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INTERPRETING SEXUAL DISPARITIES IN ELITES: THE UNRECOGNIZED IMPLICATIONS OF GAUSSIAN DISTRIBUTIONS

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In his speech to the NBER on January 14, 2005, President Summers suggested that it was possible that the distributions of intellectual talent of men and women differed, specifically that the standard deviation for men was larger and that this might explain the disparity in the presence of men and women on the science faculties at elite institutions.¹ The rest, as they say, is history.

Our goal is a modest one. It is to explore and elucidate the relationship between the nature of the Normal (or Gaussian) distribution and the disparate representation of the sexes within certain intellectual elites in order to resolve an apparent paradox. On the one hand, there is a widely shared view that as groups men and women are approximately equal in mental acuity. On the other hand, it is similarly clear that women are very much under-represented in the elite precincts of the natural sciences. Two conflicting facile intellectual moves are available to resolve this seeming conflict. First, one can employ the distribution at the elite precincts to qualify the judgment that the sexes are more or less equal in ability. Second, one can employ one's stronger belief in equality to qualify one's judgment that the distribution of the sexes in the elites tracks ability. The latter move does not of course necessarily imply the presence of some sort of invidious discrimination, but it does imply that something other than pure talent is at play.

What we wish to establish is that this conflict is more apparent than real. We shall employ some elementary statistics to undermine both these mistaken conclusions. Relatively small changes in either the dispersion or the means of the distributions of mental acuity between men and women—differences that would be imperceptible in the normal activities of life—can result in stark differences in the frequencies at the very tails of the distribution.² And it is from the very tip of the right-hand tail that the science faculties at elite educational institutions are drawn.

It need hardly be said that if the distribution of talents of men and women are actually identical—not nearly so, but precisely so—then the relative frequencies of

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¹ The speech is available at <http://www.president.harvard.edu/speeches/2005/nber.html>.

² Diane F. Halpern, *Sex, Brains & Hands: Gender Differences in Cognitive Abilities*, 2 SKEPTIC 96 (1994) (quoting research studies finding that sex differences are most reliably found at the tail-ends of the distribution).

talent in the tails will perforce be identical as well. If the distributions among faculties of science at elite institutions are not, then the explanation must lie elsewhere. But neither theory nor empirical evidence compels identical distributions between men and women. Men differ from one another in mental acuity, likewise women, and men and women differ from one another in a host of dramatic ways. So there seems no reason to expect precisely identical distributions of mental acuity for men and women.

Let us see what results from small differences in either the dispersion or the central tendencies of the distributions. The population of the United States is approximately three hundred million, about half men and half women. Let us assume that one-third in each group is of the age that could currently be represented in the elite of the most demanding intellectual professions. In order to delve further into the relative frequencies in the tail of the distribution, we need to make some assumption about the shape of the specific distribution. For the purpose of this exercise we will assume that the distribution is Normal. Why Normal? First, in fact little turns on the precise shape. Any approximate bell-shaped curve will do, and the Normal distribution is the most widely used. Precision is not absolutely vital as we seek to demonstrate broad relationships, not a specific numerical result; we are trying to build a garage—not a piano. But there is more to be said for the Normal distribution than that. Many natural and social phenomena are approximately Normally distributed. The underlying natural and mathematical reason for this is derived from one of the most extraordinary and beautiful theorems in all of mathematics, the Central Limit Theorem. The Central Limit Theorem states that regardless of the underlying distribution of any variable, that both sums and means of samples drawn from that population will have a shape that comes ever closer to Normality as the size of the samples increases. Because many human characteristics such as height, mental acuity, longevity, blood pressure, etc., are the “sum” of a host of genetic and environmental factors, even if each of these factors has a binary distribution the “sum” of them will be “approximately” Normal in shape. Beyond that there is well-established literature dating more than a century of actually operationalizing mental acuity and demonstrating its approximate Normal shape.³

We do not mean to suggest that cognitive ability is singular in character. Indeed, there is much evidence that there are distinct verbal, visual-spatial, and quantitative abilities.⁴ While highly correlated with one another, these separate abilities do differ across individuals. That mental acuity is a congeries of abilities makes our argument all the more plausible in that it makes it all the more unlikely that men and women would have identical endowments of each of them. That said,

³ See RICHARD HERRNSTEIN AND CHARLES MURRAY, *THE BELL CURVE* (1994).

⁴ Halpern, *supra* note 2, at 96. Halpern explains, for example, that verbal ability consists of sub-abilities which include things like vocabulary fluency, verbal analogies, reading comprehension, grammar questions, etc. Similarly, spatial abilities and quantitative abilities are heterogeneous in nature. To further complicate matters, some of the cognitive differences between the sexes are small, but others are quite large, on mental rotation, for example, men score one standard deviation above women.

for the sake of clarity and simplicity we will treat mental acuity as a single entity expressed by the common factor that expresses itself in all mental tests, first isolated by the pioneer in mental testing Charles Spearman and named by him as *g*, for general intelligence.⁵ This common core of all manifestations of intelligence is operationalized as IQ.⁶ But, do not misunderstand us. We do not mean to assert anything in particular about *g* or IQ. Rather, we wish to make an observation about the more general human capacity of intelligence or perhaps about that portion of intelligence most valuable in performing at the leading edge in the sciences.

While there is a great body of literature comparing the intelligence of men and women,⁷ we do not rely on any specific result. Instead, ours is an exercise in pure statistics. So to begin let us assume that men and women have the same mean mental acuity, i.e., $\mu_f = \mu_m$, but very modest difference in the dispersions of the distributions, specifically $\sigma_f = 0.90\sigma_m$.⁸ Normal distributions are thick near the center and get progressively thinner as we march out into the tails. 68% of the distribution lies within one standard deviation of the mean; 95% within two standard deviations of the mean; and over 99.7% of all observations fall within 3 standard deviations of the mean. But when searching out the frequencies in the scientific elite of a country of three hundred million people, we are looking at a still tinier segment of the distribution. If we consider the probability distribution above 4.0 standard deviations, for example, we find that only 0.003167% lie above that point. Of the fifty million men in the cohort we identified as potential candidates for positions in the scientific and intellectual elite, this would amount to only 1,580 men. Given our assumption of a smaller standard deviation for women ($\sigma_f = 0.9\sigma_m$), how many women would fall into this same elite region?

Dividing 4.0 by .9 yields 4.444 . . . This means that the level of mental acuity that corresponds to 4.0 standard deviations into the tail of male distribution represents 4.444 . . . standard deviations into the tail of the female distribution. Once more, from the Normal distribution, we learn that approximately 0.00041% lies above 4.444 . . . standard deviations. So of the fifty million women in our cohort only 205 women would find themselves in this rarified air. The ratio of men to women is then almost 8 to 1. And of course, we see a similar disparity in the

⁵ Charles Spearman, *General Intelligence, Objectively Determined and Measured*, 15 AM. J. PSYCHOL. 201 (1904).

⁶ ARTHUR R. JENSEN, *THE G FACTOR: THE SCIENCE OF MENTAL ABILITY* (1998).

⁷ See DIANE F. HALPERN, *SEX DIFFERENCES IN COGNITIVE ABILITIES* (3d ed. 2000).

⁸ RICHARD HERRNSTEIN & CHARLES MURRAY, *THE BELL CURVE*, 275 (1994) (reporting that men and women have almost identical mean IQ scores, but men's standard deviation is larger). Quoting the National Longitudinal Survey of Youth, available at: <http://www.bls.gov/nls/home.htm>, the authors report that using the Armed Forces Qualification Test, women's mean is 0.06 standard deviations lower than men's, and their standard deviation is 89% of men's standard deviation. However, gender differences are confined to mathematical and spatial intelligence, but not in verbal, musical, interpersonal or intrapersonal intelligence. See generally A. Furnham & G. Fong, *Self-estimated and Psychometrically Measured Intelligence: A Cross-cultural and Sex Difference Study*, 2 N. AM. J. PSYCHOL. 191 (2000); A. Furnham and R. Rawles, *Sex Differences in the Estimation of Intelligence*, 10 J. SOC. BEHAV. & PERSONALITY 741 (1995); N.J. Mackintosh, *Sex Differences and IQ*, 28 J. BIOSOC. SCI. 559 (1996).

opposite tail, but that tail is nearly not so prominent nor so visible.⁹ Thus, a striking disparity in the representation of the sexes, one that might signal to some profound differences in mental acuity between the sexes or, alternatively, gross suppression of female prospects, can be entirely explained by the small differences in their standard deviations of their respective distributions.

Now, let us assume that the standard deviation of men and women is identical, $\sigma_f = \sigma_m$, but that the two means for this particular subset of mental acuity are somewhat different, $\mu_f = \mu_m - 0.4\sigma_m$, that is, the center of the female distribution is 0.4 standard deviations lower than the male distribution. Were this the case, the average women would rank higher than 34% of all men, and the average man higher than 66% of all women. The difference in the means between the two populations would be 4/10 as large as the "typical" difference between two individuals chosen at random. But now let us look at the differences in the tails. We already saw that there are only 0.003167% of the male population, or 1,580 men, that have mental acuity above 4.0 standard deviation. The corresponding point in the female distribution would be 4.4 standard deviation above the female mean (given the assumption of the female mean being 0.4 standard deviations below the male mean), which translates into 0.0005413% of the distribution, or only 270 women. And so we would see a ratio of almost 6 males to each female in this rarified region.

We do not hope to end all the rancor of the recent debate generated by the remarks of President Summers. Our hope is merely to suggest that some of this debate is overwrought. Perhaps people believe there is more at stake in explaining the relative frequencies of men and women at elite science institutions than is the case, that if the differences in frequency is entirely, largely, or somewhat explainable by differences in ability that this implies some profound inequality between men and women. We have endeavored to establish that is completely untrue. Even if the entire difference in tail frequencies is explainable by differences in ability, this fact traces itself back to the smallest of differences in either the means or the standard deviations.

Now to some this will still be unacceptable. They demand that men and women be not merely approximately equal in intellectual endowments but identically so. We know of no ontology that commands this result, no ethics or politics that demands it, and no empirical evidence that suggests it. To insist that such a position is the only acceptable one reflects all the vices of political rectitude. It is an embarrassment to the academy.

⁹ Halpern argues that there are disproportionately more males at the left-end tail of mental ability distribution, with men over-represented in some categories of retardation, and learning disabilities, like dyslexia. See Halpern, *supra* note 2, at 96.