Intelligence 77 (2019) 101402

Contents lists available at ScienceDirect

Intelligence

journal homepage: www.elsevier.com/locate/intell

Intelligence, family income and parental education in the Sudan

Nagat Ibrahim Abd Elmaged Husain[a], Gerhard Meisenberg[b], David Becker[c], Salaheldin Farah Bakhiet[d,*], Yossry Ahmed Sayed Essa[d], Richard Lynn[e], Faris Mohsen Humayjan Al Julayghim[d]

[a] National Commission for Gifted Education, Sudan
[b] Department of Biochemistry, Ross University, School of Medicine, United States of America
[c] Department of Psychology, Chemnitz University of Technology, Wilhelm-Raabe-Str. 43, D-09107 Chemnitz, Germany
[d] Department of Special Education, College of Education, King Saud University, Riyadh, Saudi Arabia
[e] University of Ulster, Coleraine, UK

ARTICLE INFO

Keywords:
Raven's progressive matrices plus
Sudan
Sex-differences
Simber-effect
Parental education
Parental income

ABSTRACT

The SPM+ was administered on a sample of 5189 school children from Sudan in 2016. Data about age, sex, locality, school type and stage, parental education and profession, family size and birth order were collected. Results for intelligence are congruent with the literature, giving the sample a mean IQ of ≈80 on British norms. Sex-differences are largely negligible. Differences in intelligence were found between three locations and are consistent with differences in parental education and income. Family income is a better predictor than parental education for children's intelligence. Children in private schools outperform children in public schools with mean IQs of 84–78 but path analysis points to a possible negative effect of private education. IQ-differences between age-groups and school-stages were found but no Simber-effect. The effects of selective processes along the educational pathway are shown and discussed with reference to the need for samples more representative for total populations.

1. Introduction

With a size of 1,861,000 km^2, Sudan is the third largest African country after Algeria and the Democratic Republic of Congo. Its size is matched by great diversity in ecology, ethnic composition, and socio-economic development. Sudan is one of the best researched African countries in terms of intelligence, thanks to a large number of studies in which IQ tests were administered to large and representatively selected samples. These administrations were collected and/or reported in chronological order by Bakhiet (2008), Irwing, Hamza, Khaleefa, and Lynn (2008), Khaleefa, Lynn, Abulgasim, Dosa, and Abdulradi (2010), Bakhiet and Lynn (2015c), Batterjee and Ashria (2015) and Dutton, Bakhiet, Ziada, Essa, and Blahmar (2017). They are summarized in Table 1 with original sources in the rightmost column. Estimated IQs vary between 65.90 and 84.03, with an unweighted mean of 75.73 (SD = 5.46) or 76.75 if weighted for sample size according to Lynn and Becker (2019). This mean score is consistent with the country's geographical location between North Africa (Libya with an IQ of around 81, Egypt with an IQ of around 76) and sub-Saharan Africa (Eritrea with an IQ of around 69, Ethiopia with an IQ of around 68, South Sudan with an IQ of around 59). As expected for a country as large and diverse as Sudan, regional differences of up to 19 IQ points were reported by Bakhiet and Lynn (2015c) on the WISC-III performance scale between the south-western province of Darfur (with an IQ of around 64) and the northern provinces Al Shamaliah/Ash Shamaliyah and River Nile (both with an IQ of around 79).

However, despite the huge amount of reported data, many from large and representative samples, studies about correlates of IQ differences within Sudan are rare at the individual as well as regional level. An exception is a study by Batterjee and Ashria (2015), who reported a statistically significant (p < .001, self-calculated) and age robust advantage in intelligence, measured with the SPM, for school children visiting private schools against children visiting predominantly or exclusively public schools. However, the magnitude of this advantage remained stable across the ages, except the first and last year of measurement when it completely disappears. Therefore, it is not a result of accelerated cognitive development in private schools. These authors also reported a moderately strong relationship between intelligence and parental socioeconomic status. Therefore, socioeconomic advantage, rather than or in addition to better instruction, is a plausible cause for

* Corresponding author.
E-mail addresses: david.becker@s2009.tu-chemnitz.de (D. Becker), bakhiet@ksu.edu.sa (S.F. Bakhiet).

https://doi.org/10.1016/j.intell.2019.101402
Received 25 March 2019; Received in revised form 24 September 2019; Accepted 24 September 2019
0160-2896/ © 2019 Elsevier Inc. All rights reserved.

Table 1
Survey of measured IQs on representative or random samples in Sudan.

Year	Test	Location	*N* of subj.	Ages of subj. (y)	IQ	*α*	Source
1997/1998	SPM	Khartoum (state)	6877	9 to 25	79.99	0.54 to .93[a] 0.70 to .96[b] 0.88 to .97[c]	Alkhateeb and Almotwakel (2001)
1999	SPM	Khartoum (state)	3893	9 to 25	79.80*	–	Khaleefa, Khatib, Mutwakkil, and Lynn (2008)
2003	SPM	Khartoum (state)	145	8 to 9	84.03	0.60 to .94[b,d]	Attallah (2003)
2006	CPM	Khartoum (state)	1683	6 to 9	70.46	0.63 to .83[b] 0.63 to .81[d]	Alkhateeb, Almotwakel, and Hussain (2006)
2007	SPM	Kusti (city)	537	8 to 12	72.29	0.75 to .89[b] 0.69 to .89[d] 0.92 to .94[e]	Attallah, Almotwakel, Haseeb, Gumaa, and Alhassan (2007)
2008	SPM	Khartoum (state)	3185	7 to 11	74.83	–	Irwing et al. (2008)
2008	SPM	Darfur	1006	8 to 18	65.90	–	Khaleefa et al. (2010)
2010	WISC-III	Seven regions	1460	7 to 16	75.53	–	Khaleefa, Taha, and Al-Hussein (2012)
2010	SPM	Khartoum (state)	5659	9 to 25	72.06*	–	Khaleefa (2011)
2015	SPM	Eight provinces	4109	9 to 26	82.37*	0.75 to .89[b] 0.69 to .89[d] 0.92 to .94[e]	Batterjee and Ashria (2015)

Notes: Average IQs from all Sudanese studies, along with averages from other countries of the world, are reported in Lynn and Becker (2019); unweighted mean IQ is 75.73 (unweighted) or 76.75 (weighted for sample size); indizes of reliability.
[a] Split half.
[b] Spearman-Brown.
[c] Koder-Richardson.
[d] Guttmann.
[e] Cronbach.

the higher scores of private school students. Irwing et al. (2008) showed that focused training delivered on top of the regular school curriculum is quite able to accelerate the cognitive development of Sudanese schoolchildren substantially. This training effect indicates that higher IQ test scores can be achieved by improvements in the Sudanese education system.

The present study presents results for a new sample from Sudan which was recruited in three districts of the Khartoum metropolitan area: the southern part of the capital Khartoum al-Chartūm, its northern part Bahrī, and the city Umm Durmān (Omdurman) in the northwest of Khartoum. Al-Chartūm is the business center of the area, including Khartoum International Airport, important universities (University of Khartoum, Al Neelain University, Al Mughtaribeen University), and a high density of national and international banks (e.g. Aljazeera Bank, Qatar National Bank, Abu Dhabi Islamic Bank, Arab Bank for Economic Development in Africa). Al-Chartūm and Umm Durmān are similar in having both many upper-class and poverty-stricken lower-class areas, and also many refugee camps. Squatter settlements are more frequent in Umm Durmān and Bahrī, and agricultural land is mostly concentrated in Bahrī which also has the highest density of primary schools, whereas Chartūm and Umm Durmān have the lowest. Nutritional status is similar between al-Chartūm and Umm Durmān and better than in Bahrī (Pantuliano et al. 2011).

No detailed, reliable and current statistics could be found about socio-economic differences, e.g. average family income, which could be compared between the three observed districts of the Khartoum metropolitan area. Faki, Nur, Abdelfattah, and Aw-Hassan (2012) reports a higher estimate of food poverty in Umm Durmān compared to al-Chartūm and Bahrī, and Eltayeb (2003) a higher share of better residential areas in al-Chartūm compared to Umm Durmān and Bahrī, but numbers given by both sources are from pre-millennial reports. However, prices for basic food, cloth, housing and education might be adequate indicators and were given by Numbeo 2019. These prices (USD, estimated in 2018 or 2019) are more than twice as high in Khartoum compared to Umm Durmān, e.g. $0.25 vs. $0.13 for a 0.33 l bottle of water, $1.37 vs. $0.27 for one liter of milk, $2.28 vs. $0.44 one kg of white rice, $18.50 vs. $6.65 for one pair of jeans, $241.89 vs. $44.33 for an apartment with one bedroom in the city center or $130.68 vs. $33.25 outside of the city center, $58.50 vs. $17.73 for full day pre-schooling per child and month, and so on. Bahrī was not listed separately by the source.

The area was strongly affected by Sudan's massive urbanization and internal migration due to wars in Ğanūb Kurdufān (South Kordofan), an-Nīl al-ʾAzraq (Blue Nile) and Dār Fūr (Darfur). It has also become an increasingly popular destination for immigrants and refugees from other parts of the Arab-Muslim world and Africa, especially Eritrea, Ethiopia, Nigeria and Syria. Most of these have come for economic reasons including work, study and escape from extreme deprivation, but a minority have come to avoid military service or to escape from conflict and oppression (IOM 2017). In addition, the independence of South Sudan in 2011, followed by civil war between the South Sudanese government and various rebel factions, caused an increase in the numbers of refugees from South Sudan. Around 70% of the arrivals until the end of 2013, but only around 4% in later years, settled in and around Khartoum (UNHCR - Refugee Consultation Forum 2018).

The present study recruited a new sample. Data on intelligence and important sociodemographic and socioeconomic variables were collected, which makes it possible to examine many statistical relationships. The following are the major goals of this study:

(1) The verification of internal consistency (reliability) of the SPM+ scores in this new Sudanese sample. The reliabilities shown in Table 1 for SPM and CPM should be met or surpassed in this study. Although satisfactory reliabilities of Raven's tests have been found in many other Arabic countries (e.g. Abdel-Khalek 1988; Ahmad, Khanum, Riaz, & Lynn 2009; Al Said 2014; Al-Shahomee & Lynn 2010, 2012; Bakhiet & Lynn 2014, 2015a; Khaleefa & Lynn 2008b, 2008c), doubts about the suitability of Raven's matrices and other tests measuring analytic abilities were voiced in recent times (Dutton et al. 2018). This makes a constant inspection of the reliability necessary.
(2) Giving detailed descriptive statistics for the full sample, as well as separately for both sexes and all age groups to approach questions of gender equality and the effectiveness of the Sudanese school system in raising children's intelligence.
(3) Estimating the presence and size of sex differences in raw- and IQ-scores. Sex differences of non-trivial magnitude on Raven's tests have been found by various studies in different countries, favoring either females (e.g. Abdel-Khalek & Lynn 2006; Jinabhai et al. 2004; Khaleefa & Lynn 2008a; Spanoudis, Natsopoulos, & Lynn 2016) or males (Garcia 2016; Lynn & Chan 2003), or with sex differences changing across age groups (Bakhiet et al. 2018; Hur, te Nijenhuis, & Jeong 2017; Khaleefa & Lynn 2008d; Lynn, Allik, & Irwing 2004). Others found no significant sex differences (Ahmad et al. 2009; Bakhiet & Lynn 2015a; Sbaibi, Aboussaleh, & Ahamim 2014). This study therefore reports sex differences not only for the

total sample, but also for individual age groups.

(4) Observing age-related trends in cognitive development. Specifically, the question is whether there is a negative age-related trend in IQ (a Simber effect). Because IQ is conventionally calculated according to British norms, declining IQ with increasing age in school-aged children would indicate slower cognitive development than in the British norm samples of the test. It would suggest that conditions in the country are less favorable for the development of children's intelligence than they are in Britain. This effect has been described by Bakhiet, Dutton, et al. (2018) based on samples from Egypt, Jordan, Kuwait, Libya, Palestine, Saudi Arabia, Sudan, Oman, Qatar, the United Arab Emirates and Yemen. Environmental and biological causes were considered as possible explanations, although deficiencies in schooling and other aspects of children's intellectual environment are considered the most plausible causes.

(5) Estimating the differences between subsamples defined by school type, locality, parental education and profession, family income, birth order and number of siblings, and testing the hypothesis of effects of parental education, income, number of siblings and school type on children's IQ.

Some studies have shown that children in developing countries attending private schools perform better on Raven's tests than those in public schools. This pattern has been found in Brazil, India, Nigeria and Pakistan and is most often explained with better material equipment and better qualifications of the teaching staff in private schools (Aslam 2009; Gandhi-Kingdon 1996; Ijarotimi & Ijadunola 2007; Malloy-Diniz et al. 2008). As already mentioned, in Sudan, children in private schools outperform children in public schools but this advantage is about the same at all ages.

Higher income of parents is associated with higher cognitive abilities of children, as judged by the children's better performance in school. However, a direct causal effect of wealth seems to be limited at best (Mayer 1997). Several studies (Blau 1999; Rindermann & Baumeister 2015; Rindermann & Carl 2017; Rindermann & Ceci 2018; Rindermann, Michou, & Thompson 2011) demonstrated that parents' education is more important than family income for children's cognitive development, and it remained the best predictor when controlled for parents' educational practices, child health, and family structure.

Controls for family size and birth order, which both reduce intelligence and educational attainment, were applied in several studies (Kuba, Flegr, & Havlíček 2018; Barclay 2015a; Kristensen & Bjerkedala 2010). The birth order effect has been observed also in fully adopted children and therefore is due to parenting or other aspects of the family environment, rather than pre-natal or other biological causes (Barclay 2015b). However, Kanazawa (2012) showed that the birth order effect could be a statistical artefact, caused by the positive correlation between birth order and family size.

2. Method

In 2016 the SPM+ was administered to 5189 Sudanese children and adolescents, 2553 male and 2636 female, between 7 and 18 years of age (M = 12.40; SD = 3.18). The sample was recruited from three contiguous urban regions: the southern part of the capital Khartoum al-Chartūm (N = 1669), its northern part Bahrī (N = 1901), and the northwestern city Umm Durmān (N = 1619). The children were enrolled in public (N = 3291) or private schools (N = 1898). The complete 60-item SPM+ was administered and the time to complete the test was recorded.

Raven score, age, school grade, sex, locality and school type were recorded, as well as additional socioeconomic and sociodemographic data. Family income was rated on a scale from 1 = low to 3 = high. Parental occupation and education were inquired for fathers and mothers separately, the latter in eight categories, which were recoded to a 1 to 7 scale with 1 = illiterate, 2 = basic, 3 = elementary (Islamic), 4 = middle, 5 = secondary, 6 = university and 7 = postgraduate. A "not specified" category was excluded. Scores for father's and mother's education were averaged to a score representing overall parental education. Furthermore, the birth order of the tested child and the number of their brothers and sisters were queried. The latter was also summed to the total number of siblings. Approximately 5% of data for father's education, mother's education and father's occupation were missing. These data points were excluded by pairwise deletion from analyses involving these variables.

Raw scores were converted to IQ scores using conversion formulas given by Lynn and Becker (2019). These formulas were derived from the statistical relations between raw scores and IQ scores for each age group in the British standardization of 2007, reported in the SPM+ manual (Raven 2008). These IQs are referred to as British(−scaled) IQ, or Greenwich IQ. Formulas were successfully tested by Lynn and Becker (2019) on fit quality. Hereafter, IQ scores were corrected for norm inflation caused by the Flynn Effect with the help of the FE-calculator from the NIQ dataset (V1.3.1) from Becker (2018), based on a meta-analysis of the FLynn-Effect by Pietschnig and Voracek (2015). The SPM + was standardized in the UK in 2007, which makes a 9–10 years difference to the year of measurement. However, changes in fluid intelligence in the UK were only reported until 2008, therefore the necessary amount of correction was only −0.21 IQ-points.

The following analyses were performed:

1. Sex differences in mean raw scores were expressed as Cohen's d. Statistical significance of sex differences in means was determined with t-tests, and sex-differences in standard deviations with F-tests.
2. Differences in IQ scores by father's profession will be reported, however one case had to be excluded from parts of the report for reasons of privacy.
3. Special attention will be given to age-related cognitive development to find indications for or against the presence of a Simber Effect. Therefore, the effect sizes per year of chronological age will be compared with those of school grade. The former helps to avoid wrong conclusions from the latter, which could be caused by larger numbers of repeaters or late starters. For this purpose, a closer look will be taken at children of different ages in the highest school grade.
4. Pupils from the two different school types are compared as well to specify possible reasons for accelerations or decelerations in cognitive development.
5. We conducted correlation and regression analyses across 13 × 13 variables and path analysis with five variables. Path analysis was done with the software Mplus 7.4 (Muthen & Muthen, ©1998–2015) with the aim of examining Rindermann's (2018) concept of "cognitive capitalism" showing that parental education, income and quality of education predict children's IQ. We also examine the effect of parental education on the number of siblings and the effect of income on school type.
6. Finally, interaction effects were studied with continuous parameter estimation (CPEM). This method determines whether the correlation between two variables is affected by the value of a third variable (Gorsuch, 2005). The correlation is formed as the dot-product of the standardized values of the two variables according to the definition of the Pearson product-moment correlation coefficient. Specifically, we determined whether the correlations of IQ with father's education, mother's education, number of brothers and number of sisters were affected by school type, age, family income, and other variables.

3. Results

Internal consistency of the SPM+ is shown in Table 2. The value for Cronbach's α indicates a reliability as good as the best reported for the SPM (another 60-item test) and considerably higher than most values

Table 2
Internal reliability.

Sample	Sudan (2016)
Test	SPM+
k (items)	60
$\Sigma\sigma$ (Σ of σ across all items)	9.88
σ (across summed raw-scores)	100.49
α (Cronbach's; by var of item)	0.92

Table 3
Descriptive statistics for intelligence in the Sudan (2016) sample measured with SPM+.

Age	Sex	Raw scores					Corrected IQ	
		N	*M*	*SD*	*LL*	*UL*	*M*	*SD*
7	M + F	356	13.46	5.89	1	41	77.50	15.77
	M	170	12.89	6.26	1	41	76.03	17.35
	F	186	13.98	5.55	3	31	78.83	15.10
8	M + F	374	15.20	6.22	1	41	78.29	15.25
	M	184	14.74	5.69	4	31	77.17	14.30
	F	190	15.64	6.74	1	41	79.38	16.98
9	M + F	407	17.37	7.90	2	41	77.73	16.39
	M	192	17.52	8.17	2	38	78.10	17.30
	F	215	17.23	7.73	4	41	77.39	16.38
10	M + F	519	20.43	8.44	1	43	77.02	18.97
	M	257	18.98	8.48	1	40	73.87	18.53
	F	262	21.86	8.25	4	43	80.12	19.46
11	M + F	473	23.01	8.78	1	45	77.98	24.84
	M	199	21.77	9.33	1	42	74.43	26.69
	F	274	23.92	8.36	6	45	80.57	23.52
12	M + F	509	23.48	8.58	1	46	78.64	20.39
	M	243	22.99	8.71	1	46	77.56	20.99
	F	266	23.92	8.55	3	40	79.63	20.33
13	M + F	492	23.90	9.35	1	48	79.32	18.19
	M	253	22.17	9.12	1	46	76.03	16.96
	F	239	25.74	9.36	1	48	82.81	19.47
14	M + F	485	27.79	9.27	4	47	85.38	20.52
	M	243	26.79	9.04	4	47	82.70	19.24
	F	242	28.80	9.55	4	46	88.07	22.07
15	M + F	499	30.48	8.33	5	53	88.45	22.40
	M	265	30.30	7.70	6	52	87.26	21.36
	F	234	30.68	9.19	5	53	89.79	24.13
16	M + F	471	30.98	9.43	3	53	88.12	23.61
	M	243	30.25	9.21	7	51	86.01	23.16
	F	228	31.77	9.80	3	53	90.36	24.56
17	M + F	368	28.89	8.45	5	50	80.14	18.52
	M	174	30.05	8.29	5	50	82.47	19.11
	F	194	27.84	8.69	7	47	78.05	18.62
18	M + F	236	27.67	9.43	8	45	69.46	28.22
	M	130	28.26	8.97	8	43	71.36	26.60
	F	106	26.94	10.25	9	45	67.13	30.63
Total	M + F	5189	23.74	10.03	1	53	80.43	20.68
	M	2553	23.29	10.02	1	52	79.02	20.24
	F	2636	24.17	10.03	1	53	81.79	21.07

obtained with other estimates of reliability. The result shows that the SPM+ is at least as reliable as the SPM and CPM for IQ measurements in Sudan.

Table 3 shows descriptive statistics for raw- and IQ-scores of the total sample as well as separated by age and sex. The total sample obtained a mean raw score of 23.74 (SD = 10.03) which is equivalent to the 9.6th British percentile and a British-scaled IQ of 80.43 (SD = 20.68). This score is within the range of results reported in Table 1. Sex differences in mean raw scores are marginal (Tables 3, 4). There is a statistically significant but very small advantage for females in the total sample of 0.88 raw score points or 2.77 IQ points (d = −0.09; t = −3.170; p = .002). Raw scores for percentiles and distributions of IQ scores for both sexes can be found in the appendix (Table A1, Fig. A1 and A2).

Raw scores rise with age at a mean annual rate of +1.29, which is only slightly below the annual increase of +1.41 in the British sample. The trend is continuously positive from the age of 7 to the age of 16. However, between the ages of 16 and 18 years, raw scores declined from 31.0 (SD = 9.4), equivalent to the 21.4th British percentile and a British IQ of 88.1 (SD = 23.6), to a raw score of 27.7 (SD = 9.4), which is equivalent to the 2.1th British percentile and a British IQ of 69.5 (SD = 28.2). As a result, the IQ was relatively stable from 7 to 16 years of age but then decreased dramatically compared to British norms. Overall, British-scaled IQ declined by 8.0 points from age 7 to age 18, although it rose by 2.6 points from age 7 to age 17 and by 10.6 points from age 7 to age 16.

Table 4
Significance of sex-differences in SPM+ raw-scores in the Sudan (2016) sample.

Age (y)	Sex-differences in raw-scores		
	d	*t*	*p*
7	−0.19	−1.754	0.080
8	−0.15	−1.416	0.158
9	0.04	0.375	0.708
10	−0.35	−3.967	< 0.001
11	−0.25	−2.662	0.008
12	−0.11	−1.241	0.215
13	−0.39	−4.342	< 0.001
14	−0.22	−2.424	0.016
15	−0.05	−0.518	0.605
16	−0.16	−1.774	0.077
17	0.27	2.567	0.011
18	0.14	1.089	0.277
Total	−0.09	−3.170	0.002

Notes: d is Cohen's d with pooled SDs; t is unpaired; positive d and t represent higher mean score for males compared to females.

Fig. 1 shows yearly changes of British-scaled IQ scores according to chronological age and school grade, separately for public and private schools. In the upper part, the x-axis shows chronological age. Here, the per-year changes all are close to zero between the ages of 7 and 16 years except for a substantial score increase between the ages of 13 and 14 years in public schools. IQs decline between age 16 and 17 in both school types, but between age 17 and 18 this trend continues only in public schools. In conclusion, cognitive development remained relatively stable from the age of 7 to the age of 15, then decelerated in public but not in private schools.

In the lower panel of Fig. 1, chronological age is replaced by school grades. The only significant effect sizes occurred between grades 8 and 9, usually equivalent to age 13 and 14. In this interval the British-scaled IQ increased for the total sample (d = 0.44; $M_{y \rightarrow y+1}$ = 8.85; SD_{pooled} = 19.97) and the public school sample (d = 0.47; $M_{y \rightarrow y+1}$ = 9.81; SD_{pooled} = 10.99) but not for the private school sample (d = 0.22; $M_{y \rightarrow y+1}$ = 3.83; SD_{pooled} = 17.35).

Most children in 11th grade were 16, 17 or 18 years old. Comparing these three ages revealed striking differences. Mean IQ was 94.85 (N = 261; SD = 21.73) for the 16-year-olds, 80.58 (N = 301; SD = 18.20) for the 17-year-olds, and 69.27 (N = 168; SD = 27.57) for the 18-year-olds. A detailed list of effect sizes can be found in the appendix (Table A2).

Interestingly, age ranges within school grades are relatively wide. All tested children in first grade were 7 years old. Second grade children ranged from 7 to 9, 3rd from 7 to 11, 4th from 7 to 13, 5th from 9 to 14, 6th and 7th from 10 to 15, 8th from 10 to 17, and the 9th, 10th and 11th from 13 to 18. It has to be noted that, because the SPM+ is standardized only for age 7 to 18, children younger than 7 or older than 18 were not tested. This affects especially the lowest and highest grades.

Due to bias which could be caused by repeaters or late starters, as addressed in the Methods section, it was decided to eliminate all age groups which score much higher or lower than the age group that is

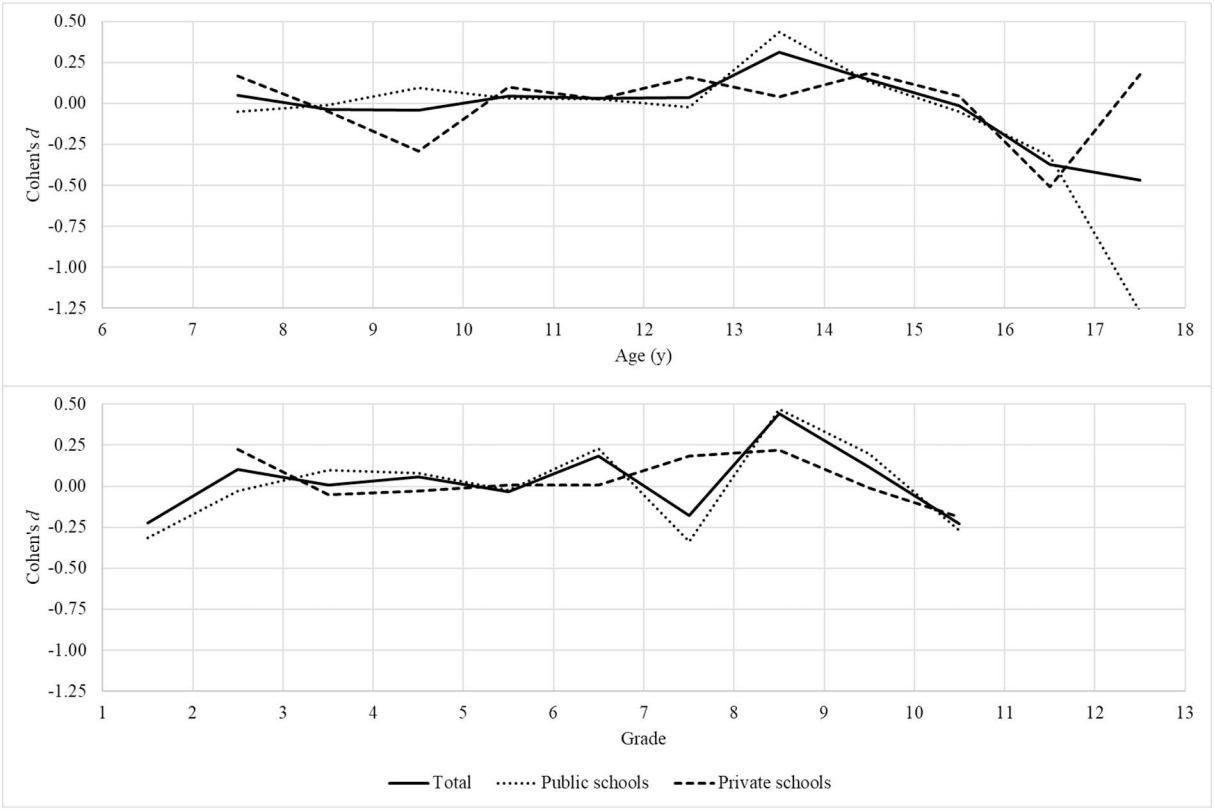

Fig. 1. Yearly change of British-scaled IQ across ages and school grades in different school types.
Notes: Cohen's *d* calculated with pooled *SD*s; positive values for Cohen's *d* represent higher IQs in later years of life or school grades; a Cohen's *d* of 0.00 would represent a speed in cognitive development identical to that in the UK norm-sample

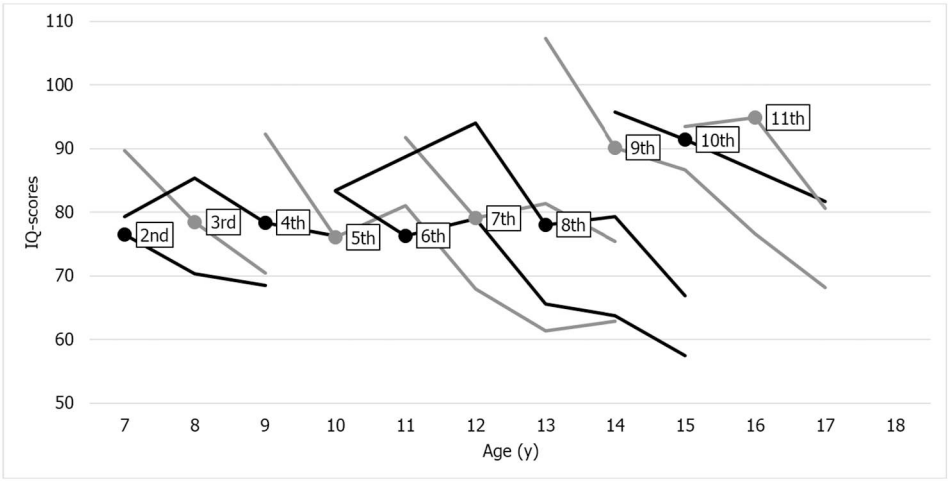

Fig. 2. Average IQs separately by school grade and age within each grade. For example, in grade 9 the average is about 108 for 13-year-olds and 68 for 17-year-olds.
Notes: Numbers in rectangles represent school grades; filled circles represent the normal ages of children per school grade according to Sudan's educational system; only age groups with mean IQs within a range of ± 1*SD* from the IQs of children with normal ages included

"normal" for the grade. Therefore, ± 1*SD* of the IQs of each grade were set as the lower and upper threshold. This means: If an age group scores more distant than 1*SD* from the IQ of the age group that is "normal" for the respective grade, it has been excluded. The 1st grade was excluded completely because the normal age of 6 years for this grade was not included in the sample. This leads in parallel to an exclusion of some of the age groups with low numbers of individuals. Fig. 2 shows the IQs for ages within school grades. There is an unambiguous pattern. Children who are older than the normal age of a grade obtain scores below the average of the grade, and children who are younger than the normal age of a grade score on average above the grade's mean. This is similar to observations that had been made by some educational psychologists in Western countries during the early 20th century (e.g., Madsen 1920). Again, we observe an abrupt rise in IQs between the 8th and 9th grade.

Table 5 compares IQ and three socio-economic indicators between the three localities, two school types, and three categories of family size. Rankings are the same for all four dependent variables according to location: (al-Chartūm > Bahrī > Umm Durmān) and school type (Public < Private), and nearly so for number of siblings. Table 6 groups children by their father's occupation. Mean IQ scores ranged from 101.17 (N = 6; SD = 40.55) for children of ministers to 62.69 (N = 15; SD = 19.38) for children of sheiks. The ranking of IQ scores corresponds closely to the ranking of father's education, with a correlation of 0.81 (p < .001).

The correlation matrix in Table 7 gives a survey of bivariate relations between all variables. As expected, correlations of IQ were

Table 5
Differences in IQ, parental education and income between localities, school types and family sizes in the Sudan (2016) sample.

Variable		Locality			School type		Siblings		
		al-Chartūm	Bahrī	Umm Durmān	Public	Private	0	1–3	> 3
IQ	M	85.08	79.78	76.94	78.48	83.81	82.68	84.45	78.36
	SD	19.83	19.43	21.83	21.67	18.45	20.93	20.70	20.45
	N	1650	1646	1893	3291	1898	118	1682	3389
Fathers' education (1–7)	M	5.37	5.34	4.87	4.80	5.81	5.46	5.61	4.95
	SD	1.52	1.48	1.76	1.78	1.02	1.34	1.31	1.72
	N	1589	1522	1832	3113	1830	99	1610	3234
Mothers' education (1–7)	M	5.05	4.88	4.44	4.37	5.45	5.26	5.37	4.45
	SD	1.64	1.71	1.92	1.91	1.29	1.61	1.46	1.86
	N	1588	1491	1829	3102	1806	98	1604	3206
Income (1–3)	M	2.11	2.02	1.86	1.57	2.72	2.26	2.26	1.85
	SD	0.83	0.78	0.77	0.62	0.47	0.76	0.74	0.79
	N	1650	1646	1893	3291	1898	118	1682	3389

Siblings					
0	1–2	3–4	5–6	7–9	10+
83.86	84.93	83.64	79.24	73.26	70.81
20.75	20.48	20.56	20.51	18.53	19.81
75	792	1872	1382	855	213
5.35	5.63	5.49	5.03	4.45	4.35
1.46	1.27	1.42	1.65	1.83	1.95
72	759	1790	1330	804	188
5.30	5.43	5.21	4.53	3.76	3.64
1.58	1.39	1.55	1.81	1.92	1.98
73	756	1785	1313	800	181
2.44	2.29	2.18	1.86	1.56	1.64
0.68	0.74	0.77	0.77	0.69	0.78
75	792	1872	1382	855	213

Notes: Coding of income: 1 = low, 2 = moderate, 3 = high; coding of education: 1 = illiterate, 2 = basic, 3 = elementary (Islamic), 4 = middle, 5 = secondary, 6 = university, 7 = postgraduate, not specified = excluded.

Table 6
Children's IQs according to their father's job profession and education.

Father's job/job-status	IQ			Fathers' education		
	N	*M*	*SD*	*N*	*M*	*SD*
Minister	6	101.17	40.55	6	6.33	2.07
Pharmacist	25	93.82	28.17	25	5.96	1.34
Ambassador	31	93.15	22.97	31	6.52	1.12
Businessman	152	90.68	18.43	149	6.02	0.72
Consultant	37	89.92	23.91	37	6.38	1.00
Doctor	146	87.87	22.98	146	6.25	0.68
Engineer	439	87.79	21.86	438	6.16	0.54
Teacher	295	87.42	19.86	293	6.18	0.76
Lawyer	61	86.72	21.77	61	6.21	0.78
No work	11	85.97	30.26	10	4.35	2.17
Employee	1092	85.69	20.24	1078	5.86	0.99
Captain	13	85.44	32.08	13	6.08	1.38
Officer	181	82.33	20.84	176	6.18	0.73
Veterinarian	9	81.17	32.86	9	6.11	1.65
Merchant	383	76.83	20.62	364	4.85	1.67
Policeman	285	75.27	17.41	260	4.04	1.82
Free business	1000	74.74	19.95	964	4.21	1.72
Driver	250	74.53	17.55	230	4.44	1.66
Worker	484	71.43	18.22	444	3.98	1.85
Sheik	15	62.69	19.38	15	3.73	1.67

Note: r between means of occupational groups for IQ and father's education = 0.81 ($p < .001$).

positive with income ($r = 0.37$; $p < .001$), parental education ($r = 0.38$; $p < .001$) and private school attendance ($r = 0.12$; $p < .001$), and negative with number of brothers ($r = -0.18$; $p < .001$) and sisters ($r = -0.14$; $p < .001$). Income is positively and strongly related with private school attendance ($r = 0.70$; $p < .001$) and negatively with the total number of children ($r = -0.32$; $p < .001$). Mother's and father's education showed a strong positive correlation ($r = 0.66$; $p < .001$), but mother's education has a slightly stronger negative relationship with number of children ($r = -0.34$; $p < .001$) than does father's education ($r = -0.27$; $p < .001$). There is only a very weak negative correlation between birth order and IQ ($r = -0.06$; $p < .001$). This negative relationship is mediated entirely by sibship size. In a regression model predicting IQ with number of siblings and birth order, the standardized beta for birth order is positive at +0.08.

The path model of Fig. 3 describes relationships between some of the variables in Table 7. On direct paths, income remained the best predictor of children's intelligence ($\beta = 0.38$; $r = 0.37$) followed by parental education ($\beta = 0.22$; $r = 0.38$), whereas most of the effect of number of siblings ($\beta = -0.06$; $r = -0.21$) disappeared and the effect of private school attendance turned from positive to negative ($\beta = -0.22$; $r = 0.12$). The indirect effect of income on IQ mediated by number of siblings is negligible ($0.012 = -0.20 * -0.06$), and income lowers IQ mediated by school type ($-0.15 = .70 \times -0.22$). The indirect effect of parental education mediated by income ($0.21 = .55 \times .38$) is as strong as its direct effect, but indirect effects through number of siblings ($0.01 = -.23 \times -0.06$) or income and school type ($0.08 = .55 \times 0.7 \times -0.22$) are negligible. The model shows a good fit (SRMR = 0.02; CFI = 0.99; TLI = 0.96; $df = 2$), however it is only able to explain 21% of the variance in IQ.

Table 8 shows results from a CPEM analysis. Some observations for the correlations of IQ with parents' education could be found: (1) parents' education is a better predictor of IQ for children of poorer parents, and especially at the lower levels of parental education. (2) Parents' education predicts child's IQ better in public schools than in private schools (public schools are coded 1 and private schools are coded 2). (3) Parents' education is a better predictor for the IQ of older children than the IQ of younger children. (4) Parents' education predicts children's IQ

Table 7
Correlation matrix for variables of the full Sudan (2016) sample; Pearson's *r* above the diagonal, and *p* values below the diagonal.

	1	2	3	4	5	6	7	8
1 IQ	–	0.37	0.12	0.09	0.07	0.17	0.38	0.34
2 Income	< 0.001	–	0.70	0.03	0.01	0.08	0.55	0.49
3 School type	< 0.001	< 0.001	–	0.15	−0.09	0.20	0.32	0.30
4 Age	< 0.001	0.022	< 0.001	–	−0.03	0.96	0.01	0.03
5 Sex	< 0.001	0.743	< 0.001	0.028	–	0.01	0.05	0.06
6 School grade	< 0.001	< 0.001	< 0.001	< 0.001	0.540	–	0.07	0.09
7 Parental educ.	< 0.001	< 0.001	< 0.001	0.707	< 0.001	< 0.001	–	0.90
8 Fathers'educ.	< 0.001	< 0.001	< 0.001	0.022	< 0.001	< 0.001	< 0.001	–
9 Mothers'educ.	< 0.001	< 0.001	< 0.001	0.150	0.003	0.003	< 0.001	< 0.001
10 Birth order	< 0.001	< 0.001	< 0.001	0.679	0.075	0.309	< 0.001	< 0.001
11 Siblings	< 0.001	< 0.001	< 0.001	< 0.001	0.430	0.008	< 0.001	< 0.001
12 Numb. of broth.	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.010	< 0.001	< 0.001
13 Numb. of sist.	< 0.001	< 0.001	< 0.001	0.0123	< 0.001	0.260	< 0.001	< 0.001
M	80.43	1.99	1.37	12.40	1.51	6.94	4.97	5.17
N	5189	5189	5189	5189	5189	5146	5036	4943
SD	20.66	0.80	0.48	3.18	0.50	2.88	1.56	1.62

9	10	11	12	13
0.35	−0.06	−0.21	−0.18	−0.14
0.51	−0.12	−0.32	−0.25	−0.23
0.29	−0.07	−0.18	−0.12	−0.15
−0.02	−0.01	0.08	0.08	0.04
0.04	0.03	−0.01	−0.14	0.12
0.043	−0.02	0.04	0.04	0.02
0.92	−0.13	−0.33	−0.27	−0.22
0.66	−0.09	−0.27	−0.22	−0.17
–	−0.16	−0.34	−0.27	−0.28
< 0.001	–	0.53	0.36	0.43
< 0.001	< 0.001	–	0.74	0.74
< 0.001	< 0.001	< 0.001	–	0.09
< 0.001	< 0.001	< 0.001	< 0.001	–
4.77	3.16	4.65	2.36	2.31
4908	4950	5146	5133	5136
1.79	1.95	2.38	1.60	1.62

Notes: Correlations are robust in single-sex samples with $r = \pm 0.00$ to 0.10.

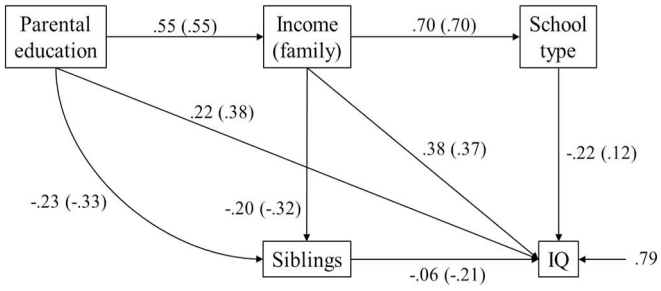

Fig. 3. Sociodemographic and socioeconomic determinants of IQ of Sudanese children.
Notes: Analysis done with Mplus 7.4 (Muthen & Muthen, ©1998–2015); standardized path coefficients (β) from STDYX standardization for continuous independent variables; Pearson's *r* in parentheses; error terms as unexplained variance at the right; $N_{obs.}$ set to 5009 (range = 5189 to 5009); $p_\beta < 0.001$ for all paths and residual variance; model fit (SRMR ≤0.08; CFI/TLI ≥ 0.95) is perfect

better in larger families. (5) Parents' education correlates better with child IQ when Raven raw score is higher.

For the relationship between IQ and number of brothers and sisters, we can observe that the negative effect of additional siblings on child IQ tends to be stronger in larger than in smaller families. It also tends to become larger as children grow older. Higher parental education and perhaps higher family income and private school attendance tend to attenuate the negative effect of siblings on IQ, specifically that of brothers.

4. Discussion

Geographically and ethnographically, Sudan is placed between the Arab world in the North and Sub-Saharan Africa in the South. This is reflected in the ancestry of the present population, which is transitional between North African and Middle Eastern Arabs and sub-Sahara Africans. Typical differences between the MENA (Middle East and North Africa) region and Sub-Saharan Africa include more advanced economic development of the former, and also moderately higher intelligence as summarized in Lynn and Becker (2019). Using this source and considering only countries directly bordering Sudan, we can note that the average IQ in Sudan of approximately 77 to 78 is similar to IQs in the other Muslim/Arab countries Libya (80), Egypt (76) and Saudi Arabia (76), but higher than IQs in Ethiopia (69), Eritrea (69) and South Sudan (59).

We found that the differences in intelligence between the three sampled locations al-Chartūm, Bahrī and Umm Durmān are associated with differences in parental education and family income, in accordance with the profound socio-economic differences in and around Sudan's capital. The higher IQ in al-Chartūm might be reflected by the higher density of above average income jobs in businesses and government bureaucracies in this area. It is conceivable that part of this is due to a selection effect, with higher-IQ families moving into this area. Another likely reason is that higher income allows access to a better quality of education, which then leads to higher IQ in children. Both causal pathways are likely to be important, and this is supported by the path analysis. Unfortunately, the high heterogeneity in settlement structures and socioeconomic groups within each of the three areas observed in this study makes it difficult to examine hypotheses about interrelations between intelligence and socio-demographic and socio-

Table 8
Results from CPEM analyses. Correlations of IQ with parental education and sibling number are correlated with hypothesized moderator variables.

Moderator	IQ × EDUfather	IQ × EDUmother	IQ × sisters	IQ × brothers
Income	−0.08**	−0.07**	0.02	0.04*
School type	−0.13**	−0.12**	0.02	0.06**
Age	0.11**	0.11**	−0.05**	−0.06**
Fathers'education	−0.30**	−0.16**	0.05**	0.07**
Mothers'education	−0.16**	−0.26**	0.01	0.05**
Father's job	0.01	0.01	−0.04*	−0.02
Mother's job	−0.01	0.01	−0.04*	−0.01
Birth order	−0.01	−0.03*	0.02	−0.02
Number of brothers	0.07**	0.06**	−0.05**	−0.19**
Number of sisters	0.06**	0.02	−0.16**	−0.05**
SPM+ score	0.06**	0.07**	−0.01	−0.03*
British-scaled IQ uncorrected	0.03*	0.05**	0.02	−0.02

Notes: Columns are correlations of IQ with father's education, mother's education, number of sisters, and number of brothers; public schools are coded 1 and private schools are coded 2; $N > 4800$ in each case.
* $p < .05$.
** $p < .001$.

cultural variables. This would require a more fine-grained analysis at the level of districts within each of the three urban areas.

There is no indication for a Simber effect in the reported sample. The annual increase in raw scores is close to the trend in the UK norm sample and therefore the British-scaled IQ is relatively stable across the ages. The sometimes rather strong IQ declines by age found in other Arabic-Muslim countries by Bakhiet, Dutton, et al. (2018) are not evident on the SPM+ in our urban Sudanese sample. Some peculiarities in cognitive development that we observed in our sample can be explained by the structure of the educational system in Sudan. The usual starting age for school is 6 years. Primary education extends over eight grades until the age of 13, followed by secondary education until the age of 17 (Pro 2018). Enrolment in education is very similar between males and females. According to MICS (2015), 22% of males and 23% of females aged 36–59 months attended early childhood (pre-school) education, the net intake rate in primary education at school entry age (age 6) is 36% for males and 38% for females, but females show higher preschool attendance immediately before starting primary school (73%) than males (66%). Of those entering primary school, 80% of males and 79% of females reach the last grade of the primary school, but more males (85%) than females (74%) complete the primary stage. This is in contrast to measured IQs, which show females outperforming males during the entire primary stage. Transition rates to secondary education are reported as 90% for males and 91% for females, but only 27% of males and 29% of females of secondary school age are actually enrolled in secondary education, against 77% of males and 75% of females of primary school age enrolled in primary (or secondary) education. The lower enrolment in secondary than primary education explains an apparent anomaly in our results: the sudden rise by about 6 IQ points between the ages of 13 and 14 years that we observed in Table 3 and Figs. 1 and 2. This rise is limited to the public school system (Fig. 1). The explanation is that many of the less proficient students in public schools leave school at the end of compulsory primary education, which typically means after age 13. Families who send their children to private schools, however, appear to keep even the less proficient ones in school until the end of secondary education. The precipitous fall of IQ in public schools at the ages of 17 and 18 years is caused by a higher share of those who had to repeat one or more grades in school. The lack of this effect in private schools suggests that these schools use methods other than grade retention to deal with weak students.

The model in Fig. 3 contradicts two stylized facts derived from research in Western countries: (1) the higher relevance of parental education than family income for children's intelligence. One reason for the apparent anomaly may be that the heritability of intelligence appears to be not only weaker in Sudan than in Western societies but also weaker than the effect of the shared environment, which is environment shared by siblings growing up in the same family (Toto et al. 2019). In Western countries, shared environment is only moderately important for population-scale individual differences during childhood and becomes rather unimportant during adolescence and adulthood (Kaplan 2012).

The usual conclusion from these observations is that an important part of the effect of parental education on the intelligence of children is mediated by transmitted genes. However, many American (though not European) studies have shown that the heritability of intelligence is lower at lower levels of socioeconomic status (Woodley of Menie, M. A., Pallesen, and Sarraf 2018). It is possible that lower heritability at lower levels of economic development is observed at the country level as well. In other words, relevant differences in environmental conditions between advantaged and disadvantaged families may be more important in poor countries than in prosperous countries. The Sudanese result of a greater effect of parental income than parental education on children's intelligence is therefore expected if parental income is more important for differences in intelligence-promoting environmental influences between families while genetic transmission is more important for the effect of parental education.

(2) The positive effect of private schools on the intelligence of children. It is almost universally believed that private school attendance is associated with higher intelligence because of greater intellectual stimulation in these schools. In this case the path coefficient from school type (meaning private school) to IQ in Fig. 3 should be positive, which it is not. While some of the apparent negative effect of private school attendance on IQ ($\beta = -0.22$) is likely to be an artefact of collinearity between income and school type, the result nevertheless suggests that it is non-school aspects of socioeconomic status, rather than private school attendance, that promotes Sudanese children's intelligence.

However, results from the CPEM analysis in Table 8 imply that the robustness of the various effects is dependent on context. That child IQ is better predicted by parents' education in public schools then private schools can perhaps be attributed to greater variance of parental education for public school students than private school students (see Table 5). The better predictivity of IQ of older children than of younger children by parent's education may reflect that children become more similar to their parents as they get older, or that IQ is measured more precisely in older children than in younger children. This may also explain why parents' education correlates better with child IQ when their raw score from the SPM+ is higher. In contrast, the better predictivity of child IQ by parents' education in larger than in smaller families is difficult to explain. Perhaps it means that small families are more likely atypical (very young or very old parents, family disruption etc.), so that effects other than parental education become more important. Admittedly, these effects are overall very small. As private

schooling and parental education weaken and older age strengthens the negative correlation between child IQ and number of siblings, it can be concluded that higher quality of education in schools and at home cushions the negative environmental effect of bigger families, which, however, accumulates across childhood.

5. Conclusion

The findings presented here provide strong evidence for the need to expand intelligence studies in developing countries to include socio-economic and socio-demographic variables as well as greater consideration of educational systems and practices for children's cognitive development. They also show that school-based samples do not adequately represent the average intelligence of young people in a country when a substantial proportion of children are not enrolled in school, as we saw with secondary school students in our sample. Intelligence is believed to be an important causal factor for economic development and many other country-level outcomes (Lynn & Becker 2019). Therefore, intelligence research in developing countries should be promoted with the aim of informing educators and politicians about ways to raise the population's intelligence.

Declaration of Competing Interest

None.

Acknowledgements

The authors extend their appreciation to the Deanship of Scientific Research at King Saud University for funding this work through Research Group no. RG-1438-007.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.intell.2019.101402.

References

Abdel-Khalek, A. M. (1988). Egyptian results on the standard progressive matrices. *Personality and Individual Differences, 9*, 193–195.
Abdel-Khalek, A. M., & Lynn, R. (2006). Sex differences on the standard progressive matrices and in educational attainment in Kuwait. *Personality and Individual Differences, 40*, 175–182.
Ahmad, R., Khanum, S. J., Riaz, Z., & Lynn, R. (2009). Gender differences in means and variance on the standard progressive matrices in Pakistan. *Mankind Quarterly, 49*, 50–57.
Al Said, T. B. T. (2014). The relationship between nonverbal intelligence and emotional intelligence among children in UK and Oman. *International Journal of Psychological Studies, 6*, 79–86.
Alkhateeb, M., & Almotwakel, M. (2001). *The manual of usage of standard progressive matrices in the Sudan.* Khartoum. (Arabic): Sharikat matabe al-omlah.
Alkhateeb, M., Almotwakel, M., & Hussain, A. (2006). *Standardization of CPM for the pupils of basic stage in Khartoum state.* Khartoum.(Arabic): Sharikat matabe al-omlah.
Al-Shahomee, A. A., & Lynn, R. (2010). Norms and sex differences for the standard progressive matrices in Libya. *Mankind Quarterly, 51*, 97–107.
Al-Shahomee, A. A., & Lynn, R. (2012). A standardisation of the standard progressive matrices for Libyan adults aged 38 to 50 years. *Mankind Quarterly, 52*, 292–310.
Aslam, M. (2009). The relative effectiveness of government and private schools in Pakistan: Are girls worse off? *Education Economics, 17*, 329–354.
Attallah, S. (2003). *The Psychometric characteristics of the standard progressive matrices, of children of (8) years of age in Khartoum state. Vol. 6.* Arabic: Gezira Magazine for Human and Educational Sciences.
Attallah, S., Almotwakel, M., Haseeb, B., Gumaa, N., & Alhassan, S. (2007). *Psychometric properties of the standard progressive matrices (SPM) among the pupils 8 to 12 years old in the basic schools in Kusti city. Vol. 6*, Arabic: Juba Magazine for Arts & Science10–31.
Bakhiet, S. F. A. (2008). Application of progressive matrices in the Sudan. *Arab Psynet, 19*, 223–225.
Bakhiet, S. F. A., Dutton, E., Ashaer, K. Y. A., Essa, Y. A. S., Blahmara, T. A. M., Hakamia, S. M., & Madison, G. (2018). Understanding the Simber effect: Why is the age-dependent increase in children's cognitive ability smaller in Arab countries than in Britain? *Personality and Individual Differences, 122*, 38–42.
Bakhiet, S. F. A., & Lynn, R. (2014). A study of intelligence in Jordan. *Psychological Reports: Mental & Physical Health, 115*, 515–516.
Bakhiet, S. F. A., & Lynn, R. (2015a). A study of intelligence in Oman. *Psychological Reports: Mental & Physical Health, 115*, 840–841.
Bakhiet, S. F. A., & Lynn, R. (2015c). Regional differences in intelligence in Sudan. *Intelligence, 50*, 150–152.
Bakhiet, S. F. A., Sles, N., Lynn, R., & Meisenberg, G. (2018). A study of the standard progressive matrices plus in Cambodia. *Mankind Quarterly, 58*, 580–587.
Barclay, K. J. (2015a). A within-family analysis of birth order and intelligence using population conscription data on Swedish men. *Intelligence, 49*, 134–143.
Barclay, K. J. (2015b). Birth order and educational attainment: Evidence from fully adopted sibling groups. *Intelligence, 48*, 109–122.
Batterjee, A. A., & Ashria, I. (2015). Intelligence and education: The Sudan case. *Mankind Quarterly, 56*, 135–166.
Becker, D. (2018). The NIQ-dataset (V1.3.1). Chemnitz, Germany. From: http://viewoniq.org/?page_id=9
Blau, D. M. (1999). The effect of income on child development. *The Review of Economics and Statistics, 81*, 261–276.
Dutton, E., Bakhiet, S. F., Ziada, K. E., Essa, A. A. S., & Blahmar, T. A. M. (2017). A negative Flynn effect in Khartoum, the Sudanese capital. *Intelligence, 63*, 51–55.
Dutton, E., Becker, D., Osman, H. H., Bakhiet, S. F., Essa, Y. A. S., Ali, H. A. A., & Alfaleh, A. S. H. (2018). The Raven's test performance of South Sudanese samples: A validation of criticisms of the utility of Raven's among Sub-Saharan Africans. *Personality and Individual Differences, 128*, 122–126.
Eltayeb, G. E. (2003). Urban slums reports: The case of Khartoum. Sudan. Retrieved from http://sigus.scripts.mit.edu/x/archived/challengecourse/pdfs/pdfscities/khartoum.pdf.
Faki, H., Nur, E. M., Abdelfattah, A., & Aw-Hassan, A. A. (2012). *Poverty assessment Northern Sudan.* Aleppo: ICARDA.
Gandhi-Kingdon, G. (1996). The quality and efficiency of private and public education: A case-study of urban India. *Oxford Bulettin of Economics and Statistics, 58*, 57–82.
Garcia, I. Q. (2016). *Normativos da Forma Geral das Matrizes Progressivas de Raven numa Amostra da Comunidade.* Coimbra: Dissertação de Mestrado em Psicologia Clínica Ramo de Especialização em Terapias Familiares e Sistémicas.
Gorsuch, R. L. (2005). Continuous parameter estimation model: Expanding the standard statistical paradigm. *Journal of the Science Faculty of Chiang Mai University, 32*(1), 11–21.
Hur, Y.-M., te Nijenhuis, J., & Jeong, H. U. (2017). Testing Lynn's theory of sex differences in intelligence in a large sample of Nigerian school-aged children and adolescents (N > 11,000) using Raven's standard progressive matrices plus. *Mankind Quarterly, 57*, 428–437.
Ijarotimi, O. S., & Ijadunola, K. T. (2007). Nutritional status and intelligence quotient of primary school children in Akure community of Ondo state, Nigeria. *Tanzania Health Research Bulletin, 9*, 69–76.
IOM (2017). *Migrants in Sudan: Pilot study on migrants' motivations, intentions and decision-making in Khartoum.* Khartoum: International Organization for Migration.
Irwing, P., Hamza, A., Khaleefa, O., & Lynn, R. (2008). Effects of abacus training on the intelligence of Sudanese children. *Personality & Individual Differences, 45*, 694–696.
Jinabhai, C. C., Taylor, M., Rangongo, N. J., Mkhize, S., Anderson, S., Pillay, B. J., & Sullivan, K. R. (2004). Investigating the mental abilities of rural primary school children in South Africa. *Ethnicity and Health, 9*, 17–36.
Kanazawa, S. (2012). Intelligence, birth order, and family size. *Personality and Social Psychology Bulletin, 38*, 1157–1164.
Kaplan, J. S. (2012). The effects of shared environment on adult intelligence: A critical review of adoption, twin and MZA studies. *Developmental Psychology, 48*, 1292–1298.
Khaleefa, O. (2011). Norms of standard progressive matrices test in Khartoum state. *Psychological Studies, 5*, 41–76 (Arabic).
Khaleefa, O., Khatib, M., Mutwakkil, M., & Lynn, R. (2008). Norms and gender differences on the progressive matrices in Sudan. *Mankind Quarterly, 49*, 176–182.
Khaleefa, O., & Lynn, R. (2008a). A study of intelligence in the United Arab Emirates. *Mankind Quarterly, 49*, 58–64.
Khaleefa, O., & Lynn, R. (2008b). Normative data for Raven's progressive matrices in Yemen. *Psychological Reports, 103*, 170–172.
Khaleefa, O., & Lynn, R. (2008c). Norms for intelligence assessed by the standard progressive matrices in Qatar. *Mankind Quarterly, 49*, 65–71.
Khaleefa, O., & Lynn, R. (2008d). Sex differences on the progressive matrices: Some data from Syria. *Mankind Quarterly, 48*, 345–352.
Khaleefa, O., Lynn, R., Abulgasim, A., Dosa, M., & Abdulradi, F. (2010). Norms for the standard progressive matrices for 9–18 year olds for Darfur. *Mankind Quarterly, 50*, 311–317.
Khaleefa, O. H., Taha, A., & Al-Hussein, A. (2012). Performance rates in the Sudanese States on the WISC-III (Wechsler intelligence of children) (7–16), third edition. *Journal of Educational and Psychological Studies, 6*, 121–134 (Arabic).
Kristensen, P., & Bjerkedala, T. (2010). Educational attainment of 25 year old Norwegians according to birth order and gender. *Intelligence, 38*, 123–136.
Kuba, R., Flegr, J., & Havlíček, J. (2018). The effect of birth order on the probability of university enrolment. *Intelligence, 70*, 61–72.
Lynn, R., Allik, J., & Irwing, P. (2004). Sex differences on three factors identified in Raven's standard progressive matrices. *Intelligence, 32*, 411–424.
Lynn, R., & Becker, D. (2019). *The intelligence of nations.* London: Ulster Institute for Social Research.
Lynn, R., & Chan, P. W. (2003). Sex differences on the progressive matrices: Some data from Hong Kong. *Journal of Biosocial Science, 35*, 145–154.
Madsen, I. N. (1920). High school students' intelligence ratings according to the army alpha test. *Journal of Philosophy, Psychology and Scientific Methods, 17*(17), 469–470.
Malloy-Diniz, L. F., Cardoso-Martins, C., Nassif, E. P., Levy, A. M., Leite, W. B., & Fuentes, D. (2008). Planning abilities of children aged 4 years and 9 months to 8 ½ years: Effects of age, fluid intelligence and school type on performance in the tower of

London test. *Dementia & Neuropsychologia, 2*, 26–30.
Mayer, S. E. (1997). *What money can't buy: Family income and children's life chances.* Cambridge, MA: Harvard University Press.
MICS (2015). SUDAN - multiple Indicator cluster survey 2014 key findings. From: Ministry of Cabinet; Central Bureau of Statistics https://reliefweb.int/sites/reliefweb.int/files/resources/MICS%202014_Key%20Findings%20Report%20Sudan_Signed%20%281%29_1.pdf
Numbeo (2009–2019). Cost of living. Retrieved from https://www.numbeo.com/cost-of-living/.
Pantuliano, S., Assal, M., Elnaiem, B. A., McElhinney, H., Schwab, M., Elzein, Y., & Ali, H. M. M. (2011). *City limits: Urbanisation and vulnerability in Sudan: Khartoum case study*. London: Humanitarian Policy Group.
Pietschnig, J., & Voracek, M. (2015). One century of global IQ gains: A formal meta-analysis of the Flynn effect (1909–2013). *Perspectives on Psychological Science, 10*, 282–306.
Pro, S. (2018). Education system in Sudan. From https://www.scholaro.com/pro/countries/Sudan/Education-System.
Raven, J. (2008). *Standard progressive matrices and Mill Hill vocabulary scale.* London: Pearson.
Rindermann, H. (2018). *Cognitive capitalism: Human capital and the wellbeing of nations.* Cambridge: Cambridge University Press.
Rindermann, H., & Baumeister, A. E. E. (2015). Parents' SES vs. parental educational behavior and children's development: A reanalysis of the hart and Risley study. *Learning and Individual Differences, 37*, 133–138.
Rindermann, H., & Carl, N. (2017). Indigenous Ecuadorian children: Parental education, parental wealth and children's cognitive ability level. *Learning and Individual Differences, 54*, 202–209.
Rindermann, H., & Ceci, S. J. (2018). Parents' education is more important than their wealth in shaping their children's intelligence: Results of 19 samples in seven countries at different developmental levels. *Journal for the Education of the Gifted, 41*, 298–326.
Rindermann, H., Michou, C. D., & Thompson, J. (2011). Children's writing ability: Effects of parent's education, mental speed and intelligence. *Learning and Individual Differences, 21*, 562–568.
Sbaibi, R., Aboussaleh, Y., & Ahamim, A. O. T. (2014). Sex differences in means and variance among middle school children in the rural commune of Sidi El Kamel (North-Western Morocco). *Asian Journal of Scientific Research, 7*, 376–385.
Spanoudis, G., Natsopoulos, D., & Lynn, R. (2016). Sex differences for 10 to 17 year olds on the standard progressive matrices in cyprus. *Mankind Quarterly, 57*, 283–290.
Toto, H. S. A., Piffer, D., Khaleefa, O. H., Bader, R. A.-S. A.-T., Bakhiet, S. F. A., & Essa, Y. A. S. (2019). A study of the heritability of intelligence in Sudan. *Journal of Biosocial Science, 51*, 307–311.
UNHCR - Refugee Consultation Forum (2018). *Population & operational update.* SUDAN: South Sudanese Refugee Response. From https://reliefweb.int/sites/reliefweb.int/files/resources/65912.pdf.
Woodley of Menie, M. A, Pallesen, J., & Sarraf, M. A. (2018). Evidence for the Scarr-Rowe effect on genetic expressivity in a large U.S. sample. *Twin Research and Human Genetics, 21*, 495–501.