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Regional differences in intelligence in 22 countries and their economic, social and demographic correlates: A review

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ABSTRACT

Differences in intelligence have previously been found to be related to a wide range of inter-individual and international social outcomes. There is evidence indicating that intelligence differences are also related to different regional outcomes within nations. A quantitative and narrative review is provided for twenty-two countries (number of regions in parentheses): Argentina (24 to 437), Brazil (27 to 31), British Isles (12 to 392), Chile (15), China (31), Colombia (33), Denmark (7), Finland (4), France (90), Germany (16), India (33), Italy (12 to 19), Japan (47), Mexico (31 to 32), Peru (1468), Portugal (5), Russia (29 to 79), Spain (15 to 48), Switzerland (47), Turkey (12), the USA (30 to 3100), and Vietnam (61). Between regions, intelligence is significantly associated with a wide range of economic, social, and demographic phenomena, including income ($r_{unweighted}$ = .56), educational attainment ($r_{unweighted}$ = .59), health ($r_{unweighted}$ = .49), general socioeconomic status ($r_{unweighted}$ = .55), and negatively with fertility ($r_{unweighted}$ = −.51) and crime ($r_{unweighted}$ = −.20). Proposed causal models for these differences are noted. It is concluded that regional differences in intelligence within nations warrant further focus; methodological concerns that need to be addressed in future research are detailed.

1. Introduction

It has been shown in numerous studies that intelligence among individuals is positively associated with a wide range of economic, social, and demographic phenomena, including educational attainment, intellectual achievement, income, socio-economic status (SES), health, and longevity, and negatively associated with variables such as infant mortality and crime (e.g. Hunt, 2011; Mackintosh, 2011). This relationship has also been shown for groups including (1) the districts in cities; (2) cities in countries; (3) nations; and (4) regions in countries. In Section 1, we review studies of the first three of these levels of analysis; in Sections 2 and 3, we give a review of the fourth.

1.1. The Districts in Cities

The first of these studies was carried out by Maller (1933a, 1933b) on 310 districts of New York City. IQs for the districts were obtained for approximately 100,000 10-year-olds and shown to be correlated positively with educational attainment (r = .70), and negatively with rates of juvenile delinquency (r = −.57); fertility (r = −.34); the death rate (r = −.43); and infant mortality (r = −.51).

The second study was carried out for 29 districts of London by Burt (1937). He used percentages of educationally backward children as a measure of intelligence and showed that this was correlated with rates of delinquency (r = .69); poverty (r = .57); unemployment (r = .68); overcrowded housing (r = .89); family size (r = .35); fertility (r = .62); death rates (r = .87); and infant mortality (r = .93). (The correlations are positive because a higher percentage of educationally backward children in a district indicates lower intelligence for that district). A later study of the 32 London boroughs found similar results (Kirkegaard, 2016d).

The third study was carried out for 30 districts of Manchester (England) by Wiseman (1964). He used the results of a verbal intelligence test given to 14-year-olds and showed that average scores per district were positively correlated with attainment in reading (r = .89) and arithmetic (r = .94), and negatively correlated with rates of delinquency (r = −.44); poverty assessed by public provision of free clothing (r = −.32); cruelty and neglect of children (r = −.51); and illegitimacy rates (r = −.35), but, unusually, not with infant mortality (r = .01).

1.2. Cities in Countries

The first study to show that the intelligence of the populations of

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cities is associated with a number of economic, social and demographic phenomena was carried out by E. L. Thorndike (1939). He obtained data for 37 of these phenomena for 295 American cities with populations of more than 30,000 and combined these to give a measure of "General Goodness". He proposed that General Goodness was determined by intelligence and personality qualities, although he did not provide measures of either of these. He was evidently aware that the lack of a measure of intelligence made this a not wholly convincing thesis because in a further study he provided more evidence for the thesis (E. L. Thorndike & Woodyard, 1942). In this study, IQ data were given for sixth-grade children in 30 cities, and shown to be highly correlated with the General Goodness scores at $r = .86$ and with per capita income at $r = .78$. A further study the intelligence of the populations of American cities was published by R. L. Thorndike (1951). He obtained IQs of children from 154 cities, and reported that these were significantly positively correlated with percentage of native-born whites ($r = .28$); high-school graduates ($r = .33$); educational achievement ($r = .45$); owner-occupied housing ($r = .37$); and professional workers ($r = .28$); and significantly negatively correlated with percentages of adult illiteracy ($r = -.43$); overcrowded housing ($r = -.30$); and employed women ($r = -.26$).

1.3. Nations

The relation between the intelligence of nations and a wide range of economic, social and demographic phenomena, and with general indices of development and socioeconomic status, has been shown in a series of studies by Lynn and Vanhanen (2002, 2006, 2012a) and confirmed in numerous studies reviewed in Lynn and Vanhanen (2012b).

1.4. Regions within nations

The fourth set of studies consists of the relation of the intelligence of populations of regions within countries with a wide range of economic, social and demographic phenomena. The results of studies for 22 countries, primarily from the intelligence research literature, are summarized in this paper.

2. Correlates of regional differences in intelligence: A quantitative analysis

The main results showing consistencies in the studies of the regional differences in intelligence along with their economic and social correlates are given in Table 1. A more detailed narrative review noting additional demographic correlates for individual countries is provided in Section 3. Table 1 summarizes the results from studies published in the intelligence research literature relating socioeconomic outcomes to measures of cognitive ability assessed by intelligence or academic achievement tests. Five socioeconomic outcomes were selected, chosen for general relevance and because data for these outcomes was widely available. These five outcomes were income, educational attainment, health, fertility, and crime. The variable "income" was created using both per capita income and/or per capita gross product, as available, since these are statistically and conceptually related. The variable "health" was created using both infant mortality and life expectancy, since these two variables tended to be collinear and have a part-whole relationship. Several studies reported correlations for general socioeconomic status (henceforth, general SES) calculated through factor analysis, principal component analysis, or by averaging a number of social indicators. These coefficients are also reported if available.

For this quantitative review, studies were included if they: (1) provided non-redundant information; (2) measured cognitive ability with intelligence or academic achievement tests (but not with cognitive proxies such as literacy, as in Grigoriev, Lapteva, & Lynn, 2016); (3) provided correlations between relatively contemporaneous measures of cognitive ability and socioeconomic outcomes (but not between cognitive ability and outcomes from many decades apart, as in Daniele & Malanima, 2011); (4) provided zero-order correlation coefficients or a table from which these could be computed; (5) were published in peer-reviewed journals. Based on these inclusion criteria, 46 studies were identified covering 22 countries.

For two studies – de Baca and Figueredo (2014) and León and León (2014) – authors did not report correlation coefficients in their papers but provided them in personal communications. Some studies provided correlations for cognitive ability and socioeconomic outcomes for multiple years (e.g., Lynn, 2012b). In this case the coefficients for the most recent and contemporary years were used. Other studies provided correlations between closely related variables. For example, Dutton and Lynn (2014) give life expectancy for women and men separately. In this instance, the correlations were averaged for the purpose of computing overall country-level correlations. Some authors provided administrative unit-weighted and unweighted values (e.g., Carl, 2016a,b; Lynn, Antonelli-Ponti, Mazzei, Da Silva, & Meisenberg, 2017). For consistency of comparison, only unweighted values were used.

Several studies looked at different administrative levels for the same country (e.g., US states and counties; UK regions and authorities). Table 1 shows results by administrative level. To summarize, cross-country average correlations were computed using untransformed values, as r to z transformations lead to upwards bias (Schmidt & Hunter, 2014). To create the untransformed values, firstly, multiple correlations from the same study for the same outcome were averaged; secondly, correlations for the same level were averaged; and finally, correlations across countries were averaged, providing the cross-country correlation. The resulting cross-country average correlations between test scores and the socioeconomic outcomes of interest are as follows: income ($r = .56$; n of countries = 16); educational attainment ($r = .59$; $n = 14$); health ($r = .49$; $n = 14$), fertility ($r = -.51$; $n = 9$); crime ($r = -.20$; $n = 6$); and general SES ($r = .55$; $n = 12$).

A few issues deserve further comment. Crime was inconsistently related to cognitive ability; in some countries, it was positively associated while in others it was negatively associated. (See the discussion section for further comment.)

For two countries, Chile and Japan, general SES and cognitive ability did not seem to be robustly related. In the case of Chile, when population weights were used, the correlation became moderately positive ($r = .30$; Fuerst & Kirkegaard, 2016b). The authors did not provide an explanation for this or explore the issue. Japan yielded inconsistent and often near zero correlations between prefectural cognitive ability and socioeconomic outcomes. Moreover, Kirkegaard (2016a) was unable to identify a general SES factor when applying the same method as used for other countries. To identify a coherent general factor, he had to control for population density. Kirkegaard noted he was uncertain why this was the case.

Concern about using unweighted values was raised by Hunt and Sternberg (2006) in the context of cross-country analyses, and later by Fuerst and Kirkegaard (2016a) in the context of both intra-country and cross-country analyses. Arguably, it is problematic to give administrative units with one or two orders of a magnitude differences in population size equal weight, as outcomes for small populations may be more easily influenced by idiosyncratic factors. Regarding population weighing, Fuerst and Kirkegaard (2016a) compared methods for taking population sizes into account and provided a rationale for using a square-root transformation, a method which was later adopted by Carl (2016b) and Lynn et al. (2017). Another concern is the wide variability in the number of regions by county – which, in this analysis, ranged from 4 (Finland) to 1468 (Peru). Results based on few regions are likely less reliable than results based on many regions. Given these concerns, we provide a robustness check on our results as follows: we weighted correlations by the square root of the administrative unit's population size and the square root of the number of administrative units. The results of this analysis check are reported in Table 1.

Table 1
Average correlations between cognitive ability and social and demographic outcomes in 22 countries.

Country	N Studies	Level	Unit N	Income	Educational attainment	Fertility	Crime	Health	General SES
Argentina	1	1	24.0						.81
Argentina	1	2	299.0						.66
Argentina	1	3	437.0						.52
Brazil	2	1	29.0	.79	.72	−.68	−.50	.84	.81
British Isles	2	1	12.5	.58	.45		.12	.65	.72
British Isles	1	2	392.0		.46			.43	.56
Chile	1	1	15.0						.04
China	2	1	31.0	.58	.54				
Colombia	1	1	33.0						.70
Denmark	1	1	7.0		.95				
Finland	1	1	4.0	.67	.85			.49	
France	2	1	90.0	.61	.26			.30	.61
Germany	1	1	16.0	.53	.09				
India	1	1	33.0	.25		-.35		.37	
Italy	2	1	15.5	.85	.89			.86	
Japan	2	1	47.0	.22	.53	−.10	−.48	.01	−.17
Mexico	2	1	31.5	.66	.62	−.52	.24	.19	.77
Peru	1	1	1468.0	.56	.50	−.58		.42	.57
Portugal	1	1	5.0	.58					
Russia	3	1	50.0	.22	.53	−.48	.06	.43	
Spain	1	1	31.5	.50				.68	
Switzerland	1	1	47.0			−.65		.41	.68
Turkey	1	1	12.0	.81	.87	−.84		.80	
USA	13	1	47.9	.50	.41	−.44	−.69	.52	.82
USA	4	2	883.8	.38	.37	−.38	−.51	.44	.68
Vietnam	1	1	61.0						.46
$r_{\text{unweighted}}$				.56	.59	−.51	−.20	.49	.55
$r_{\text{population-weighted}}$				.51	.54	−.46	−.26	.46	.57
$r_{\text{unit-weighted}}$				.54	.51	−.51	−.24	.45	.59

Number of studies: number of studies reporting data for each level by country; level: level of administrative units (relative rank); unit N: average number of units across studies for a given administrative level; $r_{\text{population-weighted}}$: cross-country average Pearson correlation weighted by the square-root of the countries' populations; $r_{\text{unit-weighted}}$: cross-country average Pearson correlation weighted by the square-root of the countries' number of administrative units.

2.1. Causal models

A number of the authors referenced in the quantitative analysis proposed causal models. These are given in Table 2 along with the analytic methods and findings. Listed in the table are the countries, authors, the theoretical causal models proposed, the statistical methods used to test these models, and whether the results agreed with the theoretical models. Most authors took IQ differences to be causally antecedent to socioeconomic ones. There were six exceptions. Bagley (1925), Teasdale, Owen, and Sørensen (1988), Holsinger (2007), and Roivainen (2012) argued that IQ differences, in the US, Denmark, Vietnam, and Germany, respectively, were caused by educational differences. Similarly, Lynn and Yadav (2015) proposed, as one of five possible explanations for the correlation between the IQs and socioeconomic outcomes of Indian states and territories, that the IQ differences between Indian states were due to educational differences resulting from regional differences in prosperity. Finally, León and Avilés (2016) argued that IQ differences in Peru were caused by behavioral differences that were in turn caused by differences in contemporaneous UV radiation exposure. Other authors have also addressed the causes of regional IQ differences. Eppig, Fincher, and Thornhill (2011) put forward a parasite-stress hypothesis, according to which IQ differences are an effect of a developmental trade-off between IQ and immune function. Lynn (1979), Lynn (1980), Dutton and Lynn (2014), Lynn and Yadav (2015), Almeida, Lemos, and Lynn (2011), Lynn (1981), and Lynn, Sakar, and Cheng (2015) argued for and/or investigated the effect of selective migration within particular countries (respectively, Britain, France, Finland, India, Portugal, Spain, and Turkey). Kirkegaard and Fuerst (2017) (Argentina), Fuerst and Kirkegaard (2016a, 2016b) (Brazil, Chile, Colombia, Mexico, and US), Lynn and Cheng (2013) and Lynn, Cheng, and Wang (2016) (China), Lynn (2010a,b) and Templer (2012) (Italy), Kura (2013) (Japan), Lynn, Cheng, and Grigoriev (2017) (Russia), Lynn (2012a,b) (Spain), Lynn et al. (2015) (Turkey), and Fuerst and Kirkegaard (2016a), Kirkegaard (2016b), McDaniel (2006b), Pesta and Poznanski (2014), Templer and Rushton (2011) (US) proposed and/or investigated differences related to ethnicity and ancestry. For India, Lynn and Yadav (2015) also suggested differences resulting from different rates of consanguineous marriage related to religious practices (Muslim versus non-Muslim). Lastly, de Baca and Figueredo (2014) suggested both socioeconomic and ecological factors, the latter of which, according to these authors, could have acted over evolutionary time.

A frequent finding that authors attempted to account for was a positive bivariate association between absolute latitude and IQ. Mirroring international results, this was found for 12 of 15 countries in which correlations between latitude and IQ were noted by the original authors: Argentina (Fuerst & Kirkegaard, 2016a,b); Brazil (Lynn et al., 2017); Chile (Fuerst & Kirkegaard, 2016b); Colombia (Fuerst & Kirkegaard, 2016b); Italy (Lynn, 2010a); Japan (Kura, 2013); Mexico (Fuerst & Kirkegaard, 2016b); Peru (León & Avilés, 2016), Russia (Lynn, Cheng, & Grigoriev, 2017); Spain (Lynn, 2012b); Turkey (Lynn et al., 2015); and the USA (various). A positive association, however, was not found for Germany (Roivainen, 2012), India (Lynn & Yadav, 2015) or the UK (Carl, 2016a). Associations were not reported for China (Lynn et al., 2016); Denmark (Teasdale et al., 1988); Finland (Dutton & Lynn, 2014); France (Lynn, 1980); Portugal (Almeida et al., 2011); Switzerland (Kirkegaard, 2016c); or Vietnam (Holsinger, 2007). Since several models predict a fairly consistent association between latitude and cognitive or socioeconomic outcomes (e.g., Lynn's evolutionary cold winters hypothesis, and León's contemporaneous UV hypothesis) it would be useful if future researchers included geoclimatic variables, so the consistency of these associations can be assessed.

Table 2
Proposed theoretical models for the cause of regional differences in cognitive ability from the 46 studies from Section 2.1.

Countries	Study	Theoretical model	Statistical method	Results consistent with hypothesis?
Argentina/Brazil/Chile/ Colombia/Mexico/US	Fuerst and Kirkegaard (2016a, 2016b); Kirkegaard and Fuerst (2017)	Euro ancestry → IQ → SES	Correlation & path analysis	Yes
Britain	Lynn (1979)	Evol. & selective migration → IQ → SES	Correlation & path analysis	Yes
China	Lynn and Cheng (2013); Lynn et al. (2016)	% Han → IQ → SES	Correlation & regression	Yes
Finland	Dutton and Lynn (2014)	Selective migration → IQ → SES	Correlation	Yes
France	Lynn (1980)	Selective migration → IQ → SES	Correlations	Yes
Germany	Roivainen (2012)	Sociopolitical → education → IQ	Correlation	Yes
India	Lynn and Yadav (2015)	Cold selection → IQ → SES	Correlation	No
		Selective migration → IQ → SES	Correlation	No
		Indo-Euro ancestry → IQ → SES	Correlation	No
		% Muslim ~ Consanguinity → IQ → SES	Correlation	Yes
		Distance from coast → SES → IQ	Correlation	Yes
Italy	Lynn (2010); Templer (2012)	Euro ancestry → IQ → SES	Correlation	Yes
Japan	Kura (2013)	Yayoi ancestry → IQ → SES	Correlation	No
Mexico	de Baca & Figueredo (2014)	Ecological selection + social privilege → IQ/behavior → SES	Sequential canonical cascade model	Yes
Peru	León and Avilés (2016)	UV radiation → hormones → behavior ←→ IQ/SES	Path analysis	Yes
Portugal	Almeida et al. (2011)	Selective migration → cognitive ability → SES	Correlation	Yes
Russia	Lynn, Cheng, and Grigoriev (2017)	Cold selection + % ethnic Russian → IQ → SES	Correlation & regression	Yes
Spain	Lynn (1981)	Selective migration → IQ → SES	Correlation	Yes
Spain	Lynn (2012)	Euro ancestry → IQ → SES	Correlation	Yes
Turkey	Lynn et al. (2015)	Selective migration → IQ	Correlation	No
		Turkish and Caucasian ancestry – > IQ	Correlation	Yes
USA	Bagley (1925)	SES → better schooling → IQ	Correlation & partial correlation	Yes
USA	Pesta and Poznanski (2014)	Contra racial composition model	Correlation	Yes
USA	Eppig et al. (2011).	Climate → Parasite load → IQ → SES	Correlation & regression	Yes
USA	Kirkegaard (2016b); Templer and Rushton (2011); Kirkegaard and Fuerst (2016); McDaniel (2006b)	Ethnic/racial composition → IQ → SES	Correlation & path analysis	Yes

3. Regional differences in intelligence: individual countries

3.1. Argentina

IQs for the 24 provinces of Argentina, calculated from academic achievement test results, were given by Kirkegaard and Fuerst (2017). They reported that these were positively correlated with general SES ($r = .88$); HDI (Human Development Index, a composite measure consisting of life expectancy, years of education, and Gross National Income) ($r = .87$); skin brightness ($r = .69$), latitude ($r = .47$); and percentage of European ancestry ($r = .48$); and negatively correlated with temperature ($r = -.43$, such that IQs are higher in the colder provinces). The authors also calculated the correlation between general SES and cognitive ability for the municipal and district levels. For these, cognitive ability was measured from responses made by adults to five geopolitical knowledge questions; the authors reported correlations of, respectively, $r = .66$ and $r = .52$ between general SES and results on the five knowledge questions. They noted that this measure of ability had only a moderate reliability, which likely accounted for the relatively lower correlation between cognitive ability and SES compared to that found at the provincial level. The authors interpreted the results in terms of race-related regional differences. In a path analysis, both latitude/temperature and European ancestry were independent significant predictors of cognitive ability. One concern with this study is the poor measure of cognitive ability for the level of districts and municipalities.

3.2. Brazil

IQs for the 26 states of Brazil, calculated from the PISA scores for reading and math of 15-year-olds in 2012, were given by Fuerst and Kirkegaard (2016a). The authors reported that PISA scores were positively correlated with general SES ($r = .84$), HDI ($r = .78$), and European ancestry ($r = .73$). In a path analysis, both latitude/temperature and European ancestry were independent significant predictors of cognitive ability (Fuerst & Kirkegaard, 2016b). The authors interpreted the results in terms of race-related regional differences.

One problem with this analysis is that provincial cognitive scores were calculated using only one year of PISA achievement data. This issue was addressed by Lynn et al. (2017), who calculated cognitive ability scores for the 27 federal units of Brazil (26 states + federal district) from the PISA scores for reading, science, and math of 15-year-olds in 2009, 2012, and 2015. The authors reported that these scores were positively correlated with per capita income ($r = .79$); percentage of population with a university degree ($r = .72$); percentage of houses with piped water ($r = .76$); and life expectancy ($r = .87$); and negatively correlated with infant mortality ($r = -.81$); fertility ($r = -.68$); poverty ($r = -.85$); violent crime in 2015 ($r = -.50$); and latitude ($r = -.79$). Unfortunately, correlations with a general SES score were not provided.

3.3. British Isles

Lynn (1979) calculated IQs for 13 regions of the British Isles from three data sets. For England, Scotland and Wales, two of the studies were of military samples obtained in the 1940s and the third was of 8–15 year olds obtained in the 1950s. Additional data were obtained for Northern Ireland and the Republic of Ireland. The highest IQs were obtained in London and the South East (102.1). The next highest IQs, ranging from 99.6 to 100.7, were obtained for the remaining nine

English regions. These were followed by Wales at 98.4; Scotland at 97.3; Northern Ireland at 96.7; and the Republic of Ireland at 96.0. These regional IQs were positively correlated with average earnings ($r = .73$); intellectual achievement indexed by membership of the Royal Society ($r = .94$); first class university degrees ($r = .60$); urbanisation ($r = .60$); crime ($r = .51$); and net migration 1751–1951 ($r = .44$), showing net migration from the lower IQ regions to the higher IQ regions; and negatively correlated with infant mortality ($r = -.78$) and unemployment ($r = -.82$). The positive correlation of $r = .51$ between IQs and the crime rate is anomalous in view of the well established negative correlation for individuals (Wilson & Herrnstein, 1985); the explanation proposed for this was that the crime rate is highly correlated with urbanisation ($r = .86$), and it was noted that the correlation was zero when urbanisation was partialled out. One problem with this study is that regional IQ scores were compiled using different datasets; this method renders questionable the comparability of regional scores.

The interpretation proposed for the results was that the migration from the lower IQ and poorer to the higher IQ and more affluent regions over the period 1751–1951 was selective such that many of the brightest left the poorer regions to seek fame and fortune in London. Once in the capital, they settled and reared children, who inherited their high intelligence and transmitted it to future generations. The adverse effect of selective emigration on the IQ in Scotland was calculated from Maxwell's (1969) follow-up study of the sample of 1000 11-year-olds whose Stanford-Binet IQs were obtained in the 1947 Scottish Mental Survey. Maxwell showed that by the age of thirty, 17.2% of these had emigrated and their mean IQ was 108.1. This would produce a fall of 1.7 IQ points of the IQ in Scotland for that generation and hence a decline of around 4 IQ points over four generations (Lynn, 1977).

The lower IQ in the Republic of Ireland than in Britain was confirmed in a review of nine studies that concluded that the IQ was 92.5 in relation to a British IQ of 100 and attributed this to the selective emigration of those with higher IQs and the dysgenic effect of Roman Catholicism (Lynn, 2015).

A second study of IQs for 12 regions of the United Kingdom and their economic and social correlates was published by Carl (2016a,b). Carl obtained cognitive test data, collected in 2011–2013, for young adults in the 12 regions, as well as a number of socioeconomic outcomes for the regions. This study had the advantage of assessing regional ability using a large panel survey. Carl reported the IQs for the following regions: South East, 102.6; South West, 101.8; Scotland, 100.9; East of England, 100.6; East Midlands, 100.3; Northern Ireland, 100.0; London, 99.6; West Midlands, 99.6; North West, 99.2; North East, 99.1; Yorkshire and the Humber, 99.0; and Wales, 98.2. These regions do not map perfectly onto the ones used by Lynn (1979), but are reasonably close. Regional IQs were positively correlated with per capita income (log weekly earnings) ($r = .42$); longevity ($r = .51$); the percentage of 20- to 24-year-olds with tertiary higher education ($r = .36$); technological accomplishment assessed as EPO patent applications per capita ($r = .83$); log GVA (gross value added) per capita ($r = .29$); R&D workers per capita ($r = .60$); percentage of households with access to broadband ($r = .59$); and a general factor of socio-economic development ($r = .72$); and negatively correlated with unemployment ($r = -.74$); crime ($r = -.27$); percentage of working-age adults with a disability ($r = -.58$); percentage of children in workless households ($r = -.74$); percentage of the labour force unemployed ($r = -.74$); percentage of working-age adults economically inactive ($r = -.66$); percentage of working-age adults with no qualifications ($r = -.53$); percentage of households at risk of poverty ($r = -.73$); and latitude ($r = -.27$).

The correlation between Lynn's (1979) regional IQs and Carl's (2016a,b) regional IQs was weak at $r = .24$, showing that the relative measured IQs of the UK regions changed considerably from the 1940–1950s to 2011–2013. Relative to other regions, average IQs increased in the Midland, Northern Ireland, Scotland, South Western and Southern regions; and decreased in East and West Ridings, Eastern, London and South Eastern, North Midland, North Western, Northern and Wales regions. Carl suggests there are at least four reasons why the relative IQs of the UK regions might have changed over the period. First, cross-regional differentials in the magnitude of the Flynn effect (see Flynn, 2012; Lynn and Cheng, 2013; Trahan, Stuebing, Fletcher, & Hiscock, 2014): some regions might have experienced larger Flynn effects than others. Second, cross-regional differentials in the selectivity of external migration (see Lynn, 2011; Rindermann & Thompson, 2014): foreign migrants with higher IQs might have been more likely to settle in some regions than in others. Third, cross-regional differentials in the selectivity of internal migration (see Jokela, 2014; Lynn, 1980): natives with higher IQs might have been more likely to relocate to some regions than to others. Fourth, cross-regional differentials in the strength of the relationship between IQ and fertility (see Lynn & Van Court, 2004; Meisenberg, 2010; Lynn, 2011; Chen, Chen, Liao, & Chen, 2013; Reeve et al., 2013; Kanazawa, 2014; Hopcraft, 2014; Woodley et al., 2013), such that fertility might have had a more positive genetic effect in some regions than in others.

A third study was conducted by Carl (2016b), who examined the relationship between cognitive ability and socioeconomic outcomes across 392 local authorities. This study complemented that of Carl (2016a,b) by using more finely grained units of analysis, examining the association below the level of broad geographic regions. The unweighted correlations between cognitive ability and socioeconomic outcomes were as follows: for positive correlations, households in A and B social grades ($r = .55$); proportion of residents reporting good health ($r = .46$); proportion of adults with 4+ educational qualifications ($r = .46$); life expectancy at birth ($r = .43$); percentage of adults in financial, informational, scientific, and professional industries ($r = .34$); percentage of adults in the education sector ($r = .31$); percentage of households with 2+ cars ($r = .31$); average life satisfaction rating ($r = .27$); percentage of adults married or in a civil union ($r = .21$); percentage of homeowners ($r = .18$); average anxiety rating ($r = .02$); and for negative correlations, percentage of adults in the social rented section ($r = -.24$); percentage of single parent households ($r = -.42$); percentage of residents whose day-to-day activities are limited by disabilities ($r = -.44$), percentage of adults employed in routine or semi-routine occupations ($r = -.45$), unemployment rate ($r = -.48$). The correlation between the authorities' cognitive ability and their scores on a general SES factor was .56.

3.4. Chile

Cognitive ability scores were computed by Fuerst and Kirkegaard (2016b) for 15 Chilean territories based on academic tests administered between 2009 and 2013 to fourth, eighth, and 12th graders. The authors found that these ability scores did not correlate with either HDI scores ($r = -.04$) or scores on a general SES factor ($r = .04$) when the territories were unweighted for population size. When weighted by the square roots of the territorial populations, however, the correlations were $r = .33$ for HDI and $r = .30$ for general SES. The authors also found that both latitude ($r = .53$, unweighted) and European genetic ancestry ($r = .58$, unweighted) correlated with cognitive ability. In a path analysis both temperature, which was colinear with latitude, and European ancestry were independent significant predictors of cognitive ability. The authors noted that not much should be made of these results, owing to the small number of regional units sampled and the minimal variability in ability and general SES across territories.

3.5. China

Lynn and Cheng (2013) reported IQs for thirty-one regions of the People's Republic of China obtained from a Chinese-language IQ-testing website. They reported that these were positively correlated with per capita income ($r = .42$); years of education ($r = .32$); and the percentage of Han in the regional population (r = .59). This measure of regional intelligence is questionable, being based on unrepresentative results from an online survey. This concern, however, was addressed in a second study of intelligence in thirty-one regions of the People's Republic of China. This study estimated regional IQs based on the Progressive Matrices scores of 37,238 eight- to 10-year-olds (Lynn et al., 2016). IQs were positively correlated with income assessed as GDP per capita (r = .73); years of education (r = .76); and the percentage of Han in the population (r = .75).

3.6. Columbia

Cognitive ability scores were reported by Fuerst and Kirkegaard (2016a) for 32 Colombian departments based on academic tests administered between 2012 and 2014 to fifth and eighth graders. The authors found that these test scores were positively correlated with general SES factor scores calculated from 17 socioeconomic variables (r = .65); HDI scores (r = .64); and European ancestry (r = .81). In a path analysis, both temperature (but not absolute latitude) and European ancestry were independent significant predictors of cognitive ability (Fuerst & Kirkegaard, 2016b). The authors interpreted the results in terms of race-related regional differences.

3.7. Denmark

IQs and educational levels, based on data from military conscripts, for seven regions of Denmark have been given by Teasdale et al. (1988). The authors found that population density correlated with both IQ (r = .91) and educational level (r = .86). The correlation between the authors' reported provincial education and IQ averages came out to r = .95. The authors interpreted their results as in favour of a model in which educational differences caused IQ differences. This study differed from many of the others in that the IQ and outcome data were drawn from the same sample, which could explain the atypically large association.

3.8. Finland

IQs for four regions based on tests of military conscripts have been given by Dutton and Lynn (2014). IQ was highest in the southern region. Regional IQs were positively correlated with per capita income in 2010 (r = .67); percentage of population with tertiary education in 2010 (r = .85); life expectancy for men (r = .50) and for women (r = .12); migration to the southern region containing the capital city of Helsinki (r = .69); and negatively correlated with the infant mortality rate in 2001 (r = −.79); and the percentage of unemployment (r = −.38). Owing to the tiny regional sample size (n = 4), not much weight can be placed on these results.

3.9. France

The IQs of 257,000 military male conscripts for the 90 departments of France, obtained in the mid-1950s, have been given by Lynn (1980). The highest IQs were obtained by conscripts from the Paris regions and the lowest by conscripts from Corsica. These departmental IQs were positively correlated with average earnings (r = .61); intellectual achievement indexed by membership of the Institut de France (r = .26); unemployment (r = .20) (the positive correlation is anomalous); and with net migration 1801–1954 (r = .56) showing net migration from the lower IQ departments to the higher IQ departments; and negatively with infant mortality (r = −.30). The interpretation proposed for the results was that migration from lower-IQ and poorer to higher-IQ and more affluent departments has been selective and hence augmented the higher IQ in the Paris region. On re-analyzing the data, Kirkegaard (2015) found a correlation of r = .61 between department IQ and a general SES factor extracted from Lynn's (1980) data.

3.10. Germany

The IQs of young men (military conscripts) in 1992 and 1998 for the 16 states of Germany were given by Roivainen (2012). There was conscription into the military in Germany in the 1990s and about half of the cohorts served. The 1992 IQs were lower at 95 in the five Eastern states than at 101 in the 11 Western states, but the 1998 IQs exhibited almost no difference between the Eastern and Western states: 99 in the Eastern and 100 in the Western. The 1992 IQs ranged from 93 in Brandenburg, Mecklenburg-Vorpommern and Sachsen-Anhalt in the East to 102 in Baden-Württemberg and Bayern in the West. The 1998 IQs ranged from 96 in Sachsen-Anhalt in the East to 102 in Bayern in the West. The IQ in Berlin was 100 in 1992 and 98 in 1998 and therefore about average. IQs for 2000, calculated from PISA scores, were virtually the same at 98 for the Eastern and 99 for the Western states and for 2006 at 102 (Eastern) and 101 (Western). GDP was lower in the Eastern than in the Western states at 169 compared with 269 in 2000, and at 202 compared with 296 in 2006. Thus, both the IQs and the per capita income in the Eastern states had improved relative to those in the Western states from 1992 to 2006.

For Germany as a whole, state IQs were positively correlated with per capita GDP in 1992 (r = .79) and in 1998 (r = .27); with educational attainment as assessed by percentage gaining Abitur certificates in 1990 (r = .51); and with religiosity assessed by church membership (r = .33); and negatively correlated with latitude (r = −.51) (the Eastern states are more northerly); and with educational attainment in 1998 (r = −.33). Roivainen (2012) suggests that this negative correlation may be attributable to the large numbers of low-IQ immigrant school students in some of the higher-IQ western states.

3.11. India

IQs for 33 states and union territories of India have been reported by Lynn and Yadav (2015). These regional IQs were positively correlated with average earnings assessed as per capita GDP (r = .25); teacher quality assessed by the percentage of teachers with professional qualifications and other measures (r = .17); the Infrastructure Index, including the percentage of schools with chairs, desks, drinking water, kitchens, and toilets (r = .52); life expectancy (r = .34); and having a coast line (r = .50); and negatively with infant mortality (r = −.39); child mortality (r = −.37); the fertility rate (r = −.35); the percentage of Muslims (r = −.32); and latitude (r = −.43), showing that IQs were higher in the southern states.

Lynn and Yadav's (2015) confirmed explanation for the higher IQs in the southern states was that more of these have coastlines that facilitate trade and increase incomes as argued by Collier (2008), and that they have fewer Muslims who have high rates of cousin marriages that depress intelligence. The deleterious effect of consanguinity on intelligence is well established, with results showing an effect ranging from −2.5 to −3.5 IQ points for first cousins (Jensen, 1983) to −6 to −34 IQ points depending on the coefficient of inbreeding (Fareed & Afzal, 2014).

3.12. Italy

IQs measured by PISA for 12 regions were given by Lynn (2010a) and shown to be positively correlated with per capita income in 2003 (r = .94); stature in 1980 (r = .93); latitude (r = .94; that is, IQs are higher in the north); and years of education in 2001 (r = .89); and negatively correlated with the infant mortality rate 1999–2002 (r = −.86). The IQs ranged from 89 in Sicily in the south to 103 in Friuli-Venezia in the north. It was proposed that the higher IQs in the north are attributable to immigrants from North Africa and the Near East with lower IQs than those of Europeans.

This thesis was criticized by several Italian researchers who argued that PISA scores are a measure of educational attainment rather than of intelligence and proposed economic, educational, and social explanations for the north-south differences in IQs and PISA scores (Beraldo, 2010; Cornoldi, Belacchi, Giofre, Martini, & Tressoldi, 2010; Daniele & Malanima, 2011; Felice & Giugliano, 2011; D'Amico, Cardaci, Di Nuovo, & Naglieri, 2012; Cornoldi, Giofrè, & Martini, 2013; Daniele, 2013; and Daniele, 2015).

Replies to the critics are found in Lynn (2010b, 2012a) in which it was contended that the PISA tests measure understanding and hence are measures of intelligence; that educational attainment is so highly correlated with intelligence in individuals and populations that any measure of it is necessarily also a measure of intelligence; that across 108 national populations PISA scores are correlated with IQs at $r = 1$ (Lynn & Meisenberg, 2010); and that it has been shown by Haworth, Asbury, Dale, and Plomin (2011) in a study of 4000 pairs of 12-year-old twins in the UK that school differences account for only 12% of the variance in educational attainment and that major effects are genetic (50%) and shared environmental influences (25%), i.e., family influences that twins share.

New data were presented in Lynn (2012a) for 16 Italian regions for the 2009 PISA study, confirming that IQs are higher in the north and were correlated with latitude at $r = .91$. These results were further confirmed by data given for abilities in math and language comprehension in the INVALSI survey of school students in five Italian regions: the northwest and northeast (scoring the highest), the center (receiving an intermediate score), and the south and the islands of Sicily and Sardinia (scoring lowest). Data were also given confirming that the proportions of North African genes in the Italian regions are higher in the south than in the north, while the proportions of central and northern European genes in the Italian regions are higher in the north than in the south. These data consisted of the percentages of the populations with blond hair, a marker for northern European ancestry, and of the frequency of the haplogroup xR1 allele, a marker for European Mesolithic populations, considered by the author as representative of the original inhabitants of Europe, with higher frequencies in central and western Europe and lower frequencies in southern Europe. Further data for the proportion of North African ancestry in the Italian regions were given: the frequency of the haplogroup E1b1b allele, a marker for North African ancestry, reaches frequencies above 50% and peaks at around 82% in Tunisia.

Additional evidence for the north-south IQ differences in Italy was given by Templer (2012) for IQs measured by an intelligence test for 19 regions. IQ was highest in the most northerly region of Friuli-Venezia at 104.5 and lowest in Sicily at 91.8. Regional IQs were positively correlated with per capita income in 2003 ($r = .75$); absolute latitude ($r = .83$); the cephalic index ($r = .72$; that is, the populations of regions with higher IQs have a higher cephalic index, an index of the ratio of the maximum breadth of a skull to its maximum length), the percentages of the population with multiple sclerosis ($r = .63$); the percentages of the population with schizophrenia ($r = .40$); and literacy rates in 1880 ($r = .32$); and negatively correlated with the percentages of the population with black hair ($r = -.72$) and black eyes ($r = -.61$), attributable to the greater proportions of those of North African and Near Eastern origin in the south. Templer argued that these results confirmed that there are genetic differences related to Near Eastern and European ancestry and differences in intelligence between the populations in the north and south of Italy. Further evidence for genetic differences between the populations of the north and south of Italy was given by Rindermann, Woodley, and Stratford (2012) who showed that across five regions IQs were correlated with haplogroups HsA at $r = .81$ and with HsB at $r = -.61$. Similar results were shown for Spain.

Still more evidence for north-south differences in IQs in Italy was published by Piffer and Lynn (2014), who reported the PISA 2012 Creative Problem Solving test scores for five regions. The results were transformed to IQs and showed that these were highest in the northwest (102.5) followed by the northeast (101.6), the center (99.5), the islands (95.2), and the south (93.3). The difference of 9.2 IQ points between the northwest and the south confirmed previous studies. New data were presented showing higher percentages of Middle Eastern and Southwest Asian genes in the south and higher percentages of North European genes in the north.

3.13. Japan

IQs for 47 prefectures in Japan measured by math and verbal tests taken by 11- to 14-year-olds in 2007 to 2012 were given by Kura (2013). Prefecture IQs were positively correlated with per capita income measured as logGDP ($r = .25$); stature ($r = .52$); absolute latitude ($r = .44$); skin brightness ($r = .42$); and negatively correlated with the homicide rate ($r = -.60$); the divorce rate ($r = -.69$); and the infant mortality rate ($r = -.08$). There was a negligible correlation with the suicide rate ($r = .08$) and a small one with fertility ($r = -.14$). The author noted that the predictions of a model in which those with more Yayoi/recent East Asian ancestry had higher IQs was not supported. As with a number of other studies, this one suffers from a failure to examine the association between IQ and general SES.

This concern was addressed by Kirkegaard (2016a) who attempted to create a general SES factor using 44 social outcome variables, and correlate this general SES factor with Kura's (2013) prefecture cognitive scores. No clear SES factor was identifiable until the prefectures' population density was controlled for. The correlation between cognitive ability and a statistical summary of all SES variables was $r = -.17$. Many of the variables correlated with cognitive ability in inconsistent ways (for example: life expectancy of males, $r = .11$; life expectancy of females, $r = -.12$). Since Kirkegaard's (2016a) SES data was based on a much larger data set, his results can be taken as a more reliable representation of the general association between IQ and outcomes.

3.14. Mexico

IQs for Mexico's 32 federal entities (31 states + federal district) calculated from PISA 2009 were given by Cabeza de Baca and Figueredo (2014). IQ was positively correlated with a "brumal" factor constructed from annual average temperature and a composite of altitude and latitude ($r = .39$); slow life history assessed from low rates of fertility, crime, infant mortality, AIDS, and high life expectancy ($r = .34$); and human capital assessed from length of schooling, poverty, and average household income ($r = .68$); and negatively with a "hydrological" factor constructed from annual average precipitation and tropical-humid climate ($r = -.48$) (Figueredo, 2017, personal communication). The authors' interpretation of the results was that ecological and socio-cultural factors effect cognitive ability and slow life history, which together determine cognitive ability. They interpret the negative correlation ($r = -.48$) between their "hydrological" factor and intelligence as supporting the cold winters theory that higher intelligence evolved in colder environments.

A problem with this study is the use of just one year of PISA data as a measure of state IQ. To address this issue, Fuerst and Kirkegaard (2016a) computed cognitive scores for Mexico's 31 states using based on 2003, 2006, 2009, and 2012 math and reading PISA scores. They found that cognitive ability correlated with a general SES factor extracted from 23 diverse indicators ($r = .77$); with state HDI ($r = .74$); and with European ancestry ($r = .51$). In a path analysis both temperature (but not absolute latitude) and European ancestry were independent significant predictors of cognitive ability (Fuerst & Kirkegaard, 2016b). The authors interpreted the results in terms of race-related regional differences.

3.15. Peru

León and León (2014) proposed a UV radiation model to explain international differences and their association with both latitude and cold weather. León and Avilés (2016) tested this model by analyzing the relation between cognitive ability, geographic variables and social outcomes across 1468 Peruvian districts (lower level administrative units). Using path analysis, they found that higher cognitive ability was negatively related to fertility and altitude and positively related to better social outcomes. They interpreted these results as being consistent with their UV model since individuals are exposed to more UV radiation at higher altitude. In personal communication, León (2016) reported the following district-level bivariate correlations with average math and reading scores: family income (r = .56); level of education (r = .50); life expectancy (r = .42); fertility (r = −.58); and a general developmental factor (r = .57).

3.16. Portugal

The IQs of 4829 school students aged 11 to 18 were measured by a Portuguese test in 2007. The results for five Portuguese regions were reported by Almeida et al. (2011). The highest IQ was in central Lisbon and the correlation of the regional IQs with per capita income in 2008 was r = .58).Owing to the tiny regional sample size (n = 5), not much weight can be placed on these results.

3.17. Russia

There have been four studies of regional differences in intelligence and their economic and social correlates in Russia. In the first of these, Grigoriev, Lapteva, and Lynn (2016) reported data for 50 Russian provinces in the late nineteenth century. Differences in intelligence were inferred from literacy rates and were shown to be significantly positively correlated with the stature of military recruits (r = .56) and with latitude (r = .33, such that intelligence was higher in the more northerly provinces); and negatively correlated with fertility (r = −.75); the infant mortality rate (r = −.28); and longitude (r = −.43, such that intelligence was higher in the more westerly provinces). The use of literacy as an index of intelligence in this study is problematic, since literacy can also represent a social outcome, which is why these results were not included in the quantitative analysis.

In the second study, data for differences in average scores on the Unified State Examin for 2014, as a proxy for intelligence, were reported for 79 of the 83 provinces of the Russian Federation (including European and Asian Russia) by Grigoriev, Ushakov, Valueva, Zirenko, and Lynn (2016). The average intelligence of the provinces was significantly positively correlated with urbanisation (r = .43); the percentage of ethnic Russians (r = .39); net migration (r = .54, such that the provinces with higher IQs had gained from migration); and latitude (r = .35, such that intelligence was higher in the north); and significantly negatively correlated with infant mortality (r = −.43); fertility (r = −.39); and longitude (r = −.36, such that intelligence was higher in the west). One concern with the measure of intelligence in this study is that the scores were obtained from individuals who had been accepted into universities and so they may not be representative of the provincial populations as a whole.

In the third study, by Chmykova, Davydov, and Lynn (2016), IQs for 29 provinces of the Russian Federation were obtained with the Standard Progressive Matrices. IQs were negatively correlated with fertility at r = −.57. Unfortunately, data was only available for a limited number of constituent entities of Russia and no other correlations with socioeconomic variables were reported.

Some of these concerns were addressed in the fourth study, in which IQs of 15-year-olds in 42 provinces and cities of the Russian Federation were assessed using 2015 PISA results (Lynn, Cheng, & Grigoriev, 2017). PISA scores were positively correlated with the scores on the Unified State Examination in 2014 (r = .53) reported by Grigoriev, Ushakov, et al. (2016); per capita income (r = .31); literacy rates in 1897 (r = .50); the percentage of ethnic Russians in the population (r = .45); latitude (r = .35, such that intelligence was higher in the north); and negatively correlated with infant mortality (r = −.53) and longitude (r = −.25, such that intelligence was higher in the west).

3.18. Spain

In the first study of Spain, IQs for 48 regions were calculated from approximately 130,000 male military conscripts and shown to be positively correlated with average incomes (r = .65); literacy (r = .36); and achievement assessed by percentages listed in the *World Who's Who* (r = .11); and negatively correlated with infant mortality (r = −.54) (Lynn, 1981).

In the second study, Lynn (2012b) reported IQs for 15 regions of Spain assessed by PISA reading, math, and science 2006 and 2009 scores. This study was novel in that measure invariance was tested and found to hold on the regional level. As no composite cognitive score was created for summary purposes, for expediency only the correlation between 2009 reading scores and outcomes will be discussed. IQs were positively correlated with per capita income in 1961 (r = .34); per capita income in 2001 (r = .33); life expectancy (r = .82); the percentage employed (r = .85); literacy (r = .80); and latitude (r = .81, such that IQs were higher in the north); and negatively correlated with years of North African occupation (r = −.92), such that intelligence was higher in the northern regions that had been occupied for the fewest years by North Africans.

Genetic data for Y-chromosomal haplogroup frequencies were given showing that North African ancestry is greater in southern than in northern Spain. Further evidence for genetic differences between the populations of the north and south of Spain was given by Rindermann et al. (2012) who showed that, across four regions, IQs were correlated with the frequency of haplogroups HsA and HsB at r = .68 and r = −.30, respectively.

3.19. Switzerland

Kirkegaard (2016c) examined the association between the percentage of draftees receiving the highest marks on army examinations and social and demographic outcomes for 47 French-speaking provinces in 19th-century Switzerland. Percentages receiving high scores were positively correlated with educational attainment (r = .70) and general SES (r = .70); and negatively correlated with the percentage Catholic (r = −.57); infant mortality (r = −.11); fertility (r = −.65); and percentage of males working in agriculture (r = −.69). A detailed discussion of this pre-19th century military exam was not provided and a copy of the original test could not be located to determine to what extent it exhibited face validity as a measure of intelligence. As such, these results should be taken with caution. Also, as the data were from 1888, this study provides limited information about the present-day association between cognitive ability and outcomes in Switzerland.

3.20. Turkey

Lynn et al. (2015) gave IQs assessed by PISA 2012 math, reading, and science scores for 12 Turkish geographical regions. Total PISA scores were positively correlated with per capita income (r = .81); the percentage of graduates (r = .63); life expectancy (r = .83); educational attainment of 17-year-olds in a range of subjects in 2012 (r = .87); inward migration (r = .70); and latitude (r = .35), such that intelligence was higher in the north; and negatively correlated with fertility (r = −.84); infant mortality (r = −.80); longitude (r = −.76, such that intelligence was higher in the west); and the percentage of Kurds (r = −.87), who are more numerous in the east. As with other studies, it would be useful to know the correlation between composite measures of IQ and SES.

3.21. United States

For the United States, there have been at least fifteen studies of state

IQs and their economic and social correlates. In the first of these, Alexander (1922) correlated Army Alpha scores by state, obtained from World War I soldiers, with state outcomes. For 41 states (he excluded states with fewer than 500 cases), he found that test scores were positively correlated with population density ($r = .62$); home ownership among Whites ($r = .68$); farm ownership among Whites ($r = .70$); average wage for farm labor ($r = .83$); literacy among Whites ($r = .54$); school "educational efficiency" ($r = .72$); and a variable created from averaging these indicators ($r = .89$). Alexander noted that the associations could be interpreted from either a hereditarian or an environmentalist perspective.

The second study was reported by Bagley (1925) who found that Army Alpha and Army Beta scores obtained by soldiers were positively correlated with the states' per capita incomes ($r = .73$); "school efficiency" (computed from variables such as percentage of children at school, average number of days attended, etc.) ($r = .88$); per capita circulation of magazines ($r = .91$); and percentage in *Who's Who* ($r = .87$); and negatively correlated with the number of criminals ($r = -.73$). He interpreted the results as evidence of the effects of education.

In the third study, state means for over 300,000 male high school and college students on the A-12V-12 test as a measure of intelligence were given by Davenport and Remmers (1950). This study did not identify the states but reported that state IQs were positively correlated with per capita income in 1945 ($r = .81$); percentages in *Who's Who* as a measure of achievement ($r = .67$); and school expenditure per pupil ($r = .80$); and negatively correlated with the lynching of Blacks ($r = -.53$); the percentage of Blacks ($r = -.70$); and the percentage of rural homes without a privy as a measure of rural poverty ($r = -.66$).

In the fourth study, state IQs estimated from Scholastic Aptitude Test (SAT) scores for 50 states and the District of Columbia were given by Kanazawa (2006). The SAT is taken by senior high school students for entry to college and is correlated with *g* at $r = .82$ (Frey & Detterman, 2004) so it can be regarded as a valid measure of intelligence. SAT scores were converted to IQs and showed a range from 109.9 in Massachusetts and 109.4 in Connecticut to 62.7 in Mississippi and 73.3 in Arkansas. The results showed that state IQs were positively correlated with gross state product ($r = .32$) and median family income ($r = .57$); and negatively correlated with the percentages of the state populations in poverty ($r = -.35$). It should be noted that the IQ estimates used in this study have been criticized by McDaniel (2006a) on the grounds that there are wildly different SAT participation rates across different US states. Generally, owing to the flawed methodology for estimating state IQ, these results can be given little weight.

In the fifth study, state IQs were estimated from a composite of ACT and SAT scores constructed by McDaniel (2006a) for 48 states. The IQs ranged from 102.5 in Massachusetts and 102.2 in Connecticut to 91.4 in Arizona and 81.7 in Arkansas and were positively correlated with the median income ($r = .18$) and State Gross Product (GSP) per capita ($r = .10$); and negatively correlated with the percentage of the state populations in poverty ($r = -.30$).

In the sixth study, McDaniel (2006b) calculated IQs from the National Assessment of Educational Progress (NAEP) tests in reading and math taken by public school students in grades 4 and 8 in 50 states. The IQs ranged from 104.3 in Massachusetts and 104.2 in New Hampshire to 94.2 in Mississippi and 95.3 in Louisiana. The results showed that state IQs were positively correlated with gross state product ($r = .28$); health ($r = .75$); expenditure per pupil ($r = .39$); and government effectiveness ($r = .34$); and negatively correlated with the percentage of Whites not in public schools ($r = -.63$); pupil-teacher ratios ($r = -.38$); percentage of Blacks ($r = -.51$); percentage of Asians ($r = -.27$); percentage of Hispanics ($r = -.34$); percentage of infants with low birth weight ($r = -.71$); percentage of mothers receiving no prenatal care during the first trimester of pregnancy ($r = -.58$); and violent crime ($r = -.58$). McDaniel (2006b) suggested a partial ethnic composition model for the cause of state differences.

In the seventh study, Shatz (2008) showed that Kanazawa's (2006) IQs for 50 states and the District of Columbia were negatively correlated with states' birth rates (live births per 1000 population) ($r = -.32$); fertility rates (births per 1000 women aged 15–44 years) ($r = -.37$); and the fertility rates (sums of birth rates for 5-year age groups multiplied by 5) ($r = -.29$).

In the eighth study, Reeve and Basalik (2010) showed that McDaniel's (2006b) IQs for 50 states were positively correlated with the percentage of Asians ($r = .68$); GSP (gross state product per capita) ($r = .32$); percentage of mothers who breastfed their children ($r = .33$); immunization (percentage of children immunized) ($r = .20$); mammogram rate (percentage of women aged 40 years and above having a mammogram within the past two years) ($r = .24$); colonoscopy rate (percentage of adults aged 50 years and above having a colonoscopy) ($r = .47$); dental care (percentage of adults having their teeth cleaned in the last year ($r = .51$); exercise (percentage of adults reporting moderate or vigorous physical exercise each week ($r = .51$); and percentage of non-smokers ($r = .29$); and negatively correlated with the percentage of Blacks ($r = -.51$); health care expenditure ($r = -.07$); teenage fertility ($r = -.77$); total fertility ($r = -.34$); death rates from HIV/AIDS ($r = -.39$); adult obesity ($r = -.36$); child obesity ($r = -.46$); infant mortality ($r = -.54$); overall mortality ($r = -.46$); and deaths from heart disease ($r = -.56$).

In the ninth study, Pesta, McDaniel, and Bertsch (2010) showed that McDaniel's (2006b) IQs for 50 states were positively correlated with income ($r = .57$), health ($r = .75$), and the percentage of adults with bachelor's degrees ($r = .41$); and negatively correlated with rates of crime ($r = -.76$) and religiosity ($r = -.55$).

In the tenth study, Templer and Rushton (2011) found that McDaniel's (2006b) IQs were positively correlated with life expectancy ($r = .51$) and income ($r = .54$); and negatively correlated with the percentage of Blacks ($r = -.48$); the AIDs rate ($r = -.39$); the birth rate ($r = -.35$); the infant mortality rate ($r = -.47$); the murder rate ($r = -.64$); the rape rate ($r = -.14$); the robbery rate ($r = -.46$); and the assault rate ($r = -.47$).

In the eleventh study, Eppig et al. (2011) showed that McDaniel's (2006b) IQs for 50 states were positively correlated with average incomes ($r = .34$); median household incomes ($r = .27$); gross state products ($r = .28$); and wealth ($r = .32$); and negatively correlated with parasite stress ($r = -.67$). The authors interpreted their results in terms of their infectious disease model for outcome differences.

In the twelfth study, Pesta, Bertsch, McDaniel, Mahoney, and Poznanski (2012) reported that state IQs measured by NAEP achievement scores were positively correlated with health behaviors ($r = .45$); and negatively correlated with chronic disease ($r = -.51$) and metabolic syndrome ($r = -.53$). The authors replicated other outcome associations originally found by Pesta et al. (2010).

In the thirteenth study, Pesta and Poznanski (2014) examined the association between McDaniel's (2006b) state IQs and cold weather, as well as several other variables. They found state IQs were positively correlated with educational attainment ($r = .41$); health ($r = .75$); income ($r = .57$); and a composite measure of general well being ($r = .83$); and negatively correlated with temperature ($r = -.75$, such that colder states had higher IQs); percentage Black ($r = -.50$); religiosity ($r = -.55$); and crime ($r = -.76$). There was no correlation with the percentage Native American ($r = -.07$). Pesta and McDaniel (2010) argued that natural selection was not necessary to explain the regional association between cold weather and cognitive ability.

In the fourteenth study, Fuerst and Kirkegaard (2016a) computed new NAEP-based scores for 49 states (Hawaii was excluded, owing to ethnic composition). They reported that state IQs were positively correlated with *AHDI* (the US intra-national version of the HDI) ($r = .57$); general SES ($r = .75$); and European ancestry ($r = .67$).In a path analysis, both temperature (which was collinear with absolute latitude) and European ancestry were independent significant predictors of cognitive ability (Fuerst & Kirkegaard, 2016b).

In the fifteenth study, León (2016) used path analysis to investigate the relation between NAEP-based state student achievement scores, latitude, percentage of the population who identify as White, percentage European ancestry, parasite stress load, and income. The author reported that percentage White and percentage European ancestry were not significantly related to state cognitive ability after latitude and parasite stress were included in the model. The path diagrams showed significant relations between cognitive ability and income, with standardized path coefficients ranging from $\beta = .54$ to $\beta = .64$ depending on the model. The author interpreted the results in light of his UV radiation theory of regional cognitive differences. Fuerst and Kirkegaard (2016b) replied to one of the key conclusions drawn by León (2016). Fuerst and Kirkegaard (2016b) introduced an alternative method for exploring the association between percentage ethnicity and regional outcomes. (See also Kirkegaard & Fuerst, 2016.) To sidestep the problem of an indefinite number of possible between-state environmental confounds (Pesta, 2016), they looked at the correlation between percentage White and the difference between the total state cognitive scores and the total scores with the White group removed. This allowed for a determination of the statistical effect of percentage White on state scores independent of geographically bound environmental factors. Their general finding was consistent with an ethnic compositional model.

There have also been four American studies that have reported associations between county-level IQ and socioeconomic outcomes. In the first of these, Beaver and Wright (2011) used Peabody Picture Vocabulary Test (PPVT) (cite the test) scores from the National Longitudinal Study of Adolescent to Adult Health (Add Health) to compute IQs for 243 counties (the remainder had insufficient data). The authors found that county-level IQ correlated negatively with, among other things, a composite index of crime ($r = -.53$); percentage of Blacks ($r = -.43$); proportion of female-headed homes ($r = -.56$); percentage of residents making less than $15,000 ($r = -.27$); frequency of reliance on public assistance ($r = -.46$); and unemployment rates ($r = -.38$).

In the second study, Barnes, Beaver, and Boutwell (2013) reported, for 96 counties, negative correlations between county-level IQ assessed with PPVT scores from Add Health and, among other things, county disadvantage ($r = -.49$); infant death rate ($r = -.38$); AIDS death rate ($r = -.44$); and rate of low birth weight infants ($r = -.32$).

In the third study, Boutwell, Franklin, Barnes (2013) reported negative correlations between county-level IQ assessed with PPVT scores from Add Health and both fertility ($r = -.38$) and parental investment (as indexed by the portion of males and females married and of two parent households) ($r = -.42$).

In the fourth study, Kirkegaard (2016b) looked at the association between cognitive ability based on NAEP math and reading scores and socioeconomic outcomes across 3100 US counties. Cognitive ability was found to correlate positively with per capita income ($r = .38$); educational attainment ($r = .37$); general SES status ($r = .68$); and percentage of Whites ($r = .59$); and negatively with infant mortality ($r = -.49$) and rates of violent crime ($r = -.48$).

3.22. Vietnam

Holsinger (2007) examined the association between cognitive test scores and levels of inequality in education for 61 Vietnamese provinces. The cognitive scores, based on a nationally representative sample of Vietnam schools, were calculated by Holsinger (2007) by averaging provincial math and reading benchmark achievement rates for fifth graders. Holsinger found that cognitive benchmark scores correlated with both within province educational inequality ($r = -.54$) and provincial human development index rank ($r = -.46$, with a higher human development rank indicating worse outcomes). The author felt that the association between cognitive ability and provincial HDI supported an educational explanation for provincial differences in ability. One concern with this study is the measure of provincial socioeconomic outcomes: while HDI is typically highly correlated with general SES, exceptions have been found (Fuerst & Kirkegaard, 2016a).

4. Discussion

There is a large measure of consistency in the 22 countries for eight of the correlates of economic, social, and demographic phenomena with regional differences in intelligence. First, in all countries, regional IQs were positively correlated with per capita income measured as average earnings, per capita GDP, or some similar measure. These results are consistent with numerous studies showing that intelligence is a determinant of income among individuals, e.g., Jencks (1972, 1979) and Irwing and Lynn (2006). It is proposed that at the group level this association arises through a positive feedback loop, such that groups with high IQs secure high income and high income increases the IQs of children by improving nutrition, health, education, and other environmental inputs been unemployed.

Second, in thirteen out of fourteen countries, regional IQs were positively correlated with various measures of health. Japan, with a correlation of $r = .01$, was the sole exception. These results are consistent with numerous studies showing that intelligence is a determinant of health and longevity at the individual level (e.g., Bratsberg & Rogeberg, 2017; Deary & Der, 2006; Savage, 1946). Regional IQs were negatively correlated with infant mortality in Brazil, the British Isles, Finland, France, Italy, Spain, Turkey, and the United States, consistent with the association between parental IQs and infant mortality among individuals [cite].

Third, regional IQs were positively correlated with measures of educational attainment in fourteen out of the fourteen countries for which data were available. These results are consistent with numerous studies showing that intelligence is a determinant of educational attainment among individuals, e.g., Jencks (1972, 1979), Gottfredson (1997), Hunt (2011), and Mackintosh (2011).

Fourth, regional IQs were positively correlated with measures of intellectual achievement assessed as membership of the Royal Society and first class university degrees in the British Isles, technological accomplishment assessed as patent applications in the United Kingdom, and intellectual achievement assessed as membership of the Institut de France in France. These results are consistent with numerous studies showing that intelligence is a determinant of intellectual achievement among individuals, e.g., Gottfredson (1997), Hunt (2011), Mackintosh (2011), and Lubinski (2016).

Fifth, regional IQs were positively correlated with measures of occupational achievement assessed as listings in *World Who's Who* in Spain and in *Who's Who* in the United States. These results are consistent with numerous studies showing that intelligence is a determinant of occupational achievement among individuals, e.g., Jencks (1972, 1979), Gottfredson (1997), Hunt (2011), and Mackintosh (2011).

Sixth, regional IQs were positively correlated with measures of migration from the lower-IQ and poorer regions to the higher-IQ and richer regions including capital cities in the British Isles, Finland, France and Russia. These results are consistent with studies showing that intelligence is a correlate of migration among individuals, e.g., for migrants from Scotland (Lynn, 1977) and for blacks from the south of the United States migrating to the north (Tolnay, 1998; Vigdor, 2002).

Seventh, regional IQs were negatively correlated with fertility in nine out of the nine countries for which data were available. These results are consistent with the negative correlation between county-level IQ and fertility rates in the United States reported by Boutwel et al. (2013), and with numerous studies showing that intelligence is negatively correlated with fertility among individuals reviewed in Lynn (2011) and confirmed by Reeve, Lyerly, and Peach (2013) and Woodley, te Nijenhuis, and Murphy (2013).

Eighth, regional IQs were negatively correlated with crime rates in Brazil, Japan, and the United States, consistent with studies showing that intelligence is negatively correlated with crime among individuals, e.g., Wilson and Herrnstein (1985), Herrnstein and Murray (1994), Beaver, Schwartz, Nedelec, Connolly, et al. (2013). However, this association was not present in the British Isles, Mexico, and Russia—that is, three out of the six countries for which data were available. These results suggest that there may be important aggregation effects for crime rates, possibly attributable to population density, immigration, and urbanisation.

5. Conclusions and Limitations

The conclusions of this review are that there are differences in the mean IQs of the populations of the regions in all twenty-two countries and that these are typically associated in the same direction with a wide range of economic, social, and demographic phenomena. These associations generally confirm those reported for individuals, for the districts in cities, for cities in countries, and for nations noted in the introduction, and provide further evidence for the position of intelligence as "a unifying construct for the social sciences" (Lynn & Vanhanen, 2012a).

A limitation of this review is that the scope was limited to studies in the intelligence literature. Data noted in educational reports, such as PISA reports, were not reviewed, even though these at times reported regional scores and indices of development for the regions reviewed. For example, Reddy (2006, p. 48) provides a graph showing PISA and HDI scores and notes that there "seems to be a correlation between the provincial HDI and the provincial achievement scores". We did not attempt to calculate coefficients from these data or from other educational reports, which typically focus on the relation between educational attainment and inequality as measured by the Gini coefficient. Attempting to review this literature was judged to be beyond the scope of the present study, as the methods of analysis/data presentation and the research aims were substantially different from the studies that we did review.

5.1. Recommendations for future research

This quantitative review raised several methodological issues, which are worth pointing out to inform future research. First, as detailed in Section 3, there are numerous social and economic indicators that can be investigated in relation to cognitive ability. It would be advisable to include measures of several key outcomes such as the five examined in the quantitative review, and also to calculate a general SES variable.

Second, given the differences in population sizes between administrative units, it seems questionable to weigh them equally in analyses. As noted previously, this issue was first raised in the context of global analyses by Hunt and Sternberg (2006). The appropriate method is not clear; whether population weighting is reasonable may depend on the theoretical framework researchers are working from. Most authors did not weigh administrative units; however, some did, e.g., Carl (2016b) and Lynn, Antonelli-Ponti, et al. (2017). It would be helpful if authors were provided clear reasons that they weighted or refrained from weighing administrative units by population size, or if they could calculate both weighted and unweighted correlations for use in future reviews.

Third, capital cities were treated inconsistently across studies. Some authors excluded them on account of finding them to be factor structural outliers (e.g., Fuerst and Kirkegaard, 2016a,Fuerst and Kirkegaard, 2016b). Other studies included them (e.g., Lynn et al., 2017). Still others reported values both with and without the capitals (e.g., Carl, 2016b). The concern is that capital cities are often outliers with respect to specific socioeconomic outcomes given the amount of resources that can be diverted to them and the presence of government institutions. It would be helpful if authors explicated their rationale for exclusion/inclusion of federal districts.

Fourth, authors should consider using lower-level divisions to increase sample size and hence precision. Studies relying on only a few, e.g., 4 or 5 units (as for Finland and Portugal) are unlikely to produce stable results. Furthermore, using first order administrative level data has a high chance of resulting in aggregation effects, which occur when highly dissimilar units are averaged into a single unit, producing strong within-unit heterogeneity. The use of lower-level data would make it possible to aggregate the data into higher-level units and examine the consistency of results across levels of analysis, including factor-structure similarity of the general SES factor. Two such studies have been done (Kirkegaard, 2016b; Kirkegaard & Fuerst, 2017), both of which found fairly consistent results across levels.

Fifth, the literature shows a strong US-centric bias: there were no less than 15 studies of United States and a further 4 studies of counties in the United States. Researchers are urged to diversify focus. Within the last two decades, intra-national IQ and achievement data have become available for numerous countries, including many non-Western ones. Knowledge of the demographic and geoclimatic correlates of intelligence in a diverse sample of countries would help adjudicate between competing theoretical models for the causes of differences and the causal pathways by which these act. Further, to help evaluate between these models, researchers are urged to include proposed predictors such as ethnicity, parasite load, and geoclimatical variables like UV radiation, latitude, and temperature.

Sixth, researchers are advised to use modelling approaches that are more informative about causality than mere correlations, such as path models (e.g., León & Avilés, 2016) or cascade modelling (e.g., de Baca & Figueredo, 2014). If possible, researchers should locate cross-temporal data to allow for better tests of the proposed hypothesis. Several longitudinal studies of regional units have been carried out, though not by intelligence researchers (Deryugina & Hsiang, 2014; Fulford, Petkov, & Schiantarelli, 2016).

Seventh, regional data are known to be spatially autocorrelated, meaning that units close to each other are more similar than would be expected by chance. This results in correlated errors in models which possibly confound results (Gelade, 2008; Hassall & Sherratt, 2011). Several methods have been developed for examining spatial autocorrelation issues, but these have been inconsistently applied in the regional studies reviewed here (Fuerst & Kirkegaard, 2016a; Kirkegaard, 2016b; Lynn, Antonelli-Ponti, Mazzei, Silva, & Meisenberg, 2017). Generally speaking, these analyses found that confounding via spatiotemporal autocorrelation was not a serious issue for the links between intelligence and various outcomes, but the issue deserves more attention.

Eighth, only one study reviewed attempted to test for measurement invariance (MI) between regions (Lynn, 2012b). While it is not necessary to establish MI to investigate regional associations, it is necessary to establish MI to infer that the differences between regions have the same psychometric meaning as the differences between individuals within regions. For certain theoretical models, this is an important issue to explore.

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