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National differences in intelligence and educational attainment

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Abstract

We examine the correlations between the national IQs of Lynn and Vanhanen (Lynn, R. and Vanhanen, T. (2002). *IQ and the wealth of nations*. Westport, CT: Praeger. Westport, CT: Praeger, Lynn, R. and Vanhanen, T. (2006). *IQ and global inequality.* Athens, GA: Washington Summit Books.) and educational attainment scores in math and science for 10- and 14-year olds in 25 countries and 46 countries (respectively) given in the TIMSS 2003 reports. It was found that national IQs had (attenuation corrected) correlations of between 0.92 and 1.00 with scores in math and science. The results are interpreted as a validation of the national IQs. They suggest that national differences in educational attainment may be attributable to differences in IQ, or alternatively that national IQs and in educational attainment are both indicators of the mental ability of national populations. It is also shown that national IQs are positively associated with national per capita income (r=.61). It is proposed that these have a reciprocal positive feedback relationship such that each augments the other.

Keywords: National IQs; Educational attainment; TIMSS

1. Introduction

This paper reports high across country correlations between the national IQs calculated by Lynn and Vanhanen (2002, 2006) and national differences in educational attainment in mathematics and science. The paper has three objectives. First, to show that these correlations provide some validation of the national IQs. Second, to discuss the mechanisms underlying these correlations. And third, to examine the relationships between national differences in IQ and educational attainment and a number of educational, economic and demographic variables.

The first objective is addressed because of the controversy concerning the validity of the national IQs. Among those who have accepted the national IQs as valid, it has been argued that they are a significant correlate of economic growth (Weede & Kämpf, 2002; McDaniel & Whetzel, 2004; Dickerson, 2006; Jones & Schneider, 2006; Whetzel & McDaniel, in press), measures of education (Barber, 2005), rates of suicide (Voracek, 2004), and skin color and winter temperature (Templer & Arikawa, 2006).

Others, however, have contended that the national IQs presented by Lynn and Vanhanen (2002) have no validity. Among these, Ervik (2003, p.406) has written: “the authors fail to establish the reliability …of intelligence (IQ) test scores” (a measure that has no reliability must necessarily have no validity). Volken

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(2003, p.411) criticises the national IQs on the grounds of the "highly deficient data…in the type of IQ test used". Barnett and Williams (2004, p.392) criticise the IQs on the grounds that the samples "are, in many cases, not representative of the countries from which they are derived" and assert that the cross-country "comparisons are virtually meaningless". Hunt and Sternberg (2006, pp. 133,136) also assert that "the estimates of national IQ are technically inadequate" and "the concept of national IQ is meaningless".

The classical method of establishing the validity of intelligence tests is to show that they are correlated with educational attainment: "thousands of studies have been published, in numerous languages throughout the world, attempting to demonstrate the validity of intelligence tests against academic performance in school" (Matarazzo, 1972, p.281). Here we apply the same method to establish the validity of national IQs by showing that they are highly correlated with scores on tests of mathematics and science.

The second objective of the present paper is to discuss the mechanisms underlying the correlations between national IQs and educational attainment in mathematics and science. National differences in educational attainment in mathematics and science have been reported since the 1960s in a series of reports of the International Mathematics and Science Studies (Husen, 1967; Comber & Keeves, 1973; Baker & Jones, 1993; Beaton et al., 1996a,b; Beaton et al., 1996a,b). The national differences in average scores in these studies have been quite consistent. In general, the Chinese, Japanese and Koreans have achieved the highest scores, followed by the Europeans, while a number of developing countries have had the lowest scores. It has not proved possible to find a full explanation for these differences. Several hypotheses have been examined, including those that the differences may be partly determined by expenditure on schools, class size, and the qualifications of teachers, but none of these have produced substantial associations with educational attainment.

Although it is forty years since the publication by Husen (1967) of the first study of national differences in educational attainment in mathematics, the possibility that these might be associated with differences in intelligence, or even partly caused by differences in intelligence, has never been considered. The reason for this is that there have been no data on national differences in intelligence that could be used to examine these possibilities. This situation has changed with the publication by Lynn and Vanhanen (2002, 2006) of IQs for all nations in the world. This makes it possible to test the hypothesis, and this is the second objective of the present paper.

The hypothesis that the national differences in educational attainment are associated with differences in intelligence is derived from the numerous studies in many countries showing that intelligence is associated with educational attainment at a magnitude of a correlation of around .5 to .7. The results of nine studies showing this are summarized in Table 1. This is not a complete list of such reports, but we believe it is typical. The first column gives the country, the second column gives the number in the sample, the third gives the age at which intelligence was measured, the fourth gives the age at which educational attainment was measured, and the fifth gives the educational subjects assessed by tests. The correlations range between .45 and .74 with a

Table 1
Correlations between Intelligence and Educational Attainment

	Country	Number	Age IQ	Age ed. att.	Subject	*r*	Reference
1	Canada	208	13	13	Several	.55	Gagne and St. Pere, 2002
2	England	85	5	16	English	.61	Yule et al., 1982
3	England	85	5	16	Math	.72	Yule et al., 1982
4	Britain	20,000	11	16	GCSE	.74	Deary, 2004
5	N. Ireland	701	16	16	GCSE	.65	Lynn et al., 1984
6	USA	–	–	–	Several	.71	Walberg, 1984
7	USA	455	13	13	Reading	.68	Lloyd and Barenblatt, 1984
8	USA	–	18	18	Math	.66	Lubinski and Humphreys, 1996
9	Switzerland	82	11	11	Math	.45	Tewes, 2003

median of .66. It makes little difference to the size of the correlations whether intelligence is measured early in childhood or in adolescence. One of the highest correlations (.72) is between intelligence measured at the age of 5 years and educational attainment in mathematics at the age of 16 years.

2. Method

In their first study Lynn and Vanhanen (2002) published IQs for 81 countries obtained from studies in which intelligence tests have been administered to samples of the populations. In their second study the number of studies in which intelligence tests have been administered to samples of the populations and for which IQs were calculated was increased to 113 countries (Lynn & Vanhanen, 2006). For most of these countries IQs were measured by the Progressive Matrices, a non-verbal reasoning test. In other cases IQs were measured by a variety of other non-verbal tests including the Cattell Culture Fair and the Goodenough Draw-a-Person test. National IQs were calculated in relation to a mean IQ of 100 in Britain and standard deviation of 15. The increases in intelligence known as the Flynn effect were taken into account in these calculations.

They also estimated IQs for a further 79 countries for which there is no evidence from intelligence tests. IQs for these 79 countries were estimated from the measured IQs of similar and geographically adjacent countries. For example, the IQ in Afghanistan was estimated at 84 on the basis of the measured IQ of 84 in neighboring Iran and Pakistan. By the use of this method they provided IQs for all the 192 nations of the world with populations over 40,000. Some of the national IQs reported in Lynn and Vanhanen's second study differ slightly from those reported in their first study. The explanation for this is that they had collected more studies in the second study, but the differences are very small.

The data for counties' educational achievement in science and mathematics in were taken from the TIMSS 2003 study. This study was carried out by testing representative samples of school students from each country. The student samples were obtained by random sampling. At the first stage of the sampling procedure, 150 public and private schools were selected in each country. At the second stage, random sampling was used to find one class in every school that had two or more classes of students of the required age. The percentage of excluded students was less than five percent from the desired sample. The average number of students tested in a country was 4498 for the grade 4 study and 4777 students for the grade 8 study. The smallest number of students tested in a country was 2890 and the largest number was 9829 (Martin, Mullis, Gonzales, & Chrostowski, 2004, pp. 369–375). The students of grade 4 were 10 years old and the students of the grade 8 were 14 years old. The same students were involved in the science and in the mathematics study in both grades.

The TIMSS tests included the same tasks in all the participating countries. The tests represented the curricula

Table 2
National IQs and TIMSS scores on math and science

Countries	IQ	Math	Science	Math	Science
		Grade 4	Grade 4	Grade 8	Grade 8
Armenia	94*	449	438	470	455
Australia	98	507	520	506	525
Bahrain	83*	–	–	406	442
Belgium	99	544	518	534	515
Botswana	70*	–	–	369	366
Bulgaria	93	–	–	475	479
Chile	90	–	–	394	421
Cyprus	91*	511	483	459	444
Egypt	81	–	–	406	423
England	100	534	538	502	540
Estonia	99	–	–	531	548
Ghana	71	–	–	282	258
Hong Kong	108	565	540	581	550
Hungary	98	526	529	526	539
Indonesia	87	–	–	413	426
Iran	84	395	424	414	458
Israel	95	–	–	492	489
Italy	102	504	517	483	493
Japan	105	566	541	569	546
Jordan	84	–	–	428	476
Korea, Rep. of	106	–	–	585	550
Latvia	98*	531	532	507	512
Lebanon	82	–	–	432	396
Lithuania	91	529	510	500	518
Macedonia	91	–	–	435	451
Malaysia	92	–	–	505	510
Moldova	96	502	499	457	471
Morocco	84	356	306	390	399
Netherlands	100	536	518	535	532
New Zealand	99	502	519	497	518
Norway	100	462	470	465	496
Palestine	86	–	–	395	439
Philippines	86	362	332	380	378
Romania	94	–	–	472	472
Russia	97	527	527	505	512
Saudi Arabia	84*	–	–	339	398
Scotland	97	499	502	500	510
Serbia	89	–	–	473	468
Singapore	108	580	558	596	569
Slovakia	96	–	–	505	517
Slovenia	96	486	492	492	520
South Africa	72	–	–	278	257
Sweden	99	–	–	499	522
Taiwan	105	559	551	580	565
Tunisia	83	330	317	409	412
United States	98	521	534	502	526

Table 3
Correlation coefficients (corrected for attenuation in brackets) between TIMSS 2003 results and IQ

Subject	Grade	All countries	Measured IQ countries
Mathematics	Fourth grade	0.87 (.95)	0.89 (.97)
Science	Fourth grade	0.85 (.92)	0.86 (.93)
Mathematics	Eighth grade	0.92 (1.0)	0.93 (1.0)
Science	Eighth grade	0.91 (.99)	0.91 (.99)

of the countries as well as possible (Martin et al., 2004, p.359). The science tests included items on life science, chemistry, physics, earth science, and environmental science. The test items were on three cognitive domains — factual knowledge, conceptual understanding, and reasoning and analysis (Martin et al., 2004, p.356). Altogether 152 items in the test for the fourth grade level and 189 test items were used in the test for the eighth grade. The items in the tests were in multiple-choice format. 1200–2000 students answered every test item. Every correct answer was awarded one or two points depending on the complexity of the item. The international average scores were 489 in the fourth grade and 474 in the eighth grade. The reliability of the measures was 0.84 for both grades (Martin et al., 2004, pp. 356–386).

The TIMSS 2003 mathematics test was composed and administered analogously to the TIMSS science tests. The mathematics test included items on number, algebra, measurement, geometry, and data. The items were in four cognitive domains: knowing facts and procedures, using concepts, solving routine problems, and reasoning (Mullis, Martin, Gonzales, & Chrostowski, 2004, p.343). About 40% of the items were in multiple-choice format. The international average scale sore was 495 in the fourth grade and 467 in the eighth grade. The reliability was 0.87 for the fourth grade test and 0.89 for the eighth grade mathematics test (Mullis et al., 2004, p.367).

In addition, questionnaires were given to students, teachers and school head-teachers. The answers give information about the learning and teaching background in schools and homes.

The publication of the 2003 Trends International Mathematics and Science Study (TIMSS) makes it possible to examine the relation between the national scores in mathematics and science and the national IQs calculated by Lynn and Vanhanen in their more recent

Table 4
The correlation coefficients between TIMSS test results in grade 8 science and school characteristics (the labels are explained below of the table)

	Mean TIMSS	IQ Lynn	Textbook	Class size	Teach Univ +	Sch Cl Low	Stud safety	Life expectancy	>50% EDH	GDP USD	Computer	Study desk
Mean TIMSS	1.00											
IQ Lynn	0.91	1.00										
Textbook	0.34	0.31	1.00									
Class size	−0.46	−0.38	−0.15	1.00								
Teach Univ+	0.45	0.43	0.16	−0.15	1.00							
Sch CL Low	−0.49	−0.51	−0.28	0.19	−0.31	1,00						
Stud safety	0.68	0.66	0.39	−0.66	0.22	−0.31	1.00					
Life expectancy	0.72	0.75	0.22	−0.37	0.45	−0.65	0.62	1.00				
>50% EDH	−0.78	−0.73	−0.29	0.56	−0.41	0.54	−0.58	−0.57	1.00			
GDP USD	0.55	0.61	0.01	−0.34	0.18	−0.42	0.38	0.52	−0.63	1.00		
Computer	0.66	0.70	0.12	−0.38	0.25	−0.59	0.41	0.64	−0.74	0.83	1.00	
Study desk	0.73	0.69	0.22	−0.43	0.28	−0.46	0.58	0.52	−0.74	0.47	0.64	1.00
Parent Univ	0.44	0.43	0.27	−0.45	0.49	−0.37	0.55	0.40	−0.51	0.43	0.36	0.50

TIMSS — the arithmetical average of the TIMSS grade 8 science sub-tests.
IQ — the national values of IQ from Lynn and Vanhanen (2006).
Textbook — percentage of students taught by teachers who report textbooks as primary bases for lessons.
Teach Univ — percentage of students whose teachers have university degrees or equivalent.
Sch Cl Low — percentage of students whose principals assess school climate as low.
Stud safety — percentage of students who assess high their being safe in schools.
>50% EDH — the percentage of students in schools with more than 50% economically disadvantaged students according to school principals' reports.
GDP USD — Gross domestic product (from The World Factbook, 2005).
Computer — percent of students who have computer in the home.
Study desk — percent of students who have a study desk/table in the home.
Parent Univ — percentage of students whose parents finished university or equivalent or higher.

(Lynn and Vanhanen, 2006) publication. The 2003 International Mathematics and Science Study gives scores for grade 4 school children for 25 countries and for grade 8 school children for 46 countries in mathematics (Mullis et al., 2004) and science (Martin et al., 2004). These reports also give sub-test scores for different areas of mathematics and science.

3. Results

The average sub-test scores for both subjects and both grades are given in Table 2, together with the national IQs calculated by Lynn and Vanhanen (2006). Six of the IQs are asterisked to show that they are estimated IQ. The remaining 40 are measured IQs. The data for Belgium are for the Flemish-speaking part of the country; the data for Palestine are for the Palestinian National Authority. The IQ of 86 for Palestine is given in Lynn (2006) and the IQ of 97 for Scotland is given in Lynn (1979).

The Pearson correlations between the TIMSS 2003 results and IQ are given in Table 3. The correlations are given for all countries (column 3) and for measured IQ countries (column 4). The correlations for all countries and for measured IQ countries are virtually identical, suggesting that the estimated IQs must be accurate. The correlations are also given corrected for attenuation for all countries and for measured IQ countries. The reliability coefficients for calculating the corrections for attenuation were derived as follows. The reliability of the national IQs is given by Lynn and Vanhanen (2006, p.62) as 0.92, derived as the correlation between pairs of IQs obtained from the same country and based on 71 countries for which there are two IQ measures. The reliability of the national mathematics scores is derived as the correlation between the scores of the grade 4 and the grade 8 children ($r=0.92$), and the reliability of the national science scores is derived in the same way ($r=0.92$). The correlations corrected for attenuation are given in brackets in Table 3.

We have considered whether any other variables could explain the national differences in scores in mathematics and science and examined the possible effects of a number of school and demographic variables including teacher training, school climate, economic development. The data were taken from the TIMSS international Science report for grade eight (Martin et al., 2004). The correlations between these and scores in science for the 8 grade students are shown in Table 4. It will be seen that many of the correlations are high but the correlation between TIMSS science scores and IQ is the highest. Regression analysis for the eighth grade science results revealed only one statistically significant predictor — IQ. Coefficients of partial correlation revealed that no characteristic of schooling had a statistically significant relationship with TIMSS results when IQ was partialed out.

4. Discussion

The first question addressed in this paper is whether the validity of the national IQs can be demonstrated by showing that they are highly correlated with national scores on tests of mathematics and science. We have examined the relationships between the national IQs and the results of the four TIMMS studies of international achievement in mathematics and science of grade 4 and grade 8 school students published in 2003. The study has found very high correlations between national IQs and the scores obtained in mathematics and science. These correlations range between .85 and .93; and, corrected for attenuation, between .93 and 1.0. We believe that these high correlations establish beyond reasonable dispute that the national IQs have a high degree of validity.

The second question addressed in this paper is how to explain the relationships responsible for the national differences in IQ and attainment on tests of mathematics and science. It has been noted by Luo, Thompson, and Detterman (2003) that there are three theories to explain the correlations between IQs and educational attainment at the level of individuals. These are (1) intelligence is a cause of educational attainment "because *g* is commonly acknowledged as more pervasive in intellectual tasks, and appears to be more biologically rooted than school achievement" (Jensen, 1998, p.68); (2) intellectual abilities are partly a product of education (Ceci, 1991); (3) intelligence, measured by intelligence tests, and scholastic performance are both partly determined by "basic cognitive processes, which are measured using tasks such as simple reaction time, inspection time, and memory recall and recognition tasks" (Luo et al., 2003, p. 67). These authors produce evidence supporting the last of these theories and conclude that "individual differences in mental speed are a main causal factor underlying the observed correlation between general intelligence and scholastic performance in children between the ages of 6 and 13."

These theories can be applied to explain the cross-country correlations between IQs and the mathematics and science attainment: (1) we can follow Jensen and regard national differences in intelligence (operationalized by IQs) as virtually entirely responsible for differences in mathematics and science attainment; (2) we can follow Ceci (1991) and posit that differences in education have had an effect on both national IQs and educational attainment in math and science. There is little doubt that education affects IQs at the level of individuals, as Ceci (1991, p.703) has concluded: "Schooling fosters the development of cognitive processes that underpin performance on most IQ tests". More recently the positive effect of education on IQ has been confirmed by Whaley, Fox, Deary, and Starr (2005) who have found that the level of education is an independent predictor of intelligence at age 64 after controlling for childhood IQ and other predictors. Further evidence has been provided by Blair, Gamson, Thorne, and Baker (2005).

(3) We can follow Luo et al. (2003) and regard national IQs and educational attainment in math and science as measures of the same latent construct that they describe as "basic cognitive processes". The cross-country correlations between the IQs and mathematics and science attainment scores are so high (at between .93 and 1.0, corrected for attenuation) that this appears a plausible theory. This conclusion is supported by genetic studies that have found that the relationship between academic attainment and IQ is largely due to common genetic influences (Wainwright, Wright, Geffen, Luciano, & Martin, 2005; Kovas, Harlaar, Petrill, & Plomin, 2005).

The third objective of the paper has been to explore further the relationships between national IQs and mathematics and science attainment and a number of educational, economic and demographic variables. The correlation matrix showing the inter-relationships between these is given in Table 4. It will be seen that a number of these correlations are moderately high. Educational attainment and IQ are correlated with the use of textbooks as primary bases for lessons (r=.34, .31), the percentage of teachers with university degrees (r=.45, .43), the percentage of students whose principals assess the school climate as low (r=−.49,−.51), the percentage of students who assess their schools as safe (r=.68, .66), the percentage of students in schools with more than 50% economically disadvantaged students according to school principals' reports (r=−.78,−.73), the percentage of students who have a computer in the home (r=.66, .70), the percentage of students who have a study desk or table in the home (r=.73, .69), and the percentage of students whose parents had university degrees or equivalent (r=.44, .43). There are also substantial correlations between national IQs and mathematics and science attainment and gross national per capita domestic product (r=.55, .61) and life expectancy (r=.72, .75).

We suggest that these correlations arise from a complex network of relationships. We propose that the two most fundamental are national IQs and per capita GDP (a measure of per capita income) that are correlated at 0.61. We suggest that these two variables have a reciprocal positive feedback relationship such that each has a causal effect on the other, i.e. national IQs have a positive effect on per capita income and per capita income has a positive effect on national IQs. National IQs have a positive effect on per capita income because a nation whose population has a high IQ can earn more, just as individuals with high IQs can earn more than those with low IQs. Conversely, national per capita income has a positive effect on national IQs because a nation whose population has a high per capita income can spend more on education, nutrition and health care, and these have a beneficial effect on intelligence. The other correlations given in Table 4 appear to arise largely as effects of per capita income on educational variables. For instance, national populations with high per capita incomes can afford to buy their children desks (r=.47) and computers (r=.83), and can afford to have smaller classes (r=−.34). National populations with high per capita incomes have high life expectancy (r=.52) probably largely because they can provide a high standard of nutrition and health care and also because intelligence is associated with longevity, as shown by Whaley and Deary (2001).

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