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Review: The Mathematics of Sex: How Biology and Society Conspire to Limit Talented Women and Girls

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The Mathematics of Sex: How Biology and Society Conspire to Limit Talented Women and Girls. By Stephen J. Ceci and Wendy M. Williams. Oxford University Press, Oxford–New York, 2010, xv + 270 pp., ISBN 978-0-19-538939-5, $34.95.

Reviewed by **Susan Jane Colley**

The participation of women in scientific careers, or the relative lack thereof, has been a topic of both interest and concern for decades. I have been aware of it since I began to think of myself as a (child) mathematician in the 1970s. Like religion and politics, the subject has incited such strong and impassioned reactions that it has not always been a suitable topic for dinner conversation. And, as we know, the recent history has been remarkable: the proportion of women in all professions—law, medicine, business, and academia—has increased dramatically in the last forty years. Women now earn the majority of all bachelor's degrees in the United States, are roughly half the students in medical and law schools, and earn Ph.D.'s in a variety of fields at rates that exceed those of men. In fact, in 2008–09 a slight majority, 50.4%, of the doctoral degrees awarded in the United States were earned by women [**4**]. As an old cigarette ad opined: "You've come a long way, baby."

Except, it seems, in the most mathematically intensive fields within science. Despite the fact that women have made significant gains in their representation, they continue to earn fewer than a third of the Ph.D.'s in mathematics, and fewer than 25% in computer science and in engineering; in addition, they constitute a still smaller proportion of the faculty in top research departments in these fields than the statistics stated above. For many years, this situation was thought to be a pipeline issue that would, in time, resolve itself. But the underrepresentation of women in the most highly mathematical of STEM (science, technology, engineering, mathematics) fields has stubbornly and unexpectedly persisted. It's natural and reasonable to ask why.

In January, 2005, at a Cambridge conference of the National Bureau of Economics Research, Lawrence Summers, then president of Harvard University, notoriously discussed possible explanations for the continued disparity of representation of men and women in tenured positions in science and engineering at the top research institutions [**5**]. He proposed three possible explanations: (1) what he called the "high-powered job hypothesis" (i.e., that women more than men choose not to embark on, or choose to leave, careers that demand extraordinarily high levels of commitment and intensity), (2) the "different availability of aptitude at the high end," and (3) continuing issues of socialization and discrimination. He expressed his belief that the first two explanations accounted for much of the gender disparity. Summers' talk, especially his suggestion that men and women may have different innate abilities for mathematics, ignited a firestorm of comment and controversy, including a rare public rebuke from three fellow university presidents [**3**]. It certainly reinvigorated the popular debate about why women remain so underrepresented at the top ranks in highly quantitative fields, and what, if anything, should be done.

Summers' speech generated plenty of heat; the book under review makes a serious effort to generate some light as well. Professors Ceci and Williams are accomplished developmental psychologists from Cornell and no strangers to the topic at hand. (See [**1**] and [**2**], for example.) The subject matter of their volume certainly hits home for them, as they are

a married couple with three daughters, including one who earned a graduate degree in engineering. Together Ceci and Williams have undertaken a Herculean task of reviewing more than 400 primary sources in an effort to provide rational, evidence-based discussions and explanations. They carefully describe and analyze both biological and environmental arguments, and give due consideration to longitudinal and cross-cultural comparisons.

One thing is clear: men and women (or boys and girls) do present different statistical distributions on the mathematical parts of the SAT and GRE and other tests typically used to measure mathematical aptitude. The respective means are about the same; what is different is that both the left and right tails are much larger for males. And it is in the right tail, even the extreme right tail, where one expects to find those most likely to succeed in a STEM career. Presumably, this is what Summers was referring to with his phrase "different availability of aptitude at the high end." However, as Ceci and Williams point out, there are various possible reasons for the different distributions, and they do not appear to be immutable. And, of course, one can question the degree to which "mathematical aptitude" and SAT performance really do coincide.

Ceci and Williams consider many potential biological mechanisms for the observed sex differences in mathematical performance. Most of the research that they analyze concerns potential explanations for sex differences in spatial abilities, which is generally believed to correlate with mathematical performance and even to be predictive of it. In particular, studies show that men outperform women in problems involving three-dimensional mental rotations. Research demonstrates differing levels of pre- and postnatal hormones in males and females, and greater cerebral lateralization in males (i.e., that male brains are organized so that processing involves more neuronal activity localized within a particular hemisphere—as opposed to female brains that demonstrate more diffuse activity and communication between hemispheres). Additionally, the authors cite some large-scale studies that indicate that females have a "people" orientation, while males are more oriented towards mechanical devices ("things"); moreover, this differential "people-things" orientation appears to be stable across more than fifty nations. Ultimately, however, Ceci and Williams, while noting that there is support in the literature for biological sex differences accounting for differing performance in STEM fields, remain unconvinced that biology offers a primary explanation. They point out inconsistencies in the research, and, more significantly, the fact that there are few studies that focus on the right tail of the aptitude distribution—most conclusions are drawn from studies of general populations.

If biology is not the primary determinant of sex differences in mathematical achievement, then perhaps environment (i.e., socialization, implicit or explicit bias and discrimination) is. Yet here, as well, there is conflicting evidence. Ceci and Williams discuss research showing that cultures that value gender equity have narrower sex differences in mathematics, studies that show that sex difference can be altered by changing the environment, and certain negative findings of assumed sex differences in brain activation during performance of certain tasks. They note that the test performance of women and girls relative to men and boys varies across nations, and over time, findings that would seem to argue strongly against the biological explanation. However, women currently make up close to 50% of the undergraduate mathematics majors in the United States, and, it turns out, achieve better grades than men. Thus the environmental explanation for the underrepresentation in mathematically intensive STEM careers in the US would seem to require arguments that do not primarily

involve claims of differential parental treatment, early presence of gender stereotypes or discrimination, etc. One possible explanation that Ceci and Williams offer, and crucial to their overall conclusions, is that the literature shows that men and women have maintained persistent differences in patterns of child rearing and other domestic responsibilities (e.g., caring for elderly parents), as well as differing attitudes towards work and careers. This is, in a sense, a more carefully expressed version of Summers' "high-powered job hypothesis." However, the authors note that it plays out in similar ways for women in non-mathematically intensive careers. Thus the puzzle of significantly smaller representation of women in mathematically intensive fields is not completely solved by this argument either.

Ultimately Ceci and Williams draw the conclusion that while both biological differences and lingering bias and environmental factors may account for some of the unequal representation of women in mathematically intensive STEM careers (especially academic ones), the main effect comes from what they call the "personal preference" of women to undertake something other than a mathematically intensive career. This preference arises both from the family-oriented career choices that women make to a much greater degree than men, as well as from an apparent preference by women for less mathematically intensive areas of inquiry (the "people-things" orientation at work). The authors describe the manner in which the various factors combine to result in the significant underrepresentation of women as follows:

> ... (*1*) fewer women scoring at the right tail in math, which reduces their chances of acceptance into math-intensive graduate fields for which the GRE-Q scores are an important consideration for admission; (*2*) fewer women who do score at the right tail in math preferring to enter mathematical fields even though they have the mathematical aptitude to be successful, preferring instead more organic, people-oriented fields; (*3*) fewer women opting to compete for tenure-track posts upon receipt of their doctorates; (*4*) more women leaving the field for family reasons; and (*5*) more women leaving the field as they advance, for career changes. Note that none of these factors entails overt discrimination against women. (pp. 188–189)

In short, biology and the environment make somewhat fewer women available for scientific careers and women's individual choices cause their already unequal numbers to drop much more significantly. Of course, Ceci and Williams allow that the issue of personal choice is itself not immune to social and cultural influences and expectations, but its impact on the fraction of women in scientific fields is robust. And since its effect appears to be abiding (at least for the foreseeable future), the authors offer some commonsense suggestions for ways to reshape the typical university environment and possible academic trajectories to make mathematically intensive careers more hospitable for women.

I find the issue of "personal choice" to be more complicated than Ceci and Williams seem to, especially as it relates to family-oriented matters. Contemporary social mores are such that the day-to-day responsibilities for raising children and caring for elderly parents fall more heavily on women than men, and thus are in conflict with demands and typical timelines of research careers. Ceci and Williams certainly recognize all this, but they do not appear to consider adequately the pressures and possible additional biases (by both men *and*

women) arising from this situation. Thus the notion of individual "choice" may be somewhat of a misnomer in this regard.

I also can't help but wonder, as do Ceci and Williams, about the chain linking spatial ability to performance on standardized tests to successful careers in mathematics. Work in certain areas of mathematics seems to me to be far removed from ability with mental rotation tasks. Moreover, the authors point to research showing that training can enhance performance, so the connections between spatial ability, mathematical performance, and sex are no doubt subtle and tricky. Mathematical research in the 21st century requires plenty of education and training. While elementary numeracy and understanding of symmetry may be hard-wired, surely facility with sheaf cohomology is not. Thus it would seem to me that the innate superior spatial ability of males, if it exists, may not be all that relevant to a high-level mathematical career.

Overall, Ceci and Williams have worked hard to produce a measured, nuanced, and even-handed work. The title notwithstanding, there is no sensationalism here, no extremist soapbox, and those with an axe to grind should read elsewhere. In addition, this is by no means an easy or "fun" text to read: it is a thorough and thoughtful review of the technical literature intended for a well-educated audience. I believe that Ceci and Williams have succeeded in bringing an important issue to the fore in an unbiased and constructive manner, and in so doing they have rendered a real service to the scientific community.

References

1. S. J. Ceci and W. M. Williams, eds., *Why Aren't More Women in Science? Top Researchers Debate the Evidence*, American Psychological Association, Washington, DC, 2007.

2. S. J. Ceci, W. M. Williams, and S. M. Barnett, Women's underrepresentation in science: Sociocultural and biological considerations, *Psychological Bulletin* **135** (2009) 218–261.

3. J. Hennessey, S. Hockfield, and S. Tilghman, Women and science: The real issue, *The Boston Globe*, February 12, 2005; available at http://www.boston.com/news/education/higher/articles/2005/02/12/women_and_science_the_real_issue (accessed September 15, 2010).

4. C. Sanchez, Women outnumber men earning doctoral degrees, *Morning Edition*, National Public Radio, September 15, 2010; avaliable at http://www.npr.org/templates/story/story.php?storyId=129874290 (accessed September 15, 2010).

5. L. H. Summers, Remarks at NBER conference on diversifying the science and engineering workforce, Cambridge, MA, January 14, 2005; available at http://www.president.harvard.edu/speeches/summers_2005/nber.php (accessed September 15, 2010).

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