The role of height in the sex difference in intelligence

SATOSHI KANAZAWA and DIANE J. REYNIERS
London School of Economics and Political Science

Recent studies conclude that men on average have higher intelligence than women by 3–5 IQ points. However, the ultimate evolutionary question of why men should have evolved to have higher intelligence than women remains. We suggest that men may have slightly higher intelligence than women through 4 mechanisms: (1) assortative mating of intelligent men and beautiful women, (2) assortative mating of tall men and beautiful women, (3) an extrinsic correlation between height and intelligence produced by Mechanisms 1 and 2, and (4) a higher-than-expected offspring sex ratio (more sons) among tall (and hence intelligent) parents. Consistent with our suggestion, we show that men may have higher IQs than women because they are taller, and once we control for height women have slightly higher IQs than men. The correlation between height and IQ and the female advantage in intelligence persist even after we control for health as a measure of genetic quality, as well as physical attractiveness, age, race, education, and earnings. Height is also strongly associated with intelligence within each sex.

The question of whether there is a sex difference in intelligence in the population has remained a controversial topic in psychometrics over the years (Jensen, 1998, pp. 531–543). It has long been part of the conventional wisdom in intelligence research that men and women have the same mean IQ, but men have greater variance than women (Geary, 1998, pp. 309–310, 313–315). Most recently, however, a series of studies have shown that men on average may have a slightly higher mean IQ than women.

In two comprehensive meta-analyses, Lynn and Irwing (2004; Irwing & Lynn, 2005) concluded that men were slightly but consistently more intelligent than women. In the first, Lynn and Irwing surveyed 57 studies of sex differences in the general population in performance on Raven's Standard and Advanced Progressive Matrices, which are considered to be the most reliable test of general intelligence. They concluded that, among adults, men scored about 5 IQ points higher than women. In the second meta-analysis, Irwing and Lynn conducted a similar survey of 22 studies of sex differences among university students and concluded that men scored higher than women by 3.3 to 5.0 IQ points.

Although there has been academic debate about Lynn and Irwing's findings (Blinkhorn, 2005; Irwing & Lynn, 2006; Blinkhorn, 2006), more recent studies seem to support Lynn and Irwing's conclusion. For

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example, Nyborg's (2005) analysis of a representative Danish sample showed that men on average had higher intelligence by 3.15 IQ points. Colom, Garcia, Juan-Espinosa, and Abad's (2002) study of a Spanish standardization sample for the Wechsler Adult Intelligence Scale III suggested that men had higher intelligence than women by 3.6 IQ points. Jackson and Rushton (2006) analyzed SAT scores of more than 100,000 American adolescents in 1991 and found that men scored 3.63 IQ points higher than women. The SAT is considered to be a good measure of general intelligence (Frey & Detterman, 2004; Kanazawa, 2006a). Finally, Arden and Plomin's (2006) longitudinal study of white British twins from birth through age 10 showed that although girls had significantly higher mean general intelligence from age 2 to 7, boys had a significantly higher mean by age 10. In contrast, a study of a Spanish sample suggested that the male advantage in intelligence might not emerge until age 14 (Colom & Lynn, 2004).

Although there appears to be emerging evidence that men on average may have slightly higher general intelligence than women, these analyses leave unresolved the ultimate evolutionary question of *why*. Why should men have evolved to have higher intelligence than women? General intelligence is the ability to reason deductively or inductively, think abstractly, use analogies, synthesize information, and apply it to new domains (Gottfredson, 1997; Neisser et al., 1996). The *g* factor, which is often considered synonymous with general intelligence, is a latent variable that emerges in a factor analysis of various cognitive (IQ) tests. They are not exactly the same thing; *g* is an indicator or measure of general intelligence, not general intelligence itself (Kanazawa, 2007c, p. 284n).

There are two possible explanations for higher intelligence among men. First, some argue that the traditionally male task of hunting has been cognitively more demanding, and has thus required higher intelligence, than the traditionally female task of gathering throughout human evolutionary history (Kaplan, Hill, Lancaster, & Hurtado, 2000; Lynn, 1994). It often takes 10 to 20 years of experience for men to learn to identify and track prey (Gurven, Kaplan, & Gutierrez, 2006).

Second, sex differences in mate preferences (women prefer to mate with intelligent men, whereas men choose women on the basis of other qualities such as youth and physical attractiveness) can also lead to sex differences in intelligence (Miller, 2000). Sexually dimorphic traits are often caused by sexual selection rather than natural selection. Sawaguchi (1997) suggested that social complexity was a component of intrasexual male competition. Given that male intrasexual competition for mates is much more intense than female intrasexual competition for mates, this could also lead to higher intelligence among men.

Both of these explanations predict a *genuine* sex difference in intelligence, in which men are actually more intelligent than women. In support of this prediction, some point out that men have larger brains than women, even after adjusting for body size (Ankney, 1992; Rushton, 1992), and brain size is significantly positively correlated with intelligence (Jensen & Sinha, 1993). However, this does not explain why male advantage in IQ does not emerge until after puberty, given that boys have larger brains than girls, adjusted for body size, from birth onward (Jackson & Rushton, 2006).

Theories of the evolution of general intelligence (Kanazawa, 2004, 2008), including Lynn's (2006) own account of the evolution of race differences in intelligence, suggest that general intelligence evolved to solve evolutionarily novel problems of survival and reproduction in new ecological niches, brought about by migration or climate change.[1] Despite the universal sexual division of labor among hunter–gatherer groups, on the whole men and women have occupied the same ecological niches throughout human evolutionary history, and there is therefore no reason to believe that men have faced more evolutionarily novel adaptive problems to solve. If the fauna that our male ancestors hunted was novel because they migrated to a new ecological niche, then the flora that our female ancestors gathered must also have been equally novel (although animals, unlike plants, move around, migrate, and try to evade hunters). If general intelligence evolved to deal with evolutionarily novel problems, why should men be more intelligent than women?

Here we suggest an alternative explanation for why men may have evolved to have slightly higher intelligence than women. It involves four separate mechanisms.

1. *Assortative mating of intelligent men and beautiful women.* If intelligence is desirable in men (because intelligence, at least in evolutionarily novel

environments, often leads to higher status and greater resources) and beauty is desirable in women (because beauty is an indicator of health and fecundity), then there should be assortative mating between intelligent men and beautiful women and between less intelligent men and less beautiful women. Because both intelligence and physical attractiveness are highly heritable, such assortative mating will produce an extrinsic correlation between intelligence and beauty (Kanazawa & Kovar, 2004).

2. *Assortative mating of tall men and beautiful women.* If height is desirable in men (because bigger and taller men can provide better physical protection for their mates and children and because taller men on average make better hunters and warriors and thus have higher status), as recent evolutionary psychological research shows (Nettle, 2002; Pawlowski, Dunbar, & Lipowicz, 2000), although the crucial measure of body size may be weight in nutritionally poor environments, and beauty is desirable in women, then there should be assortative mating between tall men and beautiful women. Because both height and physical attractiveness are highly heritable, such assortative mating will produce an extrinsic correlation between height and beauty.

3. *An extrinsic correlation between height and intelligence.* Mechanisms 1 and 2 produce an extrinsic correlation between height and intelligence. Since the end of the 19th century (Porter, 1892), psychometricians have known that body size (height and weight) positively correlates with intelligence (Jensen & Sinha, 1993; Schreider, 1964; Tanner, 1969; Case & Paxson, 2006).

4. *Higher-than-expected offspring sex ratios (more sons) among tall parents.* The generalized Trivers–Willard hypothesis (gTWH) (Kanazawa, 2005) suggests that parents who possess any heritable trait that increases the male reproductive success at a greater rate than female reproductive success in a given environment will have a higher-than-expected offspring sex ratio (more sons). The gTWH has been confirmed with respect to several different heritable traits (Kanazawa, 2006c, 2007a; Kanazawa & Apari, 2009; Kanazawa & Vandermassen, 2005). Because larger body size is more adaptive for sons than for daughters, big and tall parents tend to have slightly more sons than other parents (Kanazawa, 2005, 2007b).[2]

If Mechanisms 1–4 hold over many generations, then tall (and thus intelligent) parents will produce more sons, and short (and thus less intelligent) parents will produce more daughters, creating an extrinsic correlation between sex and intelligence, where the mean intelligence among men gradually exceeds the mean intelligence among women. If this is true, then men should be more intelligent than women *only* because they are taller; they should be no more intelligent than women once height is controlled. In this article we test this hypothesis with data from the National Longitudinal Study of Adolescent Health (Add Health).

EMPIRICAL ANALYSIS

Data

A sample of 80 high schools and 52 middle schools in the United States was selected to be representative with respect to region of country, urbanicity, school size, school type, and ethnicity. A total of 20,745 adolescents in grades 7–12 were personally interviewed in their homes in 1994–1995 (Wave I) and again in 1996 (Wave II). In 2001–2002, 15,197 of the original Wave I respondents were interviewed again in their homes. We use the Wave III sample from Add Health, in which respondents are now young adults (ages 18–28 years, $M = 22.0$, $SD = 1.77$).

Dependent variable: Intelligence

Add Health measures respondents' intelligence with the Peabody Picture Vocabulary Test (PPVT). The PPVT is properly a measure of verbal intelligence, not general intelligence. However, verbal intelligence is known to be highly correlated with (and thus heavily loads on) general intelligence. Miner's (1957) extensive review of 36 studies showed that the median correlation between vocabulary and general intelligence was .83. Wolfle (1980) reported that the correlation between a full-scale IQ test (Army General Classification Test) and the General Social Surveys (GSS) synonyms measure was .71. As a result, the GSS synonyms measure is used widely by intelligence researchers to assess trends in general intelligence (Huang & Hauser, 1998).

With respect specifically to PPVT, Zagar and Mead's (1983) hierarchical cluster analysis of the Wechsler Intelligence Scale for Children–Revised (WISC-R), the Peabody Individual Achievement Test (PIAT), the Beery Developmental Test of Visual–Motor Integration (VMI), and the PPVT showed that the PPVT and the VMI, along with some components of the WISC-R, loaded on a first-order factor that they called perceptual motor ability, which in turn loaded on a second-order factor that they called general intelligence. As a result, their conclusion was that the WISC-R, VMI, and PPVT were good tests of general intelligence, whereas the PIAT was a test of academic achievement. Stanovich, Cunningham, and Feeman's (1984) study of first, third, and fifth graders showed that the correlation between the PPVT and Raven's Progressive Matrices was .22 (*ns,* $n = 56$) among the first graders, .52 ($p < .05$, $n = 18$) among the third graders, and .52 ($p < .05$, $n = 20$) among the fifth graders. It appears that the PPVT becomes a better measure of general intelligence as children get older; our Add Health respondents are young adults.

In our analysis, the raw PPVT scores (0–87) are age standardized and converted into the IQ metric, with the mean of 100 and standard deviation of 15. We use the standardized IQ score as our dependent variable. One hundred fifty-seven respondents (1.1%) had single-digit IQs (7 or 8). We assumed that these were data entry errors, and we excluded them from our analyses. Our main conclusions would remain the same if we included them.

RESULTS

The Add Health data provide support for all four mechanisms identified earlier. In support of Mechanism 1, the correlation between IQ and physical attractiveness, objectively measured by an interviewer on a 5-point ordinal scale (1 = *very unattractive,* 2 = *unattractive,* 3 = *about average,* 4 = *attractive,* 5 = *very attractive*) is $r = .11$ ($p < .0001$, $n = 14{,}452$).[3] In support of Mechanism 2, the correlation between height and physical attractiveness net of weight is $r = .06$ ($p < .0001$, $n = 7{,}217$) among women and $r = .09$ ($p < .0001$, $n = 6{,}479$) among men. In support of Mechanism 3, the correlation between height and IQ is $r = .11$ ($p < .0001$, $n = 13{,}964$). It is important to note that although all these bivariate correlations are highly statistically significant because of the large sample size, their absolute magnitude is nonetheless small. In support of Mechanism 4 and replicating an earlier study (Kanazawa, 2005), controlling for education and income (measures of social class predicted to influence offspring sex ratio; Trivers & Willard, 1973), height has a significantly positive effect on the likelihood that the first child is a boy. Each inch in height increases the odds of having a boy by 3% ($p < .05$). This result provides further support for the gTWH.

Table 1, Column 1, replicates earlier studies (Colom et al., 2002; Irwing & Lynn, 2005; Lynn & Irwing, 2004; Jackson & Rushton, 2006, Nyborg, 2005) and shows that men are slightly but significantly more intelligent than women. Men on average score 1.14 IQ points higher than women ($p < .0001$, $n = 14{,}470$). This sex difference is smaller than the 3–5 points that earlier researchers reported, but this is probably because Add Health measures IQ with a vocabulary test, on which women are known to do better relative to men than on more heavily *g*-loaded tests such as Raven's Progressive Matrices. Nonetheless, men score significantly higher than women on the PPVT.

Table 1, Column 2 shows that men may be more intelligent than women because they are taller, however. Once height (measured in inches) is controlled, women have significantly higher IQs than men. Net of height, women score 2.14 points higher on the PPVT. In contrast, each inch in height is worth more than half an IQ point (0.56). A comparison of standardized coefficients shows that the effect of height is more than twice as large as that of sex. Because American men on average are 5 inches taller than American women (5'10" vs. 5'5"), this translates into 2.80 IQ points, overcoming the 2.14-point advantage of women and making men appear more intelligent when height is not controlled. Note that although Lynn and Irwing (2004; Irwing & Lynn, 2005) contended that men were more intelligent than women because they had larger brains, after adjusting for body size, we are able to eliminate and reverse the sex difference in intelligence with only height and no measure of brain size.

There may be other mechanisms that produce a positive correlation between height and intelligence, however. For example, Miller's (2000) general fitness (*f* factor) model suggests that people with greater genetic quality and developmental health (measured by the *f* factor) may simultaneously have higher intelligence and greater stature (Prokosch, Yeo, & Miller, 2005). If this view is correct, then the correlation between height and intelligence is an artifact and should disappear once genetic quality is controlled.

TABLE 1. Sex differences in intelligence

	1	2	3	4
Sex (1 = male)	1.1411****	–2.1393****	–2.3568****	–0.9017**
	(0.2382)	(0.3338)	(0.3371)	(0.3398)
	.0398	*–.0750*	*–.0835*	*–.0341*
Height		0.5635****	0.5692****	0.3791****
		(0.0405)	(0.0405)	(0.0408)
		.1628	*.1662*	*.1172*
Health			0.4811*****	–0.2053
			(0.1218)	(0.1426)
			.0341	*–.0132*
Physical attractiveness				0.7678****
				(0.1455)
				.0476
Age				–0.4030****
				(0.0704)
				–.0536
Asian (1 = yes)				–3.7035****
				(0.4458)
				–.0763
Black (1 = yes)				–7.6250****
				(0.3021)
				–.2272
Native American (1 = yes)				–2.3423****
				0.5106)
				–.0410
Education				2.3688****
				(0.0639)
				.3480
Earnings ($1,000s)				0.0160*
				(0.0074)
				.0201
Constant	98.9270	62.7064	62.5139	52.1690
	(0.1635)	(2.6147)	(2.6163)	(3.1015)
R^2	.0016	.0151	.0168	.1892
n	14,470	13,964	13,633	10,301

Note. *Main entries are unstandardized regression coefficients. Numbers in parentheses are standard errors. Italicized entries are standardized regression coefficients (betas).*
*p < .05. **p < .01. ***p < .001. ****p < .0001.

In order to test this alternative explanation, we controlled for the respondents' health. We used four indicators to construct a general health index: (1) the number of medical conditions for which the respondent has taken prescription medication in the last 12 months (0–17), (2) the number of times the respondent has been seen in an emergency room in the last 5 years (0–99), (3) the number of times the respondent has been hospitalized in the last 5 years (0–99), and (4) self-reported general health (1 = *poor,* 2 = *fair,* 3 = *good,* 4 = *excellent*). We performed a principal component factor analysis, and the four indicators all loaded on one factor, with reasonably high factor loadings (medication = .5248, emergency room = .7742, hospitalization = .6974, self-report = −.4666); no other factors were extracted. We reversed the sign of the factor, so that higher values indicate higher levels of health, and used this health index factor to measure the respondents' general health.

Table 1, Column 3, shows that although health has a significantly positive effect on intelligence ($b = .4811$, $p < .0001$), height continues to have a significant positive effect as well. The association between height and intelligence is not attenuated by the inclusion of the general health index; in fact, it is slightly stronger now than before ($b = .5692$ vs. $.5635$). The comparison of standardized coefficients shows that height ($\beta = .1662$) is twice as strongly associated with intelligence as sex ($\beta = -.0835$) and nearly five times as strongly as health ($\beta = .0341$); the effect of health on intelligence is indeed very small.

The significant association between height and intelligence remains even after we control for respondents' physical attractiveness, age, race (with three dummy variables, Asian, black, and Native American, with whites as the reference category), education (in years of formal schooling), and earnings (in thousands of dollars) (Table 1, Column 4). These additional control variables increase the explained variance from .02 to .19, but, net of all of them, women are still more intelligent than men (now only by 0.9 IQ point), and each inch in height is still worth nearly four tenths of an IQ point ($b = .3791$). The effect of height on intelligence ($\beta = .1171$) is stronger than the effect of any other variable in the model except for being black and education (although the latter is most likely to be a consequence rather than a cause of intelligence). Health no longer has any significant effect on intelligence; in fact, it has a nonsignificant *negative* effect ($b = -.2053$, *ns,* $\beta = -.0132$).

Table 2 repeats the same regression analysis of Table 1 separately by sex. It shows that the association between height and intelligence remains significant, and its magnitude is comparable within each sex. Each inch of height increases IQ by 0.38 point both for men and women. For both sexes, as in the pooled analysis presented in Table 1, the height has the strongest association with intelligence except for being black and education. Replicating the recent results by Case and Paxson (2006), taller men and women are more intelligent than their shorter counterparts, net of health, physical attractiveness, age, race, education, and earnings. The results presented in Table 2 further suggest that men on average may be more intelligent than women only because they are taller.

DISCUSSION

Although earlier studies found that both height and weight (as two indicators of body size) were positively correlated with intelligence, Add Health data show that weight is significantly *negatively* correlated with IQ among women ($r = -.06$, $p < .00001$, $n = 7{,}389$) and uncorrelated with IQ among men ($r = .02$, *ns*, $n = 6{,}626$). If we substitute weight (measured in pounds) for height in Equation 2 in Table 1, it has a significantly negative association with IQ ($b = -.0041$, $\beta = -.02$, $p < .05$). We believe this is because, in the contemporary United States, weight is a measure less of body size than of obesity and eating habits, and obesity is negatively correlated with intelligence (Deary, Whiteman, Starr, Whalley, & Fox, 2004; Elias, Elias, Sullivan, Wolf, & D'Agostino, 2003; Kanazawa, 2006b). In the Add Health data, IQ is significantly negatively correlated with the number of days that the respondents ate at a fast-food restaurant in the past week ($r = -.13$, $p < .0001$, $n = 14{,}490$).

The current analysis suggests that men may have become slightly more intelligent than women via assortative mating of intelligent men and beautiful women and that of tall men and beautiful women, coupled with a greater tendency of tall parents to have sons. The analysis shows that men may be more intelligent than women because they are taller than women, but women may be more intelligent than men net of height. The association between height and intelligence remains even after measures of genetic quality are entered into the equation, and it holds within each sex. The magnitude of the association is identical for men and women. Further research is necessary to replicate the current analysis. We suggest that future analyses of sex differences in intelligence take height into consideration.

NOTES

This research uses data from Add Health, a program project designed by J. Richard Udry, Peter S. Bearman, and Kathleen

TABLE 2. The effect of height on intelligence by sex

	Male	Female
Height	0.3781****	0.3767****
	(0.0565)	(0.0591)
	.0874	*.0806*
Health	–0.5042	–0.0840
	(0.2586)	(0.1719)
	–.0250	*–.0062*
Physical attractiveness	0.8619***	0.7007***
	(0.2241)	(0.1913)
	.0494	*.0460*
Age	–0.3280***	–0.4855****
	(0.0990)	(0.1009)
	–.0438	*–.0641*
Asian (1 = yes)	–3.4409****	–3.9547****
	(0.6178)	(0.6445)
	–.0736	*–.0785*
Black (1 = yes)	–8.5654****	–6.8510****
	(0.4539)	(0.4048)
	–.2434	*–.2122*
Native American (1 = yes)	–3.5351****	–1.0620
	(0.7038)	(0.7416)
	–.0644	*–.0178*
Education	2.2114****	2.5124****
	(0.0914)	(0.0896)
	.3203	*.3696*
Earnings ($1,000s)	0.0140	0.0170
	(0.0087)	(0.0140)
	.0217	*.0157*
Constant	51.7157	52.2240
	(4.5566)	(4.4917)
R^2	.1876	.1940
n	5,038	5,263

Note. *Main entries are unstandardized regression coefficients. Numbers in parentheses are standard errors. Italicized entries are standardized regression coefficients (betas).*
$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$. $^{****}p < .0001$.

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Address correspondence about this article to Satoshi Kanazawa, Managerial Economics and Strategy Group, Department of Management, London School of Economics and Political Science, Houghton Street, London WC2A 2AE, United Kingdom (e-mail: S.Kanazawa@lse.ac.uk).

1. In contrast to the social brain hypothesis (Dunbar, 1998; Humphrey, 1976), which uses complex human social life to explain why human brains are so much bigger than those of other species, these theories mostly explain the evolution of general intelligence within the *Homo* lineage.

2. In a letter to the editors, Gelman (2007) raised three criticisms of the gTWH. The first two (the problem of stopping rules and the problem of multiple comparisons) are not novel: Kanazawa (2007a) had already addressed and corrected them even before the publication of Gelman's letter. Gelman's third criticism is novel and valid; however, it is neither substantive nor statistical, merely linguistic. Kanazawa (2007a) erroneously described his finding as saying that "'very attractive' parents are 26% *less likely* to have sons (or 36% *more likely* to have daughters)." He should instead have said that "'very attractive' parents have 26% *lower odds* of having a son (or 36% *higher odds* of having a daughter)." Despite this linguistic error, however, the substantive and statistical significance of his finding remains.

In another letter to the editors, Denny (2008) attempted to replicate Kanazawa's (2005) findings that bigger and taller parents are more likely to have sons. Instead of including measures of height and weight in his regression equations, as Kanazawa had done, however, Denny included height and body mass index (BMI). BMI is a function of both weight and height:

$$\text{BMI} = \frac{(\text{weight in kg})}{(\text{height in m})^2}$$

Thus, just as including an interaction term or a polynomial term along with the main term in a regression equation makes it impossible to interpret the coefficient for the main term by itself, the inclusion of height and BMI makes it impossible to interpret the coefficient for height by itself. The fact that the coefficient for height in Denny's equation was not significant therefore does not necessarily mean that height has no effect on offspring sex ratios, especially because height and BMI move in opposite directions (BMI decreases as height increases). Denny also failed to include family income in his equations, when it is a significant predictor of offspring sex ratios from the Trivers–Willard hypothesis and a possible confound for the gTWH. Because Denny's equations are misspecified, it is difficult to draw any meaningful conclusions about the effect of height on offspring sex ratios from them. Finally, the significant effect of height on offspring sex ratios has been replicated with an entirely different dataset from a different country (Kanazawa, 2007b).

3. It would have been ideal to have multiple raters to assess the physical attractiveness of the respondents, but they were not available for the Add Health data. However, evolutionary psychological research has shown that judgment of physical attractiveness by different people, even across races and cultures, is remarkably consistent. (See Langlois et al., 2000, and Kanazawa & Kovar, 2004, for reviews.) In one study, for example, judgments of physical attractiveness of 77 people (52 male, 25 female) on a 7-point Likert scale by 85 judges (45 male, 40 female), turned out to be very reliable (Cronbach's $\alpha = .96$) (Takahashi, Yamagishi, Tanida, Kiyonari, & Kanazawa, 2006).

We should also point out that measurement errors, as long as they are random (noise) and not systematic (bias), correlated with other variables in our models, would simply attenuate the correlations and make it more difficult for us to find significant effects. In this respect, our measure of physical attractiveness provides a statistically conservative test of our hypothesis.

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