Intelligence in Sudan and IQ gain between 1964-2008

Pr. Omar Khaleefa, Khartoum, SUDAN/JAPAN

okhaleefa@hotmail.com

Introduction

Several studies in economically developed countries reported that the mean IQ have been increasing since the 1940s. The studies were carried out in the UEA (Wheeler, 1942; Smith, 1942; Tuddenham, 1948), and Scotland (SCRE, 1949). In the period between the 1950s and 1980s many studies were carried out in Britain (Cattell, 1950; Lynn & Hamspon, 1986, 1989; Lynn, Hampson & Mullineux, 1987; Lynn, Hampson & Howden, 1988), Japan (Lynn, 1982; Lynn & Hampson, 1986), USA (Flynn, 1984). In his comprehensive study about IQ gains in 14 nations, Flynn (1987) found that IQ gains in economically advanced countries rang from 5-25 points in a single generation. Since then the phenomena named "Flynn effect" and this term was coined by Herrnstein and Murray (1994) the authors of "The Bell Curve". Flynn (1998) found that the U.S. gains is 3 points per decade from 1932-1972. For post 1972 comparison of the WISC-R versus WISC-111 showed a rate of 3.12 points, however, comparison of WAIS-R versus WAIS-111 showed the gain of 1.71 and suggested that the post 1972 gains was around 2.5 points per decade. This massive IQ increase is equivalent to 1 SD per half a century (Flynn, 1984, 1994). Similar gains were found in other studies, in Japan the mean IQ has been increasing by 7.70 per decade since 1950 and in UK by 1.71 per decade since 1932 (Lynn and Hampson, 1986).

No doubt, different economically developed nations have enjoyed different rate of gain in IQ and different kinds of IQ tests show different rates of gain: Culture reduced tests of fluid intelligence showed gains in IQ of as much as 20 points per generation (30 years); performance tests showed 10-20 points; and verbal tests sometimes showed 10 points or below. Tests closest to the content of school taught subjects such as arithmetic reasoning, general information, and vocabulary, showed modest or nil gains (Flynn, 1998). Cattle have shown that intelligence has two aspects: fluid ability and crystallized ability. Fluid ability is the dispositional variables that allow us to solve problems, to learn, to think abstractly; crystallizing ability is the result of such learning. Verbal tests are good measure of crystallized ability while performance tests such as Progressive Matrices and non-verbal tests of Wechsler 's scales are good example of fluid intelligence (Cattle, 1980).

Studies showed that performance scales gains from Wechsler samples of schoolchildren have been similar to the results from tests of fluid intelligence like Progressive Matrices (Flynn, 1987). There is no obvious tendency for gains to diminish with age, but some data from a small sample showed that Japan might be an exception. Japanese schoolchildren have double the rate of gain of white American children, whereas Japanese and USA adults showed a similar rate (Flynn, 1987, 1998). The size of the IQ gains varies somewhat with the tests used: tests of visuo-spatial abilities tend to show greater rates of increase than those of verbal-educational abilities in economically developed countries such as USA, Britain, Japan, Austria, France, and Germany (Lynn & Hampson, Lynn & Vanhanen, 2002; 1986, Flynn, 1987). Perhaps, there are two factors responsible for this. Firstly, the visuo –spatial abilities are more sensitive to nutritional effects than the verbal educational abilities. Secondly, there has been social and educational changes over time which have depressed some verbal-educational abilities and enhanced some others (Lynn, 1990).

One leading theory regarding Flynn's effect or the increase of IQ in economically developed countries proposed by Lynn (1990, 2009) was that the IQ increases in these countries were due to the improvement in nutrition. According to Lynn these large increases in intelligence were puzzling to workers in the field and no explanation for them was suggested. These increases were genuine and that their cause lies in improvement in nutrition. The improvements in nutrition are well documented in Japan through a series of post war 11 national nutrition surveys (Lynn, 1990). These showed that from 1960 to 1980 there were substantial per capita increases in the consumption of meat, milk and dairy products (300%), fruits (100%), vegetables (50%) and fish (20%) (Takahashi, 1986, cited in Lynn, 1990). Lynn (1993, 1998) pointed that nutrition affects intelligence and that the quality of nutrition has improved over the course of the twentieth century and has been responsible for increases in height and brain size of about the same magnitude as have occurred for intelligence. This theory has been endorsed as one of the causal factor by Arja, Esparo, Fernandez-Ballart et al. (2006), Colom, Lluis-Font and Andres-Pueyo (2005), and by Jensen (1998, p. 325).

Most of the evidence linking poor nutrition and intelligence came from studies performed in developing countries. It is important to understand the nature, causes and manifestations of undernutrition in poor countries. The four major nutritional problems in poor countries are protein-energy undernutrition (Waterlow, 1992), Vitamin A deficiency (Sommer & West, 1996), iron-deficiency anemia (Yip & Dallman, 1996), and iodine deficiency (Hetzel, Dunn & Stanbury, 1987). Undernutrition affected intelligence largely by damaging the brain during sensitive periods of early development, many other mechanisms, in addition to organic damage, are now recognized as important (Brown & Pollitt, 1996). Numerous studies have found that giving nutritional supplements to poorly nourished pregnant women increases the birth weight of their babies (e.g. Cameron, 1991, Mardones et all, 1991). Birth weight is positively associated with DQs in the first year of life (Lynn, 2009).

Ten studies summarized by Eysenck and Schenthaler (1997) showed that micronutrient supplements increased IQ between +0.8 to +9.6 points with an average of +3.5 points. Nine of these studies used at least one individually administered test of non-

verbal IQ and reported P values. Other important conclusions drawn from these 10 studies include (1) Inadequate levels of vitamins and minerals in the blood stream reduce a child's IQ below the optimum level for the child (2) Supplementation of the child's standard diet by vitamin and mineral pills can raise the child non-verbal intelligence (3) Supplementation affects only fluid intelligence (non-verbal tests) but not crystallized intelligence (verbal tests). (4) The younger the child, the greater the effect. There is little effect beyond the teens (5) Supplementation has no effect on children with an adequate level of vitamins and minerals (6) Vitamins deficiencies seem to be more important than mineral deficiencies, with the possible exception of magnesium and iron (7) Effects of micronutrients have so far been shown to continue for 1 year and may last even longer.

More recent psychological research about nutrition and the rise of IQ has been reviewed by Lynn (2009) who found that there have been four studies that have shown increases in the Development Quotients (DQ) of infant measured by the Bayley Scales that can be quantified. The mean rate of gain for the four data sets of the Motor Scale is 2,9 DQ points per decade and for the four data sets of the Mental Scales in the same studies is 3.4 DQ points per decade. The Australian study shows a large gain on the Mental Scales of 5.8 DQ points per decade. The mean gain for all studies of the Bayley Scales is a gain of 4.5 DQ points per decade. This rate of gain in the DQs of infants 6-22 months is almost identical to the rate of gain of the IQs of preschool children aged 4-6 years. 14 studies of these are given by Flynn (1984) and the average of these is a gain of 3.9 IQ per decade. These rate of gain are also close to the 3.1 IQ points per decade increase of the IQs of school aged children and adults assessed with the Wechsler and Binet tests calculated by Flynn (2007). Putting together all the stands of evidence summarized above it is proposed that this factor has been the improvements in the pre-natal and early post-natal nutrition during the twentieth century that have been responsible for increases in infant birth weight, head size and brain size, increases in the DQs of infants between ages 6 months and two years, increases in height, and increases of similar magnitude in Wechsler and Binet IQs of pre-school children, school age students and adults (Lynn, 2009).

The second alternative theory to the nutritional thesis of increases in intelligence is that these IQ gains were due to improvement in cognitive stimulation. This would come from parents who are better educated, better able to provide cognitive stimulation, from smaller families, greater availability of radio, television, and educational toys and possibly from improvements in education (Lynn, 1990). The increase in schooling may improve the cognitive skills required to do the Progressive Matrices. This test is sometimes described as culture reduced or culture fair and consists largely of arithmetical and geometrical progressions in design format. These mathematical skills are learned in schools and hence the greater amount of schooling the greater increase of intelligence (Lynn, 1990).

According to Flynn (1998) education seems an obvious cause of IQ increase because it awakes the mind and teaches students to analyze and criticize. During the 20th century, semiformal and formal education has been extended down into preschool years and upward into adulthood. Thorndike (1977) found that U.S children aged 6 and younger have made greater IQ gains than older ones. Therefore, he sought that casual factors are likely to affect preschoolers more than others such as TV in general and educational TV in particular. Another line of enquiry suggests a positive conclusion. If improvements in nutrition increase IQ levels at least in a proportion of children, then such improvements should be capable of being traced in the scholastic achievements of the children involved since there is a close connection between IQ and scholastic achievement (Eysenck, 1979 as cited in Eysenck & Schoenthaler, 1997).

The third theory of increase of IQ propose genetic factors. The most straightforward explanation for the same rates of gain of the DQs of infants, the IQs of the preschool children, and the IQs of older children and adults is that the same factor of factors have been responsible for both. These factors must be operating before the age of 6-12 months. This points to improvements in nutrition and genetic factor as possible candidates responsible for the Flynn effect (2009). There are two possibilities for the influence of genetic factor. The first is that there could have been a tendency for more intelligent individuals to have had more children (Lynn, 1990). However, studies showed that there is a negative correlation between fertility and intelligence (Van Court and Bean, 1985). A second possible genetic effect could consist of an increase of outbreeding. There has probably been some increase in outbreeding over the last half century as societies have become more urbanized. However, the magnitude of any possible effects on intelligence would appear to be small.

Most studies of estimation of increase of national IQs were carried out in economically advanced countries e.g., (Flynn, 1984, 1987, 1994; Lynn, 1982, 1990, Lynn and Hampson, 1986; Lynn, Hampson, & Howden, 1988) and little attention has been paid to developing countries regarding Flynn's effect. There are only six studies regarding Flynn's effect or IQ gains in developing countries, namely, three studies in Kenya (Daley et al, 2003), Dominican (Meisenberg, et al 2005), and Brazil (Colom, Mendoza and Abad, 2007), and three studies in Sudan (Khaleefa, Abdelwahid, Abdulradi & Lynn, 2008, Khaleefa, Al-Hussain & Abdulradi, 2008; Khaleefa, Sulman & Lynn, 2008). The aim of the present study is to provide data regarding IQ in Sudan as a developing country with special emphasis on IQ gain and nutrition. 20 studies carried out by Al-Simbir Research Group (SRG) will be reviewed. SRG is the first and the only group in the Sudan dedicated to the study of intelligence, gifted children and indigenization of psychology. These studies carried out by SRG can be broadly classified to six categories (a) General studies about distribution of intelligence in Sudan (1 to 3) (b) Studies carried out in different regions including Khartoum, Kordofan and Darfur (4 to 8) (c) Studies conducted on special groups (9 to 13) (d) Studies about genetic and IQ in Sudan (14, 15) (e) Studies regarding IQ and cognitive stimulation (16 to 17) (f) Studies about IQ gain in Sudan (18 to 20). Each study will be summarized and finally some conclusions will be drawn.

Distribution of IQ in Sudan

Study 1: Intelligence testing in Northern Sudan

The Wechsler Adult Intelligence Scale- Revised (WAIS-R) (Wechsler, 1981) has been administered to a random group of 801 participants in Northern Sudan in the year 1986. The number of males was 418 (52.2%) and females 383 (47.8%) and the sample was classified into 9 age-groups (16 to 75 years). The WAIS-R consists of eleven sub-tests; six are verbal and five are performance. The former measures the verbal-educational abilities (left hemisphere) and the later the visuo-spatial abilities (right hemisphere). The study showed three points of interest: (a) intelligence was normally distributed among adult Sudanese participants, the percentage of gifted (very high ability) was 2,3% , intelligent (high ability) 6,2%, above average 18,2%, average 44.6%, below average 20%, borderline 6,2%, and handicapped

(very low ability) 2.5% (b) male participants showed higher IQ scores (98,1) while females showed lower scores (90,3) (c) according to Sudanese norms Khartoum region received the highest scores (106,52), Northern (101,87), Eastern (101,03), Central (97,79), Kordofan (89,06), Darfur (80,77) (Khaleefa & Ashria, 1995, Khaleefa, Taha & Ashria, 1995).

Study 2: Adaptation and standardization of the WISC-111 in Sudan

The Wechsler Intelligence Scale for Children-111 (Wechsler, 1992) has been adapted in Sudan to a representative sample of 1460 children 6 to 16 years old both males 736 (50.4%) and females 724 (49.6%). The study showed three points of interest (a) intelligence was normally distributed among Sudanese children, the percentage of gifted (very high ability) was 1,84% , intelligent (high ability) 8,35%, above average 16,3%, average 49.72%, below average 14,52%, borderline 6,43%, and handicapped (very low ability) 2.8% (b) females participants showed higher scores in PIQ (101.02) compared to males (99.16) and the difference was significant at point 0.05 level, females also showed higher scores in VIQ (101,06) compared to males (99.12) and the difference was statistically significant at point 0.05 level. Additionally, females showed higher scores in FIQ (101.09) compared to males (99.11) and the difference was statistically significant at point 0.01 level. Generally, female children obtained 2 IQ points higher than males. The Central region obtained the highest IQ scores (105.88), Khartoum, (101.99), Northern (101.17), Kordofan (99.25), Eastern (95.45), (Darfur (87.68) (Al-Hussain, 2008).

Study 3: Adaptation of the WISC-111 in Sudan and Japan.

In Sudan, the WISC-111 (6-16 years) (Wechsler, 1992) has been translated from English to Arabic and adapted to suit the local environment (Khaleefa & Muttawa, 2002) and in Japan the test was translated from English to Japanese and adapted to suit the local environment (Ueno & Nakatani, 2003). The adapted test was applied to a group of 330 and 1125 children in Sudan (Al-Hussain, 2005) and Japan (Ueno & Nakatani, 2003), respectively. The study showed three points of interest: (a) the performance tests were identical in all countries except in Sudan and Japan. Psychologists in the two countries were highly sensitive to their environment (b) in Japan the time limit for some performance subtests was shortened from 120 to 90 seconds while Sudanese children needed more time suggested as 150 seconds. In other words, Japanese children scored very high in speedy tests while Sudanese children were very low (c) Japanese children performed better in visuo-spatial tests while Sudanese performed better in verbal-educational tests (Khaleefa, Taha & Al-Hussain, 2007).

Regional studies of IQ

Study 4: Norms and gender differences on the SPM in Khartoum

Standardization of the Progressive Matrices (SPM) (test of fluid intelligence, excellent measure of intelligence, reasoning ability and more specifically of g, the general factor presented in all cognitive tasks) (Raven, Raven & Court, 2000) was carried out in Khartoum. A sample of 6,202 males and females, aged 9 to 25 years was analysed for sex differences in means. Results showed no sex differences in means at the ages 9, 11, 12, 13 and 19 years. At age 14 through 18 years females had higher means than males, while at age 10 and 20-25 years males had higher means than females (Khaleefa, Khatib, Mutwakkil, & Lynn, 2008). These results were consistent with the developmental theory of intelligence proposed by Lynn (1994) once it is understood that maturation is delayed in economically developing countries as compared to economically developed countries (Eveleth & Tanner, 1990). Maturation accelerated by about three years in economically developed countries during the nineteenth and twentieth centuries largely as a result of improvement in nutrition resulting in a growth spurt accruing at a younger age. The effect of delayed maturation in economically developing countries like Sudan is that the growth spurt of girls takes place in mid-adolescence and gives an IQ advantage over the age range 14-18 years, rather than the 10 -13 years found in economically developed countries. The IQ advantage of males is likewise delayed until the age of 19 years and adulthood (Khaleefa, Khatib, Mutwakkil, & Lynn, 2008).

Study 5: Identification of multiple intelligences in Northern Kordofan

The study investigated the self-estimate of Multiple Intelligences (MI) (Gardner, 1983, 1999) for pupils in basic schools in Northern Kordofan State. The sample consisted of 562 pupils selected randomly from governmental schools, both males (49.8%) and females (50.2%) from both urban (64.1%) and rural areas (35.9%). The sample selected from four areas namely Al-Obied city (n=241), Al-Rahad city (n=119), Al-Mazroub town (n=122) and Al-Bahriya town (n=80). Nine indicators were used for measuring linguistic, logical, spatial, body-kinesthetic, musical, interpersonal, existential, intrapersonal, naturalistic intelligence. The study showed that Al-Rahad area has obtained the highest MI scores (103.33), then Al-Obied (100.10), Al- Al-Bahriya (98.45) and Al-Mazroub (97.60). The author attributed the higher performance of children in Al-Rahad city in MI to several factors including the availability of fresh vegetables, fruits as well as fish (African lungfish, Um Koro) (Al-Haj, 2008).

Study 6: Norms for the Standard Progressive Matrices in Darfur

Results are reported for the standardization of the Standard Progressive Matrices (SPM) in Darfur. The sample consisted of 1006 schools students aged 9 to 18 years from cities of Niyala and El-Fasher. The difference in IQ between Khartoum State and Darfur State is about 8 IQ points. However, the percentage of children enrolled in basic education in 2006 in North Darfur was 63.8% and South Darfur was 60% compared to 88% in Khartoum. The total percentage of enrolment in secondary education in 2006 in North Darfur was 25.3% and in South Darfur was 21.4% compared to 54% in Khartoum. The results showed that the younger children performed better than older children, in relation to British norms. The initial items in the SPM were measures of visualization ability, while the later items were measures of abstract and arithmetical reasoning ability. The 9 years old scored mainly on the initial visualization items because the abstract and arithmetical reasoning ability items were too difficult for them. This may because schools in Darfur do not give so much attention to teaching the problem solving skills tested in the Progressive Matrices (Khaleefa, Lynn, Abulgaism, Dosa & Abdulradi, in press).

Study 7: The IQ of children in North and South Darfur

The study investigated the rate of IQ among children in North and South Darfur in the year 2008. The Standard Progressive Matrices (SPM) has been applied to a group of 1015 schools students aged 9 to 18 years, both males 514 (50.64%) and females 501 (49.36%) from Northern Darfur 537 (52.91%) and Southern Darfur 478 (47.09%). The study showed three points

of interest: (a) The intelligence of children in Darfur decreases with the increases of age according to the Sudanese as well as the British norms (b) The first born child received the highest scores on the SPM (27.71), the second child (24.91), the forth child (22.63), the fifth child (21.99) and third one (20.01) and the difference was significant at point 0.01 level. (c) The study showed a negative correlation between family size and IQ (-0.087); families with one child obtained the highest scores on the SPM (26.69) and families with more than 12 children obtained 21.75 points with a difference of about 6 points. The researcher has analysed the results of his study with reference to the level of omega 3 fatty acid that Darfurian children had (Abulgasim, 2009).

Study 8: Intelligence of students in different faculties at the University of Khartoum

1001 first year students at the University of Khartoum were tested with the Standard Progressive Matrices in 2008, both males (n=300) and females (n=701) aged16-19 years. There were considerable differences in IQs among students in the different faculties. Engineering and medical students obtained the highest IQs and primary education students the lowest. The IQ of the electrical engineering and medical students was similar to that of European University students, but the IQ of the basic education students was the lowest. The main reason for this difference was that Khartoum engineering and medical students are highly selected on the basis of their performance in the university entrance examination. The male students at the University of Khartoum obtained higher average IQ than females by 4 IQ points (Khaleefa, Amir & Lynn, in press). Amir (2008) found that 26,9% of first year students at the University of Khartoum were the first born child, 21.4% the second child, 15.5% the third child, 11.4% the fourth child, 8.7% the fifth child and 16.1% 6+ child. Students of basic education have obtained the lowest IQ, creativity scores, academic achievement and motivation. Amir (2008) found that the scores of intelligence decreased with the increase in age among the first year university students. The score of 16 years old was (48.4), 17 (46.1), 18 (44.6), and 19 (40.6) points.

IQ testing for special groups

Study 9: Long term sequelae of childhood acute bacterial meningitis in Sudan

35 survivors of acute bacterial meningitis (ABM) from a group of 44 Sudanese children seen during 18 month (April 1985-November 1986) were prospectively followed to ascertain the long term sequelae of the disease (Salih et al (1991). At 31 months or older age, patients and their nearest-age control siblings were tested by author 2 at the Department of Psychology, University of Khartoum in 1987 using a translated version of the Standford-Binet Test. The author 2 did not know whether he was examining a case or a control child. Post-meningitic and control children presented a range of IQ from 70 to 124 in the former and 88-123 in the latter. The mean IQ scores for a subgroup of 19 post-meningitic children (92.3 SD=113.9) was found to be significantly lower than in their nearest siblings control (100.7 SD=10.2). The study showed that the difference in IQ scores was 8.3 points between the two groups (Salih, Khaleefa, Bushara, Taha, Musa, Kamil, Hofvander & Olcen, 1991).

Study 10: Application of WISC-111 to mentally retarded children in Khartoum

The WISC-111 (Wechsler, 1992) was applied to a group of 301 mentally retarded (handicapped) children 6 to 16 years in special educational centres in Khartoum, 197 (65.4%) males and 104 (34.6%) females. The study showed 5 points of interest (a) the percentage of severe retardation was 31.9%, moderate retardation 37.2%, mild retardation 28.6%, but 7 children were found to be totally free from any kind of retardation. (b) The level of intelligence (IQ) of the mentally retarded children as a result of inbreeding (cousin) was 54.4 points while for outbreeding was 57.6, the difference was 3.2 IQ points (statistically significant at 0.01 level) (c) there was a significant difference at 0.01 level in the IQ of mentally retarded children of young mothers (IQ=59) and old mothers (40+ years) (IQ=50.7) and the difference between the two groups was 8.3 IQ points (d) there was a significant difference in the IQ according to birth order of mentally retarded children favouring the first born child (IQ=58.6) compared to the last born child (IQ=54.5) and the difference between the two groups was 4 IQ points (e) mentally retarded children were overweight with an average of 44.2 kg (Ahmed, H, 2008).

Study: 11: Clinical use of WISC-111 for the gifted children in Khartoum State.

The Wechsler Intelligence Scale for children- Third Edition (WISC-111) has been administered in the academic year 2006-2007 to a group of 293 pupils in three special schools for the gifted in Khartoum, Omdurman and Khartoum North, both males 145 (49.5%) and females 148 (50,5%) whose ages ranged between 8 to 13 years old. The study showed three points of interest (a) 186 pupils obtained one standard deviation IQ above the mean, 24.23% obtained IQ between 120 -129 points, 22.53% between 120-139 and 11.26% between 140-149 points (b) The average full IQ scores for the pupils in the three schools for the gifted was 118 (c) the average full IQ for females was 118.80 and for males was 117.17 (d) the average scores for verbal fluency was 83.41, freedom from distractability 73.55, perceptual organization 109.78 and processing speed 121.31 (Ahmed, K, 2008).

Study 12: IQ of gifted children and its relation with some family variables

The Standard Progressive Matrices (SPM) was applied to a group of 300 gifted pupils both males (50%) and females (50%) as well as 300 parents of the gifted in Khartoum State. The study showed five points of interest (a) the mean age of mothers when giving birth to their gifted children was 29 years while it was 39 for fathers (b) there was a positive correlation between the IQ of pupils and the IQ of their parents. The average IQ scores of the fathers were 81 points while it was 79 for mothers according to the British norms. The correlation between the IQ of gifted pupils and their fathers was significant on point 0.05 level while it was at point 0.01 between gifted children and their mothers (c) there was a positive correlation between the IQ of gifted pupils and level of education of fathers on point 0.05 level while it was on point 0.01 level between the IQ of gifted pupils and the level of education of the mothers (d) The IQ and the level of education of the mothers is more determinant of the IQ of the gifted pupils compared to that of the fathers (Abulreesh, 2009). (e) The majority of gifted children were underweight (M=29.7KG) and their ideal weight (34.3KG) perhaps due to lack of adequate nutrition (Khaleefa, 2009).

Study 13: Teachers of the gifted students in the Khartoum State

The study included 49 teachers of the gifted children in three basic schools in Khartoum State, both males 23 (47%) and

females 26 (53%) as well as 237 gifted children. The study showed four points of interests: (a) 45% of the teachers had BA degrees, 30% higher diplomas and 25% MA degrees (b) 25% of the teachers had less than 5 years of experience, 18% between 5 to 10 years, 57% more than 10 years (c) 20% of the teachers were 20 to 30 years old, 51% between 31 to 40 years and 29% between 41 to 50 (d) The average IQ of teachers of the gifted according to the British norms was 93 on the Standard Progressive Matrices (Al-Shaikh, 2008), while the average IQ of children around 120 IQ points according to the SPM and the differences in IQ between teachers and students were 27 points (Khaleefa, 2008). The average IQ of students according to WISC-111 was 118 (Ahmed, K, 2008). The difference between teachers IQ on the SPM and students IQ on the WISC-111 was 25 points.

IQ and the genetic basis

Study 14: The IQ of outbreed children in Sudan

The Standard Progressive Matrices (SPM) has been applied to a group of 206 half-cast (outbreed) participants 6 to 25 years old. The sample was selected from families, schools and universities in Khartoum State. Results showed five points of interest according to the British norms (a) The IQ of Sudanese wife and foreign husband (n=45) was 87.09 (b) Sudanese husband and African wife (n=30) was 87.20 (c) Sudanese husband and Arab wife (n=74) was 92.19 (d) Sudanese husband and Asian wife (n=27) was 93.74 (e) Sudanese husband and European wife (n=30) was 95.20. The average IQ of the 5 groups was 91.08, is higher by15.58 IQ points (Khaleefa & Abdulradi, 2009) compared with the average of Sudanese IQ on the SPM which was 78.5 IQ points (Khaleefa, Amir & Lynn, in press).

Study 15: Dysgenic fertility for intelligence in Sudan

The Standard Progressive Matrices was administered in 2008 to a sample of 5215 students aged 9-20 years at socially representative schools in Khartoum. The scores and number of siblings were recorded for each child. The results showed a negative association between SPM scores and the number of siblings. Only children have the highest average scores (36.6) and children in 10+ families have the lowest average scores (31.9). This indicates a decline of genotypic intelligence that is estimated at 0.8 points a generation. Despite the decline of genotypic intelligence in Sudan, it has been reported that phenotypic intelligence as measured by intelligence tests for adults has been increasing in Sudan at a rate of 2.05 IQ points a decade over the years 1987-2007. This rate of increase is about the same as has been reported in numerous countries from 1940s up to the present (Lynn, Khaleefa & Haroun, 2009).

IQ and cognitive stimulation

Study 16: The effect of Abacus (UCMAS) program on the increase of intelligence

The study investigated the effects of abacus training on the intelligence of children in Khartoum. The study included 143 basic school children, both males (48%) and females (52%) from grade 2 (50%) and 3 (50%). The age of children ranged between 6 to 11 years with an average of 7.9 years. The sample was divided into groups matched for IQ, gender, class and urbanization. The experimental group (n=72) received abacus training for seven months while the control group (n=72) did not receive any training. The intelligence of the two groups was assessed by the WISC-111 before and after abacus training for the two groups. The study showed that abacus training had significantly increased the performance IQ (visuo-spatial and fluid intelligence in the right hemisphere) by 5.3 points, increased total intelligence by 4 points but had no significant effect in the increase of oral intelligence (verbal, educational and crystallized intelligence in the left hemisphere) as the increase was only 1,1 IQ points (Khaleefa & Yousif, 2009).

Study 17: Effects of abacus training on the intelligence of Sudanese children

The effect of abacus training in mental computation on intelligence assessed with the Standard Progressive Matrices (SPM) was investigated in a sample of 3185 children aged between 7 and 11 years in Sudan. The sample was divided into two groups matched for scores on the SPM, sex and urbanization. The experimental group was given an intensive abacus program training for two hours per week for 34 weeks. The control group did not receive any training. Following the end of the training, the control and experimental groups were retested with the SPM. Controlling for practice effects, the experimental group gained a statistically significant 7.11 IQ points and performed faster following the training (Irwing, Hamza, Khaleefa & Lynn, 2008).

IQ gains in Sudan

Study 18: The increase of intelligence in Sudan 1964-2006

The study examines an increase of IQ in Sudan between the years 1964 and 2006 measured by the Draw-a-Man-Test (DMT) (Goodenough, 1926, Harris, 1963). The test was standardized in Sudan in 1964 by Badri (1964, 1965a, 1965b, Badri & Dennis, 1964) on a representative sample of 1345 school children aged 4-10 years, comprising boys and girls, from rural and urban areas and in pre-schools and primary schools. The test has been restandardized in Sudan in 2006 on a similar representative sample of the same size 4-10 years old. The mean IQ of the sample was 83.45 in 1964 and 95.64 in 2006. There was a gain of 12.2 IQ points over the 42 years, representing 2.9 IQ points a decade (Khaleefa, Abdelwahid, Abdulradi & Lynn, 2008). Khaleefa, Abdelwahid & Abdulradi (2008) found that the pre-school children obtained the highest IQ scores (104.5), then grade 1 (99.8), grade 2 (96.1), grade 3 (90.7) and grade 4 (87.8). This indicates that the rate of increase of IQ decreases with the increase in age. For example, the rate of increase for pres-school children (6.61) IQ points a decade, grade 1 (3.18), grade 2 (2.28), grade 3 (1.29) and grade 4 (1.32) and the rate of IQ increase was higher for females (3.94 points) compared to males (1.77) IQ points a decade.

Study 19: An increase of intelligence in Sudan 1987-2007

Results are reported for mean IQs on the WAIS-R (Wechsler, 1981) in Sudan in 1987-2007. There was a gain of 4.05 full Scale IQ over the 20-years period, representing a gain of 2.05 IQ a decade. The verbal IQ showed a loss of 1.65 IQ points, while the performance IQ showed a gain of 7.2 IQ points. These results are broadly consistent with those in economically developed countries in showing that IQ on the WAIS-R has increased in Sudan, and the performance IQ has increased more than the Verbal IQ. In the USA, the gain on the WAIS-R during the second half of the twentieth century was about 3.0 IQ points a decade. It may be surprising that the rate of IQ increase was lower in Sudan than in the USA (Khaleefa, Sulman & Lynn, 2009). The rate of increase for females was greater than that for males, for example the rate for females for the FIQ of the WAIS-R was 2.43 IQ points while there was a loss of -0.61 IQ points

per decade for males. The IQ decreases with the increase in age. For example the IQ for the age group 16-17 years decreased by -0.26 per decade while it decreased by -5.70 for the age group 70-75 years (Sulman, 2008)

Study 20: The Increase of intelligence in Sudan between 1988 to 2008

The Wechsler Intelligence Scale for Children-Revised (WISC-R) was standardized in Sudan in 1988 by Hussain (1988) who applied it to a representative sample of 330 participants 6 to 16 years old. The Wechsler Intelligence Scale for Children-Third Edition (WISC-111) (Wechsler, 1992) was standardized in Sudan in 2008 by Al- Hussain (2008) and applied to a group of 1452 participants 6-16 years old. The study showed three points of interest (a) there was an increase of 12.06 full Scale IQ over the 20-years period, representing an increase of 6.03 IQ a decade and 18.09 per generation (b) the increase of IQ for females was greater than males. There was an increase of 13.61 IQ points for females over the 20 years period, representing an increase of 6.81 per decade and 20.43 per generation while the increase of males was 10.62 IQ points over the 20 years representing an increase of 5.31 a decade and 15.93 per generation (c) the study showed that Al-Gazira State had the highest level of IQ increase (22.68) over the 20 years period representing an increase of 11.34 a decade and 34.02 a generation. However, Darfur State showed a loss of IQ of -0.82 over the 20 years period representing a loss of -0.41 a decade and -1.23 IQ points per generation (Khaleefa, Al-Hussain, Ahmed & Abdulradi, 2008).

Summary of results

(1) Twenty studies regarding IQ in Sudan have been summarized. Five major scales of intelligence have been employed, namely: The Standard Progressive Matrices, Wechsler intelligence tests, Standard Binet Test, Draw a-Man-Test, and Multiple Intelligences Indicator. The majority of these IQ scales are used worldwide for measuring IQ gains.

(2) The total sample of these studies was 25,161 participants and the sample for each study ranged between 39 to 6,202 participants with an average of 1258 participants per study. This indicates that the majority of studies employed adequate number of sampling.

(3) The age of participants ranged between 4 to 75 years but the majority were between 6-25 years. They were students at schools and universities. The sample covered both males and females, urban, suburban and urban areas.

(4) These studies were conducted on several groups: normal, gifted children, retarded children, patients. However, the majority were conducted on normal participants. Four studies were carried out on special groups with a total number of 938 participants (3.73%).

(5) Geographically, the sample covered all regions of Northern Sudan with special emphasis on Khartoum State and three studies conducted in Kordofan and Darfur regions. No studies were carried out in the southern part of the country. Participants from Darfur region received lower scores (study 1, 2, 6) in addition to a loss of IQ on the WISC-111 (study 20). Perhaps, some social, political and economic factors depressed the performance of participants from Darfur in WAIS-R, WISC-111 and SPM. The nutritional factor can not be ruled out in the low performance in Darfur. The levels of vitamins and minerals in the blood stream need an investigation.

(6) Four studies showed that general intelligence is normally distributed in Sudan among normal adults (study 1) and normal children (study 2), as well as among special groups, namely, retarded children (study 10) and gifted children (study 11).

(7) Sudanese children are slow in responding to intelligence tests and this result was also observed by Scott (1950) who carried out the first study about measuring Sudanese intelligence. Sudanese children perform better in verbal IQ while Japanese children are quite fast and perform better in visuo-spatial abilities (study 3) and the later are sensitive to nutrition. The improvements in nutrition are well documented in Japan through a series of post war 11 national nutrition surveys

(8) Adult males showed higher IQ scores (study 1, 8), however, female children showed higher IQ scores (study 2, 4, 11). Adult males have the advantage of 4 IQ points than females. This is closely similar to the male advantage of 4.6 IQ points found in a meta analysis of 22 studies of sex differences in university students by Irwing & Lynn (2005) and the male advantage of 5 IQ points found in a meta analysis of general population sample found by Lynn & Irwing (2004) (Khaleefa, Amir & Lynn, in press). Lynn (1990, 1999) has proposed a developmental theory to the effect that there is no sex differences in intelligence up to the age of 9 years, from the age of 10 through 13 girls obtain slightly higher average IQ than boys as a result of the earlier growth spurt occurring in girls accelerated both physical and mental development. It has been shown in a meta-analysis of sex differences on the SPM that at the age of 16 years males obtain a slightly higher mean than females and this advantage increases in size into adulthood where **it** reaches about 5 IQ points (Lynn & Irwing, 2004).

(9) Young children performed better than older ones in IQ scores (study 6) and the rate of IQ increase for pre-schoolers was higher than that for older children (study 18) and younger adults performed better than older adults (study 8). This shows that intelligence decreases with increase in age and children are better in visualization ability and lower in abstract and reasoning ability. Khaleefa & Lynn (2008a, 2008b) found the same trends according to British norms in Syria and UAE. These results might support the similar findings in the USA by Thorndike (1977) who reported that young children made greater IQ gains than older ones and suggested causal factors likely to affect preschoolers more than others such as TV in general and educational TV in particular.

(10) The first born child obtained higher IQ scores compared to other children with reference to birth order (study 7, 8, 10). Study (7) stresses the importance of omega 3 fatty acid for the first born child who obtained 5 IQ higher than the last child. Laboratory test showed that new mothers had half the normal blood level of omega-3 fatty acid. Women who breastfed their babies had even lower levels of DHA because they are continuously supplying the baby's need for omega-3 fatty acids. If a woman does not replenish her store following the birth of the child, she will have lower and lower levels with each additional child. Some people suggest this is why firstborn children score higher on intelligence tests. Until now, people have attributed the well documented mental superiority of firstborn children to the fact that they spend more one-on-one time with a parent. It is now being suggested that their greater cognitive abilities may also be due to a more generous supply of maternal DHA (www.naturalnews.com/016353.html).

(11) Retarded children from old mothers (40+ years) have lower 8.3 IQ scores compared to those from young mothers

(study 10). The majority of gifted children had young mothers (age=29 years) (study 12).

(12) Mentally retarded children suffered overweight (study 10) and mentally gifted children underweight (study 12).

(13) The rate of IQ and the level of education of mothers are more determinants to the IQ of gifted children (study 12). Gifted children had higher IQ scores compared to their teachers by 24.83 points on the WISC-111 and 27.2 on the SPM (study 13).

(14) Basic education students at the University of Khartoum obtained the lowest IQ scores, lowest creativity, academic achievement and motivation compared to engineering and medical students. The IQ differences between engineering and educational students in US universities is10 IQ points while in Sudan is around 42 points (study 8).

(15) Meningitis had significant effect on lowering IQ by 8.3 points compared to their nearest siblings (study 9)

(16) There is a negative correlation between number of siblings (family size) and IQ (study 7, 15). Families with one child obtained higher IQ scores compared to families with more than 10 children. Study 7 stresses the importance of omega 3 fatty acid.

(17) Inbreeding has negative influence on the IQ of mentally retarded children. Sudanese outbred mentally retarded children had higher (3.2) IQ scores (study 10), half-cast children had 15.2 IQ points higher than the average IQ of the general population in the SPM (Study 14). These two results might confirm the theory of genetics and intelligence. However, perhaps the effects of these results are limited on the national large scale because very few Sudanese individuals married from abroad and the majority of Sudanese have big families. These results might support the assumption formulated by Lynn (1990) that the genetic theory factors might not be a strong cause for increasing intelligence. Because studies showed that there is a negative correlation between fertility and intelligence (Van Court and Bean, 1985) and there has probably been some increase in outbreeding over the last half century as societies have become more urbanized. However, the magnitude of any possible effects on intelligence would appear to be small (Lynn, 1990).

(18) Providing cognitive stimulation for children through intensive abacus training increases IQs (fluid intelligence) by 7.11 points as well as high level of speed (study 17). Additionally, abacus training increased visuo-spatial intelligence (right hemisphere) by 5.3 points as well as high level of processing speed of information more than verbal educational intelligence (left hemisphere) which increased by only 1.1 IQ points (study 16). These results might support the cognitive stimulation theory. The results suggest that introduction of a greater emphasis on problem solving skills in Sudanese schools may be expected to increase general intelligence (Irwing, Hamza, Khaleefa & Lynn, 2008).

One limitation to the study was that the children were retested shortly after the training and therefore the long term effectiveness of the program is not known. It is likely that the effectiveness of the training diminishes over time, but it showed the possibility to retain its effectiveness with the introduction of a greater emphasis on problems solving skill (Irwing, Hamza, Khaleefa & Lynn, 2008). However, education in Sudan tends to concentrate on rot learning and memorisation (Khaleefa, Erdos & Ashria, 1996a, 1996b) and there is limited scope for problem solving skills. Another limitation of the cognitive stimulation theory is that verbal and educational abilities taught in schools were found to be decreasing (study 19) and intelligence decreases with the increase in age (Study 7, 8, 18).

(19) There is a decline of genotypic intelligence in Sudan estimated at 0.8 points a generation. Despite the decline of genotypic intelligence it was reported that phenotypic intelligence, as measured by intelligence tests for children and adults in three studies, increased. There is no contradiction between these two phenomena. The explanation of the apparent inconsistency is that decline of genotypic intelligence has been masked by improvements of the environmental conditions fostering intelligence such as improvements in nutrition, health and education (Lynn, Khaleefa & Haroun, 2009) (study 15).

(20) IQ has been increasing in Sudan since 1964 i.e. eight years after independence, in the DMT, WISC-R, WAIS-R (study, 18, 19, 20). The studies showed that different IQ tests yielded different results of IQ gains and the gain is more on the fluid as well as visuo-spatial intelligence which are more sensitive to nutritional effects compared to the gain in crystallized and verbal educational intelligence. The increase of IQ for females is greater than that for males (study, 18, 19, 20), the rate of increase decreases with the increase in age. There was a gain 12.1 IQ points on the DMT over 42 years between 1964 to 2006 representing 2.9 IQ points a decade (study, 18), There was also 4.05 IQ points on the WAIS-R over the 20 years period between 1987-2007 representing 2.05 IQ points a decade (study, 19) and also a gain of 12.06 points on the WISC-R over the 20 years period between 1988-2008, representing 6.03 IQ points a decade (study, 20). The average IQ gain in Sudan ranged from 6.15 to-18.09 per generation while the IQ gains in economically advanced countries ranged 5-25 points in a single generation. The average gains in the three studies in Sudan was 3.66 IQ points a decade and 0.98 per generation and more than I SD per half a century (study 18, 19, 20).

Compared to economically developing countries, the IQ gain in Sudan in DMT, for example (2.9) is closely similar, although slightly greater than the gain on Draw a-Man Test of 2,4 points a decade in Brazil (1930 to 2002) reported by Colom et al (2007). It may be that the IQs in the economically developing nations such as Sudan will catch up with those in economically developed nations in the decades that lie ahead. Only time and future research will tell (Khaleefa, Abdelwahid, Abdulradi & Lynn, 2008). IQ increases are associated with an increase in living standards that have had a variety of beneficial effects such as improvements in nutrition, education and cognitive stimulation. There has been some increase in the standard of living in Sudan during the last half- century as indexed by life expectancy, which increased from 41 years in 1956 to 54 in 2006 (Khaleefa, Sulman & Lynn, 2009).

IQ and nutrition

The review of IQ studies did not mention a single psychological study dedicated entirely to the study of nutrition and IQ in Sudan. However, there were 8 studies (40%) stressing the importance of nutrition in IQ differences in Sudan. For example, study 4 stressed the factor of nutrition in the differences of the age of puberty in Sudan and economically developed countries. Study 5 mentioned the availability of fish (African lungfish, Um Koro) in Al-Rahad city which obtained the highest IQ scores in MI. Study 12 attributed the underweight of gifted children to lack of nutrition. Studies 15, 18, 19, 20 attributed the increase of intelligence to the improvement of

nutrition in Sudan. Study, 7 attributed the higher IQ of the first born child, the negative association between IQ and family size as well as the decrease of intelligence with the increase of age to the lack of omega 3 fatty acids. The general notion that nutrition is a vital element in mental well-being is of course neither new nor anything but obvious. As the German proverb says, *Man ist was man isst* –one is what one eats. Without food we would starve (Eysenck & Schoenthaler, 1997).

The analysis of results of IQ testing in Sudan suggests that nutrition perhaps is a more determinant factor of IQ gain between the years 1964 to 2008. Perhaps, present children eat better than their parents and grandparents, have better visual cognitive stimulation and live in a world with computer games, videos, disks, mobile phones, and internet. According to Lynn (1998) there are some evidences against the theory that improvement of cognitive stimulation would be expected to act most strongly on the verbal educational abilities learned formally and informally in the family and in schools, and least strongly on the visuo-spatial abilities. Studies showed that the verbal-educational abilities as a whole have shown quite small increases. However, it seems difficult to estimate precisely the effect of each of the genetic factor, cognitive stimulation and nutrition in the gain of IQ in Sudan. This package needs to be broken down into pieces. According to Flynn (1998) efforts to identify the environmental factors that have caused IQ gains were not convincing. The history of science shows many instances in which causal explanation awaits clarification of the package of effects to be explained.

The field of nutrition and particularly micronutrient supplements needs further intensive research in Sudan, specifically on malnourished babies, children and mothers. I agree with Lynn (1990) that it may be time for governments to take a more active role in securing better nutrition, perhaps by providing nutritional supplements to pregnant women and to children. This would yield a valuable social return. Intelligence is a major determinant of educational attainment, employment, occupational success, scientific and cultural achievements. The increase in intelligence that can be anticipated if further improvements in nutrition could be secured should yield significant social benefits.

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