3	105.7	103.0	—	McCarthy
8	97.7	92.7	104.7	92.1	96.4	94.2	103.3	106.6	111.1	101.7	99.4	—	McCarthy
6	100.6	96.2	103.8	94.5	—	—	106.0	105.5	—	—	—	—	WPPSI
6	101.2	97.8	106.2	92.1	—	101.1	97.1	111.1	—	—	—	104.6	WISC-R
7	100.0	95.6	106.0	88.1	—	101.1	95.1	112.1	—	—	—	104.6	WISC-R
8	102.1	97.9	106.5	91.6	—	102.1	96.1	111.1	—	—	—	115.6	WISC-R
9	102.3	99.0	105.8	93.1	—	97.6	100.6	108.1	—	—	—	114.1	WISC-R
10	104.1	101.0	106.5	94.1	—	102.1	105.6	109.6	—	—	—	117.1	WISC-R
11	104.0	100.7	106.2	94.1	—	102.1	107.1	110.1	—	—	—	116.6	WISC-R
12	104.4	100.9	106.1	92.1	—	102.1	117.1	109.6	—	—	—	116.6	WISC-R
13	103.4	100.3	104.8	93.1	—	98.6	112.1	107.6	—	—	—	118.1	WISC-R
14	104.0	100.8	105.4	94.1	—	102.6	109.6	108.4	—	—	—	119.1	WISC-R
15	104.2	101.3	105.4	95.1	—	101.1	107.1	107.1	—	—	—	119.6	WISC-R
16	103.3	100.8	103.0	94.1	—	106.1	110.6	104.1	—	—	—	118.1	WISC-R

5% significance levels: deviations of 5.1 from 100 on the McCarthy Scales, 2.6 from 100 on the WPPSI, and 3.6 from 100 on the WISC-R.

trends. Firstly, they could be an effect of a superior environment acting on an inferior genotype. This would be a cumulative advantage effect, such as Caucasoid children display relative to Negroid children in the deep south of the United States, as shown by Jensen (1977).

The alternative reading of the data is that Japanese children are slow maturers. It is believed that this is the preferable explanation. There are extensive data showing generally slow maturation rates among young Japanese children derived from the Denver Developmental Screening Test. This test measures a variety of indices of motor and cognitive development from birth to 6 years and has been standardised in Japan with a substantial normative sample by Ueda (1978). The results show that Japanese infants and young children shown significant later maturation on a number of measures, as compared with Caucasoid norms derived from the United States. The slower development of Japanese infants is apparent at 1–2 months in head lifting and continues in head turning to a voice, rolling over at 3–5 months and removing garments at 15–20 months. At 2–4 years Japanese late maturation appears in early cognitive tasks including copying a circle and the size of vocabulary, and vocabulary remains significantly retarded in young Japanese children up to the age of 6 years. There is evidence from elsewhere to suggest that slow maturation is a general characteristic of Mongoloids. Thus late skeletal maturity is present among Chinese infants in Hong Kong and ethnic Japanese infants in California (Eveleth and Tanner, 1976, p. 200).

It is proposed therefore that the low means obtained by young Japanese children aged $2\frac{1}{2}$–5 years on the McCarthy Scales are best interpreted as functions of the slower maturation of Mongoloids which is shown for motor and early cognitive development by the Denver Development Screening Test and is a general characteristic of Mongoloid infants and young children.

3. Looking now at the Japanese IQs for the verbal and visuospatial group factors, we see that at all ages the Japanese are stronger on the visuospatial than on the verbal abilities. The difference is about 4–6 IQ points among $2\frac{1}{2}$–4 year olds, widens to about 10 IQ points among 5–8 year olds, and then narrows again to around 5–6 IQ points. Because of the slow maturation of Japanese children, to adopt the hypothesis proposed above, very young Japanese children tend to be inferior to American Caucasoids on both these abilities. But by age $5\frac{1}{2}$ they are superior to the Caucasoids on the visuospatial abilities at a statistically significant level, while remaining inferior on the verbal abilities. This curious and striking pattern is retained throughout the rest of the age range.

4. The four verbal primaries—comprehension, fluency, immediate verbal memory and number—consistently reproduce the low scores on the group verbal factor between the ages of $2\frac{1}{2}$–$6\frac{1}{2}$ years. Thereafter, verbal comprehension remains weak, but both immediate verbal memory and number ability improve considerably. It is proposed that these improvements in immediate verbal memory and number ability should be attributed to the exceptional effectiveness of Japanese schools in teaching arithmetic. Number ability is mental arithmetic, while immediate verbal memory is tested by memory for digits and it is suggested that the greater familiarity and practice with digits to which Japanese children are exposed in their schools is the explanation for their marked improvement in this primary during the school years. Several observers of Japanese schools have noted that their efficiency is of a totally different order from those in the United States and, for that matter, of Europe. The whole question of the efficiency of Japanese schools and the high educational standards of Japanese children has been reviewed in a separate publication (Lynn, 1987). Compulsory schooling in Japan begins at the age of 6 years, and it is from about this age that Japanese children show a strong increase in their number and memory span abilities.

The school effects on raising the number and immediate verbal memory primaries contribute to the increase in the strength of the Japanese verbal group factor from the age of about 9 years onwards. It is therefore proposed that the true value of Japanese verbal abilities, uncontaminated by school effects, is represented by the scores made by 6–8 year olds, i.e. around 97.

5. On the two visuospatial primaries—spatial ability and drawing—the very young Japanese children are weak. This is attributed to their slow maturation in the early years of childhood. From the age of 4 years upwards they are consistently strong on both these primaries. On spatial ability, treated here as a single primary following Cattell (1971), the superiority of Japanese children is around one-half of a standard deviation (7–8 IQ points) from the age of $5\frac{1}{2}$ years upwards. The second visuospatial primary given in Table 1 is drawing ability. It has been shown by Noland and Sanders (1973) that this ability is much more highly correlated with the performance scale of the Wechsler Test (WISC) than with the verbal scale and it is on the basis of this and other evidence

that it is placed with the visuospatial abilities. It will be noted that Japanese children are exceptionally strong on this primary.

6. The last three columns of Table 1 give Japanese values for three further primaries which do not clearly belong to either of the verbal or visuospatial group factors. Inductive reasoning is as close a measure as can be obtained of Spearman's g. Over the age range $2\frac{1}{2}$–5 years Japanese children obtained about the same means as American Caucasoids, but from $5\frac{1}{2}$–8 years they score a little higher and at the age of $7\frac{1}{2}$ the Japanese superiority is statistically significant. The proposed explanation for this trend is that the values among the young age groups are depressed by the late maturation of Japanese children. The means for the $5\frac{1}{2}$–8 year olds are the true values and confirm that Japanese children are a little higher than American Caucasoids for Spearman's g.

The second primary ability in this group is musical rhythm. The means of the Japanese children are about the same as the American. The third primary is perceptual speed. The means of this ability are calculated from the WISC-R coding and are very substantially higher than the American means. Coding appears to be a visuospatial skill, but factor analyses of the WISC-R show that it does not load on the visuospatial factor. For this reason it is shown in Table 1 as an independent primary. Nevertheless, it is suggested that coding is in fact a visuospatial skill but one which places heavy demands on visuospatial memory in the fast comparison processes that are required by the task. Some data consistent with this interpretation are reported by Majeres (1983). It is suggested therefore that the very high scores obtained by Japanese children on this ability confirm our conclusion that the Japanese are strong on all visuospatial abilities.

7. Conclusions: It is proposed that among the considerable data set out in Table 2 the following four generalisations can be made on the abilities of Japanese children in relation to American Caucasoids. Firstly, they are slow maturers. This accounts for their low initial scores on all abilities followed by subsequent improvement. Secondly, Japanese children are marginally superior for Spearman's g. Thirdly, they are weak on the verbal abilities. Fourthly, they are quite strongly superior on the visuospatial abilities. In the next section we examine how far these generalisations are corroborated by other studies on the intelligence of the Japanese.

2. FURTHER STUDIES OF JAPANESE INTELLIGENCE

1. The Minneapolis–Sendai Study

This study compared Japanese 6 and 10 year olds from the city of Sendai with comparable Caucasoid American children from Minneapolis. One part of the study consisted of the results of ten cognitive tests (Stevenson, Stigler, Lee, Lucker, Kitamura and Hsu, 1985). These tests fell into three groups. Firstly: there were five verbal tests of vocabulary, information, verbal memory for stories, words and numbers. Of the ten comparisons derived from these five tests for the two age groups, the American children performed better in all ten cases, of which eight were statistically significant. Secondly: a test of spatial relations adapted from Thurstone's Primary Mental Abilities. On this Japanese children in both age groups performed significantly better. Thirdly: a test designated verbal–spatial representation and requiring both verbal and spatial abilities, on which there were no differences between Japanese and American children. Fourthly: a perceptual speed test involving matching a drawing to one of a set, i.e. a version of the Matching Familiar Figures Test (see below). On this Japanese 6 year olds scored significantly higher than American, but at the 10 year old level the difference was not significant. The last test should probably be considered as a further measure of visuospatial abilities.

In a further part of this study, educational achievement tests of arithmetic, reading vocabulary and reading comprehension were administered to the 10 year olds (Stigler, Lee, Lucker and Stevenson, 1982). It was found that the Japanese children were well ahead of the American children on arithmetic. The authors rightly conclude that this is largely due to the superior teaching efficiency of Japanese schools. This result is consistent with the Japanese superiority on number ability derived from the arithmetic scale of the WISC-R (see Table 1). On the two reading tests the Japanese scores were below those of the American, although only in the case of reading vocabulary was the difference statistically significant. Our interpretation of this result is that it is a reflection of the underlying weakness of Japanese verbal abilities.

The interest of this study is that it provides data on Japanese and American strengths and weakness using carefully matched samples for a wide range of abilities, and especially for the verbal abilities which are difficult to obtain. It is clear that the results give strong support to the generalization that the Japanese are weaker than American Caucasoids on the verbal abilities and stronger on the visuospatial abilities.

2. The Differential Aptitude Test

This American test provides measures of the major primary abilities. Summarised here is a study comparing American, Japanese and British 13–15 year olds on the abstract reasoning and space relations scales, reported in greater detail in Lynn, Hampson and Iwawaki (1987). The abstract reasoning scale consists of series problems in the form of geometric designs, similar to those in the Progressive Matrices, and should be regarded as a pure Spearman's g test. The space relations scale consists of problems involving the transposition of two dimensional designs into three dimensional shapes. It requires visualisation; males do better on this test than females, and it is undoubtedly a test of the spatial primary or, more narrowly, visualisation.

The test was standardised in the United States in 1972 and in Britain in 1978. When the means are 'race and time' adjusted, the British means are 99.4 on abstract reasoning and 101.0 on space relations. The interest of this result is that it shows the virtual identity of the means of the two Caucasoid populations drawn from the United States and Britain, and therefore suggests that Americans Caucasoids adequately represent Caucasoids from the rest of the economically advanced world.

The two scales were administered to a sample of 178 Japanese adolescents in 1985. The 'race and time' adjusted means were 104.5 for abstract reasoning and 114.0 for space relations, both of which are significantly higher than the American and British means. The result confirms the generalisation that the Japanese are marginally superior to Caucasoids on Spearman's g, represented by the abstract reasoning test, and substantially higher on the spatial primary.

3. The Columbia Mental Maturity Scale

This is an American test first published in 1954 and revised and restandardised in 1972 (Burgemeister, Blum and Large, 1972). It covers the age range 3.6–9.6 years. The norms of the 1972 test were obtained from a representative sample stratified by sex, racial group, geographical region and parental occupation. The CMMS consists of a series of five pictures of objects or geometric shapes and the child has to find the common concept to which four of the pictures belong and identify the discrepant item. In some of the later items the pictures are conceptually linked in two pairs, again leaving one remaining picture to be identified. It is described by the authors as a test of general reasoning ability. This is correct and, in terms of the hierarchical model of intelligence, it is a pure test of Spearman's g. This is evident firstly from the nature of the test and secondly from a study in which the test was administered to a sample of children together with the Primary Mental Abilities Test. The correlations between the CMMA and the PMA scales were: Reasoning, 0.61; Verbal Comprehension, 0.51; Spatial, 0.31; Perception, 0.48; Number, 0.41 (Mill and Turner, 1955). This result shows that the test is principally a measure of general reasoning and is not strongly biased towards either the verbal or the visuospatial abilities.

The test was standardised in Japan in 1982 on an apparently well drawn sample stratified for sex, geographical region and urban–rural location. The mean IQ of the Japanese sample, in relation to an American mean of 100, was 113. This figure requires race and time adjustment downwards. This entails the subtraction from the Japanese mean of 1.7 IQ points for a comparison with American Caucasoid children only, and a further 3.0 IQ points for the 10 years separating the two standardizations. In addition, the CMMS has a standard deviation of 16, whereas we are working throughout on a standard deviation of 15. This adjustment requires a further reduction of the Japanese IQ of 0.8.

The three adjustments together require the subtraction of 5.5 IQ points from the Japanese mean, giving a final figure of 107.5. This figure is somewhat higher than the estimates of Japanese values for Spearman's g derived from the McCarthy Scales, the WPPSI and WISC-R.

4. The Matching Familiar Figures Test

This test (the MFFT) consists of the presentation of a drawing of a common object (e.g. a boat, pair of scissors, hen) together with four, six or eight other drawings of which one is identical and the others are almost identical to the standard drawing. There are twelve of these problems. The test was originally constructed in the United States by Kagan, Rosman, Day, Albert and Phillips (1964) and was intended to measure a cognitive style trait designated reflection—impulsivity. The theory was that some individuals are reflective, i.e. cautious, slow and accurate, whereas others are impulsive, i.e. rash, fast and inaccurate. The test is scored for both accuracy and speed and it is therefore possible to characterise individuals as slow-accurates (reflectives) or fast-inaccurates (impulsives).

There is no doubt that the MFFT is to some degree a measure of intelligence. A comprehensive review by Messer (1976) lists 23 studies in which the MFFT was administered together with an intelligence test. All the studies found positive correlations averaging around 0.30 between intelligence and accuracy, but speed as such has only low positive correlations with intelligence. MFFT scores correlate more highly with visuospatial than with verbal abilities. Thus MFFT scores for both accuracy and speed correlated more highly with the non-verbal section of the Otis–Lennon Mental Abilities Test than with the verbal section (Eska and Black, 1971). Similarly, Plomin and Buss (1973) reported that MFFT accuracy correlated 0.38 with the performance scale of the WISC but only 0.05 with the verbal scale.

It is suggested that the MFFT measures the following cogntive abilities in addition to the cognitive style for which the test was originally designed. Firstly, it is proposed by Jensen (1980, p. 618) that it is a reasonably good measure of Spearman's g. This is because the individual with high g takes a reflexive approach to problems and strives primarily for accuracy. Secondly, the test is largely a measure of the visuospatial abilities. At the primary ability level, the MFFT appears to be measuring the visual memory primary of Ekstrom, French and Harman (1976). The test requires the memorisation of all the features of the pictures and then a comparison of all the facsimiles with the standard to identify the perfect match. To achieve accuracy and speed on the test therefore requires accurate visual memory.

In view of the strong visuospatial abilities of Japanese children, it would be expected that they would do well on the MFFT. Extensive data on this question have been published by Salkind, Kojima and Zelniker (1978). The samples consisted of 2,255 American children and 760 Japanese children in the age range of 5–10 years. In addition there were approx 1,500 Israeli children. The samples were selected to be representative of middle class children of normal intelligence in the three countries. The most interesting measure to be derived from the test is accuracy because this is the primary correlate of intelligence. The results for children of the three nationalities are shown in Table 2. The data are given as the mean number of errors for each of the six age groups. It will be seen that the Japanese 5–9 year olds make fewer errors and are therefore more accurate than either the American or Israeli children. All these differences are statistically significant. However, among 10 year olds the relationship between the nationalities is reversed. The reason for this is that at this age the Japanese work considerably faster than either the American or Israeli children.

The differences in error scores between the Japanese and American children have been calculated as proportions of the American standard deviations and are shown in that form in column four of Table 2. The mean of these six figures is 0.50, indicating that the total Japanese sample achieved a higher score than the American sample by one half of an American standard deviation,

Table 2. Results on the Matching Familiar Figures Test for Japanese, American and Israeli children. Source: Salkind, Kojima and Zelniker, 1978

	Errors				Time		
Age	Japanese	American	Israeli	J–A Difference	Japanese	American	Israeli
5	18.4	22.6	26.0	0.60	11.9	7.2	6.0
6	15.6	17.6	24.1	0.29	12.5	10.6	7.8
7	10.7	14.8	13.4	0.63	14.7	12.0	14.2
8	7.7	12.7	12.2	0.80	14.8	13.4	15.2
9	7.3	9.1	10.5	0.31	13.7	16.4	16.5
10	8.4	7.4	8.2	−0.19	9.8	17.2	22.0

corresponding to 7.5 IQ points. This figure is close to the Japanese superiority on the visuospatial abilities shown previously in Table 1.

The MFFT is also scored for the time taken by the child to complete the test. These times for the six age groups are shown for the three nationalities in columns 5, 6, and 7 of Table 2. It will be seen that the younger Japanese children (the 5–8 year olds) are slower than the American but the older Japanese children (the 9–10 year olds) are faster. These time figures provide the explanation for the slightly higher error scores made by Japanese 10 year olds in contrast to the lower error scores of the Japanese 5–9 year olds. It is apparent that Japanese 10 year olds are much faster than American 10 year olds and that they achieve closely similar error scores in about half the time. It is evident therefore that the Japanese 10 year olds achieve better results if these are considered in terms of the number of correct responses per unit time.

When the error and time scores of the three nationalities are considered together, it is clear that Japanese 5–8 year olds adopt the strategy of an accurate and relatively slow approach to the problems, while the American and Israeli children are inaccurate but fast. Japanese children are therefore reflexives and American and Israeli children are impulsive. The 9 year old Japanese children are both faster and more accurate than American and Israeli children. The Japanese 10 year olds are faster still but at this age they are trading accuracy for speed and are making slightly more errors. Salkind, Kojima and Zelniker (1978) suggest that these trends indicate that there is what they call a "developmental shift" in all three cultures, such that young children tend to be impulsives with a fast-inaccurate performance and that as they grow older they become more reflexive. In this development, as these authors point out, Japanese children are about two years ahead of American and Israeli children. The authors suggest that socialisation pressures in the Japanese family are probably responsible for the earlier acquisition of a reflexive strategy among Japanese children but they offer no evidence for this speculation. The results can be explained economically in terms of Japanese superiority for Spearman's g and the visuospatial abilities and clearly corroborate the data set out in Table 1.

5. The Weschler Intelligence Scale for Children

This test was constructed and standardised in the United States in 1948 and in Japan in 1951. The performance subtests were retained almost entirely unaltered in the Japanese standardisation, but the verbal subtests underwent considerable alteration with the exception of Digit Span. The Japanese means on the subtests for which a comparison can be made with the American means have been calculated and published by the writer (Lynn, 1977a). On the performance scale the Japanese children obtained a mean IQ of 103.1. This can be considered as a measure of the visuospatial abilities. The figures needs to be reduced by 0.9 to 102.2 because of the 3 year time lag between the two standardisations, but no further reduction entailing the removal of American Negroids is necessary because this test was standardised in the United States on Caucasoids only. The Japanese superiority of 2.2 IQ points is statistically significant and therefore confirms the later results showing high Japanese visuospatial abilities.

As noted, the only verbal test for which a Japanese–American comparison could be made was Digit Span. The mean Japanese IQ computed for this single subtest is 90, which needs to be reduced to 89.1 because of the three year time lag between the two standardisations. Thus the WISC results from 1952 show the same Japanese pattern of low verbal–high visuospatial ability. Both abilities are somewhat lower than they were in the 1970s as shown in Table 1. The explanation for this is that all Japanese abilities have been increasing faster than American over the last three decades, as we have shown in detail in Lynn (1982) and Lynn and Hampson (1986d).

6. The Wechsler Adult Intelligence Scale

This test was standardised in the United States in 1954 and in Japan in 1956. Unfortunately the test was considerably changed in the Japanese standardisation and only three subtests were retained unaltered, namely Digit Span, Digit Symbol and Block Design. Japanese IQs computed from these three tests are 100.0, 105.4 and 106.0 (Lynn, 1977a). These three figures require race and time adjustment downwards by 1.7 IQ points for race and 0.6 IQ points for the two year time lag between the two standardisations, making a total of 2.3 IQ points. This gives a figure of 97.7 for Digit Span showing a relatively weak score on this test of immediate verbal memory which was apparent in the WISC-R and also in the WISC. The adjusted Digit Symbol and Block Design IQs are 103.1 and 103.7. The Digit Symbol test in the WAIS is a measure of the visuospatial abilities. This is clearly apparent from factor analyses of the entire test which show that Digit Symbol belongs to the visuospatial group (Berger, Bernstein, Klein, Cohen and Lucas, 1964). Block Design is of course also a visuospatial test and the results on these two tests evidently confirm the Japanese strength on these abilities.

7. The Goodenough–Harris Drawing Test

It was shown early in the century by Burt and Goodenough that tests of drawing ability are positively related to general intelligence and these conclusions have been confirmed by numerous investigators (Jensen, 1980). In the Goodenough–Harris test the child is asked to draw a picture of a man, a woman, and self. These drawings are scored according to stipulated criteria and the scores transformed into IQs on the basis of extensive normative data collected in the United States (Harris, 1963). The test appears to be primarily a test of the visuospatial abilities, especially in so far as it is scored from the correctness of proportions (MacFarlane and Smith, 1964).

The test was administered by Hilger, Klett and Watson (1976) to an apparently representative sample of 30 Japanese 6 year olds in a village school in the Japanese island of Hokkaido. The mean IQ of these Japanese children, in terms of an American mean of 100, was 138. This remarkable figure will possibly strain the credence of some readers, but it should nevertheless be noted that Japanese $6\frac{1}{2}$ year olds achieved a mean IQ of 119.4 on the drawing test in the McCarthy Scales, as shown in Table 1, and there is little doubt that Japanese children are strong on this primary component of the visuospatial abilities.

8. The Embedded Figures Test

This test (the EFT) was first constructed by Gottschaldt and consists of the identification of a simple figure embedded in a complex one. In nature this ability is used to perceive a well camouflaged animal against a background and is useful for the detection of both prey and predators who are frequently so camouflaged. This ability was considered by Thurstone (1944) to be a measure of the primary ability he designated *Flexibility of Closure* and this has been accepted by Cattell (1971) and Ekstrom, French and Harman (1976). On the basis of correlational and factorial studies Smith (1964) and Pawlik (1966) consider that this primary is one of the visuospatial abilities and there is little doubt that they are correct. Thus, to note a subsequent study, Bergman and Engelbrekson (1973) found that among Swedish university students the Embedded Figures Test was correlated about twice as highly with tests of spatial ability as with vocabulary. Boys tend to do better on this test than girls and this is a well known marker for a test of the visuospatial abilities.

A comparison between Japanese, American and British 9–10 year olds on the Embedded Figures Test has been made by Bagley, Iwawaki and Young (1983). They report means for six samples of Japanese children, four samples of American children and four samples of British children. All six Japanese means were higher than all of the eight American and British means and the Japanese superiority is undoubtedly statistically significant. Simple averaging of the means of all the samples gives the Japanese children a grand mean approx 0.9 of a standard deviation higher than that of the combined American and British children, equivalent to an IQ of 113.5. The interest of this result is that it shows the superiority of Japanese children on one of the visuospatial primaries for which evidence has hitherto been unavailable and at the same time confirms the strength of Japanese children on this group of abilities.

9. The Kyoto NX Test

This is a Japanese intelligence test constructed and standardised by psychologists at the University of Kyoto. It consists of 12 scales measuring reasoning, verbal comprehension, numerical and visuospatial abilities. The test has been administered to children in the United Kingdom, thereby introducing a change to the usual procedures in which American tests have been first constructed and standardized in the United States and subsequently standardised in Japan (Lynn and Dziobon, 1980). Five of the verbal tests were considered to be untranslatable because of Japanese language characteristics for which equivalents could not be found in English. The remaining seven tests were measures of non-verbal reasoning, numerical and visuospatial abilities and should probably be considered collectively as largely a measure of Spearman's g. This reduced form of the test was administered in 1978 to a sample of 212 British 9–10 year olds. Also administered to the sample was the American Primary Mental Abilities Test to make it possible to calibrate the Kyoto Test against a well normed American test. The results indicated a Japanese mean IQ of 110.3 as the equivalent of an American mean of 100. The Japanese mean requires race and time adjustment downwards by 1.7 and 3.0 IQ points (the PMA and the Kyoto test were standardised in 1962 and 1972 respectively), giving a Japanese IQ of 105.6.

10. The Kyoto New NX Test

This is a Japanese group test consisting of 12 subtests measuring verbal, numerical and visuospatial abilities, constructed and standardised in Japan in 1968. There are three versions of the test designed for different age groups. We have administered the 9–15 year old version to 216 13–14 year olds in Northern Ireland. The results of this study are reported in detail in Lynn, Hampson and Bingham (1987).

The tests can be described as follows. The verbal subtests consist of jumbled sentences, verbal comprehension and memory for a story; the numerical tests consist of addition and subtraction problems; the visuospatial tests consist of paper folding and other visualisation problems.

In addition to the Kyoto Test, the subjects also took the Standard Progressive Matrices. The purpose of this was to make it possible to calibrate the Kyoto Test against a well standardised British test and so calculate Japanese IQs in relation to a British mean of 100. The sample obtained a mean IQ of 99.2 on the SPM, indicating that it was as representative of British children as could be expected. On the Kyoto Test the mean IQs of the British children, after adjustment for the time interval between the two standardisations, were 102.9 for verbal ability, 103.3 for number ability and 106.7 for visuospatial ability. The results for the verbal and visuospatial abilities are reasonably close, although slightly higher, to those given for this age group in Table 1 (100.8 and 105.4 respectively) and confirm the relative strength of the Japanese on the visuospatial abilities in relation to their verbal abilities. The Japanese numerical abilities however appear rather weaker in this study than those given in Table 1 derived from the WISC-R (103.3 as against 110.5). The reason for this is that the comparison in this study is between Japanese and British children whereas the WISC-R data are a comparison between Japanese and American children. Numerical ability is to some degree determined by the efficiency with which arithmetic is taught in schools and British schools are more effective in this regard than American. A review of the evidence on this question is given in Lynn (1987).

Although the Kyoto Test does not contain non-verbal reasoning problems of the kind which provide the best single measure of Spearman's g, an approximate measure of Spearman's g can be obtained by averaging the means for the verbal and visuospatial tests. The resulting figure is 104.8 and is closely similar to the mean of 104.0 for 14 year olds given in Table 1.

11. The Denver Developmental Screening Test

This test has been described already in connection with the problem of the tendency of young Japanese children in the 2–5 year age range to be retarded on all cognitive abilities. The test contains vocabulary items and on these Japanese children score substantially lower than American children up to the age of six years, the last year covered by the test. This result is therefore consistent with the generalisation that Japanese children are weak on the verbal abilities, but it is not certain to what degree their weakness on this test is attributable to a general maturational lag affecting all cognitive abilities.

12. Conclusions

This section has presented summaries of eleven studies of Japanese intelligence in order to examine how far they corroborate the results derived from the McCarthy Scales, the WPPSI and WISC-R set out in Table 1. We have seen that five studies confirm that Japanese children are superior to American and British Caucasoids in regard to Spearman's g. These are the studies employing the DAT, the CMMS, the MFFT, the Kyoto NX Test and the Kyoto New NX Test. The four of these studies for which a figure for Spearman's g can be calculated all yield higher values than those obtained from the WISC-R (the values derived from the McCarthy and the WPPSI being set aside as too low by virtue of the slow maturation of the Mongoloids). The values obtained from these four tests are 104.5 (the DAT), 107.5 (the CMMS) 105.6 (the Kyoto NX) and 106.2 (the Kyoto New NX). These are all higher than the values for Spearman's g derived from the WISC-R, which range between 98.8–103.1 and average 101.7. These discrepancies can be ascribed to two factors. Firstly, different methods have been employed for the calculation of Spearman's g. In the case of the WISC-R, Spearman's g was calculated from the factor loadings on the first principal component. This method gives a verbal bias to the values for Spearman's g because the verbal tests have higher loadings on the first principal component than the visuospatial tests. Since the Japanese tend to be weak on the verbal abilities, this verbal bias reduces their scores for Spearman's g. The DAT and the CMMS are abstract reasoning tests and can be considered as pure measures of Spearman's g, while the two Kyoto tests contain a mix of various verbal and visuospatial tests which have been averaged to yield a measure of Spearman's g. It will be evident that the precise Japanese value of Spearman's g will vary within limits according to how it is measured. Nevertheless, the five studies reviewed in this section and the WISC-R results all show that Japanese values for Spearman's g are higher than those of Caucasoids in the United States and Great Britain.

Eight studies reviewed in this section show that Japanese children are particularly strong on the visuospatial abilities. These are the Minneapolis–Sendai investigation and the studies employing the DAT, the MFFT, the WISC, the WAIS, the Goodenough–Harris Drawing Test, the EFT and the Kyoto New NX Test. Five studies confirm that the Japanese are either absolutely or relatively weak on the verbal abilities. These are the Minneapolis–Sendai investigation, the WISC, the WAIS, the Kyoto New NX Test and the Denver Developmental Screening Test. Thus, the eleven studies reviewed in this section establish on a reasonably secure footing the conclusions proposed in the preceding section, namely that the Japanese are characterized by high Spearman's g, strong visuospatial abilities and relatively weak verbal abilities. We turn next to a consideration of whether this pattern of abilities also holds for Mongoloids in the United States.

3. THE INTELLIGENCE OF MONGOLOIDS IN THE UNITED STATES

The accumulated evidence on the intelligence of Mongoloids in the United States has been reviewed relatively recently by Vernon (1982) and it is unnecessary to do more than give a brief summary of his conclusions and update his review. On the basis of the data as a whole, Vernon observes that the earlier studies showed quite considerable weakness in the verbal abilities which should be attributed to difficulties with the English language among recent immigrants, but that some degree of this weakness is still present among thoroughly acculturated American Mongoloids. He concludes that the more recent studies "indicate mean IQs on verbal group tests of about 97 (i.e. a little below the white average) and 110 on non-verbal and spatial tests (much above average)" [Vernon, 1982, p. 28]. The non-verbal IQs are based on tests of abstract reasoning such as the Progressive Matrices and should be considered as pure Spearman's g tests. One of the largest of the studies leading to this conclusion is Flaugher and Rock's (1972) investigation of some 18,000 high school juniors in Los Angeles, where the ethnic Orientals obtained higher means than the Caucasoids on reasoning and spatial tests but lower on verbal tests. They also did better on mathematics, which among this age group depends largely on Spearman's g. Undoubtedly the most compelling, by virtue of the vast size of the sample, of the American investigations on the intelligence of Mongoloids is the Coleman, Campbell, Hobson, McPartland, Mood, Weinfeld and York (1966) study of some 650,000 children drawn from all over the United States. If the mean IQ of American Caucasoids is set at 100 (SD: 15), then the mean non-verbal IQ assessed by tests of abstract reasoning, a pure test of Spearman's g, of 6-year old American Mongoloids was 103.75, and their verbal intelligence 97.60. In Table 1 three readings for Japanese 6-year olds have been given, of which the average are 101.0 for Spearman's g and 97.0 for verbal ability. Considering that different tests were used in these two inquiries it is impossible not to be struck by the close similarity between the ability patterns of these two samples of Mongoloids in such widely different geographical locations.

Furthermore, it should be noted that many of the American studies on the intelligence of Mongoloids have been carried out on samples consisting largely or even entirely of ethnic Chinese. The appearance of the typical Mongoloid ability pattern in these samples suggests that it is not confined to the Japanese but is a universal pattern among Mongoloid peoples.

Since the appearance of Vernon's review, several papers have been published on the Hawaii Family Study of Cognition. In this study a number of intelligence tests have been administered to approx 6,500 parents and children in Hawaii and within this sample approximately one-third are Caucasoids and one-third Mongoloids of Japanese origin, while the remaining third are native Hawaiians and various minorities such as Chinese. The means of the different ethnic groups on the tests have not been published but it is nevertheless apparent from the published results that the Caucasoids scored significantly higher on the verbal tests than on the spatial and that the reverse pattern was present in the Mongoloids (Nagoshi and Johnson, 1985).

Another study of the abilities of American Mongoloids published since Vernon's review is that of Wing (1980). She reports the results of some 1,400 young adult applicants for the civil service in a large Western city. As part of the selection procedure the applicants were required to take five tests of the following abilities: verbal, judgement (verbal comprehension), induction, deduction and number. The applicants were then divided by race into Blacks, Mexican American, Filipino, Asian and White. The Asian group displayed once again the low verbal–high reasoning ability profile characteristic of Mongoloid populations.

4. THE INTELLIGENCE OF MONGOLOIDS IN SOUTH EAST ASIA

There are three countries in South East Asia for which there is evidence on Mongoloid intelligence, namely Hong Kong, Singapore and Taiwan. In Hong Kong a sample of 4500 Chinese 13-year olds were given the Progressive Matrices, a pure test of Spearman's g, in a study by Chan (1976). The mean IQ in relation to the British norms was approx 120. However, the British norms date from 1938 and Chan's investigation was carried out in the mid-1970s and so the Hong Kong mean requires adjustment downwards. It has been shown that the mean IQ derived from the Progressive Matrices in Britain has been increasing by 1.86 IQ points per decade (Lynn and Hampson, 1986d). The appropriate downwards adjustment is therefore 6.70 IQ points, giving a mean IQ for Hong Kong Chinese of 113.3. This is clearly a high figure for a test of Spearman's g.

In Singapore a representative sample of Chinese 13-year olds was administered the Progressive Matrices in the mid-1970s in a study of which an account is given in Lynn (1977b). The mean IQ was approx 110.0. This figure requires the same adjustment downwards as the Hong Kong figure given above, i.e. by 6.7 IQ points, giving a mean IQ of 103.3.

In Taiwan a sample of approx 1290 16-year olds was tested by Rodd (1959), using Cattell's Culture Fair Test, a pure test of Spearman's g. The sample was divided into indigenous Taiwanese and immigrants from mainland China, and the mean IQs of the two groups were 104 and 106 respectively. These means require time adjustment downwards by approximately three IQ points, giving means of 101 and 103.

It will be evident from this summary that Mongoloids in Hong Kong, Singapore, and Taiwan tend to achieve the high values of Spearman's g which are characteristic of those in Japan and the United States. So far as is known, there is no evidence currently available on the relative strength of the verbal and visuospatial abilities in these people. This is a question that must await future investigation.

5. CONCLUSIONS

This review of the abilities of Mongoloids began with the presentation of a synthesis of three studies of the intelligence of the Japanese, derived from the McCarthy Scales, the WPPSI and the WISC-R. It was seen that the Japanese differ from American Caucasoids in four respects, namely that they have higher Spearman's g, low verbal ability (from the ages of $2\frac{1}{2}$–9 years but not thereafter), high visuospatial ability, and a developmental trend in which all abilities increase in strength over the years of early childhood. It is then seen that these features of Japanese abilities are confirmed by a number of other studies. It is shown next that these characteristics are also present among Mongoloids in the United States and, so far as the evidence goes, in the three Far East nations of Hong Kong, Singapore and Taiwan. It appears therefore that this distinctive ability profile is characteristic of Mongoloids in a variety of geographical locations. This raises the question of the factors responsible for this pattern of abilities among Mongoloids, and it is to this problem that we turn now.

II. ENVIRONMENTAL THEORY OF CAUCASOID–MONGOLOID INTELLIGENCE

In this part we discuss environmental explanations of the four features of intelligence distinguishing Caucasoids from Mongoloids.

1. Spearman's g

Environmental theorists have sought to explain group differences in Spearman's g, such as have often been found between social classes and also between Caucasoids and Negroids, largely in terms of differences in socio-economic status, incomes and family environment (see e.g. Flynn, 1980; Scarr and Carter-Saltzman, 1982). It is immediately clear that this line of explanation cannot be employed to explain the high Spearman's g of Mongoloids. None of the Mongoloid peoples for whom data on intelligence have been assembled in the first part of this paper enjoys higher incomes or socio-econmic status than Caucasoids. In the United States most of the Mongoloids were initially labourers recruited to build the railways and perform other unskilled work in the West and at this stage were well below Causcasoids in incomes and socio-economic status. Over the decades they have improved their position and by the second half of the present century are approximately the equals of the Caucasoids in these regards (Vernon, 1982). So far as Mongoloids in the countries of the Far East are concerned, their per capita incomes have been well below those of the United States and Britain for the whole of the present century. Per capita incomes for 1960, 1965 and 1970, taken as representative years of the period in which many of the samples for whom IQs have been presented were young children, are shown for the respective countries in Table 3. It will be seen that the per capita incomes in the four Mongoloid countries were consistently well below those of the United States and Britain. These data clearly refute the proposition advanced by many environmentalists to the effect that low per capita income causes low IQ. Nevertheless, environmentalists are probably correct in their supposition that income has some positive effect on intelligence, or, more strictly, serves as a proxy for the quality of the environment which has this beneficial effect. It follows that the values for Mongoloid abilities given for the four Far East nations should probably be regarded as under-estimates of the values that would be obtained where Mongoloids and Caucasiods are reared in more closely matched environments. Since Mongoloids in these relatively unaffluent nations already obtain higher means for Spearman's g than Caucasoids in the United States and Britain, the inference that these means are under-estimates clearly provides a problem for environmental theory.

An alternative environmentalist theory might propose that Mongoloid parents provide a superior family environment for the cognitive development of their children. This theory encounters three difficulties. Firstly, direct comparisons of the cognitive socialisation techniques of Japanese and American mothers have failed to show that Japanese mothers are in any way superior (Stevenson, Azuma and Hakuta, 1986). Secondly, it seems intrinsically implausible that hitherto undiscovered superior cognitive socialisation techniques would be consistently present among Mongoloid parents in such disparate cultures as Japan, Singapore, Hong Kong, Taiwan

Table 3. Per capita national incomes in U.S. dollars in 1960, 1965 and 1970 (Source: United Nations Statistical Yearbooks)

Country	1960	1965	1970
Japan	421	694	1660
Hong Kong	333	—	735
Singapore	417	508	921
Taiwan	100	185	—
Britain	1277	1467	2606
United States	2560	2910	4270

and the United States. Thirdly, Japanese children are characterised by strikingly lower mean IQs over the age range 2½–5 followed by later superiority. An environmental explanation for this developmental curiosity would have to posit that Japanese parents are poor cognitive socialisers of young children but efficient cognitive socialisers of older children. It seems hardly credible that this could be the case. These are all difficult problems for environmental theorists.

2. Low verbal–high visuospatial abilities

These two abilities are taken together because the problem for environmental theory is to find some set of environmental variables which could act differently on the two abilities and raise the visuospatial abilities some 6–10 IQ points higher than the verbal abilities. The data set out in Table 1 show that the mean IQ for Japanese verbal abilities over the age range 6–9 years is approx 96 and from 10–16 years approx 100. The mean IQ for Japanese visuospatial abilities is approx 106 over the whole of the age range 6–16 years. The increase in the verbal abilities can probably be explained in environmental terms as an effect of Japanese education. It has been shown in detail that Japanese schools are far more efficient than those in the United States and Europe in the inculcation of scholastic skills (Lynn, 1987). These scholastic skills have considerable overlap with the verbal abilities, e.g. verbal comprehension and arithmetical ability play an important part in both sets of abilities. Thus the increase of these abilities over the years of schooling is best interpreted in environmentalist terms as a manifestation of the principle of cumulative advantage in a favourable environment.

If this is granted, the true Japanese IQs for the verbal and visuospatial abilities, uncontaminated by school effects on older children, are around 96 for verbal and 106 for visuospatial. The problem for environmental theory is therefore to find environmental variables which will depress the verbal abilities by around four IQ points and raise the visuospatial abilities by around six IQ points. It is clear that it will not be easy to find environmental conditions that could have this effect.

This problem of differential values for different abilities in different populations is a familiar one which has long been known so far as Caucasoid–Negroid differences are concerned. It has frequently been found that Negroids in the United States are weak on Spearman's g, relatively strong on the verbal abilities and relatively weak on the visuospatial abilities. This pattern of Negroid abilities was shown by Shuey (1966) in an extensive review of the literature, by Coleman *et al.* (1966) so far as the selectively strong verbal abilities of Negroids is concerned, and by Jensen (1973b), Reynolds and Gutkin (1981) and Jensen and Reynolds (1982). It has been pointed out by Jensen (1973b) and again by Vernon (1979) that the existence of this pattern poses a problem for environmental theory because it is necessary to find a variable that depresses the several abilities differentially. The problem is particularly difficult because the pattern of abilities differentiating the races is not the same as the pattern differentiating the socio-economic classes. It is well known that the ability that most differentiates the socio-economic classes is verbal ability, whereas that which most differentiates the races is visuospatial ability (see Jensen and Reynolds, 1982, for the most sophisticated treatment of this issue). It is evident therefore that the environmental factors which differentially determine the pattern of abilities between the socio-economic classes cannot be operating to determine the differences between the races.

These phenomena pose difficult problems for environmental theory. Leading environmental theorists such as Flynn (1980) and Scarr and Carter-Saltzman (1982) have ignored these problems, and the inference to be drawn is probably that environmental theory cannot handle these data.

3. Developmental trends

The data set out in Table 1 show that Japanese children tend to show improvements in all abilities over the age range 2½–16 years. Young Japanese children aged 2½–3 years obtain significantly lower means for Spearman's g and the verbal abilities than American Caucasoids. These abilities gradually improve over the course of childhood, until by the age of six years Japanese children are significantly higher on the visuospatial abilities.

It has already been noted in our discussion of Spearman's g that the approach of environmental theory to these developmental trends would have to be to posit some environmental factors which act adversely on Japanese children aged 2½–3, but which are replaced three or four years later by other environmental factors which act advantageously. It is obviously going to be very difficult to identify the environmental factors that could operate in this contradictory manner.

Probably the best strategy for the environmental theorist on this developmental problem would be to concede that Mongoloids are genetically programmed slow maturers up to the age of around five years. From this age onwards environmental theory would posit an advantageous family environment acting on all Mongoloid populations. An explanation along these lines would of course be the thin end of the wedge but is probably the best and the most promising position.

However, even this position presents a difficulty for the environmental theorist. An advantageous environment would be expected to act cumulatively over time, leading to gradually rising IQs over the years of childhood and adolescence. This phenomenon is known as cumulative advantage and its converse as cumulative deficit. Its existence has been demonstrated among Negroids in the deep South of the United States as compared with Caucasoids, i.e. these Negroids display progressively lower IQs with increasing age due to their disadvantageous environment (Jensen, 1977). The expected cumulative advantage does take place in Japanese children in the case of the verbal abilities. These increase from about 97 among 6-year olds to 101 among 16-year olds. This 4 IQ point increase should probably be attributed to the efficient teaching provided by Japanese schools. But there is no sign of any cumulative advantage effect for the visuospatial abilities. These remain constant at approx 106 throughout the 6–16 age range. An environmentalist theory of the developmental trend of the visuospatial abilities of Japanese children would have to find a variable that raises the IQ from 100 among 4-year olds to 106 among 6-year olds, and thereafter has no further effect. Clearly it would be very difficult to discover an environmental variable which acts solely during these two critical years.

4. Conclusion

It is a well known phenomenon in science that as the evidence in a field accumulates it becomes progressively more difficult to construct a theory which will explain the totality of the data. I suggest that environmental theory is now confronted with this problem so far as Mongoloid–Caucasoid differences in intelligence are concerned. It has been argued that it is not possible to formulate plausible environmental explanations for any of the four principal features of Mongoloid intelligence, namely the high values for Spearman's g, the low verbal abilities, the strong visuospatial abilities, and the developmental trends. Taken together the problems posed by the totality of the data are probably insuperable for environmental theory. We therefore turn next to the question of whether a plausible explanation for the data can be provided by genetic theory.

III. GENETIC THEORY OF MONGOLOID INTELLIGENCE

A genetic theory of Mongoloid intelligence would begin by positing that the various features of Caucasoid–Mongoloid differences in abilities and their developmental trends are genetically programmed characteristics differentiating the two races. Genetic theorists do not propose that genetic factors are the sole determinants of racial or other population differences in abilities (see e.g. Eysenck, 1984), but they do maintain that these are powerful determinants and that where populations are living in broadly comparable social and economic conditions the differences in their abilities are to a considerable extent a function of genetic differences. A genetic theory would explain the major features of the intelligence of Mongoloids as follows:

1. The consistency with which the same pattern of Mongoloid abilities is found in different environments follows naturally from the assumption that there is a substantial element of genetic programming of these abilities. If Mongoloids are genetically programmed to display high values for Spearman's g from the age of 6 years onwards, weak verbal abilities, strong visuospatial abilities, and retarded development in infancy and early childhood, then these features will be found in all Mongoloid populations living in roughly comparable affluent societies. It has been seen that so far as the data go this prediction is confirmed for Mongoloids in such disparate environments as Japan, the United States, and the nations of the Far East.

The consistency with which the characteristics of Mongoloid abilities appear in diverse environments poses a major problem for environmental theory, since it requires that the same set of environmental factors is operating to produce the Mongoloid ability profile throughout these different environments. Genetic theory handles these consistencies well.

2. Genetic theory can provide an explanation for the developmental trends of the different abilities along the following lines. Firstly, Mongoloids are genetically programmed slow maturers in infancy and early childhood. This accounts for the low initial values and steady developmental increase of all abilities in Japanese children over the age range $2\frac{1}{2}$–5 years and the delayed maturation of Mongoloid infants in Hong Kong and California. From the age of around 6 years Japanese children are exposed to a more efficient education system than those in the United States or elsewhere in the West, as shown in detail elsewhere (Lynn, 1987). The efficient Japanese education system acts only on the verbal abilities, especially numerical ability, which are taught in schools. Hence the verbal abilities all show increases over the 6–16 year age range. This is a straightforward case of cumulative advantage. The Japanese education system has no effect on the visuospatial abilities, which are not taught in schools. Hence the visuospatial abilities of Japanese children remain constant at approx 106 throughout the 6–16 year age range. Japanese Spearman's g is broadly an average of the verbal and visuospatial abilities and hence shows a small rise throughout the years of childhood and adolescence.

3. Apart from educational effects, there is still the problem of the differential of approximately ten IQ points between the verbal and visuospatial abilities of Mongoloids. This problem can be handled by genetic theory by the assumption that this happens to be the way Mongoloid abilities are genetically programmed. This explanation is all very well so far as it goes and it does have the merit of explaining the consistency of the Mongoloid profile in diverse environments, which is a problem for environmental theory. Nevertheless, to provide a satisfying explanation of this pattern of abilities the genetic theorist should offer an account in evolutionary terms for the origin of this ability profile. The unusual pattern of abilities of Mongoloids must have arisen through the operation of unique selection pressures operating on the Mongoloid peoples over a long period of time. At some point the genetic theorist is called upon to offer an account of these selection pressures and of how they brought about the observed Mongoloid ability profile. It is to the presentation of a theory of these selection pressures that we turn to next.

IV. THE EVOLUTION OF MONGOLOID INTELLIGENCE

Here we present an evolutionary theory of the principal features of the intelligence of Mongoloids. We begin with an account of the general principles governing the evolution of intelligence; continue with accounts of the selection pressures responsible for the strong visuospatial abilities in males and strong verbal abilities in females; consider next the evolution of the Mongoloids' high Spearman's g and their strong visuospatial abilities; and finally offer an explanation of the weak verbal abilities of Mongoloids.

1. The evolution of Spearman's g in the Hominids

For an understanding of the evolutionary processes responsible for the intelligence of Mongoloids it is necessary to understand the general principles underlying the evolution of intelligence, of which the present problem is a special case. These principles have been worked out by Jerison (1982). The most important of these principles, and the only one that need be called upon in this discussion, is that from time to time during the course of evolution a population moves into a new environmental niche in which survival demands greater intelligence. When this occurs the brain grows in size or efficiency in order to produce the greater intelligence that is required. The effect of the operation of this principle is that intelligence, and the brain size accommodating it, has evolved in jumps followed by long periods of equilibrium as populations have moved into new niches and then solved the problems of surviving in them.

One of the most important of these jumps took place approximately 220 million years ago. At this time the dominant species were large reptiles. Small reptiles found a new niche by becoming nocturnal. They rested quietly in burrows during the day time, undetected by carnivorous large reptiles, and they came out at night when the large reptiles were asleep. This new niche was a good one, but it carried with it certain problems. For one thing it was cold at night, and so these small nocturnal reptiles evolved internally regulated temperature and became mammals. Another problem was that their visual sense was not a great deal of use to them, particularly on dark moonless nights. To obtain adequate information about the world they came under selection pressure to develop their auditory, olfactory and tactile senses, which were not impaired in the hours of darkness, and to develop a larger brain in which information from all four senses could be integrated and analysed. In response to this selection pressure they evolved a substantial increase in brain size to accommodate the new and more demanding information processing abilities.

Another of these jumps in intelligence took place approximately five million years ago among some of the apes living in East Africa. These apes were tree living animals, like other primates, who had found an arboreal niche in which they could keep out of the way of predators and subsist on a diet of fruits, nuts, leaves and insects. This niche began to deteriorate some 12 million years ago. The climate in Africa became drier and the forests gradually disappeared and were replaced by grasslands. As a result a number of these ape populations were forced onto these grasslands. They were poorly adapted for this new habitat and many of them perished.

Nevertheless, some managed to survive and for these the open grasslands acted as a challenging new niche. Survival in this new niche demanded greater intelligence, and in response to this selection pressure some of the apes developed a larger brain. They evolved into the species *Australopithecus* and they survived living in small groups by the shores of lakes and rivers and subsisting on a diet of grass seeds, fruits, nuts, shell fish, insects and tubers obtained by foraging (Isaac, 1978; Parker and Gibson, 1979).

The precarious new environment exerted continuous selection pressure for improved intelligence and in response to this pressure they evolved increases in all three of the major components of intelligence, i.e. general reasoning, verbal and visuospatial abilities. These increases in intelligence were developed from the rudimentary forms of all three abilities which must have been already possessed by the australopithecines since they are present in the extant apes. The ability of apes to reason was demonstrated by Kohler (1925) in his classical experiments with chimpanzees in which he showed that these animals can solve "insight problems" such as the comprehension of the relationships involved in slotting together two rods to form an extended hoe with which to pull bananas into a cage. In addition the extant apes possess a primitive form of verbal ability insofar as members of a troupe communicate with one another by sounds and gestures; and also of visuospatial ability which they employ in the use of tools such as twigs to extract ants and termites from their nests. All that was required for the australopithecines was to improve the abilities which they already possessed in primitive form.

The selective advantages of improved cognitive abilities were these. With better general reasoning they could plan for the future and solve a number of the great variety of problems involved in survival, group cooperation and maintaining a cohesive social structure. With improved verbal abilities they could communicate more effectively with one another in the planning and execution of group activities, in sharing knowledge which was useful for survival, and in passing knowledge down from parents to children. With improved visuospatial abilities they were able to make tools and weapons and to organise group hunting expeditions. Under the impact of the continuing demands of this new niche, *Australopithecus* evolved into the successive hominid species of *Homo erectus* and *Homo sapiens* and the size of the brain grew approximately three-fold.

2. Evolution of the verbal and visuospatial abilities in males and females

We now consider more closely the evolution of the verbal and visuospatial abilities and the way in which these became differentiated in males and females. Both these groups of abilities conferred selection advantages, the verbal abilities for communication and the visuospatial abilities for foraging and hunting. It is suggested by Lovejoy (1981) that these two abilities began to develop differentially in males and females quite early in hominid evolution. Males began to specialise in foraging and hunting, and for this purpose developed their visuospatial abilities, and females began to specialise in child rearing and education, and for this purpose developed their verbal abilities, including the teaching of language and the passing on of useful acquired knowledge from one generation to the next. These respective specialisations were of course already present to some degree in other primates and indeed in many carnivorous mammals such as hunting dogs and wolves, and we can safely assume they were present in rudimentary form among the australopithecines.

We follow Lovejoy in his thesis that, so far as males were concerned, the initial form of this specialisation was that they went out foraging for food. They developed the ability to construct simple tools for digging up edible tubers and for breaking open shell fish. These skills provided them with new food sources relatively inaccessible to competitors, as Parker and Gibson (1979) have pointed out. The cognitive basis for the development of these skills was good visuospatial abilities, with which they could visualise the food hidden under the ground, in the case of tubers, or within shells, in the case of shell fish. This development also provided the primary impetus for the development of bipedalism which was in many ways a disadvantageous adaption because a bipedal animal cannot run as fast as a quadripedal. The compensatory adaptive advantages of bipedalism were that they freed the hands for making and using tools and for carrying food back to females and children. Initially the male australopithecines were not sufficiently skilled to hunt, but as they improved their intellectual abilities they were able to develop hunting skills. All three components of intelligence would have contributed to these hunting skills, but the visuospatial abilities would have been the most important. There were two principal ways in which improved visuospatial abilities facilitated the development of hunting. Firstly, they enabled the male australopithecines to throw rocks accurately at small animals and to stun, immobilise or kill them. Many small animals such as young baboons, rabbits and so forth sit-still at a distance of some yards from a predator and do not run for cover until the predator approaches. It has been suggested by Calvin (1982) that male australopithecines exploited this propensity by developing accurate stone throwing skills by which they were able to kill such small prey from a distance. These accurate stone throwing skills depend upon good visuospatial abilities, to judge the distance, direction and velocity with which the missile has to be thrown. This dependence has been demonstrated by Kalakowski and Malina (1974) in a study in which they showed a positive correlation among adolescent boys between throwing accuracy and spatial ability measured by a standard intelligence test. Males are better at throwing stones than females and this superiority is present among 5–7 year olds (Jenkins, 1930). It is probable that Calvin is right in his suggestion that this male specialisation was an australopithecine adaptation.

The second advantage of the visuospatial abilities for hunting was that they promoted the efficient organisation of the group hunting expedition. The early hominids were social animals living in groups from which the adult and adolescent males went out on hunting trips in bands of a dozen or so. These hunting groups had sophisticated strategies such as driving their prey into bogs, the loops of rivers and so on (Passingham, 1982). For this they would have needed good visuospatial abilities to plan and execute strategies for surrounding their prey and driving them into natural traps where they could be caught.

At the same time that males developed strong visuospatial abilities to facilitate their specialisation as hunters, females developed strong verbal abilities to improve their own specialisation for the rearing of children. Good verbal abilities, especially those of verbal fluency and immediate memory, enabled mothers to teach language and useful knowledge, e.g. which foods are poisonous, what animals are dangerous and so forth. It is proposed that this division of labour between the sexes provides the explanation for the high visuospatial–low verbal pattern of abilities in males and the reverse pattern of abilities in females which has been virtually invariably found by intelligence testers among all contemporary races of *Homo sapiens*.

Nevertheless, to speak of a male and a female intelligence is an over-simplification. We follow Levy (1974) in supposing that there was overlap between the sexes and also individual differences within each sex in the relative strength of the verbal and visuospatial abilities. A continuum can be envisaged. At one extreme would be individuals with very high verbal abilities and very weak visuospatial abilities. They would have been predominantly but not exclusively female, and their special contributions to the well being and survival of the group would have been their exceptional language abilities and their long term verbal memories. At the other extreme would be those with the converse pattern of very strong visuospatial abilities and weak verbal abilities. Their contribution would have been the solution of visuospatial problems involved in the construction of better tools, weapons, shelters and hunting strategies. They would have been predominantly male and they would have been taciturn animals—strong silent males—with relatively poor verbal fluency and memory. Most individuals of both sexes would not have been at either of these extremes. They would have been generalists, fairly good in both the verbal and visuospatial areas, females tending to have the high verbal–low visuospatial pattern and vice versa in males.

In short, the early hominids developed a balanced polymorphism in which several genotypes representing different mixes of the verbal and visuospatial abilities coexisted in different individuals because each genotype made its own contribution to the survival of the group. It will be noted that this thesis implies the existence of a negative association between the verbal and visuospatial abilities, such that the presence of high values of one is secured at the cost of low values for the other. This problem is taken up later in the paper.

3. Evolution of Spearman's g in Mongoloids

By approximately 250,000 years ago *Australopithecus* had evolved into *Homo sapiens*, and had acquired strong general intelligence and good verbal and visuospatial abilities. The next stage of the evolutionary process took place about 120,000 years ago.

By this time *Homo sapiens* was well adapted to survival in Africa and some groups began to migrate northwards into Europe and Asia. Those who remained in Africa were the ancestors of the living Negroids who retained the dark skin that gave protection from strong sunlight and the peppercorn hair that reduced the rapid evaporation of sweat, protects the head from excessive heat and from sunstroke. Those who migrated northwards evolved the pale skins which enabled them to absorb vitamin D from sunlight. At this stage these pale skinned populations were a single undifferentiated race (Nei, 1978).

A further stage of this evolution occurred approximately 60,000 years ago. From this time the ice ages began to descend on the northern regions and their effects were particularly severe in North East Asia. The reasons for this were firstly that this region is such a large land mass and secondly that the Himalayas acted as a barrier in the south. The effect was that the populations in North East Asia found themselves boxed in between the encroaching ice from the Himalayas in the south and from the Arctic region in the north. The cold to which they were subjected in this region was far more severe than that experienced by the other pale skinned populations in Europe, who were relatively close to the sea and had no southern ice barrier equivalent to the Himalayas. It was in response to this extreme cold that these populations evolved their distinctive physical adaptations of the epicanthic fold and the slit eyes to afford protection against the cold and the glare of the sunlight on the snow, and the flattened face and shortened limbs to reduce heat loss (Coon, 1955; Bodmer and Cavalli-Sforza, 1976). These physical adaptations to extreme cold differentiated the Mongoloid race from the Caucasoids in Europe and the Middle East.

It is suggested that this hostile environment acted as a new environmental niche which exerted selection pressure for a further increase in intelligence. As Jerison has observed "it takes more brains to make a living in some niches than in others" (1982, p. 747), and if ever there was a niche in which it took brains to survive it was surely North East Asia during the ice ages. This was the coldest part of the world inhabited by early *Homo sapiens*. Even today temperatures of −87°F have been recorded in Siberia, and this would have been just an average day for the Mongoloid people during the ice ages. To survive in these temperatures they would have had to construct shelters well insulated from the cold, to build fires, to make warm clothes, to store food and to plan ahead for the winters which were even colder than the summers. For all of these the selection pressure for improved general intelligence would have been stronger than for the Caucasoids and the Negroids. It is therefore proposed that this is the most probable explanation in evolutionary terms for the high general intelligence (Spearman's g) of the Mongoloids.

4. Evolution of Mongoloid visuospatial abilities

The extreme cold of the ice ages would have generated a second selection pressure on the Mongoloids in addition to that for improved general intelligence, and this would have been for an increase of their visuospatial abilities. The reason for this is that the Mongoloids would have become heavily reliant on hunting for their food and the visuospatial abilities underlie good hunting skills.

Both early *Homo sapiens* and primitive peoples scattered throughout the world today are known as hunter–gatherers because they obtain their food partly by hunting and partly by gathering. But the proportions of hunting and gathering vary in different latitudes. In tropical and subtropical regions contemporary tribes subsist largely by gathering plant foods. These are available throughout the year and can be easily harvested, and so for people in these latitudes hunting for meat is not strictly necessary and forms only a minor part of their diet. Since this is the case for hunter–gatherer peoples in equatorial latitudes today, no doubt Lee (1968) and Passingham (1982) are correct in inferring that this has always been true of people in these regions.

However, when the first groups of *Homo sapiens* migrated northwards into Europe and Asia they found that there was no longer a ready supply of plant foods throughout the year. Plant foods became seasonal and during the winter and spring these peoples would have had to rely on meat foods. To obtain these they had to improve their hunting skills and hence they came under selection pressure for an increase of their visuospatial abilities. This pressure would have been strongest for the Mongoloids because it was they who occupied the coldest regions where plant foods were least available. We can reconstruct the life style of the three major races from that of contemporary hunter gatherers studied by Lee (1968). Those in tropical and subtropical latitudes are mainly gatherers; those in temperate zones hunt and gather in approximately equal proportions; and those in the coldest latitudes live largely by hunting. The life style of the Mongoloids during the ice ages must have been similar to that of Eskimos who live very largely by hunting and fishing and have to do so because for much of the year no plant foods are available. The Eskimos, like the Mongoloids in Asia, have developed good visuospatial abilities (Berry, 1966; Vernon, 1979) and it is suggested that they have done so for the same reason.

To hunt effectively in the Arctic requires not only the visuospatial abilities of accurate stone throwing and the formulation of group hunting strategies. In addition, as Harris (1978) suggests, it requires the ability to isolate slight variations in visual stimulation from a relatively featureless array, such as the movement of a white Arctic hare against a background of snow and ice; to recall visual landmarks on long hunting expeditions away from home and to develop a good spatial map of an extensive terrain. All these requirements would have acted as selection pressures for the improvement of the visuospatial abilities and it proposed that this is the explanation in evolutionary terms for the strong visuospatial abilities of the living Mongoloids.

5. Evolution of Mongoloid verbal abilities

We come now to the puzzling question of the poor verbal abilities of Mongoloids. It has been argued that the inhospitable environment of the ice ages provided the selection pressure for the increase of general intelligence and of the visuospatial abilities of the Mongoloid peoples. It would appear to follow that this selection pressure would have acted also on the verbal abilities. These also would have conferred a selective advantage for survival, giving better communication skills, and therefore the verbal abilities should also have increased. Yet, as we have seen, the verbal abilities of Mongoloids are weaker than those of Caucasoids.

There are two ways of dealing with this problem. Firstly, it may be that the Caucasoid peoples were subjected to some other strong selection pressure for an increase of the verbal abilities which was not present to the same degree for the Mongoloid peoples. However, it is difficult to imagine what such a selection pressure could be. It is generally considered that verbal abilities, including the acquistion of language, developed because they facilitated group co-operation and the transmission of cultural knowledge from one generation to the next. The selection pressures for the development of the verbal abilities would surely have been at least as strong for the Mongoloid peoples in North East Asia as for the Caucasoid peoples in Europe and the Middle East. An explanation along these lines is therefore considered unpromising.

A second approach to the problem is that the enhancement of the visuospatial abilities in the Mongoloids took place at the expense of the verbal abilities. I believe that this is the correct explanation and that what evolved in the Mongoloids was a trade-off in which the verbal abilities were sacrificed to permit an increase in the visuospatial abilities. It has already been suggested that the first trade-off of this kind occurred much earlier in hominid evolution between the sexes, when males sacrificed their verbal abilities to permit an enhancement of their visuospatial abilities, and vice versa in females. The Mongoloids took this trade-off a stage further and in developing stronger visuospatial abilities they made a greater sacrifice of their verbal abilities.

The first trade-off in which males sacrificed some of their verbal abilities to secure better visuospatial abilities was relatively minor compared with the second trade-off made by the

Mongoloids. Males differ from females on the visuospatial abilities by an average of around 2 IQ points (Jensen and Reynolds, 1983). For this relatively small gain males only needed to make some sacrifice of the verbal primaries of fluency and immediate verbal memory; it was not necessary to sacrifice verbal comprehension which remains as strong in males as in females (Maccoby and Jacklin, 1974; Jensen and Reynolds, 1983). The Mongoloid trade-off was more substantial. The difference between the Mongoloids and the Caucasoids on the visuospatial abilities is approx 8 IQ points, about four times the difference between males and females. To secure an increase in the visuospatial abilities of this magnitude it was necessary to make greater sacrifices of the verbal abilities. The fluency and immediate verbal memory primaries were therefore reduced further and verbal comprehension was sacrificed as well. Hence the Mongoloid–Caucasoid differences in the verbal–visuospatial balance of abilities mirrors but exaggerates the male–female differentiation from which it developed. As was noted earlier, this thesis implies that there is a negative association between the verbal and visuospatial abilities.

V. THE NEUROLOGY OF MONGOLOID INTELLIGENCE

The evolution of a distinctive pattern of intelligence in the Mongoloids must have entailed the development of distinctive features of the neurology of the brain. This is the problem we take up here. We consider first the neurology of general intelligence as it evolved from *Australopithecus* to *Homo sapiens*; secondly, the neurology of the verbal and visuospatial abilities; thirdly, the different neurological structures that evolved in males and females to serve their respective specialisations in the visuospatial and verbal abilities; fourthly, the further neurological structures that evolved in Mongoloids in which their visuospatial abilities increased at the expense of their verbal abilities; and fifthly, the as yet unresolved problem of the slow maturation rates of the Mongoloids.

1. General intelligence determined by brain size and neural efficiency

When a species comes under selection pressure for an increase of its intelligence there are two ways in which the brain responds. These are, firstly, that the brain grows in size; and secondly, that it increases its efficiency for the processing, analysing and storing of information. The growth of brain size is the more readily apparent of these two developments. Stated quite generally, if a species has to become more intelligent to deal with the problems of survival, it needs a larger brain. This principle was stated some four decades ago by Lashley in the following terms: *The only neurological character for which a correlation with behavioral capacity in different animals is supported by significant evidence is the total mass of (cortical) tissue, or rather, the index of corticalisation* [i.e. the ratio of brain weight to body weight] (Lashley, 1949, p. 37). This position has subsequently been confirmed in detail by Jerison (1982).

There are three principal sets of data on which this principle rests. Firstly, the relationship between brain size and general intelligence, as tested for example by problem solving ability, holds over a wide range of species. Much evidence in support of this relationship has been assembled by Jerison (1982). This principle has been questioned by Macphail (1982) but his challenge has not been considered convincing. It is clear that animals with large brains, such as apes, dolphins and mammals generally as compared with reptiles and birds, are far more efficient at solving learning set problems, insight problems of the kind originally devised by Kohler (1925) and are far less easily fooled by sign stimuli, than animals with small brains (see e.g. Mackintosh, Wilson and Boakes, 1985, for a discussion of some of these problems). Secondly, the relationship between brain size and intelligence holds between human beings. It has been estimated by Van Valen (1974) that the correlation is approx 0.3, although Jerison (1982) considers that the correlation, although positive, is considerably lower. Thirdly, the relationship holds for the amount of cortical tissue serving relatively narrow skills, e.g. far more cortex is devoted to the motor control of the fingers than of the toes and of the lips than of the ears. The reason for this must be that considerably more complex skills are executed by the fingers and the lips than by the toes and the ears.

The principle that greater intelligence requires a large brain came into operation when the first protohominids were forced out of the forests and obliged to survive on the open grasslands. Over the course of some four million years the brain grew in size approximately 3-fold as *Australopithecus* evolved into *Homo erectus* and finally into *Homo sapiens*.

When the Mongoloids came under particularly strong selection pressure to increase their intelligence in order to survive during the ice-ages, the most straightforward neurological adaptation would have been a further increase in brain size. However, there was a problem. To secure larger brained adults it was necessary that these should be born as larger brained babies, and this in turn required mothers with larger pelvises through which these babies had to pass. It seems that the demands entailed in this adaptation were too great to be overcome. This problem had already been encountered much earlier in hominid evolution. As we have noted, the brain grew 3-fold from *Australopithecus* to *Homo sapiens*, but the female pelvis did not grow 3-fold to permit the birth of babies with increasingly larger heads. The solution was that babies were born earlier and more immature and the head grew after birth instead of before. Thus the head of the human baby at birth remains about the same size as that of the baby ape (Tobias, 1981). Nevertheless, there seems to have been some constraint on this process of mothers giving birth to progressively more immature babies. This constraint put a stop to any further increase of brain size in *Homo sapiens* approx 250,000 years ago.

Because of these problems some other process apart from increases in brain size had to evolve in response to the continuing selection pressure for improved intelligence. The brain's adaptation to this problem was to increase its neural efficiency as an information processor. It is for this reason that positive correlations are found in human subjects between quite simple measures of neural efficiency and complex intelligence tests. These simple measures of neural efficiency are of three kinds, namely the speed and accuracy of neural transmission of stimuli from the sense organ to the cortex, as measured by the evoked potential, and first demonstrated by Ertl and Shafer (1969); inspection times, e.g. the psychophysical threshold at which subjects can distinguish which is the longer of two very briefly presented lines (e.g. Brand and Deary, 1982); and simple reaction times, i.e. the speed with which a subject can press a button when presented with a visual or auditory stimulus (e.g. Carlson and Jensen, 1982). We follow Eysenck in interpreting the correlations between intelligence and these simple tasks as evidence for "the existence of a fundamental biological property of the CNS underlying success on orthodox IQ tests" (Eysenck, 1982, p. 259). This biological property is the efficiency of the neural information processing capacity. It does not appear to be crucial whether the correlations between these simple measures of neural efficiency and complex intelligence test performance are of the order of 0.8, as proposed by Eysenck, or only around 0.3, as preferred by Mackintosh (1986). The correlation of 0.3 is sufficient to sustain the theory that intelligence in *Homo sapiens* is a function of neural efficiency.

It is therefore proposed that when the Mongoloids came under unusually severe selection pressure for a further increase of intelligence, the most straightforward adaptation of an increase in brain size was not feasible because of the constraints outlined above. The Mongoloid brain consequently evolved the alternative adaptation of increasing its neural efficiency. There is, so far as it has been possible to ascertain, no evidence to show that Mongoloids have superior neural processing efficiency as measured by evoked potentials, inspection times or simple reaction times. Nevertheless, we follow Popper (1959) in the belief that a progressive theory generates hitherto untested predictions and this is one of the many which will be found in this paper for those who have Mongoloid subjects at their disposal and are able to carry out the necessary investigations.

2. Neurology of the verbal and visuospatial abilities

The starting point for the consideration of the neurology of the verbal and visuospatial abilities must be that, broadly speaking, the verbal abilities are located in the left cerebral hemisphere and the visuospatial abilities in the right. This generalisation holds for the approx 95% of the population who are right handed and for about a third of left handers. In the interests of simplification it will be assumed henceforth that it applies to the whole population and the 3–4% for whom the generalisation does not hold will be ignored.

The specialisation of the left hemisphere for the verbal abilities was first shown by Broca (1861) and has been confirmed by countless subsequent investigators. The specialisation of the right hemisphere for the visuospatial abilities was first proposed by Hughlings Jackson (1876) and has also been confirmed by countless subsequent investigators (see, e.g. Bradshaw and Nettleton, 1983; Levy, 1980). It may well be that some analogue of these specialisations of the two hemispheres appeared some 220 million years ago with the evolution of the first mammals. These early mammals were small animals, not unlike the contemporary rat, and the rat analyses spatial information in the right cerebral hemisphere (Denenberg, 1981; Damasio and Geschwind, 1984), although what the rat analyses in the left hemisphere does not appear to be known. There is however evidence that macaque monkeys analyse the vocal calls they make to each other in the left hemisphere (Petersen, Beecher, Zoloth, Moody and Stebbins, 1978). These admittedly patchy findings suggest that there may well have been an early differentiation of function between the left and the right hemispheres which served as a pre-adaptation in the evolving hominids for the localisation of the verbal abilities in the left hemisphere and visuospatial abilities in the right.

We have seen that quite early in the evolution of the hominids males began to develop stronger visuospatial abilities to improve their foraging and hunting skills and females to develop stronger verbal abilities for the rearing and education of children. In order to accommodate these respective specialisations the male and female brain (more strictly, the *typical* male and female brain) must have developed different structures. The neurology of these developments can be envisaged at two levels of generality. Firstly, and more generally, the male brain must have allocated more cortex to the visuospatial abilities and in so doing had to allocate less cortex to the verbal abilities. The alternative trade-off must have taken place in the female brain. This inference follows from the general principle that when animals come under selection pressure for an increase in intelligence the brain responds by increasing in size. In the present case of the male and female specialisations, the male brain followed this principle by increasing the amount of cortex devoted to the visuospatial abilities and the most economical way of doing this was to sacrifice some of the cortex devoted to the verbal abilities.

The second problem is what precise neurological structures evolved in the male and female brain to accommodate these two trade-offs. A number of neuropsychologists such as Levy (1974), McGlone (1980) and Bradshaw and Nettleton (1983) have pondered on this problem and it cannot be claimed that any of them have formulated a solution that has commanded universal assent. Nevertheless, we adopt here the solution proposed by Bradshaw and Nettleton (1983) in order to show how a plausible neurological model can be formulated to handle the male–female differences in the verbal and visuospatial abilities and the Mongoloid–Caucasoid differences which grew out of them.

3. The Bradshaw–Nettleton model of the neurology of sex differences in abilities

The Bradshaw–Nettleton model states that in males the whole of the left hemisphere was allocated to the verbal abilities and the whole of the right to the visuospatial abilities. In females, the whole of the left hemisphere was also allocated to the verbal abilities, but in addition a supplementary verbal centre was established in the right hemisphere. In this way males secured more cortex for their visuospatial abilities while females sacrificed some of their visuospatial cortex in their right hemisphere and used the space more profitably for an enhancement of their verbal abilities.

This model requires supporting evidence if it is to be rendered credible, and the required evidence is of two principal kinds. Firstly, in dichotic listening experiments where verbal stimuli are presented to the right or left ears, males but not females show a right ear advantage. The inference from this is that males can only process verbal input to the right ear in the left cerebral hemisphere. Verbal input to the left ear cannot be processed by the right hemisphere because males have no verbal processing centre in this hemisphere and hence these stimuli have to be relayed over to the left hemisphere, thereby producing the right ear advantage. In females, however, there is no right ear advantage for verbal inputs. The reason for this is that they can process verbal stimuli presented through the left ear by the verbal centre in the right hemisphere. In the case of non-verbal stimuli these sex differences are not present. Both sexes process these stimuli in the right hemisphere and hence show a left ear advantage. The same sex differences are found when verbal and perceptual stimuli are presented visually in either the right or left visual fields. All of this evidence is summarised by Bradshaw and Nettleton (1983).

The second source of evidence for some representation of verbal abilities in the right hemisphere in females but not in males arises from the differential effects of damage to the left hemisphere in causing aphasia. Left hemisphere damage has more serious effects for language in males than in females. The inference is that females suffering left hemisphere damage can continue to use the language centre in their right hemisphere. Males do not have this facility and are accordingly more seriously impaired. This sex difference in the seriousness of aphasia following left hemisphere damage has been found by a number of investigators whose work is reviewed by McGlone (1980).

4. Brain structure of Mongoloids

We begin by noting that the Mongoloid brain is similar in its general neurological structure to the Caucasoid brain in so far as the verbal abilities are broadly localised in the left hemisphere and the visuospatial abilities in the right (Endo, Shimizu and Nakamura, 1981). The Mongoloid brain also has the same sex differences as the Caucasoid brain, with males having relatively higher visuospatial abilities (Lynn, Hampson and Iwawaki, 1987).

These similarities would be expected from the common evolution of the two races from *Australopithecus* to *Homo sapiens*. What was required when the Mongoloids came under selection pressure during the ice ages for an increase of their visuospatial abilities was for the brain to find more cortex to accommodate this increase, and it was prepared to sacrifice some verbal abilities to achieve this end. There would probably have been two ways in which this problem was solved. Firstly, there were various miscellaneous abilities handled by the right hemisphere, such as the perceptual analysis of the howling of wolves, barking of dogs, bleating of sheep, singing of birds and insects and other animal sounds. These would have been transferred from the right hemisphere to the left, thereby freeing cortex in the right hemisphere for better visuospatial ability and at the same time sacrificing some of the verbal cortex in the left. Evidence for this and similar minor adaptations is present in the work of Tsunoda (1978) who has shown that the Japanese process a variety of sensory inputs in their left hemisphere which are processed by westerners in the right. These sensory inputs include vowel sounds, animal sounds, the singing of insects and Japanese music. Tsunoda posits a subcortical switch mechanism which directs these sensory inputs to the right hemisphere in westerners and to the left hemisphere in Japanese. If this is the case the right hemisphere in the Japanese is freed from dealing with these sensory inputs and can be devoted more fully to the visuospatial abilities, while at the same time, the Japanese left hemisphere has to process these inputs and hence has less cortex for the verbal abilities. It is only fair to state that Tsunoda himself believes that the different neurological organisation of the Japanese brain is acquired environmentally through the distinctive features of the Japanese language, whereas our own view on the basis of the evidence presented earlier is that the pattern of Japanese abilities and their neurological basis must have some genetic basis which may possibly be enhanced by environmental processes.

It is probable that what may be called the *Tsunoda solution* was not sufficient and that the Mongoloid brain needed to evolve a further adaptation to devote further cortex to the visuospatial abilities. It is proposed that it accomplished this by the establishment of a supplementary visuospatial centre in the left hemisphere. The effect was that the Mongoloid left hemisphere retained the long established hominid function of serving the verbal abilities but these were slightly reduced by the encroachment of the visuospatial abilities. This pattern of neurological organisation would therefore be the converse of the Bradshaw–Nettelton model of the neurological structure of Caucasoid females.

Experimental evidence supporting this theory of the neurological structure of the Mongoloid brain has been provided by an investigation by Hatta and Dimond (1980). In this study two experiments are reported comparing Japanese students in Osaka with British students in Cardiff. In the first experiment sequences of six digits were presented for two seconds in the left and in the right visual fields. Both Japanese and British subjects perceived the digits more accurately in the right visual field than in the left and there were no significant differences between them. Our interpretation of this result is that both Japanese and British subjects process verbal input in the left hemisphere, to which stimuli presented in the right visual field are directly relayed, and for this reason are perceived more efficiently. In the second experiment what are described as "random forms", i.e. irregular geometric shapes, were presented in the left and right visual fields, in the same way as with the digits in the first experiment. The British students perceived the shapes more accurately in the left visual field, but the Japanese students perceived the shapes with equal accuracy in both visual fields. Our interpretation of this result is that the British students could only analyse these visual stimuli with the right hemisphere, thereby giving a left visual field superiority. The

Japanese students, having visuospatial processing centres in both hemispheres, perceived the stimuli equally well in the left and the right visual fields. The total accuracy score of the Japanese students was higher than that of the British by approximately half a standard deviation. This would be expected and is the order of the superiority of the Japanese on visuospatial tasks, but in this case the number of subjects was too small (30 from each group) for the difference to reach statistical significance.

5. The slow maturation of Mongoloids

We come now to the problem of the slow maturation of Mongoloids which, as we noted earlier in this paper, is present at birth, in infancy and in early childhood up to the age of around 5 years. In this regard the Mongoloid–Caucasoid difference once again mirrors the male–female difference, since males and Mongoloids are both slow maturers and have high visuospatial abilities as compared with females and Caucasoids. It is probable that the explanation for these parallels is that the Mongoloid brain used the same endocrinological mechanism to secure its high visuospatial abilities as had evolved earlier in hominid evolution in males for the same purpose. These mechanisms appear to be that the relatively low levels of androgen and estrogen in females are responsible for fast maturation, as Ounsted and Taylor (1972) and Waber (1979) have proposed. The suggested mechanism is that the verbal abilities develop in infancy before the visuospatial abilities. Hence the faster maturation in girls leads to the rapid establishment of the verbal abilities in both the left hemisphere and in a supplementary centre in the right. In boys slower maturation delays verbal development and allows the visuospatial abilities to establish themselves throughout the right hemisphere (Bradshaw and Nettleton, 1983; Corballis, 1983).

The role of androgens and estrogens in this process is inferred from three strands of evidence. Firstly, females with Turner's syndrome are exposed to unusually low fetal levels of androgen and estrogen and develop an exaggerated version of the female cognitive profile consisting of normal verbal abilities but weak visuospatial abilities (Rovet and Netley, 1980). Secondly, the converse pattern is shown by females with congenital adrenal hyperplasia. This disorder increases prenatal androgen levels and produces females with enhanced spatial ability (Resnick, Berenbaum, Gottesman and Bouchard, 1986). Thirdly, the critical role of faster maturation in girls as a determinant of the female high verbal–low visuospatial ability profile is suggested by a study of triple X chromosome females. The triple X chromosome slows growth rates and produces females with the masculine profile of low verbal–high visuospatial abilities (Rovet and Netley, 1983).

The faster maturation rates of females in infancy and early childhood are well established and are present for physical growth, motor development, verbal development and general cognitive abilities. In physical growth, the skeletal age of girls at birth is 4–6 weeks ahead of boys, and they retain this lead until adolescence (Tanner, 1970). The earlier physical maturation of girls is followed by the earlier development of motor skills (Denckla, 1973, 1974) and of language, where by the age of 18 months girls are significantly ahead of boys (Moore, 1967). Even in the visuospatial abilities girls are slightly ahead of boys at the ages of 4–6 years as assessed by the performance scale of the WPPSI (Kaiser and Reynolds, 1985). One of the most valuable of these studies of sex difference is the analysis of the McCarthy Scales standardisation sample by Kaufman and Kaufman (1973). They found that girls were uniformly and significantly ahead of boys over the age range $2\frac{1}{2}$–$8\frac{1}{2}$ years by approx 2.7 IQ points on all five of the scales measured by the test, i.e. the general cognitive index (general intelligence), the verbal and visuospatial abilities, numerical ability and motor development. This result suggests a general maturational acceleration in girls affecting all aspects of cognitive and motor development. Further studies indicating the acclerated maturation rates of girls are reviewed by Wolff (1981). From the age of about 6 years girls begin to display the high verbal–low visuospatial ability pattern. Their high verbal abilities are most prominent in verbal fluency and in immediate verbal memory, tested by digit span where girls have virtually invariably been found superior to boys, but their advantage does not typically appear in verbal comprehension (Maccoby and Jacklin, 1974; Jensen and Reynolds, 1983). At the same time girls begin to display weaker visuospatial abilities as measured by the performance subtests of the WPPSI and WISC-R (Kaiser and Reynolds, 1985; Jensen and Reynolds, 1983). Hence males and Mongoloids are similar, as compared with females and Caucasoids, in regard to their slow maturation and their weak verbal–strong visuospatial ability profile. The proposed explanation for these parallels is that when the Mongoloids came under selection pressure for an increase of their visuospatial abilities they developed further the endocrinological mechanisms which had already evolved in males to secure stronger visuospatial abilities. Mongoloids would therefore have evolved greater androgen and estrogen outputs during pregnancy. This would act on the fetus to slow down the maturation rate prenatally, in infancy and in early childhood. This theory is offered as the probable physiological mechanism by which the slow maturation of Mongoloids is linked, as it is in males, with their weak verbal–strong visuospatial ability profile.

VI. PSYCHOMETRIC ANALYSIS OF THE TRADE-OFF BETWEEN THE VERBAL AND VISUO-SPATIAL ABILITIES

It is now time to address a problem which has no doubt been present in the minds of many readers, namely what psychometric evidence can be marshalled to support the theory that a trade-off evolved between the verbal and visuospatial abilities. It will be recalled that it has been proposed that this trade-off occurred twice in the evolutionary history of the hominids: firstly, when the male australopithicines traded some of their verbal abilities to secure an increase of their visuospatial abilities; and secondly, when the Mongoloids traded more of their verbal abilities to secure a greater increase of their visuospatial abilities.

It has already been noted that the terms the *male and female brain* and the *Mongoloid and Caucasoid brain* are used as simplifications for what is more strictly a continuum running from high verbal–low visuospatial individuals (predominantly females and Caucasoids), through generalists to low verbal–high visuospatial individuals (predominantly males and Mongoloids). It is clear that this thesis implies that there must be a negative association between the two sets of abilities, such that the stronger the one, and in neurological terms the more cortex devoted to it, the weaker must be the other, and the less cortex devoted to it. The problem is therefore to show in psychometric terms that these two sets of abilities display the negative association demanded by the theory.

This possibility has rarely been considered by psychometricians who are used to examining matrices of correlation coefficients between tests of various cognitive abilities and noting that these coefficients are invariably positive. This was first shown empirically by Spearman (1904) and proposed by him as a general law which he designated the law of positive manifold. Psychometricians have either followed Spearman or the alternative thesis advanced by Thurstone (1938) in his earlier work to the effect that the primary abilities are independent.

The third possibility that the relationship between some of these abilities might be negative has never, so far as I am aware, been seriously argued. The difficulty in demonstrating that there is a negative association between the verbal and visuospatial abilities lies in the ubiquitous and powerful operation of Spearman's g, which forces all abilities into positive relationships. The nature of Spearman's g should probably be considered as 2-fold. Firstly, it consists of some general physiological properties of the brain, of which, as has been proposed above, size and neural efficiency are the most probable characteristics. Secondly, physiological components of Spearman's g will be strengthened by common environmental variance acting on all cognitive abilities, i.e. favourable environments will tend to raise all cognitive abilities and bring them into positive intercorrelation.

The problem for one who wishes to demonstrate the existence of a negative relationship between the verbal and visuospatial abilities is therefore to remove the effects of Spearman's g. There are two ways in which this can be done. Firstly, it is possible to take a population which is homogeneous for Spearman's g. A study which goes some way towards meeting this requirement has been reported by Stafford (1972). His subjects were all freshmen at an American university. These would be drawn from the upper part of the intelligence distribution and so would be relatively homogeneous for Spearman's g. Stafford computed the correlations between the freshmen's scores on a test of visuospatial ability and their grades on ten modern language courses. All ten correlations were negative. The highest negative correlations were of the order of -0.20 to -0.25 and were statistically significant in themselves, and the whole set of results is clearly highly statistically significant.

Another study of this kind has been reported by Smith (1964). The subjects were English children in the town of Oldham who took tests of verbal and spatial intelligence at the age of 10 years for selection to grammar schools and were successful. These children would have comprised approximately the top 15% of the ability range and hence were fairly homogeneous for Spearman's g. Five years later these children took the English public examination known as the General Certificate of Education (GCE). The correlations between the intelligence test scores taken at age 10 and the scores in various subjects in the GCE examination were then computed. It was found that spatial ability at age 10 was consistently correlated positively at around 0.40 with examination performance in Mechanical science, Metal work, Art and Mathematics but negatively correlated at around −0.25 with subjects with a large language component including English Language, English Literature, German, Chemistry and Biology (the last two subjects being examined by essay questions and hence demanding verbal ability). It will of course be noticed that these two studies could not have succeeded in achieving the complete removal of Spearman's g, which would certainly be present among any set of American university freshmen and English school children passing the grammar school selection examinations. What these two investigations did achieve was a sufficient reduction of the variance of Spearman's g to reveal the true negative relationship between the verbal and visuospatial abilities. It can be inferred that if Spearman's g had been more completely removed the negative correlations would have been greater.

A second strategy for an attack on this problem is to use a normal representative population and attempt to remove Spearman's g statistically. A simple and straightforward way of doing this is to calculate the partial correlations between the verbal and visuospatial abilities, partialling out Spearman's g. We have adopted this strategy for the standardisation data of the WISC-R and the WPPSI. For the WISC-R data, Spearman's g is estimated from the first factor derived from the Schmid–Leiman factor analysis computed by Jensen and Reynolds (1982). These authors consider this first factor to be a measure of Spearman's g and we agree with them. The verbal abilities are best represented by Vocabulary, a measure of the verbal comprehension primary, and by Digit Span, a measure of immediate verbal memory, which are respectively the highest loading tests on these two primaries. The visuospatial abilities are best represented by Block Design which is the highest loading test on the visuospatial factor. We therefore predict that the partial correlations between Block Design and Digit Span and between Block Design and Vocabulary will be negative. The partial correlations for males and females separately are shown in the first four rows of Table 4. It will be seen that, as predicted, all four partial correlations are significantly negative.

The second set of data used for the examination of these predictions was the WPPSI. Here Spearman's g is estimated from the first principal factor calculated by Kaiser and Reynolds (1985), the verbal comprehension primary from the Vocabulary test, immediate verbal memory from Sentences (a test in which the child has to repeat a sentence), and the visuospatial abilities from the Mazes test, a well known test of the visuospatial abilities. The predicted negative partial correlations calculated for males and females separately are shown in rows 5–8 of Table 4 and once again it will be seen that all four are significantly negative.

Lest the sceptical reader should suspect that any pair of tests plucked out of these sets of data would yield negative partial correlations, we have calculated the partials between pairs of tests of visuospatial abilities (viz. Block Design and Mazes in the WISC-R and Block Design and Picture Completion in the WPPSI), and between pairs of tests of verbal abilities (viz. Digit Span and Vocabulary in the WISC-R and Similarities and Sentences in the WPPSI). These partial correlations are shown in rows 9–16 of Table 4. It will be seen that none of them is significantly negative and three are significantly positive. These results are consistent with our theory: the theory does not predict that one micro verbal ability or micro spatial ability is traded off against another, and hence there should be no negative associations between the micro abilities within each of the two families of the verbal and visuospatial abilities.

We conclude that the negative partial correlations shown in rows 1–8 of Table 4 are sufficiently strong to demonstrate the correctness of one of the central theorems of the theory advanced in this paper, namely that during the evolution of the hominids a neurological trade-off took place twice, the first when males sacrificed some of their verbal abilities to secure improved visuospatial abilities and the second when Mongoloids sacrificed more of their verbal abilities to secure further improvements in their visuospatial abilities. These trade offs entailed the negative relationships between the two sets of abilities whose existence, once the effects of Spearman's g have been removed, has been shown in this section.

Table 4. Partial correlations between selected subtests from the WISC-R and the WPPSI after Spearman's g has been partialled out

Population	Tests	Partial correlations
WISC-R, males	Block Design × Digit Span	−10*
	Block Design × Vocabulary	−28**
WISC-R, females	Block Design × Digit Span	−07*
	Block Design × Vocabulary	−25**
WPPSI, males	Mazes × Vocabulary	−24*
	Mazes × Sentences	−25**
WPPSI, females	Mazes × Vocabulary	−14*
	Mazes × Sentences	−16*
WISC-R, males	Block Design × Mazes	+11*
	Digit Span × Vocabulary	+01
WISC-R, females	Block Design × Mazes	+17*
	Digit Span × Vocabulary	−05
WPPSI, males	Similarities × Sentences	+06
	Block Design × Picture Completion	−03
WPPSI, females	Similarities × Sentences	+09*
	Block Design × Picture Completion	−02

One and two asterisks indicate statistical significance at the 5% and 1% levels respectively. Decimal points omitted.

VII. CONCLUSIONS

This paper has been concerned with four objectives. Firstly, it was considered that the existing data base for theories of the causes of racial differences in intelligence has been too narrow in so far as it has been principally confined to differences between Caucasoids and Negroids in the United States. Secondly, these differences have been largely discussed in terms of general intelligence considered as a single entity and relatively little attention has been paid to racial differences in the more specific abilities. It is true that Jensen has done something to widen the data base by providing evidence on the intelligence of other racial populations in the United States and on the more specific abilities differentiating the races and the socio-economic classes (Jensen, 1973a, 1973b; Jensen and Reynolds, 1982). Nevertheless, these data have been largely ignored by environmental theorists.

The first part of this paper was therefore concerned with extending the data base on racial differences in intelligence by documenting the characteristics of the intelligence of Mongoloids. It is shown here that the Mongoloids in Japan, the United States, and, so far as the evidence goes, in Hong Kong, Singapore and Taiwan, are characterised by high values for Spearman's g, low verbal abilities, high visuospatial abilities, and slow maturation rates. The result of these generalisations is that the data which require explanation by environmental and genetic theories are extended to Mongoloids and to the distinctive pattern of Mongoloid abilities in addition to their general intelligence. This part of the paper concludes with the proposition that it is not possible to construct an environmentalist theory capable of explaining the totality of the data.

The third objective of the paper has been to present an evolutionary theory for the Mongoloid pattern of abilities. It is proposed that the crucial selection pressure responsible for the Mongoloid pattern of abilities was the extreme cold of the ice ages and that the four characteristics of Mongoloid intelligence can be understood as adaptations to this pressure. The high Spearman's g and strong visuospatial abilities are considered as direct adaptations conferring selective advantage in these severe conditions, while the weak verbal abilities and slow maturation rates were explained as indirect consequences of these adaptations.

The fourth objective of the paper has been to present a neurological theory of the distinctive brain structure that must have evolved in Mongoloids as a result of these adaptations. It is proposed firstly that the Mongoloid brain would have developed an improvement in general neural efficiency and secondly that it would have devoted more cerebral cortex to the visuospatial abilities at the expense of cortex devoted to the verbal abilities. A theory is offered of the details of these distinctive neurological structures in Mongoloids.

All the theories advanced in this paper have been formulated in such a way that they yield many predictions for further investigation. The empirical base of the theory can be tested by further studies of the ability profiles of Mongoloid and Caucasoid populations in different geographical locations, including the Far East and Europe. The evolutionary theory can be tested by the investigation of the abilities of other racial populations, such as the Negroids, the American Indians, and the Australian Aborigines, who have been exposed to their own distinctive selection pressures. The neurological theory can also be subjected to further empirical testing. This paper has been concerned only with Mongoloid–Caucasoid differences in abilities, but it is believed that the theories advanced provide an economical and comprehensive framework in terms of which further racial differences in abilities can be understood and explored.

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