Critique of “Understanding current causes of women’s underrepresentation in science”

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Here are some criticisms of Ceci and Williams’s “Understanding current causes of women’s underrepresentation in science.” This article, which appeared in the February 7, 2011 edition of the Proceedings of the National Academy of Sciences, repeats many arguments in Ceci and Williams’ book *The Mathematics of Sex* (reviewed in the May-June 2010 *Association for Women in Mathematics Newsletter* and discussed further in the November-December 2010 *Association for Women in Mathematics Newsletter*).

The article discusses “math-intensive fields.” The meaning of this term is not given explicitly, but is suggested by the lists in the Supporting Information (SI text): computer science, chemistry, economics, mathematics, physics, chemical engineering, civil engineering, electrical engineering, and mechanical engineering. Psychology and biology are considered not to be math-intensive fields.

Inaccurate title and abstract. Despite its title and abstract, “Understanding current causes of women's underrepresentation in science” appears to be a discussion of women’s underrepresentation at the top 100 or research-intensive academic institutions, rather than their overall participation in academic and non-academic science. Women are half of the full-time permanent faculty in mathematics departments at two-year colleges (see CBMS 2005 Survey, p. 170). This survey occurs as reference 4 in the PNAS article’s supporting information). Women are 28% of tenure-track mathematics faculty in BA-granting institutions, 33% in MA-granting institutions, and 24% at PhD-granting institutions (see CBMS 2005 Survey, p. 104). In all fields of science, National Science Foundation statistics show a consistent trend over the past three decades: increase in percentages of women earning PhDs and in tenure-track and tenured positions (see *Thirty-three Years of Women in S&E Faculty Positions*, reference 3 in the PNAS article’s supporting information).

Misleading use of “orders of magnitude.” Paragraph 1 of the PNAS article says:

> Since 1970, women have made dramatic gains in science. Today, half of all MD degrees and 52% of PhDs in life sciences are awarded to women, as are 57% of PhDs in social sciences, 71% of PhDs to psychologists, and 77% of DVMs to veterinarians. Forty years ago, women’s presence in most of these fields was several orders of magnitude less; e.g., in 1970 only 13% of PhDs in life sciences went to women (1). In the most math-intensive fields, however, women’s growth has been less pronounced (2-4).

The reader might conclude that increase of women’s share of PhDs, as measured by order of magnitude, was smaller in math-intensive fields than in other scientific fields. In fact, the opposite is true. Measured in orders of magnitude, growth in women’s share of PhDs has been far greater in engineering than in psychology or biology. The percentage of engineering PhDs that went to women was 0.5% in 1970 but 20.2% in 2006, a forty-fold increase. In contrast, for psychology, it was 23.5% in 1970 and 71.3% in 2006, a three-fold increase. Increases for mathematics and physical sciences fall between these extremes. (For statistics, see *Thirty-three Years of Women in S&E Faculty Positions*.)

Misquoted statistics. Paragraph 1 of the PNAS article says:

> Among the top 100 US universities, only 8.8-15.8% of tenure-track positions in many math-intensive fields (combined across ranks) are held by women, and female full professors number ≤10%. (SI Text, S1)

The 8.8-15.8% comes from percentages for positions at “all ranks” in economics, chemistry, mathematics, computer sciemce, astronomy, physics, chemical engineering, civil engineering, electrical engineering, and mechanical engineering in a survey conducted by Nelson and Brammer in 2007. The survey did not collect statistics on tenure status. The corresponding percentages for assistant professors are 18.0-30.8%. See Table

11 of Nelson and Brammer's survey. This survey occurs as reference 1 in the PNAS article's supporting information (SI Text).

Thus, the article attempts to explain percentages for "all ranks" at top 100 institutions with studies of current hiring. However, percentages of women in all faculty ranks reflect past as well as current hiring and promotion practices.

No analysis of journal acceptance rates in math-intensive fields. Ceci and Williams recount studies of journal acceptance rates in ecology and evolution as well as biogeography and neuroscience. However, women's representation in these fields is greater than in fields such as physics, mathematics, computer science, and engineering. We would like to see studies of journal acceptance rates in the latter fields.

Missing chronology in discussion of search and hiring outcomes. Ceci and Williams quote the National Research Council study *Gender Differences at Critical Transitions*:

> "If women applied for positions at R1 institutions, they had a better chance of being interviewed and receiving offers than male job candidates."

Ceci and Williams comment: "These results are inconsistent with initiatives promoting gender sensitivity training for search committees and grant panels, which assume bias in funding and hiring of women (ref. 47, also see refs. 11, 56, and 57). Such initiatives target historical rather than current problems facing women scientists." This seems to refer to selected aspects of the National Science Foundation's ADVANCE program and related initiatives. Some chronology may be helpful.

ADVANCE was established in 2001. Its description begins: "The goal of the ADVANCE program is to develop systemic approaches to increase the representation and advancement of women in academic science, technology, engineering and mathematics (STEM) careers, thereby contributing to the development of a more diverse science and engineering workforce."

Data for the NRC study of hiring discussed by Ceci and Williams were collected at Research 1 institutions for 2002-03 and 2003-04 hires in biology, chemistry, civil engineering, electrical engineering, mathematics, and physics. At that time, ADVANCE was its infancy.

There seem to be no recent overall statistics for the percentage of women among tenure-track and faculty at such institutions. However, at PhD-granting mathematics departments, women went from 20% of tenure-track faculty in 2000 to 24% in 2005 (CBMS Survey, p. 104). Statistics for 2002 and 2005 from Nelson and Brammer's survey show increases in percentages of female assistant professors in "math-intensive" fields (see November-December 2010 AWM Newsletter or Nelson and Brammer's survey). At the top 50 mathematics departments, women were 19.6% of assistant professors in 2002, but 28.0% in 2007. Some corresponding percentages for other fields are: 10.8% to 19.5% in computer science; 15.7% to 18.2% in mechanical engineering; 30.4% to 36.0% in biological sciences. This is consistent with the hypothesis that ADVANCE's attention to hiring practices increased the percentage of women hired. Moreover, Ceci and Williams fail to note that such attention to hiring practices includes more than a discussion of bias.

Issues of statistical sampling are ignored, e.g., selection bias. The 1.6 million talent search scores collected over 30 years by Wai et al. (ref. 60) may sound impressive, but as Wai et al. note, the sample was not random. (For further discussion of this study, see the September-October 2010 *AWM Newsletter*.) Likewise, selection bias can also explain why, in the presence of gender discrimination, female scientists might still fare as well as their male colleagues in some respects if their work was better on average than that of their male peers. Studies that compare approval rates by gender with application rates by gender do not address this objection. As described by Ceci and Williams, the studies documented by references 31-33, 36-46 are of this nature.

What does the right-tail study tell us? The study by Wai et al. focuses on SAT-M and ACT test results of 7th graders. Andreescu et al. in their article "Students with Exceptional Talent in Mathematical Problem Solving" (Notices of the AMS 2008, p. 1248-1260) point out that these particular tests can not predict who will become research mathematicians.

> Since these tests lack questions that require creative thinking and insight into higher-level mathematical concepts, they do not identify childeren with extermely high innate ability in mathematics, thas is, ones who may go on to become top research mathematicians.

Andreescu et al. demonstrate that some Asian and Eastern European countries often produce girls with profound ability in mathematical problem solving, whereas other countries including the USA do not. Thus the results of Wai et al. are not replicated across other cultures and do not explain the underrepresentation of women in mathematics or other math-intensive sciences.

Omission of conflicting evidence and hypotheses. The article cites the National Research Council study *Gender Differences at Critical Transitions*, but does not mention the findings that suggest female scientists don't fare as well as male scientists in day-to-day interactions. For example, “Female faculty reported that they were less likely to engage in conversation with their colleagues on a wide range of professional topics” (Finding 4-7, p. 145). These topics included research, salary, and benefits. The report notes, “This distance may prevent women from accessing important information and may make them feel less included and more marginalized in their professional lives.&rdquo

Moreover, the study documented in *Gender Differences at Critical Transitions* found that women were underrepresented among candidates for tenure relative to the number of women assistant professors (Finding 5-1, p. 147), and were less likely to receive tenure (Finding 5-2, p. 147). This is consistent with the explanations in the conclusion of the article. However, like NRC Finding 4-7, it is also consistent with the hypothesis mentioned in *Gender Differences at Critical Transitions* (p. 278) that some women find the climate to be chilly at certain research-intensive institutions. (Note that women earn their PhDs at such institutions.) However, this chilly climate hypothesis is not considered. Consistent with this chilly climate hypothesis is Finding 3-8: “The percentage of women on the search committee and whether a woman chaired the committee were both significantly and positively associated with the percentage of women in the applicant pool” (p. 67). This is also consistent with the NRC finding that “the number of family-friendly policies advertised by the institution did not appear to be associated with the percentage of female applicants” (p. 50). However, the explanation may be that some are aware that they may be stigmatized for using the policies and require further evidence of family-friendliness. (See p. 17 of *Designing and Implementing Family-Friendly Policies in Higher Education.*)

Furthermore, the two-body problem is not discussed, despite the fact that it occurs in the title of reference 63. Female scientists are more likely to be part of a two-scientist couple than are male scientists. Women in the natural sciences and engineering are more likely to be partnered with someone in the same field than are female social scientists (see *Dual-Career Academic Couples*, especially Figure 13, and November-December 2009 *AWM Newsletter*).

Comment. Publicity related to articles like the PNAS article creates a situation in which scientists may often perceive only two choices:

- do not respond to colleagues or the public about the article;
- formulate an accurate response, by taking the time to read the article and the studies it cites.

More care in writing and refereeing articles like “Understanding current causes of women’s underrepresentation in science” would reduce the burden of the second choice, which is likely to fall disproportionately on women.