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Inbreeding depression and IQ in a study of 72 countries

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ABSTRACT

In this ecological study, a robust negative correlation of $r=-.62$ ($P<.01$) is reported between national IQs and consanguinity as measured by the $\log_{10}$ transformed percentage of consanguineous marriages for 72 countries. This correlation is reduced in magnitude, when IQ is controlled for GDP per capita ($r=-.41, P<.01$); education index ($r=-.40, P<.01$); and democracy index ($r=-.42, P<.01$). Multiple regression analysis revealed that in the absence of the democracy index; percentage consanguineous marriages, education index and GDP per capita all exhibited stable final standardized β coefficients, however consanguinity had the least impact ($\beta=0, P>.05$) whereas GDP per capita had the highest ($\beta=.35, P>.01$). This result is interpreted in light of cultural feedback theory, whereby it is suggested that consanguinity could subtly influence IQ at larger scales as a result of small IQ handicaps bought about through inbreeding being amplified into much larger differences through their effect on factors that maximize IQ such as access to education and adequate nutrition. Finally, consideration is given to future potential research directions.

1. Introduction

Intelligence researchers have studied the effects of inbreeding on the psychological development of individuals extensively. “Consanguinity”, which can be broken down into *con* meaning ‘with’ and *sanguine* meaning ‘blood’, traditionally describes the property of two people sharing the same “blood line” which in a more modern sense equates to closely shared genetic heritage. Consanguineous marriages are described as those involving individuals who are biologically second-cousins or closer; defined in terms of the kinship coefficient (F) as having a kinship of greater than or equal to .0156 or 1/64 (Bittles et al., 2001).

Table 1 describes the range of potentially consanguineous relationships. Incestuous marriages (involving first-degree relatives) are generally strongly discouraged throughout the world, and in many countries, the most consanguineous legal relationship is the marriage of first-cousins (Bittles, 2004). Detrimental effects associated with inbreeding are attributable to the increased homozygosity of rare deleterious recessive alleles.

Consanguinity at the national level tends to be measured in two ways. Its genetic impact on a population can be described through the use of the mean inbreeding coefficient, α, which is the probability that an individual has inherited both alleles of a pair from a shared ancestor; alternatively, its prevalence (i.e. how common it is) can be estimated through a measure of the per capita percentage of consanguineous marriages.

1.1. An overview of the deleterious effects of consanguinity

The inbreeding depression that results from consanguinity has a variety of known deleterious correlates with factors that effect health, fitness and morbidity within Human populations. It has been suggested that it negatively impacts fertility due to the increase in the homozygosity of alleles that either prevent conception or have deleterious effects on embryonic development (Ober, Elias, Kostyu, & Hauck, 1992), similarly, fetuses produced via consanguineous mating are thought to be at a higher risk of being spontaneously aborted (Diamond, 1987; FitzSimmons & Tunis, 1984), in addition to being at a higher risk of spontaneous preterm birth and being born underweight (Carr-Hill, Campbell, Hall, & Meredith, 1987; Khlat, 1989). Intriguingly though, higher fitness has also been observed in consanguineous couples, where it has been speculated that it may occur as a compensatory mechanism

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Table 1
Table of consanguineous relationships along with values for the coefficients of kinship (*F*) and relatedness (*R*)

Consanguinity type	Nature of relationship	Kinship coefficient (*F*)	Coefficient of relatedness (*R*)
Full-siblings	Mating between individuals who share a full set of parents.	.25	.5
Parent–child	Mating between individuals and their biological offspring	.25	.5
Half-siblings	Mating between individuals who share a single parent	.125	.25
Grandparent–grandchild	Mating between individuals and the offspring of their offspring	.125	.25
Uncle/niece–aunt/nephew	Mating between the brothers or sisters of the father or mother and their offspring	.125	.25
Double first-cousins	Mating between individuals who are the offspring of two brothers marrying two sisters (of another family) who share each others grandparents	.125	.25
First-cousins	Mating between individuals who share a grandparent	.0625	.125
Half first-cousins	Mating between individuals whose parents are half-siblings	.0313	.0625
Double second-cousins	Mating between individuals whose parents are double first-cousins	.0313	.0625
Second-cousins	Mating between individuals who share a common great-grandparent	.0156	.0313

Note: The parental kinship coefficient *F* is numerically equivalent to the child's inbreeding coefficient, which is the child's likelihood of being homozygous as a consequence of parental consanguinity. The coefficient of relatedness *R* is two times the kinship coefficient and describes the fraction of the genome that is identical by descent in two related individuals.

for infant losses (Bittles, Grant, Sullivan, & Hussain, 2002; Schull & Neel, 1972; Tunçbilek & Koç, 1994). A recent study has also suggested that mild inbreeding (at the level of third and fourth-cousins) has been responsible for an increase in fertility amongst couples in Iceland, whereas close inbreeding reduced it. Iceland exhibits a high degree of socioeconomic heterogeneity, so the findings lend support to the theory that increases in homozygosity can enhance fertility through a variety of physiological and bio-behavioral mechanisms, provided they are relatively mild (Helgason, Pálsson, Guðbjartsson, Kristjánsson, & Stefánsson, 2008).

Consanguineous mating is known to increase the incidence of physical deformities and diseases, including childhood blindness (Baghdassarian & Tabbara, 1975), neonatal diabetes mellitus (Brickwood et al., 2003) and limb malformations (Breuning et al., 2000). A study by Jaber, Halpern, and Shohat revealed that the overall incidence of congenital malformations was 2.5 times higher amongst the offspring of consanguineous mating when compared to the offspring of non-consanguineous mating (1998). Consanguinity is also thought to predispose offspring to neuropsychological disorders such as hereditary parkinsonism (Mitsui, Kawai, Sakoda, Miyata, & Saitio, 1994).

1.2. Deleterious effects on IQ at individual data levels

The study of Bashi (1977) revealed that the extent to which consanguinity affects IQ is proportional to the degree of inbreeding. He found that based on the outcomes of three tests of cognitive ability, the children of double first-cousins (within an Arab population) exhibited on average significantly greater inbreeding depression of test scores than the children of first-cousins, who in turn scored lower than the children of non-consanguineous parents. Bashi also noted that the children of double first-cousins exhibited larger variance in test scores than the children of first-cousins. These findings tend to disconfirm environmentalist theories such as those of Kamin (1980), who proposed that socioeconomic status is the dominant factor in determining the IQ of the offspring of consanguineous mating.

Jensen concluded based on a survey of the literature that consanguinity involving first-cousins leads to an inbreeding depression of between 2.5 and 3.5 IQ points on average (Jensen, 1983; see also Bashi, 1977; Goldschmidt, Cohen, Bloch, Keleti, & Wartski, 1963; Neel et al., 1970; Schull & Neel, 1965, 1972; Slatis & Hoene, 1961), although as Jensen notes, not all of these studies generated statistically significant results owing to small sample sizes. More recent studies have reported significant reductions of means in test scores of the magnitude reported by Jensen, associated with the children of consanguineous mating amongst Indian Muslims (Agrawal, Sinha, & Jensen, 1984; Badaruddoza, 2004; Badaruddoza & Afzal, 1993).

The most pronounced effects of a consanguineous decline in IQ of the magnitude reported will be on the proportion of the group whose IQ's fall below 70 (Jensen, 1983). A study by Böök (1957) revealed an incidence of mental retardation that was over three times higher among the offspring of first-cousin consanguineous mating, when compared to a control group of non-consanguineous children in Sweden. The study used indicators of scholastic performance (grades, teacher ratings) in order to assess its subjects.

A familial study conducted by Reed and Reed (1965) similarly revealed an incidence of mental retardation among the children of first-cousins that was four times greater than in the controls. The study of Morton (1978) study revealed that the offspring of first-cousins had over a five times higher risk of mental retardation when compared to controls. The study concluded that declines in IQ and the increase of mental retardation are consistent with rare recessive alleles associated with around 325 loci, whose likelihood of being transmitted into offspring increases with the relatedness of the parents. The study of Madhavan and Narayan (1991), which reported a similarly significantly high increase in the incidence of retardation, noted that within their sample the risks were highest in cases involving uncle–niece relationships.

1.3. Deleterious effects on IQ at national data levels

Ecological research (research at the national data level) is capable of yielding valuable insights into the structure of the relationships between variables of psychological significance at large scales, however such research has to be careful so as to avoid the ecological fallacy, namely the tendency to make inferences about individuals based upon the correlative properties of large groups. In previously noting the individual data level effects on IQ of inbreeding depression, a legitimate question to ask is whether these inbreeding effects can be observed in the differences in IQ scores between countries where there are also differences in the levels of consanguinity.

The most comprehensive source of data on national IQs is the work of Lynn and Vanhanan, who demonstrated the existence of a significant correlation ($r=.68$) between $\log_{10}$-GDP per capita (gross domestic product per capita income) and the IQs calculated for 81 countries (2002). A follow up to this work, which expanded the sample size to 113 countries, re-confirmed the 2002 estimates and derived a new correlation of $r=.60$ (based on 2002 GDP per capita data), which took into account 192 countries (2006). Rindermann has additionally demonstrated the existence of a strong *g*-factor of differences between countries that emerges from the intercorrelation of tests of international cognitive achievement such as PISA, TIMSS and PIRLS ($r=.60$–.98), and IQ ($r=.85$–.86), this lends support to the arguments of Lynn and Vanhanen (Rindermann, 2007).

Based on these findings, intelligence is considered to be one of the most important variables influencing the differential affluence of countries. It is probable that, as IQ is influenced by both genetic and environmental factors, it influences GDP per capita and is in turn, to a certain degree, influenced by GDP per capita via positive feedback (Lynn & Vanhanen, 2006; Rindermann, 2008).

To date only a single study has attempted to examine the relationship between IQ and consanguinity at the national data level (Saadat, 2008). In the study, national IQ scores were independently derived following the methodology of Lynn, Meisenberg, Mikk, and Williams (2007). The mean inbreeding coefficients (α—the aforementioned probability of an individual inheriting both alleles of a pair from a shared ancestor) of 35 countries were used as a measure of consanguinity. These were derived from values for α listed by Alan Bittles, a community geneticist who has compiled a comprehensive web database of publications reporting on international consanguinity statistics (Bittles, 2001). Saadat's study concluded that a significant negative correlation of $r=-.77$ exists between national IQ and $\log_{10}\alpha$. The confounding effects of $\log_{10}$GDP per capita on IQ were also corrected for, which resulted in a significant correlation of $r=-.55$ (Saadat, 2008).

In this study, the correlation between national IQ and consanguinity will be investigated with respect to the prevalence of consanguinity, as measured by the percentage of consanguineous marriages. These data will be used in preference to values for α, as they represent a much larger dataset (72 countries). This study also aims to go beyond Saadat's study, as the robustness of the relationship between the variables will be explored, controlling for background variables, in addition to which the stability of coefficients in different samples will assessed along with the strength of their impacts when considered in the context of important social factors.

2. Methods

Consanguinity percentages were obtained for 72 countries in total. The data were sourced from a total of 201 studies, whose results were summarized by Bittles (2001), with a combined sample size of 5,688,158 individuals. In the event that there were multiple studies for a single country, the average (weighted by sample size and number) was taken. Data on national intelligence levels were obtained from Lynn and Vanhanen (2006). The range of countries was restricted by the availability of consanguinity data.

Data were also obtained for the controlling variables; GDP per capita; education; and (liberal) democracy. Data for GDP per capita and education (index) were obtained from the *Human Development Report 2007/2008* (UN Development Program, 2008) and data on democracy were obtained from the *Economist Intelligence Unit's Democracy Index*. There have been a variety of attempts to reduce democracy to a unitary measure. The metrics that have resulted can be described as being either "thin" or "thick" depending on the breadth of criteria that they consider when evaluating comparative levels of democratization (Coppedge, 2005). The EIU democracy index considers prior metrics based on measures of political freedom or civil liberties to be insufficiently "thick" in that they typically fail to assess the substantiality and quality of democracies. The EIU democracy index addresses this by taking into account five key dimensions: electoral process and pluralism; civil liberties; government function; political participation; and political culture (Kekic, 2007).

For the purposes of this study these data were $\log_{10}$ transformed in order to normalize their skewed distributions.

3. Results

3.1. Correlation analysis

A correlation of $r=-.62$ ($N=72, P<.01$) was found between national IQ and $\log_{10}$percentage of consanguineous marriages. The .95 and .99 confidence intervals for this correlation are (lower limit) −.74 and (upper limit) −.45, and (lower limit) −.78 and (upper limit) −.39 respectively. In order to compare this to Saadat's result, his values of α were correlated with the percentage marriage values for 35 countries. A correlation of $r=.96$ ($P<.01$) was found between the variables.

3.2. Correlation with another measure of cognitive ability

Rindermann's (2007) adjusted PISA 2000–2003 averages for 27 countries were correlated with equivalent values for $\log_{10}$ percentage consanguineous marriages. A correlation of $r=-.59$ ($P<.01$) was obtained.

3.3. Stability analysis

To see if the magnitude of the correlation was robust to differences in decision rules, five separate analyses of stability were performed. For the first analysis, the data set in which the

Table 2
Quality category correlations

Quality category	Correlation coefficient (r)	Sample size N
1	***−.52	42
2	*−.62	10
3	***−.57	19

*$P>.05$; ***$P\leq.01$.

Table 3
Randomized trial correlations

Randomized trial number	Correlation coefficient (r)
1	***−.68
2	***−.70
3	***−.68

$N=36$ in all cases. ***$P\leq.01$.

Table 4
Variations in the strength of the correlations with IQ that result from the decomposition of the percentage consanguineous marriage data into three magnitude classes

% Consanguineous marriages	Correlation coefficient (r)	Sample size (N)
<1%	*−.16	17
1–11%	*−.13	25
17–>50%	***−.37	30

*$P>.05$; ***$P\leq.01$.

values for percentage marriages were weighted was compared with another, in which only the highest scores were used along with scores for the majority ethnicity. The correlation obtained between IQ and percentage consanguineous marriages for the unweighted data set was $r=-.63$ ($N=72$, $P<.01$).

The second stability analysis involved the dropping of certain cases and the re-correlation of the remaining data in order to establish whether or not there was an effect on the magnitude of the correlation. For this analysis the percentage marriage and IQ scores for five countries, which were sampled using scores for percentage marriages derived from populations resident in one part of the world but representative of another, were dropped. The resultant correlation was $r=-.62$ ($N=67$, $P<.01$). The correlation that resulted from dropping the fourteen countries for which percentage marriage data were only available for a single region was $r=-.52$ ($N=58$, $P<.01$). For the third stability analysis, the data were recoded into three categories based on their quality. This was determined based on how representative of the whole country the data were deemed to be. Data from studies that had been conducted for the entire region were put into the highest quality category (1), data from studies that broke countries down on an ethnic, religious or geographic basis were put into the next highest quality category (2), and finally data from studies that only took into account single regions or involved populations representative of one country resident in another were consigned to the lowest data quality category (3). The results are presented in Table 2.

Table 2 indicates that the correlation between IQ and consanguinity was strongest (in terms of magnitude) in cases where the data were broken down on some demographic basis, however the strength of this correlation is probably an artifact of the small sample size as it is not significant. The next strongest correlation involved countries where data were only collected from displaced populations or from single regions, this correlation was significant despite a relatively small sample size. The weakest correlation involved countries for which regional studies had been conducted.

The fourth stability analysis involved the trichotomization of the consanguinity data along quantitative lines, following the protocol of McDaniel and Whetzel (2004, 2006). The data were recoded into three categories (1, 2 and 3), each representing ranges for % marriages (<1%, 1–11%, 17–>50%). The correlation between the trichotomized variable and IQ was $r=-.59$ ($P<.01$).

For the fifth stability analysis 50% of the consanguinity data were sampled at random and then correlated, this was repeated three times. The results are presented in Table 3.

Table 3 indicates that reducing the sample size increases the magnitude of the correlation between IQ and consanguinity, and that iterative randomization had little subsequent effect on the magnitude.

Table 6
Table of results for partial correlation analyses

Variables correlated	Partial correlations (r)
IQ/$\log_{10}$% marriages ● $\log_{10}$GDP per capita	***−.41
IQ/$\log_{10}$% marriages ● $\log_{10}$Education index	***−.40
IQ/$\log_{10}$% marriages ● $\log_{10}$Democracy index	***−.42

$N=72$ in all cases. ***$P\leq.01$.

Table 7
Results of a multiple regression analysis in which consanguineous marriages, education index, democracy index and GDP per capita are used to explain the variation in IQ of 72 countries (multiple $r=.76$)

Variable	Standardized regression coefficient (β)	Standard error	T statistic
Intercept	*<.01	.08	<.01
$\log_{10}$% marriages	*0	.12	0
$\log_{10}$ education index	**.24	.11	2.07
$\log_{10}$ democracy index	*.09	.11	.77
$\log_{10}$ GDP per capita	***.34	.11	.77

*$P>.05$; **$P\leq.05$; ***$P\leq.01$.

3.4. Ethno-demographic correlations

In order to study the possibility that ethnicity might function as a predictor of consanguinity, the countries were grouped based on percent consanguineous marriage into different magnitude categories (as with the trichotomization analyses) and then correlated with IQ as separate subgroups.

Table 4 indicates that the highest magnitude correlation ($r=-.37$) was found in countries where the consanguinity levels were between 17 and >50%. In nearly all of these cases, Middle Eastern Muslim or African ethnicities were dominant. The next lowest magnitude correlation ($r=-.16$) was found in countries where the consanguinity levels were less than 1%.

Table 5
Correlation table

	$\log_{10}$GDP per capita	$\log_{10}$democracy index	$\log_{10}$education index	$\log_{10}$% consanguineous marriages
$\log_{10}$% consanguineous marriage	***−.54	***−.71	***−.57	***1
IQ	***.67	***.52	***.64	***−.62

$N=72$ in all cases. ***$P\leq.01$.

The lowest magnitude correlation ($r = -.13$) was found in countries where the consanguinity levels were between 1 and 11%. In nearly all of these cases, either European, Hispanic or Asian ethnicities were dominant.

3.5. Partial correlation analysis

Partial correlation analysis was carried out in order to eliminate the effects of three possible confounding variables on IQ: GDP per capita, education and democracy. The various correlations that contributed to the analysis are presented here in a correlation table (Table 5). The results of the partial correlation analysis are presented in the subsequent table (Table 6).

Table 5 indicates that the correlation between IQ and democracy index was the weakest whereas the correlation between consanguinity and democracy was the strongest, in terms of correlation magnitude.

Table 6 indicates that the effects of controlling for each of the variables relative to IQ reduced the overall strength of the correlation between IQ and consanguinity, but that each variable had a similar overall effect on the magnitude of the correlation, with education index having the highest impact and democracy having the lowest in terms of correlation magnitude.

3.6. Multiple regression analysis

Correlative analysis alone cannot address the issue of the relative significance of independent variables. In order to investigate the effects of these variables a multiple regression analysis was performed using the best subset method, in which the effects of removing a variable on the remaining variables was determined through the stability of the final standardized regression (β) coefficients.

Table 7 indicates that consanguinity is independent of the other variables as it has a standardized β coefficient of 0. Democracy index and education index had the next highest impacts respectively, followed by GDP per capita, which had the largest overall impact on IQ. In the next analysis the effect of removing democracy from the model on the stability of the β coefficients of the other variables will be examined.

Table 8 indicates that consanguinity does not increase in its impact as an explanation for the variation in national IQ independently of education index and GDP per capita.

The conclusion is that in the presence of the other predictors, democracy index can be ignored as percentage consanguineous marriages, education index and GDP per capita exhibit stable final standardized β coefficients and GDP per capita is consistently the strongest predictor in terms of β coefficient magnitude.

Table 8

Results of a multiple regression analysis in which consanguineous marriages, education index and GDP per capita are used to explain the variation in IQ of 72 countries (multiple $r = .76$)

Variable	Standardized regression coefficient (β)	Standard error	*T* statistic
Intercept	*<.01	.08	<.01
$\log_{10}$% marriages	*0	.10	0
$\log_{10}$ education index	**.24	.11	2.12
$\log_{10}$ GDP per capita	***.35	.11	3.20

*P>.05; **P≤.05; ***P≤.01.

4. Discussion

4.1. Summary of findings

The reported correlation between IQ and consanguinity as a percentage of marriages seems robust to differences in decision rules concerning the way in which the data are correlated. The trichotomization analysis specifically indicates that the correlation is highly robust to imprecise estimates of percentage consanguinity, which indicates that highly precise estimates of percentage consanguineous marriage are not required in order to establish the reality of a strong correlation with IQ. Additionally, it has been found that metrics for both the prevalence and impact of consanguinity on a population may be used as reliable proxies for one another, owing to the high correlation between values for percentage marriage and α within 35 countries ($r = .96$, $P < .01$).

The presence of a significant correlation between the results of the PISA 2000–2003 averages and percentage consanguineous marriages for 27 countries ($r = -.59$, $P < .01$) adds weight to the potential meaningfulness of the correlation between IQ and consanguinity at national data levels, as the correlation has been demonstrated using a cognitive ability test stemming from a different psychometric tradition.

The partial correlation analysis indicates that the three confounding variables (GDP per capita, education index and democracy index) all have very similar effects on the magnitude of the correlation when they are controlled for (relative to IQ), however education index seems to have a slightly stronger effect than the others.

The multiple regression analysis reveals that in the absence of democracy index; education index, consanguinity and GDP per capita all exhibit stable final β coefficients, with consanguinity having the weakest impact ($\beta = 0$, $P > .05$) and GDP per capita having the strongest impact ($\beta = .35$, $P < .01$). It is evident however that the impact of GDP per capita cannot explain the whole of the variation in national IQ independently of the other variables, as the magnitude of the multiple correlation ($r = .76$) is greater than the correlation between IQ and GDP per capita ($r = .67$). Democracy was expected to be the most causally decoupled of the variables (aside from percentage consanguineous marriages) as its correlation with IQ was the weakest ($r = .52$).

4.2. Consanguinity in the context of national IQ differences

Despite a seemingly significant and robust correlation between consanguinity and IQ at individual levels, differences in the levels of national consanguinity do not seem able to account in any way for differences in the levels of national IQ, especially when considered in the context of other variables such as education index and GDP per capita. One possible explanation for this is that consanguinity involving first-cousins tends to reduce IQ in the offspring by only three points on average, however IQ differences between countries can be greater than 40 points, indicating a role for other, far more potent factors in creating these differences.

Even though based on the results of the multiple regression analysis, differential consanguinity does not seem to account for any of the variation in national IQ, it may in fact still account for a fraction of the variance if cultural feedback mechanisms are taken into consideration. This interactionist approach would predict that relatively small genetic disadvantages in IQ due to high levels of consanguinity could be subtly amplified into far greater disadvantages at the national level through both direct and indirect cultural feedback. The potential chain of causation in this case would involve mildly genetically disadvantaged populations being less able to optimize the most significant environmental factors that would permit for IQ maximization, such as ensuring access to nutrition through the provision of adequate diets, which would in turn detrimentally influence the degree to which that population could provide for factors which may confer additional gains in IQ, such as a certain minimum level of economic development and educational quality. This approach has been previously used in efforts to explain both the Flynn effect (Dickens & Flynn, 2001) and differences in national IQ scores (Meisenberg, 2003).

4.3. Research questions

This study raises three fundamental questions that could form the basis of future research in this area.

4.3.1. Direction of causality

Assuming strong cultural feedback as an explanation for the correlation between IQ and consanguinity at the national data level, a necessary question to ask concerns the direction of causality. It has been established already that at individual data levels, consanguinity involving first-cousins reduces the IQ in the offspring by around three points on average, however a role for low IQ's in predisposing individuals to consanguineous relationships cannot be ruled out either. A hypothetical mechanism through which this may occur involves the possibility that IQ and geographic mobility have traditionally correlated positively. In this instance, the lower geographic mobility of those with lower IQ's increases their likelihood of inbreeding, which in turn decreases the IQ of their offspring creating a positive feedback effect. Some evidence in support of this has been found by Weiss (1980), who observed that based on the frequencies of inbreeding within two German towns (as measured by the incidence of isonymy determined through parish records), when the populations are grouped based on occupation into upper (owners and professionals) and lower (workers) strata, those of the upper stratum were found to marry at both greater geographic and genetic distances. As IQ and occupational prestige are known to correlate positively (Kanazawa & Kovar, 2004), this observation could be taken as evidence of the aforementioned hypothesis that lower IQ's reduce geographic mobility and increase the likelihood of inbreeding. More data from larger samples would be required in order to determine how substantial this putative relationship is however.

4.3.2. Ethnicity as a predictor of consanguinity

At national data levels, ethnic group membership may be a predictor of how well IQ and consanguinity correlate in general. Evidence of this is presented in Section 3.4, where it was found that the first and least strongest correlations (which represented countries where the dominant ethnicities were African/Middle Eastern Muslim and Asian/Caucasian/Hispanic respectively) differed by only five countries in terms of sample size, but seemed to differ considerably in terms of correlation magnitude ($r = -.37$ vs. $r = -.13$). The implication of this finding is that the African and Middle Eastern Muslim ethnicities may be more predisposed towards consanguineous relationships than other ethnic groups. Reasons for this may include the fact that double first-cousin marriages are recognized within Islam, although it has been noted that there is no specific encouragement of consanguinity within the religion (Akrami & Osati, 2007). Tribal social structures may also be a strongly predisposing factor, as tribes are partly outbred extended families, membership in which increases the likelihood of an individual inbreeding when mating with another member of the same tribe (Hussain, 1999; Hussain & Bittles, 1998). It must be noted that despite this observation, the two weaker correlations were non-significant, however a potentially fruitful avenue of future research would be to explore the role of specific metrics for ethnicity as predictors of consanguinity with reference to larger and more comprehensive data sets.

4.3.3. Estimating national declines in IQ through consanguinity

It is evident that IQ and consanguinity correlate significantly at national data levels, however, allowing for extensive degrees of cultural feedback, in order to estimate the degree to which consanguinity has contributed to the decline of a countries' IQ, much more data than is currently available would be needed. Ideally, data from large scale IQ testing of both consanguineous and non-consanguineous groups within a variety of different countries would be needed so as to establish the precise degree of the impact (if any) of consanguinity on a countries' average IQ. Similarly, in order to infer how this has contributed to any declines in IQ over time, reliable data on the historical changes in the patterns of consanguinity within a given country would be needed, in addition to reliable data on IQ fluctuations and the degree to which consanguinity persists within family lines. As the declines in IQ caused by consanguinity are due to increases in the homozygosity of rare recessive alleles, the only factor that would stop this from being a 'one off' event in the offspring of consanguineous mating, would be if they in turn mated consanguineously. It is possible (very probable even) that consanguinity persists across generations within family lines, however a thorough investigation would be needed. Finally a clear path of causation would need to be delineated involving the various cultural mechanisms, through whose sub optimal manifestation IQ would be compromised at national levels due to genetic handicaps at individual levels. Interestingly enough a theoretical case has recently been made for heterosis (hybrid vigor) being a potential driver of the Flynn effect (Mingroni, 2007). If this is indeed the case then it is suggestive of the idea that global consanguinity levels have been in decline in recent decades.

Undertaking the aforementioned research would in theory be an especially valuable exercise as such data would allow the IQ gains that may result if consanguinity were to be effectively discouraged, to be predicted, allowing for an accurate assessment of the utility of such initiatives.

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Appendix A

Values for percentage of consanguineous marriages by country arranged in descending order or IQ, along with the combined sample size, the years in which the studies were conducted, a quality rating based on the scale developed for the analysis and the types of consanguinity identified.

Country	% consanguineous marriages	Sample size	Year(s) of measurements	Number of studies	Data quality	Consanguinity types
Hong Kong	1.8	9749	1961/4	1	1	>1C 1C <1C
Singapore	5.0	39,333	1961/4	2	1	>1C 1C <1C
Japan	4.8	18,610	1972 1983	10	1	1C $1^{1/2}$C 2C
China	2.4	78,234	1949/67 1987 1981/91	8	2	UN 1C $1^{1/2}$C D2C 2C
Italy	0.5	340,693	1953	4	1	UN AN 1C 2C
Mongolia	0.5	446	1951/76	1	3	1C
Netherlands	0.2	351,085	1948/53	1	1	UN 1C
Norway	0.7	1,295,612	1967/72 1967/81	2	1	UN 1C $1^{1/2}$C 2C
Great Britain	0.3	8594	1950/51 1972/73 1986/87	3	2	1C $1^{1/2}$C 2C
Belgium	1.0	605,849	1950/59	1	1	UN 1C $1^{1/2}$C 2C
Canada	1.5	51,729	1959	2	1	1C $1^{1/2}$C 2C
Sweden	0.6	15,802	1946/50	2	1	1C 2C
Australia	0.3	73,912	1961/64 1994/99	2	2	<1C 1C $1^{1/2}$C 2C
Czechoslovakia	0.2	19,726	1961/4	1	1	>1C 1C <1C
France	0.8	510,000	1946/58	2	1	UN 1C $1^{1/2}$C 2C
Hungary	0.1	103,891	1946 1971	1	1	UN AN 1C 2C
Spain	4.1	–	1940/3	9	1	UN 1C $1^{1/2}$C 2C
USA	0.2	133,228	1959/60	3	1	1C $1^{1/2}$C 2C
Uruguay	4.5	2931	1956/7	3	1	UN 1C $1^{1/2}$C 2C
Portugal	19.0	276,800	1952/5	2	1	UN 1C
Israel	1.5	35,263	1955/7 1969/70 1970/2000 1976/83 1981/5 1990/2 1992	8	2	UN D1C IC $1^{1/2}$C 2C
Kazakhstan	2.9	1079	1951/76	1	3	D1C 1C 2C
Argentina	0.5	270,205	1956/7 1967/79 1980/1	4	1	UN 1C $1^{1/2}$C 2C
Malaysia	7.6	15,658	1961/4	1	3	>1C 1C <1C
Érie (Republic of Ireland)	0.5	149,029	1959/68	1	1	UN D1C 1C $1^{1/2}$C D2C 2C
Chile	1.3	28,596	1956/7	4	1	UN 1C $1^{1/2}$C 2C
Croatia	0.1	8309	1961/4	1	3	>1C 1C <1C
Kyrgyzstan	45.2	2863	–	1	3	D1C 1C $1^{1/2}$C 2C
Turkey	21.1	67,867	1970/87 1988 2003/4	8	1	D1C 1C $1^{1/2}$C 2C
Costa Rica	3.4	3833	1954	1	1	UN 1C $1^{1/2}$C 2C
Ecuador	6.3	3954	1956/57	2	1	UN 1C $1^{1/2}$C 2C
Mexico	1.3	28,192	1956/57	2	1	1C $1^{1/2}$C 2C
Bolivia	0.6	4130	1956/57	2	1	UN 1C $1^{1/2}$C 2C
Brazil	4.8	2328	1967/79	8	1	UN 1C $1^{1/2}$C 2C
Indonesia	17.8	970	1990	1	3	1C $1^{1/2}$C 2C
Iraq	33.0	23,937	2004	3	1	D1C 1C
Tajikistan	42.8	1325	–	1	3	D1C 1C $1^{1/2}$C 2C
Uzbekistan	23.3	159	–	1	3	1C $1^{1/2}$C 2C
Kuwait	39.9	9360	1967/68 1983	2	1	D1C 1C $1^{1/2}$C 2C
Philippines	0.4	29,143	1961/64	1	3	<1C 1C >1C
Cuba	0.8	2277	1956/57	1	1	1C $1^{1/2}$C 2C
Peru	4.1	565	1956/57	2	1	UN 1C $1^{1/2}$C 2C
Yemen	33.9	9762	1997	2	1	1C
Afghanistan	55.4	168	1995	1	3	1C $1^{1/2}$C 2C
Colombia	3.0	34,470	1956/57	2	1	UN 1C $1^{1/2}$C 2C
Iran	32.2	323,457	1972/75 2001	3	2	UN D1C IC 2C
Jordan	39.7	1989	1969/79	5	1	D1C 1C $1^{1/2}$C 2C
Morocco	19.9	4773	1982/92	1	1	1C 2C
Pakistan	61.2	6611	1990/91	11	1	1C 2C
Panama	1.7	15,873	1961/64 1956/57	2	1	–
Puerto Rico	3.3	6013	1954	1	3	UN 1C $1^{1/2}$C 2C
Saudi Arabia	39.7	3355	1980's	7	1	1C 2C
UAE	36.0	2033	1994/95	1	2	D1C 1C $1^{1/2}$C 2C
Venezuela	1.3	1517	1967/79	1	1	D1C 1C $1^{1/2}$C 2C
Algeria	22.6	120,491	1979	1	1	1C 2C
Bahrain	44.4	10,711	1983 1989	3	3	1C $1^{1/2}$C 2C
Oman	35.9	61,395	1994/97 1995	1	1	D1C 1C $1^{1/2}$C 2C
Tunisia	26.9	5767	–	1	3	1C $1^{1/2}$C 2C
Bangladesh	10.5	12,266	1966 1976	1	2	1C 2C
India	24.7	335,489	1957/58 1959 1961/64 1966 1968/68 1969/71 1971/72 1969/74 1980/89 1981/84 1982 1992/93	23	2	UN AN 1C $1^{1/2}$C 2C

Appendix A (*continued*)

Country	% consanguineous marriages	Sample size	Year(s) of measurements	Number of studies	Data quality	Consanguinity types
Lebanon	25.1	6458	1981/82 1983/84	2	2	1C $1^{1/2}$C 2C
Egypt	28.9	53,613	1970's	5	1	D1C 1C $1^{1/2}$C 2C
Honduras	3.4	3759	1956/57	1	1	1C $1^{1/2}$C 2C
El Salvador	4.9	2494	1956/57	1	1	1C $1^{1/2}$C 2C
Sri Lanka	21.5	455	1973	1	3	1C 2C
Qatar	44.5	1515	2004	1	3	D1C 1C $1^{1/2}$C 2C
South Africa	2.8	23,754	1961/64	1	2	>1C 1C <1C
Tanzania	37.8	503	–	1	3	1C
Sudan	50.1	12,665	1969/74	2	2	1C 2C
Nigeria	51.2	489	–	1	3	UN 1C $1^{1/2}$C 2C
Burkina Faso	65.8	308	–	1	3	1C 2C
Guinea	25.9	739	–	1	3	1C $1^{1/2}$C 2C

Note: UN = uncle/niece, AN = aunt/nephew, D1C = double first-cousins, 1C = first-cousins, $1^{1/2}$C = first half-cousins, D2C = double second-cousins, 2C = Second-cousins.

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