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SYMPOSIUM: GENDER AND ECONOMICS

What is the Right Number of Women? Hints and Puzzles from Cognitive Ability Research

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A COMMENT ON: CHRISTINA JONUNG AND ANN-CHARLOTTE STÅHLBERG, "REACHING THE TOP: ON GENDER BALANCE IN THE ECONOMICS PROFESSION," *ECON JOURNAL WATCH* 5(2), MAY 2008: 174-192. LINK.

ABSTRACT

> There is no consensus as to the causes of women's slow advancement in academic economics. Even after adjusting for factors representing family background or productivity a considerable portion of the gender promotion gap remains unexplained. In addition, the search for explanations has to consider the exceptionality of economics."
>
> –Jonung and Ståhlberg (2008, 188)

HERE I FOCUS ON THE POSSIBILITY THAT THE LOW REPRESENTATION OF women in economics is partially driven by genetic differences in tastes and abilities between the sexes, differences that may show up in both means and variances. Particularly in a field like academia, where essentially all employees are above the mean in abilities, variances are likely to be important. I'll review some of the recent findings regarding the matter, some of which are more recent than the Larry Summers controversy. Some useful surveys include Munger (2007), Allen and Gorski (2002), Zup and Forger(2002), Pinker (2002), and especially Hyde (2005) and Cahill (2006); the most prominent rebuttal of the views expressed by those authors is Spelke (2005). Although there is no precise information at the genetic level, the combination of analogies from other mammals, early childhood

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studies, well-documented impacts of sex hormones on brain structure, and the repeated finding of higher means and variances in relevant mental abilities (especially mathematical abilities) in males point toward the very real possibility that men and women differ genetically on average with regard to the advanced skills useful in graduate economics as the field actually exists today.

Let g^* denote the ideal ratio of female economists/total economists, something akin to the ratio that would exist in a competitive academic market in the absence of discrimination, affirmative action, and cultural barriers to the advancement of women. The important thing is the idea of our *prior distribution* about g^*. Denote $f(g^*)$ as this prior distribution about g^*. My goal in this short comment is to help update your priors about g^*, in the hopes that you, the reader, will place substantial mass to the left of $g^*=50\%$. Indeed, I hope that by the end of this comment, readers will place some weight to the left of $\hat{g}$, the current fraction of female economists across the rich countries, since affirmative action at both public and private universities likely increases the number of female economists above what it otherwise would be. If enough of us place substantial mass of $f(g^*)$ to the left of 50% and even $\hat{g}$, discussions about the issue will be broader and more tolerant.

EVOLUTION AS A REASON FOR SOFT PRIORS

Perhaps the strongest argument that there should be some mass of $f(g^*)$ to the left of 50% comes from the theory of evolution. Adaptationism—the concept that gene-carriers quickly adapt to their surrounding circumstances—is at the heart of the modern theory of evolution, and it is difficult to imagine that male and female humans have faced identical circumstances across the millennia. Most obviously, men and women have faced systematically different challenges, framed by the nature of the reproductive cycle. Determining exactly what those challenges are, and how they would change the incentives for brain development is an exciting, ongoing research agenda, and there are few solid answers at this point. Indeed, any of the standard popular references on the topic of evolutionary psychology would work quite well for laying out the verbal "just-so-stories" that frame the literature.

Once one accepts the adaptationist worldview, one accepts that evolution has no teleology of biological gender equality. Indeed, when an economist like Brad DeLong (2005) cleanly lays out the terrible dilemma facing women in academia, he inadvertently lays out an evolutionary dilemma as well. In discussing the Larry Summers controversy, he notes:

> The process of climbing to the top of the professoriate is structured as a tournament, in which the big prizes go to those willing to work the hardest and the smartest from their mid-twenties to their late thirties.

> Given our society (and our biology), a man can enter this tournament without foreclosing many life possibilities [since he can more easily intertemporally substitute fatherhood] ….But given our society (and our biology), a woman cannot enter this particular academic tournament without running substantial risks of foreclosing many life possibilities if she decides to postpone her family, and a woman cannot enter this particular academic tournament without feeling—and being—at a severe work intensity-related handicap if she does not postpone her family.

So women and men face different tradeoffs. More broadly, men face a greater expected payoff to taking big risks in the early parts of their life, and, empirically, men *are* more likely to engage in risky behavior than women. For men and their genes, there is almost always another day. For women, the trade-off is much crueler. DeLong's economic model is implicitly evolutionary. Different trade-offs across the timeframe of evolution for men and women lead to different genetic results, some of which are *a priori* likely to have an impact on the sexual differences within the brain.

But we have more than just theory to bring to bear. There are some useful facts about male-female differences in the human genome. Drawing on a recent line of research into the male-specific Y-chromosome (only sequenced in 2003 (Skaletsky, et al. 2003)), the *New York Times* reports:

> Men and women differ by 1 to 2 percent of their genomes, Dr. [David] Page said, which is the same as the difference between a man and a male chimpanzee or between a woman and a female chimpanzee….'We all recite the mantra that we are 99 percent identical and take political comfort in it,' Dr. Page said. 'But the reality is that the genetic difference between males and females absolutely dwarfs all other differences in the human genome.' (Wade 2003)

A final genetic note: The fact that men have only one X-chromosome is a fact too large to omit. A woman has two X chromosomes, so if a particular gene is non-functioning on one X chromosome, then she is very likely to have a functioning copy on her second X-chromosome. A man, by contrast, is in no such luck. A broken X-gene means no function. An entire field of male genetic abnormalities, "X-linked recessives," is the result of this absence. Again, we have no knowledge of brain functions on the X, but then we have little knowledge of what the X does in any case.

Stepping back, it appears that we don't know much about the precise genetic differences between the sexes—at least at the level of gene coding—but we do know that many exist. We know nothing about genetically-driven sex differences in normally-functioning brains—indeed, we know little about the genetics of brains in general. New knowledge is arriving rapidly, so answers are likely to arrive in the coming decades. In the meantime, our "just-so stories" are our best source of intuition, and they indicate that men are more likely to take big risks.

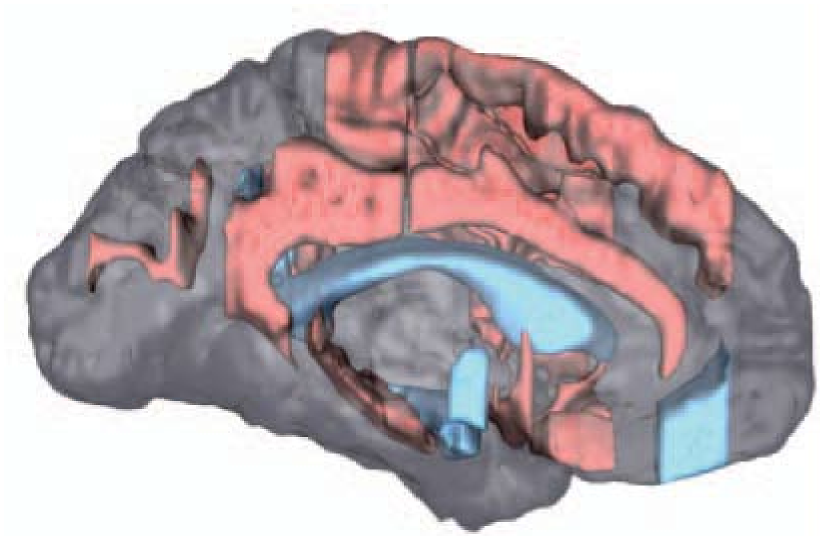
Brain Anatomy and Evidence of Sexual Differentiation

Humans and other mammals have sexually differentiated brains. As one might expect, the differences are rarely overwhelming. The best-understood channels involve readily-measurable differences in sex hormones, since lab biologists, like empirical economists, have a tendency to focus on the measurable and manipulable. The findings of Allen and Gorski (2002, 291) appear to sum up the consensus on hormones: "With respect to mammals, high levels of sex hormones—whether secreted by the testes or administered by a scientist—result in masculine brain development." That there *is* such a thing as masculine brain development, then, is the first, relatively minor point: Both tests on non-human mammals, tests on adult humans, and genetic abnormalities reinforce this view.

But do these hormonal differences drive functional differences? Halpern (2000, 180) points to a sizable area of research indicating that there appears to be in each sex a different optimizing point for one particular sex hormone, estriadol, a derivative of testosterone: "There are many studies in which low testosterone for males and high testosterone for females are associated with better performance on several different spatial tests" (171). Kimura (1999, 122) concludes that "the 'optimal' level of T[estosterone] for spatial ability in humans is that of the normal male with lower levels." Finally, when older men and older women have received hormone replacement therapy, or when people receive hormone therapy as part of a sex change operation, the "expected cognitive changes occurred" (Kimura 1999, 122). Thus, relatively well-understood hormonal differences appear to explain some of the differences in average spatial abilities between men and women. Economists use these spatial abilities in geometric and topological reasoning, so these differences may help explain why $\hat{g}$, the fraction of economists who are female, is below 50%.

Moving from hormonal differences, we can turn to differences in gross anatomy of the brain. The best-documented sexual dimorphism in mammals is in the pre-optic area of the hypothalamus, located just in front of the brain stem. This is about twice as big in human males as in human females—a difference visible to the naked eye—and is involved with reproductive behavior. Little else is known right now about the pre-optic area's precise functions, but it at least lets us know that brain anatomy is on the side of "some difference between the sexes." The hippocampus, a site related to memory and spatial organization, also differs between the sexes (Cahill 2006); it is larger in human females when adjusted for brain size—a relatively recent finding. The finding is unsurprising since women typically do better on tests of memory retrieval and spatial memory.

Figure 1. Differences in Brain Structure



Note: Pink regions indicate areas that are larger in a typical female brain, after adjusting for size differences in cerebellum. Blue regions indicate same for typical male brain. Reprinted from Cahill (2006), based on research in Goldstein, et al., (2001). (Sample size: 27 males, 21 females)

So while women typically perform worse on spatial *rotation* tasks, such as what the letter "F" looks like when rotated in three dimensions, they do better at spatial *memory* tasks, such as where she put the car keys. The typical "just-so story" invoked at this point is that males needed spatial rotation skills to hunt effectively, while females needed spatial memory skills to remember where useful plants were located.

Another well known fact regarding human brain anatomy is that men's brains weigh about 15 percent more than women's. While modern MRI scans indicate that within a given sex there *is* a positive correlation between brain size and IQ score (correlations of 0.3 to 0.4 are common), there is less evidence that men and women differ on average overall intelligence.

In the neuroscience literature, it's commonly observed that women's brains are "more balanced" or "better connected" between left and right hemispheres. Three separate connections—the corpus collusum, the massa intermedia, and the anterior commissure—are often found to be larger in women than in men (Allen and Gorski 2002; Kimura 1999, 132ff.). The evidence on the corpus collosum is more mixed than for the other two, but overall, the evidence appears to point to women having better lateral connectivity on average. Hearing and vision tests from the left and right sides likewise support the hypothesis that women's hearing and vision skills are better balanced between left and right (Kimura 1999, 135ff.).

Looking from front to back rather than from left to right, Figure 1 (Cahill

2006) tells much of the story: Women's and men's brains differ on average. Interestingly, this sample shows a *larger* corpus collosum for men—that's the apostrophe-shaped blue blob in the center of the brain. Though some of those brain differences may be environmental and social in origin—it would be surprising if it were otherwise—the impacts of fetal hormones on brain development are clear enough that there is little debate in the literature over whether *some* structural differences between men's and women's brains are genetically driven.

And not only do shapes and sizes differ between the sexes: functional MRI scans show that male and female brains consistently use *different* structures to solve the *same* kinds of problems:

> 'Every time you do a functional MRI on any test, different parts of the brain light up in men and women,' says Florence Haseltine, a reproductive endocrinologist at the National Institute of Child Health and Human Development (NICHD) in Bethesda, Maryland. 'It's clear there are big differences.' (Holden, 2005; see also Halpern 2000, c. 5)

TEST SCORES AS AN INDICATOR OF MENTAL ABILITY

I began by discussing data that are simultaneously the most unassailable and the least relevant: Sex differences in the human genome, driven by natural selection. These genetic differences are large, but we have essentially no empirics connecting them to differences in practical brain function. Instead, we have just-so stories about the different incentives faced by potential mothers and fathers across the ages. I then briefly discussed differences in brain anatomy and hormonal function. Some (but not all) of these differences are unambiguously genetic in origin, and the hormonal differences in particular appear to cause some differences in spatial abilities.

Now, we look at test score differences between men and women. These data are the most relevant to the question at hand—whether men and women differ in the abilities needed in actually existing economics—but they have the weakest ties to a clear genetic story.

First, to the question of overall intelligence. A common observation is that men have greater variability than women. Halpern (2000, 86) notes, "When we turn our attention to cognitive abilities researchers regularly (but not always) report that males are more variable than females." For instance, Feingold (1993, 74) reanalyzed a variety of national and state-wide intelligence and achievement-type tests:

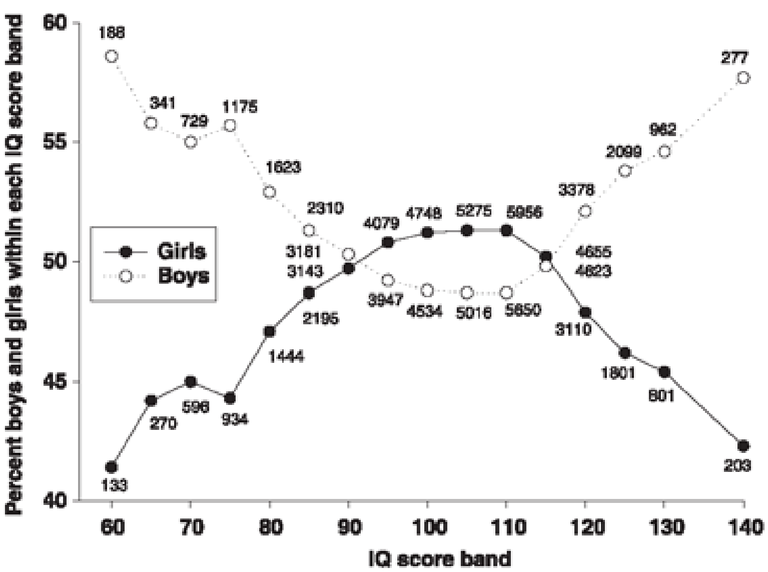
> It was consistently found that males were more variable than females in general knowledge, mechanical reasoning, quantitative

> ability, spatial visualization, and spelling. There was essentially homogeneity of variance for most verbal tests, short term memory, abstract reasoning, and perceptual speed.

The high math variances are most relevant: On the SAT-Math, Feingold found that male variances were 20-25% larger for males in the four decades before his study, while on SAT-Verbal scores, male variances were about 5% higher. Of course, this could be driven by sample selection if men faced a *much* lower SAT threshold, something relatively unlikely by the 1980s. Even on the WAIS-R standardization sample (an explicitly representative sample designed to create norms for IQ scores), male variance averaged 8% higher across subtests.

But of course, one always wonders whether samples are really representative. One paper that addresses this issue is Deary et al. (2003): In a sample of 95% of the Scottish 11-year-olds in the 1932, covering 81,000 students, girls scored 1/90 of a standard deviation higher than boys on a set of IQ tests, but boys had a standard deviation of IQ that was 5% higher (corresponding to variances roughly 10% higher for boys). Thus, boys were overrepresented at both the top and the bottom of the distribution. Even such small differences can create quantitatively significant difference three or four standard deviations above the mean: At three standard deviations above the mean and with these values (5% higher variance,

Figure 2: IQ Scores for Scottish Boys and Girls in 1932



Note: "Numbers and percentages of boys and girls found within each IQ score band of the Scottish population born in 1921 and tested in the Scottish Mental Survey in 1932 at age 11. The y axis represents the percentage of each sex in each 5-point band of IQ scores. Numbers beside each point represent the absolute numbers of boys and girls in each 5-point IQ score band." Reprinted from Deary et al (2003).

1.1% higher standard deviation), we expect to find 50% more boys than girls, while at four standard deviations, we would expect to see twice as many boys. The small mean difference has little impact on this ratio—the effect comes mostly from the difference in standard deviations. Clearly, this isn't enough to explain the overwhelming predominance of men in the sciences, but it reinforces the widespread observation that males appear to be slightly higher in variance, even on a typical IQ test.

Now, I turn to the ability that is likely most relevant to the economics profession as it currently exists: Mathematical abilities. Indeed, as Jonung and Ståhlberg state in their abstract, when it comes to the actual representation of women within the field today, "[W]e find economics to be more akin to mathematics than to the other social sciences." The usual stereotype drawn from the psychological literature is that men are better at math and visuospatial skills than women, especially at the upper end of the distribution. The crucial caveats to this generalization are that women are consistently better (on average) at arithmetic and computation than men, and women are better at spatial memory, while men are consistently better (again, on average) at spatial rotation (Kimura 1999, Halpern 2000, and indirect support from Spelke 2005).

The fact that women are better at computation is especially intriguing in light of recent changes in the accounting profession: In a field that was formerly male-dominated, more than half of all Bachelor's degrees in accounting are now conferred on women (Koretz 1997, Briggs 2007). The ability of women to make great strides in a traditionally math-heavy field like accounting should caution against sweeping statements about g*, the ideal gender balance in economics. Even if the computation/spatial rotation difference continues to hold for centuries to come, future technological change could raise the relative value of computation or other skills useful in some future version of economics. "Skill-biased technological change" is apparently a reality, a reality that should feed into any discussion of women in academia. Could teacher bias be driving these results? That's unlikely, according to Kimura (1999): She notes that boys do better on math aptitude tests (with the exception of girls' superior computation ability), while girls do better on math achievement tests. By way of explanation, Kimura notes (78):

> Since both aspects of math are taught by the same person, teacher-related factors are unlikely to be the explanation. Nor do other 'socialization' explanations such as gender bias in problem content, math anxiety, parental expectation, and so on, adequately account for the differences.

And it turns out that psychologists indeed *have* addressed the possibility that their tests are biased: They've gone out of their way to write word problems that favor females (e.g., "Martha is making square cookies," Kimura, 1999, 77) but males still perform better on female-biased spatial rotation tests.

One source of evidence on the question of male-female differences is neurological disorders. Many such disorders are more common among men than among women; one that deserves particular attention is autism. Simon Baron-Cohen and his coauthors (2004, 2005) have theorized that autism is largely an "extreme male mind," one that focuses too much on regularizing and systematizing data, and that thus is unable to see the forest for the trees. In recent work, Baron-Cohen provides neuroanatomical evidence for his hypothesis. Since autism shows up at such a young age, it would be remarkable if this sex difference in autism (on the order of 3:1) were driven entirely by environmental differences. The predominance of autism among males, like the higher levels of Tay-Sachs among Ashkenazi Jews, may turn out to be largely driven by extreme cases of otherwise normal brain function within each particular subgroup.

Another source of data is meta-studies by psychologists. In a survey of meta-studies entitled "The Gender Similarities Hypothesis," Hyde (2005) collected dozens of meta-studies of gender differences in cognitive abilities and personality traits. Among her findings is that on tests of mental rotation, spatial visualization, and spatial perception, males consistently perform better than females, with a median estimate of 0.44 standard deviations above females. Female advantages on tests of verbal fluency, language, and spelling are of the same order of magnitude. Males are overwhelming more aggressive than females (about 0.5 standard deviations, regardless of measure), and females are more agreeable and (importantly, in my view) more conscientious by about 0.2 standard deviations. The female advantage in conscientiousness is likely of first-order importance, particularly in academia, where tenure-track professors need to be self-starters.

These differences are all likely to have some measure of "biopsychosocial feedback," as the psychologists like to say, which is to say that they are deeply endogenous. But given the well-documented links from manipulable hormones to spatial ability, the links running from genetics through hormones to average spatial ability don't appear all that weak. And as long as economics relies heavily on mental rotations—manipulations of production functions, linear algebra, separating hyperplanes, and the like—this difference is likely to remain relevant when explaining the relatively low representation of women in economics.

How big are these differences quantitatively? The table below provides an illustration based on a normal distribution; it's a concrete reminder of what's going on in the tails. If the men of today actually do have an advantage in spatial ability—an advantage, based on Hyde (2005), that raises their mean 0.5 standard deviation higher than the female mean—and if we temporarily assume that men and women have the same standard deviations on this ability, then, at two standard deviations above the female mean, the ratio of men to women is 2.4:1; at three standard deviations it's 4:1, and at four standard deviations it's 6.5:1. Adding in a 5% gender difference in standard deviations (as Deary 2003 found for IQ) raises these ratios to 2.5:1, 5:1 and 11:1, respectively.

But perhaps we're overestimating that gap, or we only think half the gap is genetic, or only half of it is important to economics. If we instead cut the M-F gap in half while keeping the 5% gap in standard deviations, then the ratios shrink to 1.8:1 , 2.8:1, and 4.8:1, respectively, as shown in the fourth column. And if we note that men apparently have about twice the standard deviation at math-related skills than women, then the final column may be relevant, where males swamp females at the extremes.

Table 1: Population density, Predicted M-to-F Ratios

	5% higher male standard deviation	0.5 SD higher spatial	5% higher SD, 0.5 SD higher spatial	5% higher SD, 0.25 SD higher spatial	10% higher SD, 0.5 SD higher spatial
2 SD	1.1:1	2.4:1	2.5:1	1.8:1	2.7:1
3 SD	1.5:1	4:1	5:1	2.8:1	6.2:1
4 SD	2:1	6.5:1	11:1	4.8:1	17.2:1

Note: Each box indicates the predicted number of men to women at two standard deviations, three standard deviations, and four standard deviations above the female mean. The shifts involve increases in the male standard deviation and/or shifts (measure in standard deviation units) of the male distribution relative to the female distribution. In all cases, I assume a normal distribution. Importantly, this predicts densities *at* these cutoffs, not cumulative distributions *above* these cutoffs.

Conclusion

If women and men differ genetically in the abilities that are important in fields like economics, then it would be difficult to argue that the ideal gender balance is 50%. Whether the ideal gender balance is greater or less then 50% turns on many things, including which skills are needed in economics as it actually exists today. If non-computational math skills are of first-order importance, and if men and women are roughly equal across all other relevant skills, then the evidence presented here indicates that the ideal gender balance tilts strongly toward a male-dominated economics profession.

But even if the sexes do turn out to differ genetically on spatial rotation ability, and even if such abilities are important in thinking about abstract mathematical models, what of the consistent female advantage, across ages and cultures, in computation, spatial memory, agreeableness, and conscientiousness, each of which may likewise be genetic in origin?

Future changes in the nature of the profession—driven from within by changes in what economists find interesting, or from without as technological change makes certain skills more important—simply can't be ruled out. And of course, by the time such changes occur, scientific advances could find easy work-arounds to any innate differences between men and women's abilities. Surely, there's a market for such advances. Just as the computer made slide-rule skills of manual dexterity irrelevant, and as eyeglasses made genetic differences in vision largely irrelevant, future innovations may shift the relative worth of various mental skills.

Economics as currently practiced does appear to draw on rare skills that are more common among men than among women: The higher male mean and variance on key abilities is likely to quantitatively swamp the areas of female strength. That said, the evidence for those male advantages being *genetic* isn't as strong as evidence for the mere *existence* of such advantages. With current scientific understanding, the male-female differences on mathematical skills appear likely to persist, even under plausible social interventions like gender-neutral teaching methods. So actually-existing economics is likely to remain a male-dominated field, as long as the supply of and demand for relative skills in the profession remain roughly constant. Thus, if the academic job market is close to competitive—indeed, since it is likely influenced by affirmative action in favor of female hires—then there are good reasons to place a sizable amount of the mass of $f(g^*)$ in the vicinity of $\hat{g}$. In other words, we may not be that far from the ideal ratio of female economists to total economists.

How could this change? How could economics change itself so that it has as many high-performing women as there are in fields such as literature, history, or sociology? The question answers itself: Economics could change itself so that it draws on the skills at which women, on average, excel. A more literary and historical economics, one more driven by verbal fluency and conscientious archival work, would be an economics that created greater opportunities for women. Other methods surely exist for raising the number of high-performing women in economics–by encouraging recalcitrant male economists to treat female economists fairly, by lengthening tenure clocks for promising female academics who bear children, and surely through other methods. But if men have substantially and persistently higher means and variances in the key skills that go into making an economist, then the only intervention of first-order importance may be to change economics itself.

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