2009

Which Came First, the Data or the Politics? Disentangling Questions about Women's Aptitude for Science

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Recommended Citation
21 Yale Journal of Law and Feminism 261-296 (2009)

Which Came First, the Data or the Politics? Disentangling Questions About Women's Aptitude for Science

Review of *Why Aren't More Women in Science? Top Researchers Debate the Evidence* (Stephen J. Ceci & Wendy M. Williams eds., 2007)

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† Professor, New York Law School. Great thanks are due to many people for the birthing of this piece amidst difficult times (for the country, and for me). First and foremost, I must thank the editors of the *Yale Journal of Law and Feminism* for their patience in accommodating numerous delays due to personal circumstances. They have been a pleasure to work with and generous in their treatment of my repeated entreaties for more time. I particularly want to thank BJ Ard for the most helpful edit letter I have ever received. And I especially want to thank Bradley Powles, my patient and hard-working research assistant, without whose efforts there would be no book review. Thanks are also due to my faculty assistant Sondy Ortiz, without whom nothing would be possible, to Professor Stephen J. Ellmann, whose comments are always thoughtful and useful, and to Judy Rabinovitz, whose comments and encouragement were immeasurably helpful. Finally, I want to thank my mother Lee and my sisters Muffie and Erica Meyer, who shouldered many burdens which should have been mine during recent days, as they have done so many times before.

Biology gives you a brain. Life turns it into a mind.
– Jeffrey Eugenides, *Middlesex*[1]

There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact.
– Mark Twain, *Life on the Mississippi*[2]

INTRODUCTION

Is the dearth of women in STEM fields—science, technology, engineering, and math—primarily a product of innate or evolved gender difference, social conditioning (acculturation), discrimination, or "all of the above"?[3] The answer we select might influence not only where we put societal resources, but also the outcomes of individual life choices.[4] In addition, it may affect legal battles over everything from educational equity in schools and colleges to academic tenure decisions.[5] But what if there can be no definitive answer? What if, indeed, we cannot meaningfully distinguish what is innate (nature) from what is generated by historical and environmental (including cultural) influences? How then should we decide questions of resource allocation and make wise career path or tenure decisions? We must, I think, presume that more than 2000 years of ideology asserting the inferior intelligence and lack of rationality of women has resulted in an extraordinary depth of systemic discrimination against them in science, as elsewhere, that justifies shifting the burden of proof to those who

1. JEFFREY EUGENIDES, MIDDLESEX 479 (2002).

2. MARK TWAIN, LIFE ON THE MISSISSIPPI 173 (Oxford Univ. Press 1996) (1883).

3. WHY AREN'T MORE WOMEN IN SCIENCE?: TOP RESEARCHERS DEBATE THE EVIDENCE (Stephen J. Ceci & Wendy M. Williams eds., 2007) [hereinafter WOMEN IN SCIENCE]. The sweeping inclusion of "science" in STEM is not quite accurate; while women are relatively well-represented in biology and medicine overall—though not in certain subfields—there are far fewer women than men in physics and computer science. Males enroll and receive degrees in the "hard" sciences in far greater numbers than do women. *See* Stephen J. Ceci & Wendy M. Williams, *Are We Moving Closer and Closer Apart? Shared Evidence Leads to Conflicting Views*, *in* WOMEN IN SCIENCE, *supra*, 213, 220-21; Janet Shibley Hyde, *Women in Science: Gender Similarities in Abilities and Sociocultural Forces*, *in* WOMEN IN SCIENCE, *supra*, at 131, 131; Doreen Kimura, *"Underrepresentation" or Misrepresentation?*, *in* WOMEN IN SCIENCE, *supra*, at 39, 43. I use STEM to refer to those sciences that are predominately male, as well, of course, as technical, engineering, and math fields.

4. One could ask similar questions about the dearth of women partners in law firms, members of Congress, economics professors, leading newspaper and television commentators, or presidents of universities. Indeed, isolating the inquiry to women in the STEM professions distorts the inquiry by treating the question without putting it in the larger context of the advancement of women generally. Contributor Virginia Valian, in *Why So Slow: The Advancement of Women*, advances in a broader context the thesis she applies in *Women in Science* to women in STEM professions—that "a set of implicit, or nonconscious hypotheses about sex differences plays a central role in shaping men's and women's professional lives." VIRGINIA VALIAN, WHY SO SLOW: THE ADVANCEMENT OF WOMEN 2 (1998).

5. *See, e.g.*, John Tierney, *A New Frontier for Title IX: Science*, N.Y. TIMES, July 15, 2008, at F1 (describing investigators at some federal agencies who examine grant-recipient physics and engineering departments at major universities for possible discrimination against women).

would assert any other significant cause for the dearth of women at any level of any profession.[6]

Stephen J. Ceci and Wendy M. Williams, editors of *Women in Science*, don't purport to answer the question they pose, but rather to present the arguments in brief essays by fifteen "top researchers on gender differences in cognition in the United States, Canada, and the United Kingdom."[7] Their hope is that, "armed with accurate information, readers can decide [the answer] for themselves . . . based on scientific evidence, not politics or personal beliefs."[8] Contributors were chosen because their "scholarship in this area is well known, respected, and evidence based."[9] They were asked to support their arguments with data, and relied variously on results of standardized testing, behavioral observation under controlled circumstances, sociological data, psychological studies, survey data, neuroimaging and neuroscience data, animal studies concerning the influence of hormones on development, and clinical data about humans born with sexual abnormalities.

According to the editors, however, although the writers "often resummarize the same or similar data," they "interpret them quite differently."[10] Yet the editors remain curiously hopeful that presenting the data will "enable[] us to come to a shared understanding of whether there are sex differences in cognitive ability and, if there are, what role they play in career

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6. Contributor Doreen Kimura asserts that it is "standard form to assume that if there are fewer than 50% women in any cohort, the situation is undesirable and indicates some form of systemic or deliberate discrimination." Kimura, *supra* note 3, at 39. I don't know to whose "standard form" Kimura refers, but it is not mine. Most who challenge the dearth of women in any particular job or professional category are working with statistics more like contributor Valian's, Virginia Valian, *Women at the Top in Science—and Elsewhere*, *in* WOMEN IN SCIENCE, *supra* note 3, at 27, 27 (citing her own and others' work finding that "women make less money and advance more slowly . . . in every field . . . including nursing"), or those available from the Michelle R. Clayman Institute for Gender Research at Stanford University showing that, despite the fact that, in 2001, women earned 37% of all science and engineering degrees, only 15.4% of full professors in those fields were female, Michelle R. Clayman Institute for Gender Research, Status of Women Academics in the Sciences and Engineering, www.stanford.edu/group/gender/ResearchPrograms/GenderInScienceAndEngineering/Statistics.html (last visited Mar. 24, 2009). Job evaluation studies consider a field to be male- or female-dominated only when 70% or more of its members are of one sex, and the Equal Employment Opportunity Commission (EEOC) will not find a hiring pattern to be presumptively discriminatory until it is demonstrated that the rate of hiring for the group discriminated against is less that 80% that of the dominant group, typically as measured by the applicant pool or those who are shown to have the qualifications required for the job. *See* Am. Fed'n of State, County & Mun. Employees, AFL-CIO v. Wash., 770 F.2d 1401 (9th Cir. 1985).

7. Wendy M. Williams & Stephen J. Ceci, *Introduction* to WOMEN IN SCIENCE, *supra* note 3, at 4, 4.

8. *Id.* at 5. The authors claim to bypass "emotion, rhetoric, and politics" to "explore the hard science underlying gender differences in cognitive ability and their origins." *Id.* But the science presented is deeply inferential, and I wonder at their confidence that so-called "hard" science can solve a question that is so quintessentially one of complex human behavior, choices, and values. *See infra* Part IV.

9. Williams & Ceci, *supra* note 7, at 20.

10. *Id.* at 4.

imbalances."[11] Although the editors have done a masterful job of selecting contributors, summarizing their arguments, and outlining the numerous issues and weakness in contributors' arguments, I doubt their effort is likely to produce a "shared understanding" among either their contributors or their readers. Rather, what they demonstrate is the inconceivability of a science, especially one purporting to answer questions about the nature of men and women, that is free of "politics and personal belief."[12]

As writers Donna Haraway, Sandra Harding, and others have argued, and as this volume so plainly attests, when it comes to gender, scientific "answers" are themselves inevitably deeply influenced by ideological and cultural factors.[13] What is studied and publicized, how results are interpreted—these are anchored in individual and institutional stances and attitudes that are themselves products of a history of gender discrimination. Yet people, institutions, and juries must make choices based on the limited and partial evidence available to them.

Women in Science confirms my suspicion that these choices should be made with a skeptical attitude toward scientific data that purport to find gender difference, and an even more skeptical view of assertions that these differences, when shown, explain such multiply-caused (or overdetermined?) phenomena as the dearth of women in science. Rather, we would be wise to place a heavier reliance on the lessons of history, the teachings of humanists (including writers and filmmakers), and the partial but direct experiences of those who stand outside the mainstream of science and ideology, as well as of those who have directly encountered its biases. Several *Women in Science* contributors follow this path. Others, however, draw unwarranted conclusions from their data, conclusions that carry the danger of inappropriately reinforcing the status quo.

It is certainly true that males and females, as we have defined them—by sexual organs and sex-linked hormonal development—are different. And it may be that some of those differences can be linked to differences by gender in behavioral tendencies. But the danger in spending our resources on a quest to

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11. *Id.* at 11. The data they present goes well beyond questions of cognitive *ability*, and addresses purportedly "natural" gender-based proclivities (inclinations, drives, or preferences) for types of occupations, as well as structural barriers to women's participation in the sciences (long and sometimes unpredictable hours, lack of accommodation for caretaking obligations, and the like).

12. Patricia Adair Gowaty, editor of the excellent (and in some ways similar) volume, FEMINISM AND EVOLUTIONARY BIOLOGY: BOUNDARIES, INTERSECTIONS AND FRONTIERS (Patricia Adair Gowaty ed., 1997), found herself in a swirl of controversy and intense emotion when she sponsored a conference on the subject. Patricia Adair Gowaty, *Preface* to FEMINISM AND EVOLUTIONARY BIOLOGY, *supra*, at xi, xii-xiii. The *Women in Science* editors were themselves criticized for inviting certain commentators to present "both sides" of the gender difference debate despite their being overtly partial to specific explanations. Williams & Ceci, *supra* note 7, at 5.

13. *See, e.g.*, Donna Haraway, *Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective*, *in* THE FEMINIST STANDPOINT THEORY READER: INTELLECTUAL AND POLITICAL CONTROVERSIES 81 (Sandra Harding ed., 2004); Sandra Harding, *Rethinking Standpoint Epistemology: What Is "Strong Objectivity"?*, *in* THE FEMINIST STANDPOINT THEORY READER, *supra*, at 127.

find such differences is that it will almost inevitably end up reinforcing a powerful ideology of gender difference that has cabined women's opportunities more than it has or will shed light on the significance of gender.[14] Moreover, given what we have long known about the enormous variety in human behavior, and the powerful impact of history, culture, and ideology on it, and given what we are learning about environmental influences on brain development, it is unlikely that there exist strong biological links between gender and behavior. The notion that, were we able accurately to identify such links, they would explain the dearth of women in the sciences—when achieving positions and success in science depends on multiple factors, and relatively few of these factors depend on the traits and behaviors of the individual scientist—belongs in the category of science fiction, not science.

I. THE ONGOING NATURE VS. NURTURE DEBATE

> Frogs and snails and puppy-dogs' tails,/ That's what little boys are made of.
>
> – Nursery Rhyme[15]

When I was a young feminist in the late 1960s, we took as gospel that the dearth of women in science and throughout the professions was a matter of discrimination, not difference in innate ability.[16] Reacting to more than a century of women's confinement to the "separate sphere" of the home and concomitant exclusion from public and professional life, we were certain that to the extent that fewer women sought degrees, were hired, or advanced in science and other fields, this disparity was primarily a matter of acculturation and discrimination, not "natural" (innate or genetic) differences between the sexes. Men might be bigger, stronger, and have deeper voices, and there might be genetic differences in sexual and reproductive roles, but these differences were irrelevant to career choice except in very limited arenas, such as professional sports. The fact that boys might seem more aggressive and competitive at play, or choose trucks rather than dolls, was purely a matter of socialization.

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14. This is not to argue that we should halt studies of gender difference in cognition. Rather, it is to argue that these studies would be better accomplished with the aid of persons whose explicit purpose is to examine the research question, design, and execution for gender bias, rather like ethics committees examine for ethical compliance. And it is to suggest that funding should be prioritized for those studies whose purpose is linked to a positive social good such as understanding of brain injury and illness, rather than those studies geared toward establishing gender difference independent of plausible social benefits.

15. WILLIAM S. BARING-GOULD & CEIL BARING-GOULD, THE ANNOTATED MOTHER GOOSE: NURSERY RHYMES OLD AND NEW, ARRANGED AND EXPLAINED 175-76 (1962).

16. "A smaller percentage of women get advanced degrees in most of the natural sciences (although not biology) than in most of the social sciences, the humanities, medicine, law, business, or nursing." Valian, *supra* note 6, at 27. Yet "[w]omen make less and advance through the ranks more slowly not just in the natural sciences, but in every field . . . including nursing." *Id.* (citation omitted).

A combination of more gender-neutral parenting and removal of overt barriers to women's public participation in the world of work and politics would surely open the doors to predominately male professions, as surely as it would open the doors to predominately female professions for men. Over time, women would transform predominantly male professions, making them more hospitable to women, and the numbers would even out. Those of us who went into law fully expected that legal change—the removal of barriers to women's full participation in the economy and in politics, and to women's self-determination within the family—would greatly increase women's numbers and position in every occupation. Happily, these changes seemed to materialize in many areas (especially law), although gaps in pay, position, and prominence continued to be a problem, and some areas, including STEM fields, seemed especially resistant to penetration by women.

Then, one by one, my feminist friends began raising children and discovering that, despite their best efforts, (most of) their boys tended to be aggressive in play and begged for toy guns, while (most of) their girls opted for cooperative imagination games and asked for make-up. Can it all be socialization, we wondered, when we dressed *our* children in neutral colors (no pinks or blues for them), used the same tones of voice with both our girls and our boys, and gave them the same toys and cues? While some of us simply adjusted the time frame, realizing that social conditioning embedded in everything from pop culture to religion was not likely to be overcome by a generation or two of gender neutral childrearing, many others concluded that gender difference was at least as much a matter of genetics as acculturation, if not more so.

How could it be otherwise? This is not a puzzle that can be solved by laboratory testing and experimentation, nor by better and sharper brain imaging. We will never discover a male gene, hormone, or brain region inextricably linked to guns any more than we will find one linking female brains to make-up. Psychological testing of and behavioral experiments with young boys and girls will never be able to definitively distinguish the effects of acculturation from "innate," or biologically determined, behaviors.[17] Among other things, acculturation begins in utero, and it would be difficult to ethically fashion experiments evaluating the impact of uterine influences.[18] And, as

17. Baron-Cohen seeks to support his claim that boys' brains "systematize" while girls brains are empathic ("affective") using studies of year-old infants finding that boys' eyes focused longer on "videos of cars going past" while girls focused longer on faces. Simon Baron-Cohen, *Sex Differences in Mind: Keeping Science Distinct From Social Policy*, *in* WOMEN IN SCIENCE, *supra* note 3, at 159, 168. The leaps from such evidence to the conclusion that the boys are attempting to understand the mobile while the girls are seeking to empathize are obvious. We need to be especially skeptical about such a leap because Baron-Cohen's conclusions accord so closely with folk wisdom about gender difference.

18. Evidence is accumulating that fetuses respond in utero to sound, and are able to retain memory of auditory and other inputs, including language patterns, post-birth. Other areas (smell, for example) have not been well-studied, but an entire industry promoting pre-natal learning has arisen in response to more than two decades of research. *See, e.g.*, David E. Chamberlain, *What Babies Are Teaching Us*

some *Women in Science* authors point out, the line between nature and culture may itself be conceptually flawed, in that environmental—including socio-cultural—influences on the "natural" development of the brain begin immediately. Every millisecond the brain responds to the influences of both its own biological (hormonal) environment and to external stimuli, opening some neural pathways and not others, uniquely altering and shaping its response to the next stimulus and directing its continued development.[19]

Hence it is no surprise that neither science nor feminism has resolved the nature/nurture debate.[20] Sociobiologists continue to attempt to explain everything from male rape to female nurturing as a matter of genetic predisposition based in evolutionary necessity.[21] Post-modern feminism has responded that gender is imbedded in language,[22] hence expression of gender difference at early ages is to be expected but does not demonstrate the dominance of nature because language, according to some theorists, is a largely cultural artifact.[23] However, if language itself had a genetic basis, might it not express, as some research seemed to show, a basic difference between the sexes?[24] Carol Gilligan's research revealing a gender difference in moral

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About Violence, PRE- & PERINATAL PSYCHOL. J., Winter 1995, at 57, *available at* http://www.birthpsychology.com/violence/chamberlain1.html (citing research showing that "[f]or two decades we have had proof that full-term newborns, prematurely born babies, and even babies in utero are capable of classical conditioning and habituation" and that "[r]ecognition learning of musical passages, stories, voices, native language sounds and even children's rhymes have been shown at birth and during intra-uterine life"); *see also* David E. Chamberlain, Prenatal Memory and Learning, http://www.birthpsychology.com/lifebefore/earlymem.html (last visited Mar. 10, 2009). For one example of a company marketing pre-natal learning products, see Babyplus Prenatal Education System, http://www.babyplus.com/prenatallearning.php (last visited Mar. 10, 2009).

19. *See infra* notes 135-140 and accompanying text.

20. Most participants in this debate agree that it is a matter of which is dominant, since clearly both nature and nurture, or biology and culture, play a part. *See, e.g.*, Russell Gray, *"In the Belly of the Monster": Feminism, Developmental Systems, and Evolutionary Explanations*, *in* FEMINISM AND EVOLUTIONARY BIOLOGY, *supra* note 12, at 385, 385-86.

21. DAVID P. BARASH, SOCIOBIOLOGY AND BEHAVIOR 8 (1982); *see also* EDWARD O. WILSON, SOCIOBIOLOGY: THE ABRIDGED EDITION 300 (1980). For example, Gowaty likens it to behavioral ecology in framing it within the rubric of evolutionary biology. Patricia Adair Gowaty, *Introduction* to FEMINISM AND EVOLUTIONARY BIOLOGY, *supra* note 12, at 8. The definition of sociobiology is not entirely clear. For contemporary criticisms and defenses of expanded understanding of sociobiology, see generally the essays in FEMINISM AND EVOLUTIONARY BIOLOGY, *supra* note 12, particularly Caitilyn Allen, *Intextricably Entwined: Politics, Biology, and Gender-Dimorphic Behavior*, in FEMINISM AND EVOLUTIONARY BIOLOGY, *supra* note 12, at 515, 515, asking the question "[w]hy are feminists and evolutionary biologists at odds?" (and offering explanations grounded in the different aims of science (open-ended speculation) and feminism (political and cultural change)).

22. Susan Gal, *Between Speech and Silence: The Problematics of Research on Language and Gender*, *in* GENDER AT THE CROSSROADS OF KNOWLEDGE: FEMINIST ANTHROPOLOGY IN THE POSTMODERN ERA 176 (Micaela di Leonardo ed., 1991)

23. *Id.* at 180; *see* JUDITH BUTLER, GENDER TROUBLE: FEMINISM AND THE SUBVERSION OF IDENTITY (1990).

24. Noam Chomsky is perhaps the most notorious proponent of innate grammatical and syntactical linguistics. Since the late 1950s, his work has often been opposed by structuralist philosophers throughout the academy including many feminists, despite the fact that Chomsky himself has spoken very fondly of the feminist movement, calling it "the most important development to come out of the Sixties." One former student wrote in *Mother Jones* that "Chomsky thinks he is a feminist, but—at heart—he's an old-fashioned patriarch. . . . He just has never really understood what the feminist

reasoning was widely misinterpreted as signaling biological difference between the sexes.[25] Cultural feminists lauded women's supposedly more caring and cooperative behavior, but neither focused nor agreed on its origin, which was largely irrelevant to their enterprise.[26] And although emerging "queer theory" sometimes challenges the use of sex as a category at all, its challenge—in a world pervasively differentiated along gender fault lines—has yet to gain significant traction.[27]

Yet, part of our cultural legacy—ironically, one perhaps most often challenged from within academia—is an Enlightenment faith in the power and objectivity of science, which asserts authority on the basis of its purportedly value-neutral measurement, and the replicability of its "hard" data.[28] And so, to shore up the strength or defend against criticism of policy choices (or their results), many turn to scientific "data" that purport to justify those choices. This was the path taken by Harvard President Larry Summers when, in 2005, he offered his now infamous suggestion that the dearth of women in scientific academia (at Harvard and in general) might be partly due to innate sex differences in cognitive ability. But, perhaps not surprisingly given his leadership role in academia, Summers touched off a firestorm that lead not only to his resignation, but also to a lively revival of the nature/nurture (biology/environment; nature/culture) debate and to publication of the collection of essays that is the subject of this review.[29]

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movement is about." Jay Parini, *Noam Is an Island*, MOTHER JONES, Oct. 1998, at 36, 39. When asked if there was any validity to this claim, Chomsky said he was in no position to judge, but he admitted, "in fact, it's a criticism I've been hearing for years, from friends and others. And I think there's probably some validity to it." *The Radical Vocation: An Interview with Noam Chomsky*, Interview by Adam Jones with Noam Chomsky, in Cambridge, Mass. (Feb. 20, 1990), http://adamjones.freeservers.com/chomsky.htm#interview.

25. Steven Hartwell, *Promoting Moral Development Through Experiential Teaching*, 1 CLINICAL L. REV. 505, 519 n.52 (1995).

26. Mark M. Hager, *Sex in the Original Position: A Restatement of Liberal Feminism*, 14 WIS. WOMEN'S L.J. 181, 184-86 (1999) (recognizing that there are multiple positions which cultural feminism might take, including "biological essentialism" and "the commonplace assertion that trait are labeled 'male' and 'female' by cultures," but criticizing either basis).

27. *See* ANNAMARIE JAGOSE, QUEER THEORY: AN INTRODUCTION 1-6 (1996) (discussing the difficulty in defining a singular "queer theory" but stating broadly that queer theory debunks "stable sexes, genders and sexualities . . . out of a specifically lesbian and gay reworking of the post-structuralist figuring of identity as a constellation of multiple and unstable positions"); *see also* Jennifer Finney Boylan, *The XY Games*, N.Y. TIMES, Aug. 3, 2008, at 10 (arguing that Olympic games testing for sex cannot define a biological line differentiating male from female, and that efforts to "impose a binary order upon the messy continuum of gender" are "bound to fail").

28. The division of the sciences into "hard" and "soft" itself has a notably gendered aspect.

29. Williams & Ceci, *supra* note 7, at 7; Diane F. Halpern, *Science, Sex, and Good Sense: Why Women Are Underrepresented in Some Areas of Science and Math*, *in* WOMEN IN SCIENCE, *supra* note 3, at 121, 121-30; Benedict Carey, *Criticism of Gender Theory, and a Scientist Under Siege*, N.Y. TIMES, Aug. 21, 2007, at F1; *see also* Peter A. Lawrence, *Men Women and Ghosts in Science*, PLOS BIOLOGY, Jan. 2006, at 4(1): e19. I do not propose here to address the controversy over what Summers meant by his remark that "most of what we've learned from empirical psychology in the last fifteen years has been that people naturally attribute things to socialization that are in fact not attributable to socialization." The editors of *Women in Science* and at least one of its authors have interpreted him to mean that a significant "cause" of female under-representation is that there are "too few women with the

II. WHAT DO THE DATA SAY?

> We have, as human beings, a storytelling problem. We're a bit too quick to come up with explanations for things we don't really have an explanation for.
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> – Malcolm Gladwell, *Blink: The Power of Thinking Without Thinking*[30]

Women in Science's editors skillfully present the issues, summarize the data, and posit a research agenda to promote further clarity. But "there are so many ways of looking at sex difference on cognitive measures," as they recognize, that one's "conclusion will depend on the way one approaches the question."[31] This understated point may be why gender controversies are so persistent and so intense, especially within the sciences.[32] Those who lean toward cultural and historical explanations for differences in the social positions of males and females wonder why if, as Haier points out, "[m]ost of the differences [in "cognitive strengths and weaknesses" by gender] are rather small and may have no practical consequences," so much attention and so many resources have been devoted to finding them.[33] We wonder whether part of the explanation may lie not only in a male-dominated history dismissive of the issues and perspectives of women, but also in the embodiment within science of an ideology of objectivity, neutrality, and (more recently) individualism, which themselves grow out of that history.

Beginning in the 1980s, many feminist scholars of science began to assert what they termed "standpoint theory" as a challenge to the supposed objectivity of science and other truth-seeking epistemologies.[34] These writers, although

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cognitive abilities that are needed for careers in science and math." Summers' first example of what empirical psychology has purportedly revealed relied on much-criticized conclusions drawn from the so-called "separated twin studies." *See, e.g.*, Paul Ehrlich & Marcus W. Feldman, *Genes, Environments & Reductionism*, 136 DAEDALUS 5, 5-6 (Spring 2007).

30. MALCOLM GLADWELL, BLINK: THE POWER OF THINKING WITHOUT THINKING 69 (2005).

31. Williams & Ceci, *supra* note 7, at 11. The editors do not address whence, if not from politics and personal belief, one's choice of approach might derive.

32. *See supra* note 12 (describing controversy surrounding the feminism and evolutionary biology conference).

33. Richard J. Haier, *Brains, Bias, and Biology: Follow the Data*, *in* WOMEN IN SCIENCE, *supra* note 3, at 113, 113 (2007). Haier himself persuasively argues that, because male and female brains are anatomically different, we can learn much about the brain's function in general by comparing them. *See* Richard Haier, Professor, Univ. of Cal.-Irvine Med. Sch., Speech at American Enterprise Institute's Conference on Women and Science (Oct. 1, 2007), *available at* http://www.aei.org/events/filter.all,eventID.1536/transcript.asp. Perhaps, but the data revealed by such studies is not self-interpreting, and within a culture in which cognitive difference is so often assimilated to a binary hierarchy which favors men even when it (occasionally) purports to highlight women's advantage or greater skill, the data are likely to be misinterpreted.

34. See the essays in THE FEMINIST STANDPOINT THEORY READER, *supra* note 13. *See also* Joan Williams, *Is Law an Art or a Science?: Comments on Objectivity, Feminism and Power*, 7 AM. U. J. GENDER SOC. POL'Y & L. 373, 375 (1999) ("[P]eople often confuse objectivity critiques with the belief

differing in the degree to which they were willing to abandon traditional notions of objectivity and what they meant by the term, were unified in bringing attention to the importance of power in determining the allocation of scarce scientific resources: determining what gets studied, where resources are spent, what conclusory leaps are apt to be made from the data, and how those leaps are portrayed in mainstream media. These writers were also unified on the position that the views, issues, concerns, and realities of women and other groups previously underrepresented (or entirely absent) among decisionmakers were not adequately taken into account. And they demonstrated the many ways in which that failure undermined the objectivity of science itself. Issues of importance to the less powerful had been ignored. But equally important, critical examination of the data from "below"—examination that might question the assumptions underlying study design or interpretation of results from the perspective of the powerless—was largely absent.

Women in Science's laudable aim is, in part, to redress this situation (the majority of its authors are women researchers), yet it presents its contributors as offering an objective alternative to mere "politics or personal belief." Ultimately, the essays it contains demonstrate how little can be resolved by the data, and how much is driven precisely by deeply-ingrained standpoints which are themselves a product of politics and personal belief. [35]

Those who believe that cognitive gender difference explains the "science gap"—primarily Kimura and Baron-Cohen[36]—tend to rely on the highly culturally and historically specific assumptions that individual ability and inclination explain professional success; that cognitive ability is in significant measure innate rather than cultivated, conditioned, and defined by culturally and historically specific influences; and that preference is generated in great measure by ability. These assumptions pervade the effort to explain job distribution using standardized test data, and the further reliance on data

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that nothing is true . . . . This is silly: it mistakes a conversation on epistemology, on what truth claims mean, with a claim that truth claims are incoherent.").

35. Editors Ceci & Williams note that "[t]he way the arguments are framed makes it difficult to pit one type of evidence against the other," precluding one's ability to determine which way the preponderance of the evidence leans. Ceci & Williams, *supra* note 3, at 213. But they decline to address whether it is *possible* to frame the arguments such that they fully engage, given that each embodies within it numerous unproven (and perhaps unprovable) assumptions about human nature, human culture, and, indeed, the nature of science itself. The depth of difference in ideological or cultural underpinning may well make them simply incommensurable.

36. Others read the data to potentially support cognitive gender difference, but disclaim any certainty with respect to its explanatory significance in relation to the dearth of women in some sciences. *See* Ruben C. Gur & Raquel E. Gur, *Neural Substrates for Sex Differences in Cognition*, *in* WOMEN IN SCIENCE, *supra* note 3, at 189, 189, 195-96 (stating that although "findings substantiate some *hypotheses* . . . for sex difference in cognition," "[t]he state of knowledge on the neurobiology of sex difference is far from enabling strong statements"; and "biology can only offer a limited perspective and . . . not much more than conjectures" (emphasis added)); Haier, *supra* note 33, at 113-14, 116 (citing studies that show gender difference in cognitive ability but opining that "[a]t this stage of research, it is not certain that genes play a role either in mathematical talent among individuals or in any sex differences in the size of the talent pool" and declining to speculate about behavioral outcomes).

indicating that high scorers obtain elite jobs,[37] to argue that they do so because they have greater ability. (They also underlie the tendency of at least some scientists, represented, in this volume, by Doreen Kimura, to view their own data without adequately situating it socially and historically.)[38] Not coincidentally, these arguments tend to justify the status quo.

Some who emphasize innate cognitive difference caution that other factors may also help explain women's absence from STEM fields, but they still fail to explore the way in which hidden assumptions might be deeply and problematically influencing their emphasis or conclusions (although, in fairness, they were held to a strict word limit).[39]

Only Kimura and Baron-Cohen are willing to assert a clear link between innate gender difference in brain function (hence aptitude) and professional outcomes (fewer women in science; fewer men in nursing and education).[40] Others, such as Gur and Gur and Haier agree that the data seem to suggest, if not establish, cognitive gender difference, but they call for further research and are less ready to affirm the link between the differences identified and career outcomes.[41] Lubiniski and Benbow, while relying to some extent on evidence supporting different "ability patterns" by gender, also identify differences in potentially socially conditioned "interest" and the highly culturally specific

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37. *See* David S. Lubinski & Camilla Persson Benbow, *Sex Differences in Personal Attributes for the Development of Scientific Expertise*, *in* WOMEN IN SCIENCE, *supra* note 3, at 79.

38. Kimura writes that it "is almost certainly correct" that "the lower number of men in [nursing and education] reflect a lesser talent or interest" in those fields. *Kimura*, *supra* note 3, at 39. Kimura is evidently blissfully unaware that males predominated in the field of education for centuries and that, in nursing, males advance more rapidly than females, as Valian reports, *supra* note 6. It does not seem to occur to Kimura that men's lesser interest in nursing in the past might have had more to do with the low salaries and lack of prestige commanded by the profession until relatively recently than any intrinsic disinterest in or capacity for the work involved.

39. Baron-Cohen explicitly warns that scientists must be "sensitive to this history of conflict," in which researchers like him were accused of gender essentialism, "by cautiously looking at the evidence and being careful not to overstate what can be concluded." Baron-Cohen, *supra* note 17, at 160. But Baron-Cohen then goes on to do what he warns against. Based on limited and contested data, he concludes not only that female brains are characterized by empathic ("affective," "emotional") responses while male brains systemize and are rule-oriented, such that "the explanation is exact, and its truth value is testable," but also that these are "wholly different kinds of processes" which "*depend on separate, independent regions in the human brain.*" *Id.* at 160-61 (emphasis added). His latter statement fails to acknowledge research which suggests that our complex brains and the regions within them are interdependent and pliable in ways that we have not begun to fathom. *See, e.g.*, NORMAN DOIDGE, THE BRAIN THAT CHANGES ITSELF: STORIES OF PERSONAL TRIUMPH FROM THE FRONTIERS OF BRAIN SCIENCE (2007) (stating that victims of accidents who lose certain brain functions are able to recover by rewiring neuronal circuits); OLIVER SACKS, MUSICOPHILIA 163 (2007) (citing evidence that visual cortex of persons blind from birth adapts to other uses). Moreover, in constructing a dichotomy between empathic and systemic responses as "wholly different" processes, Baron-Cohen seems to exhibit precisely the lack of "sensitivity" he warns against. Granted, his word count was limited, but his contribution includes not even a scintilla of reflection on the degree to which the studies on which he relies (his own and others') might be influenced by a history of assigning the less valued trait—typically emotion (affective empathy) to women, and the more valued one—often reason (systemizing thought)—to men.

40. *See* Baron-Cohen, *supra* note 17; Kimura, *supra* note 3.

41. *See* Gur & Gur, *supra* note 36; Haier, *supra* note 33.

"number of hours [men and women are] willing to devote to their careers" as important factors in the dearth of women holding advanced positions in science.[42]

The remainder, a majority of them women, argue that much of the data suggesting ability difference is flawed (and perhaps always will be), and that the inferences drawn from it are even worse. These authors argue that socio-cultural explanations better elucidate women's relative absence from the sciences, and most challenge "the assumption that there is a direct relationship between cognitive ability, career choice and success."[43]

But almost all on both sides agree on the following propositions: Although there are cognitive and developmental differences between those we typically designate male and those we typically designate female, the evidence "says nothing about individuals";[44] the differences within genders are greater than those between them; and both nature and nurture play a part in female/male development—indeed, Hines and Halpern argue that, given what we know about the brain, the dichotomy between natural and environmental influences is virtually incoherent.[45]

A. Gender May Explain a Good Deal

Ultimately, although several authors interpret the data as supporting meaningful cognitive difference between the sexes, only Kimura and Baron-Cohen are willing to conclude that there is a definite link between that difference and the dearth of women in science.[46] Others, although they treat as helpful data purporting to demonstrate meaningful cognitive difference by sex,

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42. Lubinski & Benbow, *supra* note 37, at 80. Of course, "willing" is a loaded word, one which locates women's hours of work in individual choice rather than such institutional factors as discrimination or a patriarchal allocation of responsibility for child and elder care.

43. Halpern, *supra* note 29, at 121; Hyde, *supra* note 3, at 212; *see also* Sheri A. Berenbaum & Susan Resnick, *The Seeds of Career Choices: Prenatal Sex Hormone Effects on Psychological Sex Differences*, *in* WOMEN IN SCIENCE, *supra* note 3, at 147, 154 ("It is also important to recognize that career outcome and its value depend not just on individual characteristics but on the actions of social institutions.").

44. Baron-Cohen, *supra* note 17, at 159.

45. *See* MELISSA HINES, BRAIN GENDER 4 (2004); Halpern, *supra* note 29, at 127 ("The distinction between biology and experience is hopelessly blurred when you consider that the architecture of the brain is also shaped by experience . . . ."). Halpern points to data showing, for example, that areas of the brain related to spatial skills were enlarged in London cab drivers. *Id.* For similar data related to musicians and enlargement of the corpus callosum, see, for example, SACKS, *supra* note 39, at 94 (citing Christian Gaser & Gottfried Schlaug, *Brain Structures Differ Between Musicians and Non-Musicians*, 23(27) J. NEUROSCIENCE 9240 (2003); and Siobhan Hutchinson et al., *Cerebellar Volume of Musicians*, 13 CEREBRAL CORTEX 943 (2003)). In a later study, Maguire along with colleague Woollett demonstrated that the "[g]rey matter increases in various parts of the brain [that] have been identified in a number of skilled groups such as musicians, mathematicians, bilinguals, jugglers, and medical students" may come at a mental cost in performing other memory tasks. Katherine Woollett & Eleanor A. Maguire, *Navigational Expertise May Compromise Anterograde Associative Memory*, 47 NEUROPSYCHOLOGIA 1088 (2009) (citations omitted).

46. *See* Baron-Cohen, *supra* note 17; Kimura, *supra* note 3.

are more reluctant to assume that it contributes significantly to explaining employment outcomes.[47] Kimura and Baren-Cohen, but also Newcombe, Geary, Newcombe and Lubinski, and Benbow emphasize data revealing male performance superiority in areas that are arguably important to success in STEM fields, such as mathematics reasoning, spatial ability (especially mental rotation tasks), and mechanical reasoning, as well as greater orientation to objects rather than people.[48] These proclivities, some suggest, lead to a gender difference in preferred activities (types of play, for example, and affinity for school subjects) and thus widen the gender gap in both ability and interest.[49] Females, the argument goes, tend to avoid STEM areas as they grow older, and instead to prefer subjects and fields that favor their own skills and interests as well as those that are more people-oriented.[50] These scholars focus heavily on test scores and experimental data revealing "large effect sizes favoring males"[51] on tests of mental rotation of objects in space and mechanical reasoning ("imagining real-world interactions of mechanical items").[52] In addition, "men generally greatly outnumber women at the high end of math and spatial reasoning tests,"[53] and contributing researchers Lubinsky and Benbow have shown that science professionals at elite universities are chosen largely from the extreme high end of the ability curve.[54] In addition, some (like Baron-

47. Berenbaum & Resnick, *supra* note 43 (acknowledging hormonal influences but emphasizing the importance of social and institutional forces); Nora S. Newcombe, *Taking Science Seriously: Straight Thinking About Spatial Sex Differences*, *in* WOMEN IN SCIENCE, *supra* note 3, at 69, 75 (". . . I doubt that extra increments of the same cognitive ingredients explain much variance.")

48. *See, e.g.*, Baron-Cohen, *supra* note 17.

49. *See* Kimura, *supra* note 3, at 41 (taking issue with those who suggest childhood social conditioning leads to adult outcomes and arguing that it is "equally possible," indeed "probable," that "superior abilities influence the activities rather than the other way around"). Several other contributors disagree with Kimura on this point. *See, e.g.*, Jacquelynne S. Eccles, *Where Are All the Women? Gender Differences in Participation in Physical Science and Engineering*, *in* WOMEN IN SCIENCE, *supra* note 3, at 199, 209 (arguing that early preferences are based not on differences in aptitude, but rather "inaccurate stereotypes" that "begin influencing educational decisions quite early in life"); *see also* Newcombe, *supra* note 47, at 71 (pointing to evidence that low-income youngsters did not exhibit sex differences in two spatial tasks, and suggesting that "[t]he most natural explanation . . . is that boys in low-income environments lack access to the experiences that enhance spatial skill (e.g., computer games, puzzles, and building sets)").

50. Ceci & Williams, *supra* note 3.

51. Kimura explains,

> Effect size refers to the magnitude of the difference between two means, taking into account the variability or dispersal of the scores around each mean. If variability is small, there is less overlap between the groups, so the effect size is larger. If variability is large, effect size will be smaller.

Kimura, *supra* note 3, at 40 n.1.

52. *Id.* at 40.

53. *Id.* at 40; Lubinski & Benbow, *supra* note 37, at 79.

54. Lubinski & Benbow, *supra* note 37, at 80. Their Study of Mathematically Precocious Youth (SMPY) focuses on "the talented" top 1% of math test-takers because "most STEM professionals come from those in the top 10% in ability." *Id. See* Larry V. Hedges & Amy Nowell, *Sex Difference in Mental Test Scores, Variability, and Numbers of High-Scoring Individuals*, 269 SCIENCE 41 (1995) (reviewing the findings of six studies showing that "males outnumbered females in the top 1% of mathematics and spatial reasoning ability by a ratio of 7:1" and concluding that "small mean differences [in ability]

Cohen) offer data suggesting greater object-orientation on the part of males, and people-orientation on the part of females (data which is strongly challenged by Hyde and by Spelke and Grace).[55]

Experiments with young children indicate that some of these differences are present at early ages, and other data reveal that they occur "across cultures that vary in social pressures to conform to a gender norm."[56] In addition, while "both sexes benefit by short-term intensive training on spatial tasks," average differences by gender remain, and have "not radically" changed "over the past three or four decades."[57]

In addition, some point to evidence of gender difference in prenatal and early post-natal hormonal development—evidence that has been linked to behavioral difference in animal experiments as well as clinical observation of humans with unusual sexual development.[58] For instance, Kimura notes that male rats are better than females at learning spatial mazes, but these differences "can be reversed by hormonal manipulation in early postnatal life."[59] And she and Geary point out that male meadow voles, but not other types of voles, develop better spatial ability during their hormone-induced mating season, seemingly because their mates, unlike those of other types of voles, are territorial and widely dispersed, so that success at sexual competition (which is

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combined with modest differences in variance" might explain women's under-representation in the sciences). As Williams and Ceci point out,

> Everyone agrees that [the 50% mark of the ability distribution] is not where the action is; females do as well or better than males in math and science, on average. They get better grades, take more demanding coursework, matriculate in college in greater numbers, graduate in higher numbers (57% of all graduates of four-year programs are now female), and profess greater post-secondary professional aspirations. Scientists, especially those in mathematically intensive fields, do not come from the middle of the ability distribution.

Williams & Ceci, *supra* note 7, at 12. Notably, however, despite significantly superior scoring by Singaporean and Japanese girls over American and Canadian boys on international tests (on tests in 2002 and 2003, Japanese girls outscored U.S. boys by 62 points and Singaporean girls by 104, whereas U.S. boys only outscored U.S. girls by 2-5 points), Valian, *supra* note 6, at 29, this pattern has neither lead to larger numbers of girls in those societies entering STEM professions, nor to a predominance of Singaporean or Japanese Nobel winners in math or science.

55. Hyde, *supra* note 3, at 131-45; Elizabeth S. Spelke & Ariel D. Grace, *Sex, Math, and Science*, *in* WOMEN IN SCIENCE, *supra* note 3, at 57, 58 (pointing to some data that females actually learn some "object mechanics" tasks earlier than males, and that "male and female toddlers learn at indistinguishable rates how to fit blocks into holes and build towers").

56. Kimura, *supra* note 3, at 41.

57. *Id.* But as the *Women in Science* editors point out, in 1975 "there was a substantial male advantage in the mean scores on the British Volume and Heaviness test, but . . . this advantage disappeared by 2004"; further, while in 1983 the top 1% on the SAT-M (math) reflected a male to female 13:1 ratio, by 2005 that ratio had shrunk to 4:1. Williams & Ceci, *supra* note 7, at 11-12. Plainly, what constitutes a "radical" change may depend on one's (political?) predisposition.

58. *See, e.g.*, Kimura, *supra* note 3, at 41.

59. *Id.* From this data, Kimura draws the inference that early interest rather than early experience causes later-life gender difference in spatial ability. *See also* David C. Geary, *An Evolutionary Perspective on Sex Differences in Mathematics and the Sciences*, *in* WOMEN IN SCIENCE, *supra* note 3, at 173, 175-76 (extrapolating from hormonal influences on meadow voles to support his evolutionary explanation of gender difference in spatial ability).

central to species survival) depends on spatial ability.[60] Geary, in *An Evolutionary Perspective on Sex Differences in Mathematics and the Sciences*,[61] asks readers to "consider the possibility that [evolution has selected for] sex differences in certain cognitive abilities and personal interests [that] contribute to long-term engagement in mathematical and scientific endeavors and to ease of learning some aspects of [these]."[62]

Although all contributors are psychologists, it is notable that Gur and Gur and Haier, who focus on evidence emerging from neuroscience imaging, are far more hesitant to make leaps from anatomical to behavioral difference, let alone to employment outcome difference. It may be that this is because they are all too aware of the tentative nature of their own results—and the results of neuroscience in general—and the degree to which drawing even the most limited conclusions from such preliminary and potentially flawed data would entail making giant leaps.

Gur and Gur, for example, confirm that there are both anatomical (structural) and physiological (functional) differences between male and female brains. But the meaning of these differences remains murky at best, and they clearly opine that "[t]he state of knowledge on the neurobiology of sex differences is far from enabling strong statements."[63] Describing findings that males have a larger volume, but females a larger percentage of "grey matter," which "can be considered as the hardware necessary for computation,"[64] they go on to suggest that "it can be argued that women have compensated for smaller cranial volume by packing a higher percentage of tissue with computational power."[65] "Can be considered" and "can be argued" reveal just how underdeveloped the neuroscience imaging project is, and just how far we have to go before it will offer us answers to questions about why there aren't more women in science. The region of the brain responsible for interhemispheric communication, Gur and Gur tell us, "is larger or at least more bulbous in women" (male brains are more lateralized than those of females) and "females displayed increased bilateral hemispheric activity for a

60. *Id.* at 173-76. Similarly, Newcombe hypothesizes that "evolutionarily important behaviors such as male-male sexual competition" (the necessity to "navigate around the territory so as to have sexual access to as large a number of fertile women as possible") explain "men's superior showing on tests of ability to mentally rotate three-dimensional objects." Newcombe, *supra* note 47, at 69, 72. Geary admits that his approach is highly speculative, typically uses terms like "may" and "potentially," and freely admits that "the knowledge bases, technical skills, and conceptual insights in mathematics and the sciences arise from a poorly understood interaction between inherent cognitive and motivational biases and culture-specific educational goals and opportunities." Geary, *supra* note 59, at 173-74.

61. Geary, *supra* note 59, at 173.

62. *Id.*

63. Gur & Gur, *supra* note 36, at 195.

64. *Id.* at 192.

65. *Id.* It surely "can be argued," but how will we determine if it is correct and, if so, what implications it has for gender difference? We may someday learn more, but at the moment we are dealing in speculation upon speculation about the revelations of a new technology.

variety of cognitive tasks."[66] But the conclusions that can be drawn from these revelations about male/female anatomy are hardly obvious, and Gur and Gur do no more than suggest that one can legitimately hypothesize that further study *might* reveal a link to behavior.[67]

The results of neuroimaging studies demonstrate that women and men use different regions of the brain more intensely when performing particular language or spatial problem-solving tasks. Gur and Gur note that several studies show that when handling a three-dimensional virtual maze, "[w]omen used more parietal and prefrontal regions (the latter suggesting it was an effortful task), whereas the men relied more on the hippocampus, suggesting an automatic encoding of geometric-navigation cues."[68] While the authors avoid the temptation to leap to the conclusion that males are therefore hard-wired to be better at such tasks, the "suggestion" is less likely to be closely examined by readers, much less media sensationalists, who may likely view this as a reconfirmation of previously held views. Closer examination might raise pertinent questions about the ages and experiences of the test subjects, and whether any comparative studies across age had been done that might demonstrate that the "automatic encoding," like that of bike-riding skill, was characteristic of a learned skill rather than an innate brain function.[69] It would be interesting to compare the brain regions of people just learning to ride bikes to those of people who have ridden bikes for a significant period of time to see whether something similar could be found, but to my knowledge we have not yet developed the technology for recording the neuroimages of someone riding a mobile bicycle. However, we do have information suggesting that a great deal of brain development, and perhaps usage, is environmentally driven; for example, the size of various brain structures in musicians differs substantially from the size observed in non-musicians, and there is a strong correlation between these differences in anatomy and "the age at which musical training began and the intensity of practice and rehearsal."[70]

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66. *Id.*

67. Notably, one thesis they offer concerning the "behavioral effects" of male/female brain difference is that "[f]or females, better interhemispheric communication confers advantage in language and the ability to better integrate verbal-analytical . . . with spatial-holistic . . . information processing." *Id.* at 196. For those like Kimura who are dismissive of discrimination as a primary cause of women's absence from the sciences, this hypothesis raises the question of why women don't occupy the majority of positions of authority in communicative fields, and those fields that require "holistic" approaches.

68. *Id.* at 194.

69. They might also enquire whether women's compensatory, cooperative approach to navigation—asking directions—is a more effective and successful strategy for daily success and effective pursuit of science than the individual cognitive efforts purportedly measured by test scores or pictured in brain images. See Haier, *supra* note 33, at 114, to reference to the popular idea that "men allegedly do not ever ask for or read directions."

70. SACKS, *supra* note 39, at 94. We know that humans develop automated responses that are stored separately from other memory. *See id.* at 204-06 (describing the case of Clive Wearing, who lost all experiential memory, so had no awareness of himself or his past, yet retained the ability to sing, conduct a choir, and play the piano). It would therefore seem logical and likely that any "automated" brain response is as much or more a matter of learning than physiology. *See also* MICHAEL S.

Moreover, based on evidence related to gender difference in blood flow, cerebral glucose metabolism and neurotransmitter function, Gur and Gur posit that women's brains may "better equip them for sustained mental activity."[71] If they are right, the evidence suggests that women ought to have an *advantage* in those sciences that demand sustained mental activity (and I cannot at the moment think of any sciences that do not).

Haier, whose studies have shown differences between male and female brain activity, makes no claim that his findings suggest anything significant about women's participation in STEM fields; his main aim seems to be to argue for keeping an open mind and continuing to study gender difference in cognition, because results might have uses (for example, medical interventions and the like) sufficiently valuable to make it worth the price paid by women (and some men) in popular and scientific misreading of the data.[72] He contributes evidence from his own and others' neuroscience studies, which use PET scans and MRIs to compare the brain activity of males and females performing certain specific tasks, and to examine the relationship of structural differences in male and female brains to general intelligence. For instance, he points to one widely reported study indicating that brain regions previously linked to IQ performance differ substantially in men and women. He argues that these studies may, if replicated, demonstrate that "men and women achieve the same general cognitive capability using different brain architectures."[73] In another example of gender difference, he points to a PET scan study of twenty-two males and twenty-two females taking the math SAT, or SAT-M, which revealed that "the harder the temporal lobes were working in the men, the better

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GAZZANIGA, RICHARD B. IVRY & GEORGE R. MANGUN, COGNITIVE NEUROSCIENCE: THE BIOLOGY OF THE MIND 101-05 (3d ed. 2009) (describing brain plasticity and explaining "topography," that is, the mapping of images in the brain). Increased amounts of grey matter have also been shown in mathematicians, bilinguals, jugglers and medical students. *See* Woollett & Maguire, *supra* note 45 (listing studies supporting each of these findings, and presenting research suggesting that increased gray matter in London taxi drivers in one brain region may come at the cost of brain function governed by other regions).

71. Gur & Gur, *supra* note 36, at 196.

72. As early as 1974, psychologists who examined studies on gender difference warned against biases that often lead to erroneous findings of difference. Among these were significant over-reporting of difference or positive results—for every twenty studies, nineteen findings of little or no difference go unreported, but the one positive finding is splashed across the media. In addition, stereotypes about sex differences influence the perceptions of both researchers and participants, distorting their experimental results and their interpretation of them. *See* ELEANOR EMMONS MACCOBY & CAROL NAGY JACKLIN, THE PSYCHOLOGY OF SEX DIFFERENCES 3-8 (1974) (describing biases in both reporting and interpretation of data). Writers—both popular and scholarly—want to relate social behaviors to gender ("Men are from Mars, Women are from Venus," after all) and to differences in male and female brains. *See, e.g.*, JOHN GRAY, MEN ARE FROM MARS, WOMEN ARE FROM VENUS (1992). There have been a spate of recent books and articles making claims similar to those of writer Louann Brizendine, who claims that "the female brain is so deeply affected by hormones that their influence can be said to create a women's reality," and there are "sex-specific female brain circuits . . . for talking, flirting, and socializing." LOUANN BRIZENDINE, THE FEMALE BRAIN 3, 36 (2006).

73. Haier, *supra* note 33, at 115.

their score," whereas no such relationship—nor any other—was found in the brains of women.[74]

As noted earlier, Haier is careful to note that "[m]ost of the differences [in cognitive performance by gender] are rather small and may have no practical consequences," but he holds out hope that the research will shed light on the origins "of rather substantial cognitive differences among individuals."[75] That may be so, and may have important uses in treating disease and disability. But what needs careful examination is whether, given the very minor differences revealed by many of these gender-based studies, and the questionable meaning and potentially negative effects of others (especially the testing data), cognitive science might be better served by studies that ask different questions, focus on different issues, and are differently designed.[76]

B. Gender May Explain Little: The Socio-Cultural Camp

> I note the obvious differences/ between each sort and type,/ but we are more alike, my friends,/ than we are unalike.
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> – Maya Angelou, *I Shall Not Be Moved*[77]

By contrast, contributors who emphasize the environmental factors argue both that the evidence of innate cognitive difference is flawed, and that the inferences concerning STEM careers drawn from it are insupportable. They

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74. *Id.* at 114.

75. *Id.* at 113.

76. Neuroscience is one of the areas in which women are increasingly well-represented at the graduate levels, which may ensure that questionable inferences will be less likely to be drawn from the data being produced, and study subjects may shift. Emma Hitt, *Careers in Neuroscience: From Protons to Poetry*, 318 SCIENCE 661 (2007) (describing the most recent survey of neuroscience programs, which found that women were more than sixty percent of neuroscience graduate students, but that the number of tenure-track faculty had changed little since 1998 and the percentage of women full professors remained a "low 21 percent"). Of course, this latter finding is a matter of concern, since if women lack positions of authority in these fields despite their graduate numbers, one cannot be confident that their perspectives will succeed in gaining a hearing, much less in changing the subjects studied or the approaches taken. Indeed, even if a few women reach positions of authority, it is often by virtue of mimicking the pattern of the male figures who came before them. Yet there is some hope that a few generations of women scientists in authority will produce change, just as women in other fields have. For instance, although women in the legal field have not shattered the "glass ceiling" that limits their numbers at the top of the profession, they have contributed to making significant change in the law itself, as well as in institutional culture. Women have spearheaded doctrinal change in everything from sexual harassment (a concept that did not exist before women's articulation of it as a form of discrimination) to marital rape (which was not punishable as rape). *See generally* GENDER AND LAW: THEORY, DOCTRINE, COMMENTARY (Katherine T. Bartlett, Angela P. Harris & Deborah L. Rhode eds., 3d ed. 2002). For exploration of ways in which, despite the law, gender inequality is perpetuated, see generally DEBORAH L. RHODE, SPEAKING OF SEX: THE DENIAL OF GENDER INEQUALITY (1997). For strategies of change, see generally WOMEN AND LEADERSHIP (Barbara Kellerman & Deborah L. Rhode eds., 2007). And it is not coincidental that the demise of the *in terrorem* method of Socratic teaching, personified by Kingsfield in THE PAPER CHASE (Thompson Films 1973), gave way in most law schools soon after women entered the profession in significant numbers.

77. MAYA ANGELOU, I SHALL NOT BE MOVED 5 (1990).

argue that sociological and historical evidence—particularly a long history of discrimination against women in the very definition and structuring of "science"—better explains the STEM gender gap.[78] Disputing the claimed male cognitive edge, they point out that girls, on average, get better grades than do boys in both math and science, and outperform males in elementary and middle school on some mathematical tests (arithmetic and calculation).[79] Standardized test results, especially at extreme ends of the score curve, may be measuring test-taking skill (and gendered biases) rather than cognitive difference.[80] And Japanese, Taiwanese and, lately, Singaporean females have been significantly outscoring American and Canadian males on global mathematics tests, so cultural factors are plainly influential.[81] Elizabeth S. Spelke and Ariel D. Grace cite numerous studies challenging the Baron-Cohen "evidence" that males predominate in science because they are more "object-oriented" or more numerically or "spatially gifted," to conclude that the

78. *See, e.g.*, Williams & Ceci, *supra* note 7, at 15 (citing a study that supported claims of stereotype threat, showing that girls performed significantly better on identical tests when asked their gender after the test than when asked before); Spelke & Grace, *supra* note 55, at 63 (citing studies showing a tendency of respondents to rate "average" application packages significantly lower when labeled female—45% positive outcomes for females compared to 70% for males—and to question whether "exceptional" female candidates' work was wholly their own four times more frequently than they questioned male candidates' work). On stereotype threat, see also Halpern, *supra* note 29, at 127-28.

79. *See, e.g.*, *id.* at 123-24; Hyde, *supra* note 3, at 134.

80. *See, e.g.*, Hyde, *supra* note 3, at 138-42 (discussing how boys accrue an advantage in problem solving skills due to course selection and girls are adversely affected by a stereotype threat when asked to identify their gender before math tests); *see also* Spelke & Grace, *supra* note 55, at 60 (discussing the gender bias in testing). Contributor Carol Dweck points out that studies have shown steady improvement in performance on math and spatial ability testing over time, and offers the insightful hypothesis that conceiving of abilities in terms of "earned abilities" rather than "gifts," thereby emphasizing the possibility of improvement rather than the inevitability of failure, might further reduce apparent gender difference. Carol S. Dweck, *Is Math a Gift? Beliefs That Put Females at Risk*, *in* WOMEN IN SCIENCE, *supra* note 3, at 47, 48-49. As Spelke and Grace point out, the most commonly used measure of mathematical aptitude, the SAT-M, "is composed of many different types of items, some of which are solved faster by the strategies females tend to favor and others by the strategies males tend to favor." Spelke & Grace, *supra* note 55, at 60. As a result, male/female test outcomes depend on the balance between types of questions. But without "an independent understanding of the nature of mathematical aptitude and its distribution across the sexes," one cannot determine the appropriate balance, and SAT-M performance "cannot, in itself, provide that understanding." *Id.*

81. Valian, *supra* note 6, at 29-30. On cultural difference, see also Seth Mydans, *A Different Kind of Homework for Singapore Students: Get a Date*, N.Y. TIMES, Apr. 29, 2008, at A9 (discussing a growing campaign by Singapore's government to encourage students not to wait until their career is established before having kids: "[T]oo few of the country's most eligible women, those with college degrees, [are] marrying and having children"). Obviously, a national campaign to discourage women from pursuing careers is likely to impact women's prevalence and success in STEM professions. Women's participation in science in the United States was actively discouraged for most of its history. Indeed, the growth of the professions themselves was in several, if not all, cases inextricably intertwined with the exclusion of women. See, for example, Jennifer Block's brilliant history of the medicalization of childbirth in JENNIFER BLOCK, PUSHED: THE PAINFUL TRUTH ABOUT CHILDBIRTH AND MODERN MATERNITY CARE (2007).

"research provides no evidence that boys engage with objects more intensely or systematically."[82]

Melissa Hines and Diane F. Halpern, in separate essays, challenge the claims of Doreen Kimura and others who argue that pre- and post-natal hormones lead to gender difference in cognitive ability. Hines, a researcher for thirty years on the influence of sex hormones on behavior and author of *Brain/Gender*, a balanced presentation of the science to date, titles her essay *Do Sex Differences in Cognition Cause the Shortage of Women in Science?*, and answers the question with an emphatic "no."[83] She points out that standard deviation measures of gender difference in cognition are small (0.9 or less) compared with, for example, height (2.0), but concedes that they might still be significant.[84] The differences demonstrated, however, are by no means self-evidently innate.

It is true, she writes, that numerous experimental (non-human) animal studies have verified that pre- and neo-natal hormones influence brain development, and some human behaviors have been linked, through observation of subjects born with genetic disorders that affect hormone production, to behavioral difference. For instance, girls born with an adrenal gland malfunction such that they overproduce testosterone "show increased male-typical toy, playmate, and activity preferences" and "reduced heterosexual activity and interest."[85] But the degree to which these factors influence adult preferences, choices, or activity, is far from clear, and the influence of environmental factors is likely far more significant.

Hines cautions against jumping to conclusions about hormone influence, noting that 1960s and 1970s studies purporting to show elevated IQ scores from pre-natal androgen exposure suffer from serious selection biases. Noting that "general intelligence does not show an appreciable sex difference,"[86] she points out that studies showing gender difference (mental rotation, spatial perception, math and verbal ability) have "generally not supported organizational hormone influences" and argues that claims to the contrary "do not have a sound

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82. Spelke & Grace, *supra* note 55, at 58. The contributors also note that other work shows "that girls have no edge in learning about people and their mental states," despite popular mythology to the contrary. *Id.* Although contributors address the interest rather than abilities of women, they may well be influenced by popular mythology, and they surely (though unintentionally) reinforce it. *See* Baron-Cohen, *supra* note 17, at 160 (noting that girls are more empathetic); Eccles, *supra* note 49, at 202-03 (commenting that women are more likely to enter helping professions).

83. Melissa Hines, *Do Sex Differences in Cognition Cause the Shortage of Women in Science?*, *in* WOMEN IN SCIENCE, *supra* note 3, at 101.

84. *Id.* at 102. "Sex differences of 0.8 *d* or larger are considered large, those of about 0.5 *d* are considered moderate, those of about 0.2 *d* are considered small, and only those smaller than 0.2 *d* are considered negligible." *Id.* (internal citation omitted).

85. *Id.* at 105. Hines explains that hormones influence behavior in two ways: early production affects the organization of the brain ("organizational influences"), while transient fluctuations in adulthood can activate neural circuits to produce temporary behavioral change ("activational influences"); both are at play in cognitive difference debates.

86. *Id.*

empirical basis."[87] Indeed, she argues that "more relationships have been observed in the direction opposite that predicted (e.g., testosterone relating negatively to spatial and numerical abilities) than in the anticipated direction."[88]

Hines also challenges studies purporting to show that female hormones negatively influence women's performance on certain cognitive functions at which males excel, noting a variety of weaknesses in the data, and pointing to both lack of replicability and contrary studies.[89] She concludes that there is sound evidence of neither hormonal nor genetic difference by gender in cognitive ability.[90] Instead, she points to historical and cross-cultural evidence concerning career patterns and math and science performance success, which she claims have far greater explanatory power.[91] Pointing to research demonstrating the importance of positive expectations to success, she highlights the danger of explaining women's absence from STEM fields as resulting from cognitive deficits.[92]

Halpern, too, challenges the hormone studies and conclusions drawn from those studies,[93] but the focus of her essay, like that of Hyde, is to point to the far more convincing explanatory power of socio-cultural factors.[94] Noting the strong evidence "that experience alters brain structures and cognitive abilities" so that "[t]he distinction between biology and experience is hopelessly blurred,"[95] Halpern points to evidence of the variety of ways that everything from "stereotype threat" and lowered expectations to the structuring of tenure requirements better explain the dearth of women in STEM fields.[96]

Hyde's essay both challenges the soundness of the data purporting to show any ability difference[97] and gathers data demonstrating sociocultural explanations for any such differences, pointing to different treatment by gender from "family, neighborhood, peer, and school."[98] She points to data showing that stereotype threat impedes test performance,[99] studies showing the

87. *Id.* at 105-06.

88. *Id.* Although most scientists point to them, animal studies purporting to show that sex-linked hormones drive behavioral difference suffer from the necessary but problematic assumption that the highly developed conceptual and abstract thinking which typifies human consciousness has a smaller impact on human behavior than hormonally- or genetically-driven animal instinct. This may be the case, but it is hardly obvious that the leap is warranted, especially when it comes to sexual activities which, in the case of human beings, are so emotionally complex and mediated by culture.

89. Hines, *supra* note 83, at 105-09.

90. *Id.* at 109.

91. *Id.*

92. *Id.* at 109-10.

93. Halpern, *supra* note 29, at 126-28.

94. *Id.* at 127-29.

95. *Id.* at 127.

96. *Id.* at 127-28 (pointing to the "large and old literature in psychology" demonstrating the impact of lower expectations on performance); *id.* at 128-30 (discussing structural explanations).

97. Hyde, *supra* note 3, at 131-34.

98. *Id.* at 135-38.

99. *Id.* at 138.

successful impact of training on improving performance,[100] and research showing that, for example, "cross-cultural differences in mathematics performance are enormous compared with gender differences in any one country" and that the magnitude of the difference *within* any one country "correlates . . . with the percentage of women in the workforce."[101]

Newcombe challenges the claims of evolutionary psychologists, noting that "spatial skill is needed to weave or make baskets or pottery"[102] and that there is a problem with extrapolating to humans the "beautiful observational and experimental evidence" of meadow voles (whose males exhibit superior spatial ability during the mating season when they need to seek out females).[103] Humans, she points out, lived in social groups, not widely separated territories, so there would have been no need to develop spatial skills to compete for females. Rather, "the skills it takes to impregnate many females probably include such abilities as charm and stealth, more than the ability to find one's way among a cluster of huts."[104]

Those who challenge the view that gender difference is innate and behavioral difference is thus predetermined typically emphasize the importance of socialization and cultural influences and boundaries. Valian introduces the concept of "gender schemas" to explain women's absence from STEM professions.[105] These schemas are drawn from commonly held folk wisdom about gender difference, which leads to male group advantage (social capital), which parlays into even greater advantage through accumulation, much in the way traditional capital accumulates.[106] Thus the view that males are innately superior to females at STEM occupations becomes a self-fulfilling proposition.[107]

Dweck similarly argues that the view that math ability is a "gift" disadvantages most girls from the start, and that those intrepid females who persist in math are ultimately discouraged by the attitudes of teachers and peers.[108] Many contributors point out that a host of factors other than cognitive ability, such as female preferences, and the desire (or, I would add, social pressure) to balance work and family, all play a part in keeping women out of

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100. *Id.* at 139.

101. *Id.* at 140.

102. Newcombe, *supra* note 47, at 72.

103. *Id.* at 72-73.

104. *Id.* at 73.

105. Valian, *supra* note 6, at 32.

106. *See also* Leonid Rozenblit & Frank Keil, *The Misunderstood Limits of Folk Science: An Illusion of Explanatory Depth*, 26 COGNITIVE SCI. 521, 522 (2002) (furthering this compounding explanation by stating that "knowledge of complex causal relations is particularly susceptible to illusions of understanding").

107. Valian, *supra* note 6, at 34 (discussing the manner in which advantage, reinforced by prevailing gender *schemas*, compounds into greater advantage).

108. Dweck, *supra* note 80, at 470.

STEM fields.[109] Spelke and Grace argue that, even if males did have an edge, it would not explain the extreme under-representation of women in STEM fields, particularly in light of increases in the number of women obtaining advanced STEM degrees.[110] Rather, they too focus on a history of discrimination and discouragement, as well as on institutional failures to attract and retain women.[111]

III. A NATURAL EXPERIMENT: THE STORY OF BEN BARRES

> Male and female represent the two sides of the great radical dualism. But, in fact, they are perpetually passing into one another.
>
> – Margaret Fuller, *Woman in the Nineteenth Century*[112]

Another sort of evidence about why more women do not stick with STEM professions is captured in the story of Ben Barres, widely reported in the press.[113] Barres, a top neuroscientist, detailed the discrimination he faced trying to establish a career in neurobiology as *Barbara* Barres, before completing treatments to make him, as *The Wall Street Journal* put it, "fully male."[114] As Barbara, although she was the number one science and math student in her high school, she was advised by a guidance counselor to apply to a local college rather than accept a spot in a prestigious university like MIT. She declined to follow this advice, but faced persistent discrimination at MIT. After Nancy Hopkins and colleagues at MIT released a study in 1999 revealing gross disparities in hiring, promotion, and tenure of women unexplained by other factors, MIT president Charles Vest publicly affirmed that discrimination was responsible.[115]

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109. Of course, innateness advocates argue that these preferences are genetically and hormonally programmed, and, many would suggest, driven by evolutionary necessity. *See, e.g.*, Geary, *supra* note 59, at 175.

110. Some authors also point to evidence that the number of faculty hires is not keeping pace with the number of females obtaining advanced degrees in math, engineering, and the sciences. *See, e.g.*, Williams & Ceci, *supra* note 7, at 15 (summarizing the hiring dropoff data).

111. Innate-difference advocates counter that more males choose to continue beyond the Ph.D. because, due to superior aptitude, they enjoy the work more, and point to Lubinsky and Benbow's finding that only the very top test performers, who are overwhelmingly male, get the elite jobs. They also suggest that women's (impliedly innate or evolutionarily ordained) preference for families and nurturing makes the possibility of STEM science success remote due to its time demands and career trajectory. *See, e.g.*, Geary, *supra* note 59, at 183.

112. MARGARET FULLER, WOMAN IN THE NINETEENTH CENTURY AND OTHER WRITINGS 75 (Donna Dickenson ed., Oxford Univ. Press, 1994) (1855).

113. Ben A. Barres, *Does Gender Matter?*, NATURE, July 13, 2006, at 133.

114. Sharon Begley, *He, Once a She, Offers Own View on Science Spat*, WALL ST. J., July 13, 2006, at B1.

115. *A Study on the Status of Women Faculty in Science at MIT*, MIT FACULTY NEWSLETTER (Mass. Inst. of Tech.), Mar. 1999, *available at* http://web.mit.edu/fnl/women/fnl114x.pdf; *see also* Carey Goldberg, *M.I.T. Admits Discrimination Against Female Professors*, N.Y. TIMES, Mar. 23, 1999, at A1.

When Barbara was the only one in her otherwise all-male math class to solve a particularly difficult problem, her professor suggested that her boyfriend had done it for her. Barbara had difficulty finding someone willing to serve as her thesis advisor, and, later, as a Ph.D. student, she was passed over for a fellowship for which she had been told she was best qualified. She had published six papers; the ultimate recipient had published one.

By contrast, "Ben" rapidly became a sought-after and leading neuroscientist, whom Stanford's president personally wooed away from Oxford University to head Stanford's respected neuroscience lab. Barres points to numerous forms of discrimination faced by women, from attitudes about women to structural demands on scientists that serve to exclude women.[116] All these forms feature prominently in tenure battles concerning women in math and science departments, and any number of judicial decisions examine them. But most convincing is Barres' account of the scientist overheard to remark after he lectured to top scientists at a prestigious seminar: "Ben Barres gave a great seminar today, but then, his work is much better than his sister's."[117] Ben, of course, *is* his sister.

IV. THE CHALLENGE OF COMPLEX SYSTEMS

> But experience is by far the best demonstration . . . .
>
> – Sir Frances Bacon, *Advancement of Learning and Novum Organum*[118]

Barres' story is the kind litigators yearn for—the story that clinches a jury verdict. But Barres, who hails from the natural sciences, where "proof" is a matter of measurement, tells us that "anecdotes . . . are not data."[119] He is wrong: Anecdotes are extremely important pieces of data.[120] Indeed, it may be that when it comes to understanding human behavior—for example, why we choose certain careers or organize our professions the way we do—history and the humanities will turn out to be more important than the measurements of traditional science.[121]

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116. *See* Mark L. Adams, *The Quest for Tenure: Job Security and Academic Freedom*, 56 CATH. U. L. REV. 67, 87-89 (2006).

117. Barres, *supra* note 113, at 134.

118. FRANCIS BACON, ADVANCEMENT OF LEARNING AND NOVUM ORGANUM 331 (rev. ed., Willey Book Co. 1944).

119. Barres, *supra* note 113, at 134.

120. *See, e.g.*, SACKS, *supra* note 39, at xiii-xiv (arguing the importance of both narratives that form the basis of clinical evidence and neuroscience findings).

121. *See* THOMAS LAQUEUR, MAKING SEX: BODY AND GENDER FROM THE GREEKS TO FREUD 6 (1990) (explaining that the modern and "dominant . . . view since the eighteenth century . . . that there are two stable, incommensurable, opposite sexes" has not existed forever, and that only in recent history has "[b]iology—the stable, ahistorical, sexed body" been treated as "the epistemic foundation for prescriptive claims about the social order"). LaQueur's point is the relatively uncontroversial one (at

Within science there is movement away from traditional methodology as well. Complex-systems theorists argue that a science which seeks truth by breaking things down into smaller and smaller component parts (for example, molecules, atoms, sub-atomic particles, and quarks, or DNA, genes, neurons, synapses, and electrical impulses) is unable to comprehend realities as complex as the brain, cognition, and behavior.[122] These fields require the observer to step back to look at the forest, rather than simply measure the trees, even though tree measurements can tell us useful information about the forest (for instance, its age). Science may eventually help us rule out certain explanations, like genetic determinism. But like the proverbial blind men examining different parts of the elephant, the scientist who measures smaller and smaller parts of the human organism can learn important things about how it functions, but will not thereby truly be able to comprehend the beast. For that, we need historians, humanists,[123] and practitioners of the "softer" sciences.[124]

Traditional science's methodology, these theorists contend, is ineffective to comprehend complex systems—whether social or neurological—especially when those systems are living, changing, and evolving. No matter how precise the measurement (in our case, of biological and neurological processes by gender), no matter how sophisticated our performance data, these methods cannot begin to truly comprehend the operation of the human brain, much less the behaviors that flow from the relation between brain, body, environment, and culture. According to complex systems writers, there are simply too many interacting elements to comprehend the whole by measuring component parts, especially because as we observe one part (which, in observing, we alter), the others are changing, adapting, discarding, and looping back upon themselves. Our research results are old before we can read them; our findings are

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least for academics in modern times) that science has a history which is highly culturally and contextually influenced. Put another way, inasmuch as the empirical sciences employ quantitative measures to analyze qualitative values, they can never fully explain individual choices arising in particular historical and cultural contexts.

122. *See generally* STUART A. KAUFFMAN, REINVENTING THE SACRED: A NEW VIEW OF SCIENCE, REASON, AND RELIGION (2008). This argument is typically phrased as a critique of reductionism, i.e., the impetus to study subjects in narrowly construed syllogistic schemas and devise increasingly complicated and isolated rules to explain them, in order to satisfy an aesthetic desire for absolute system predictability in emulation of classical science via Newton and Simon Laplace. A quintessential modern reductionist thinker, as identified by Kauffman, is Nobel Laureate physicist Steven Weinberg: "[A]ll explanatory arrows point downward, from societies to people, to organs, to cells, to biochemistry, to chemistry, to physics." *Id.* at 17. By this hierarchy, *Women in Science* could in time be better written by physicists than any other scientists, but the rejoinder from complexity theorists would be that Weinberg and his ilk fail to recognize that absolute system predictability is no longer feasible in the wake of Heisenberg, Einstein, and Gödel, and, furthermore, that no reductionist framework could ever take into account all the ontologically emergent entities that have and may become real in the course of a complex system's development.

123. *See* TIM O'BRIEN, THE THINGS THEY CARRIED: A WORK OF FICTION (1990) (describing fiction as presenting a truer picture of human behavior and emotion than factually accurate narrative).

124. While the line between hard and soft science is hard to pin down, most characterize sociology, anthropology, and psychology as "soft."

influenced by the past and we are, by observing and measuring, causing changes which render our own study results already obsolete.

If this is so, no amount of measurement will yield a definitive answer to the question *Women in Science* poses. Scrutiny of brain processes will surely yield answers to many puzzles and solutions to many medical conundrums. In law, it can yield information about individual brain function which may have important implications for questions of capacity and ability. What it cannot do is answer complex questions of causation, such as those involving female prevalence, or lack thereof, in the sciences. Such questions are far too deeply intertwined with hundreds of years of accumulated human social behavior, resulting in complex social systems that cannot be comprehended by measurement, however careful, nor by science's traditional method of experimental confirmation or disconfirmation.

V. SCIENCE IN THE SERVICE OF THE STATUS QUO

> The whole problem with the world is that fools and fanatics are always so certain of themselves, but wiser people so full of doubts.
>
> – Bertrand Russell[125]

Historians, particularly intellectual historians, play an especially important role when it comes to understanding science's efforts to map gender difference.[126] Science can be a dangerous tool. Grave injustice, indeed, serious harm has been done to women in the name of scientific proof of gender difference.[127] Hines, citing Stephen Jay Gould's famous *Mismeasure of Man*, reminds readers that "some eminent 19th-century scientists," including Paul Broca and social psychologist (and student of craniology) Gustave Le Bon, "contended that women and Black men were less intelligent than White men because they had smaller brains."[128] Le Bon wrote that:

> All psychologists who have studied the intelligence of women . . . recognize today that they represent the most inferior forms of human

125. HAL URBAN, THE 10 COMMANDMENTS OF COMMON SENSE 101 (2008).

126. Especially helpful in thinking about science and gender difference are intellectual historians like LAQUEUR, *supra* note 121, and SANDER GILMAN, DIFFERENCE AND PATHOLOGY: STEREOTYPES OF SEXUALITY, RACE AND MADNESS (1985).

127. However, once in a while its errors inured to women's benefit, as when scientists insisted that insemination without female orgasm was impossible. *See* LAQUEUR, *supra* note 121, at 2-3, 9 ("Any [eighteenth century] medical book or one of the scores of popular midwifery, health, or marriage manuals circulating in all the languages of Europe" would have reported that orgasm occurred "when the seed issues in the act of generation" (quoting NICHOLAS VENETTE, CONJUGAL LOVE; OR THE PLEASURES OF THE MARRIAGE BED CONSIDERED IN SEVERAL LETTERS ON HUMAN GENERATION 41 (London, 1750)) and that without orgasm "the fair sex [would] neither desire nuptial embraces, nor have pleasure in them, nor conceive by them" (quoting Aristotle, *Aristotle's Master Piece*, *in* THE WORKS OF ARISTOTLE THE FAMOUS PHILOSOPHER, at 5, 10 (William Salmon ed., 1828) (alteration in LAQUEUR).).

128. STEPHEN JAY GOULD, MISMEASURE OF MAN 104-05 (1981); Hines, *supra* note 83, at 102.

> evolution and that they are closer to children and savages than to an adult, civilized man. They excel in fickleness, inconstancy, absence of thought and logic, and incapacity to reason.[129]

Scientists helped justify women's exclusion from a wide range of activities based on innate gender differences: physiological and anatomical (such as childbirthing role; pelvic and leg construction; physical "weakness"),[130] psychological (female hysteria and emotion), and, of course, cognitive. Law disseminated bad science and enshrined these "mismeasures" in precedent.[131] Women were excluded from education, economic independence, and a wide array of jobs and professions, as well as sterilized and institutionalized, as a result.[132] Confirmation of gender difference lead in the nineteenth century to justification for a "separate spheres" ideology that confined women to homes where domestic violence was hidden from view, and justified the use of physical violence to handle creatures whose hysteria and irrationality purportedly led them to misbehave.

VI. THE LEAP FROM DATA TO CONCLUSIONS

> If a man is offered a fact which goes against his instincts, he will scrutinize it closely, and unless the evidence is overwhelming, he will refuse to believe it. If, on the other hand, he is offered something

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129. GOULD, *supra* note 128, at 105 (cited in Hines, *supra* note 83, at 102 (quoting Le Bon)). Le Bon's certainty about female inferiority was as evident as his xenophobia:

> In the most intelligent races, as among the Parisians, there are a large number of women whose brains are closer in size to those of gorillas than to the most developed male brains. This inferiority is so obvious that no one can contest it for a moment; only its degree is worth discussion.

Id. at 104.

130. *See* LAQUEUR, *supra* note 121, at 6 ("Biology—the stable, ahistorical, sexed body—is understood [beginning with eighteenth century] to be the epistemic foundation for prescriptive claims about the social order."); *see also* Brief for the State of Oregon at 18, Muller v. Oregon, 208 U.S. 412 (1908) (No. 107). The famous Brandeis brief justifying shorter hours of work for women contained such scientific truths as "[l]ong hours of labor are dangerous for women primarily because of their special physical organization . . . . Besides these anatomical and physiological differences, physicians are agreed that women are fundamentally weaker than men in all that makes for endurance: in muscular strength, in nervous energy, in the powers of persistent attention and application." *Id.*

131. *See, e.g.*, Muller v. Oregon, 208 U.S. 412, 421 (1908) ("That woman's physical structure and the performance of maternal functions place her at a disadvantage in the struggle for subsistence is obvious. . . . The two sexes differ in structure of body, in the functions to be performed by each, in the amount of physical strength, in the capacity for long continued labor, particularly when done standing, the influence of vigorous health upon the future well-being of the race, the self-reliance which enables one to assert full rights, and in the capacity to maintain the struggle for subsistence."); Bradwell v. Illinois, 83 U.S. 130, 141 (1872) ("The natural and proper timidity and delicacy which belongs to the female sex evidently unfits it for many of the occupations of civil life.").

132. *See* Stephen Jay Gould, *Carrie Buck's Daughter: A Popular, Quasi-Scientific Idea Can Be a Powerful Tool for Injustice*, NAT. HIST., July 1984, at 14 (describing sterilization based on eugenic theory unsupported by fact but affirmed by the Supreme Court in Buck v. Bell, 274 U.S. 200, 207 (1927), with Holmes' famous quotation: "Three generations of imbeciles are enough."); Alan Wolfe, *The Gender Question*, NEW REPUBLIC, June 6, 1994, at 27 ("Of all the ways that one group has systematically mistreated another, none is more deeply rooted than the way men have subordinated women. All other discriminations pale by contrast.").

> which affords a reason for acting in accordance with his instincts, he will accept it even on the slenderest evidence.
>
> – Bertrand Russell, *Proposed Roads to Freedom*[133]

As is probably obvious, I share the skepticism of those who, while they accept that there may be developmental and cognitive differences by gender, challenge the degree to which such differences have explanatory power and, as importantly, highlight the historical evidence that wrongheaded and potentially dangerous conclusions are likely to be drawn from limited data. This is especially so with regards to such issues as the gender gap in the sciences or occupations, dependent as these problems are on so many interacting factors. As contributor Geary notes, "the knowledge bases, technical skills, and conceptual insights in mathematics and the sciences arise from a poorly understood interaction between inherent cognitive and motivational biases and culture-specific educational goals and opportunities."[134] The cognitive and motivational biases are themselves highly influenced, the evidence suggests, by culture and environment.

Sophisticated geneticists and neurologists point out that environment is operating on our one hundred trillion neural pathways and one billion neurons every millisecond, and that those pathways are neither predetermined by genes, nor uniform by gender.[135] Multiple combinations of genes, together with virtually limitless variation in neural pathways, make for extraordinarily varied human behavior. As one columnist noted, "if a trait like aggressiveness is influenced by just 100 genes, and each of those genes can be turned on or off, then there are a trillion trillion possible combinations of these gene states."[136] As well-respected population theorists Paul Ehrlich and Marcus Feldman write, evolutionary psychology—the notion that evolution favors certain behavioral

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133. BERTRAND RUSSELL, PROPOSED ROADS TO FREEDOM: SOCIALISM, ANARCHISM AND SYNDICALISM 147 (1919).

134. Geary, *supra* note 59, at 173-74.

135. *See* ERIC R. KANDEL, IN SEARCH OF MEMORY: THE EMERGENCE OF A NEW SCIENCE OF MIND 109-10 (2006); *see also* Ehrlich & Feldman, *supra* note 29 (offering a cogent explanation for why genes do not and cannot predetermine behavior). Each human brain has about one billion (1,000,000,000) nerve cells (neurons) connected by one hundred trillion (100,000,000,000,000) synapses (connections). Nicholas Wade, *Brainpower May Lie in Complexity of Synapses*, N.Y. TIMES, June 10, 2008, at F6. Each synapse contains about a thousand (1000) different proteins, and these, in turn, operate within smaller units of proteins, varied in composition. *Id.* Each of these synapses has evolved into a highly complex mechanism, and each such mechanism is influenced each millisecond by environmental inputs which affect and alter its functioning. *See* Halpern, *supra* note 29, at 123 ("Learning is both an environmental and a biological phenomenon" guided by "experiences from the[] environment . . . which direct[] further learning and alter[] the underlying structures in the[] brain."); *see also* HINES, *supra* note 45, at 4 (observing that "the distinction between biological and social influences is in some senses false. All our behavior is controlled by our brain and, in this sense, is biologically based.").

136. David Brooks, *The Luxurious Growth*, N.Y. TIMES, July 15, 2008, at A19 (quoting Jim Manzi, *Undetermined*, NAT. REV., June 2, 2008, at 26); *see also* Haier, *supra* note 33, at 116 (pointing out that if one identical twin is schizophrenic, the other has only a fifty percent chance of sharing the condition, so something other than genetics is at work); Wade, *supra* note 135.

traits and not others—is based on "the misconception that genes are somehow determining our everyday behavior and our personalities."[137] Moreover, studies have, for many years, and especially in the last decade (with improved brain imagining technology), demonstrated the remarkable adaptability of the brain. Regions dedicated to the performance of one function can, when the usefulness of that function is diminished, shift to the performance of other tasks. For example, the primary visual cortex in persons who are blind can assume the sensory role of heightening hearing and touch.[138] And when one brain region is injured, other regions are often deployed to take over its function.[139] One of the most useful results of research on gender difference in brain anatomy and physiology might be to suggest different pathways for avoidance of, and recovery from, brain damage between males and females.[140]

At this stage in our understanding, for nearly every piece of data there is either a contrary explanation or another bit of data suggesting an opposite conclusion.[141] For example, from data showing a significant drop-off between the numbers of women achieving Ph.D.s in STEM fields and those moving on to become assistant professors, and a further drop between assistant and full professor, one might discern a pattern of hiring discrimination based in gender stereotyping of one sort or another (women are a presumptive waste of resources because they will drop out, get pregnant, or quit, or they might have children and lack adequate time to devote to science). Alternatively, one might argue that cognitive deficiencies or evolved traits make these "stereotypes" accurate and real, and conclude, as does Kimura, that "it must logically follow that hundreds of better qualified men have been passed over in the zeal to artificially raise the numbers of women in science."[142] (You can expect to see

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137. Ehrlich & Feldman, *supra* note 29, at 6; *see also* Carl Zimmer, *Expressing Our Individuality, the Way E. Coli Do*, N.Y. TIMES, Apr. 22, 2008, at F1 (deriding genetic determinism by pointing out that genetically identical e. coli bacteria exhibit widely varying behavioral traits due to environmental conditions and the "noise" of their own proteins, despite possessing only one fifth the number of genes as humans and far simpler systems). Ehrlich and Feldman point out that the "twin studies" on which Summers and *Women in Science* contributors rely have been discredited as "proof" of such determinism because they fail to account for the myriad non-genetic explanations for similar outcomes in later life.

138. *See* SACKS, *supra* note 39, at 163.

139. WILLIAM J. WINSLADE, CONFRONTING TRAUMATIC BRAIN INJURY: DEVASTATION, HOPE, AND HEALING 23-34 (1998) (citing the findings of Dr. Nancy C. Andreasen that "[d]ifferent areas of gray matter are specialized in different functions, such as moving, seeing, touching, listening, thinking, or modulating physical functions such as eating or sleeping. Often these areas are redundant—that is, several areas can perform the same function. Thus, when one communication center is knocked out, another may be able to take over in its place.").

140. *See* MCKAY MOORE SOHLBERG & CATHERINE A. MATEER, COGNITIVE REHABILITATION: AN INTEGRATIVE NEUROPSYCHOLOGICAL APPROACH 65-66 (2001) (pointing to the lack of research in this area and citing, among others, Kimura).

141. *See, e.g.*, John Noble Wilford, *Almost Human, and Sometimes Smarter*, N.Y. TIMES, Apr. 17, 2007, at F1 (reporting that young chimpanzees outperformed humans on a series of memorization and recall computer tests). Should we assume that this demonstrates superior chimp brain capacity or might we conclude, as the researchers speculated, that chimps are good at rote tasks because they lack sufficient brain capacity to be distracted by more complex conceptual thinking or planning?

142. Kimura, *supra* note 3, at 43-44.

Kimura cited by defendants when Title IX of the Civil Rights Act is used to challenge school and college science and math programs with few female participants.)[143]

Writers on both sides of the debate emphasize that there are alternative interpretations of the data they assemble, yet are emphatic in supporting the conclusions that they draw from the data. To cite but one example, Kimura points out that "there have been studies showing that adults who engage in spatially demanding activities also generally engaged in such activities in childhood . . . ."[144] After noting that most social (soft!) scientists interpret this data to mean that "childhood experience determined the adult pattern," she argues that the opposite is "probable": that "superior abilities influence the [early childhood] activities rather than the other way round."[145]

Moreover, the ability to be a good STEM scientist requires far more than superior math and mental rotation skills. As Harvard physicist Howard Georgi wrote in the *Harvard Crimson* in 2005:

> Talent is not a unitary thing, [but] multidimensional and difficult to measure . . . . Many different kinds of talents are critical to the advancement of . . . any . . . science interesting enough to be worth doing . . . . The spread of talents within any group, sex, race, etc., is very large compared to any small average differences that may exist between such groups . . . . [and] [t]alent can be developed and enhanced by education, encouragement, self-confidence, and hard work.[146]

Patterns emerging from the cognitive, experimental, observational, and brain imaging data suggest gender difference in the emotional and behavioral realms in such areas as "aggressive play, gross motor behavior, and sexual behavior."[147] But what are we to make of the explanatory power of these differences in relation to participation in STEM sciences? Gross motor skills are not those typically required for physics, computer science, or (most) engineering. Brain imaging data is primitive at best, is typically based on small

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143. *See* Elizabeth Weil, *Teaching to the Testosterone*, N.Y. TIMES, Mar. 2, 2008, § 6 (Magazine), at 39 (describing the current resurrection of single-sex education in public schools, often justified by supposed neurological differences between genders).

144. Kimura, *supra* note 3, at 41. *Cf.* John Schwartz, *She's Studying. He's Playing.*, N.Y. TIMES, June 14, 2005, at F1 (reporting that young female chimpanzees learn to fish for termites more quickly than do males because they observe their mothers closely, while the young male chimps are off playing, "mimic[king] some of the findings from the human child development literature" (quoting Dr. Elisabeth V. Lonsdorf, director of field conversation at the Lincoln Park Zoo in Chicago)). Does this not suggest that if mothers were engaged in complex engineering tasks or mathematical calculations, girls might learn them while boys were off playing?

145. Kimura, *supra* note 3, at 41.

146. Valian, *supra* note 6, at 28 (quoting Howard Georgi, *Talent, Skills in Math and Science Hard To Quantify*, HARV. CRIMSON, Jan. 21, 2005, *available at* http://www.thecrimson.com/article.aspx?ref=505377).

147. Williams & Ceci, *supra* note 7, at 14 (discussing the pivotal contributions of Maccoby and Jacklin to the study of sex differences).

and non-representative samples, and requires large interpretive leaps.[148] Cooperation, rather than aggression or competition, is equally if not more important in the projects of today's science.[149] And it requires a leap of Olympic proportions to suggest that science geeks and major league sports figures are propelled by evolutionary necessity to their rather different behavioral patterns. Behavioral studies of humans are problematic because they cannot rule out social and cultural explanations; indeed, the more we learn about brain development, the more it becomes clear that environmental influence begins in the womb and continues rapidly and continuously thereafter.

Decision-makers also tend to overemphasize such evidence as test score data, animal studies, and brain imagery[150] (and tend to engage with highly speculative theories when they are tied to such accepted theories as evolution), while under-emphasizing, if not altogether dismissing, sociological and historical evidence, which, unlike "hard" sciences, can neither be replicated nor, generally, falsified.[151] This means that scientists' choices of what issues to

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148. *See, e.g.*, Stephen Morse, *Brain Overclaim Syndrome and Criminal Responsibility: A Diagnostic Note*, 3 OHIO ST. J. CRIM. L. 397 (2006) (reviewing state of neuroimaging technology and pointing out weaknesses in it); *see also* Benedict Carey, *Searching for the Person in the Brain*, N.Y. TIMES, Feb. 5, 2006, § 4, at 1 (quoting Dr. J. Anthony Movshon, director of the Center for Neural Science at New York University, on how neuroimaging technology has been disappointing inasmuch as it "has told us nothing more than what a neurologist of the mid-20th century could have told you about brain functions and where they're localized").

149. Of course, cooperation is contextual, and the notion that there might be a determining biological basis for it borders on the absurd. *See, e.g.*, Gal, *supra* note 22, at 179 (noting that the Malagasy of Madagascar explicitly associate different styles of speech with men and women, and that women are excluded from public power because they are viewed as too confrontational). Regarding the importance of cooperation in science, the sheer size of many projects makes cooperation necessary. Recent examples are as varied as DNA mapping, efforts to understand and curb global warming, space station rescues, and the like. *See also* Editorial, *An Unnecessary Battle: Neuroscientists and Geneticists Don't Need To Be at Loggerheads Over the Biology of Mental Disorders*, NATURE, July 10, 2008, at 137 (decrying the conflict over the appropriate methodology to ascertain source of mental disorders and urging cooperation); *cf.* Lawrence K. Altman, *The Doctor's World; Cooperation v. Competition*, N.Y. TIMES, Apr. 14, 1987, at C2 (discussing a feud between American and French researchers over who should receive credit for discovering the AIDS virus; in light of the epidemic surrounding the discovery, the fight for professional recognition seems petty to many onlookers).

150. *See, e.g.*, Morse, *supra* note 148, at 403 (coining the phrase "Brain Overclaim Syndrome" to describe the tendency of new brain imaging data to have a "rationality-unhinging effect"); *see also* Deena Skolnick Weisberg et al., *The Seductive Allure of Neuroscience Explanations*, 20 J. COGNITIVE NEUROSCIENCE 470, 475-77 (2008) (showing that neuroscientific evidence interferes with the ability to judge the quality of explanations for everyone but experts in the field).

151. The foundation of the scientific method and science's claim to authority are rooted in its ability to show that certain propositions can be shown by replicated experiments to be false. A proposition—for example that water at sea level on this planet will boil at ten degrees centigrade—can be falsified by heating water to that temperature repeatedly under the same conditions and showing that it does not boil. Ideally, this method yields useful results when it is appropriately used. It strives to find replicable data, to control for factors extraneous to its investigation, and to rule out (or falsify) competing hypotheses. The problem arises when scientists claim authority for their answers to questions and phenomena too complex for proper controls to be put in place, or neglect to account for the influence of their own bias as an extraneous factor.

Some historical claims are proven false, but history's claims are based in realities too complex and unique to be experimentally falsified.

study, what experiments to conduct, and what results to publicize are enormously powerful. For this reason, Haier is surely mistaken that "[t]he hardest part of science is going wherever the data take you."[152] The harder and more important tasks are determining which data to seek in the first place and how to interpret them, for example, determining whether to interpret data revealing chemical, biological, or neurological difference as linked to behavioral difference or career outcomes. Indeed, perhaps the hardest part is recognizing when one's own biases and those of one's discipline are influencing, perhaps subtly, where the data lead.

Still, it is possible that innate differences, however slight, may generate social factors that, over time, alter brain structure in ways that build on and enlarge differences by gender, and that they do ultimately impact career choices. We are a long way from knowing this with any certainty. In the meantime, what should we do? Try to create and encourage gender neutrality at earlier and earlier ages, to see how reversible social patterns are? Alter the teaching about gender in educational institutions and (good luck!) popular culture? Devote more resources to recruitment and training of women, and make STEM and other fields more hospitable to them?

And why would we want to do the latter—spend resources on gaining greater entry of women into STEM fields if, in the end, the future of scientific inquiry lies not in those sciences that primarily rely on measuring component parts of systems in order to understand them (and are thereby more easily able to make claims to the purported objectivity of their careful and replicable measurements), but in those that study complex systems, aware of the inevitable subjectivity and partiality of their conclusions? Why not instead encourage women to eschew STEM professions in favor of the social sciences or the natural science study of complex systems, from biological to ecological and everything in between?

The answer, I think, is twofold. First, STEM professions remain powerful and important ones—and gender discrimination will never be overcome by finding, in Donna Haraway's words, "one more excuse for not learning any post-Newtonian physics."[153] These are professions that speak with great authority, and whose conclusions and findings have not only been given great weight, but also have been and continue to be critically important to human life. Women need to be part of the process of determining what is studied and how, and what conclusions are to be drawn from the data. We need to be able

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152. Haier, *supra* note 33, at 118. In a later piece arguing for continued study of the connection between race and IQ, Ceci and Williams similarly ignore the question of resource allocation, and minimize the possible negative impact of the choice of what to study on perpetuating stereotypes. Instead, they frame the race and IQ question as one of "free speech in science," focusing on the harm to individual careers rather than the potential harm to social groups, or to science itself from misdirecting resources. *See* Stephen Ceci & Wendy M. Williams, *YES: The Scientific Truth Must Be Pursued*, 457 NATURE 788, 789 (2009).

153. Haraway, *supra* note 13, at 84.

to assert with authority that it does *not* make sense to devote resources to this or that study, as much as to argue for where resources *should* be spent. Moreover, to say that the future of science lies elsewhere is to overstate the case. Important advances in global communications and transportation, as well as in other areas, continue to depend on STEM fields, especially the applied sciences (like engineering and computer engineering), and women cannot afford to allow males to dominate them. Indeed, the continued success of STEM fields may demand, and in any event these fields can surely benefit from, the perspectives that women and others also largely absent from these fields are able to bring.

VII. INTERVENTIONS WHILE THE QUESTIONS REMAIN OPEN

> Equality . . . is the result of human organization . . . . We are not born equal . . . .
>
> – Hannah Arendt, *The Origins of Totalitarianism*[154]

One of my favorite New Yorker cartoons is one by Mischa Richter depicting two gentlemen (academics? judges? bums?) at a bar, grasping drinks as one declares: "Then we've agreed that all the evidence isn't in, and that even if all the evidence were in, it *still* wouldn't be definitive."[155] This is surely the case, and will continue to be the case, regarding whether there are meaningful cognitive differences in ability by gender. Yet, as Columbia Law Professor Patricia Williams has noted, scientists like those contributing to this volume have a luxury that decision-makers lack. They are free to "hold themselves open to a wide, sometimes endless range of variables that might contribute to cause and effect, right down to the clichéd flapping of butterfly wings in the Amazon causing storms in British Columbia."[156]

For lawyers, on the other hand, as for policy-makers and judges, the "goal is closure, rather than eternal exploration."[157] Those deciding where to focus

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154. HANNAH ARENDT, THE ORIGINS OF TOTALITARIANISM 301 (1951).

155. Mischa Richter, *Unnamed Cartoon*, NEW YORKER, June 15, 1987, at 30, *available at* http://www.cartoonbank.com (search "Entire Site" for "36147"); *see also* J.B. Handelsman, *Unnnamed Cartoon*, NEW YORKER, Mar. 9, 1987, at 36, *available at* http://www.cartoonbank.com (search "Entire Site" for "35845") (illustrating a scruffy Charles Dickens with his publisher, who is holding a manuscript and demanding: "I wish you would make up your mind, Mr. Dickens. Was it the best of times or was it the worst of times? It could scarcely have been both."). Each cartoon, in its way, depicts the gulf between those who yearn for the clarity of mathematical precision and those who insist upon acknowledging (and depicting) life's ambiguities. Perhaps the difference between the "hard" sciences and the "soft" sciences and humanities is, in the end, less about method than about personality.

156. Patricia J. Williams, *Divining Demeanor*, NATION, June 25, 2007, at 10.

157. *Id. See also* Allen, *supra* note 21, at 515, 517-20 (making a similar point in relation to science and feminism). Scientists have the luxury of "wholesale conjecture," *see supra* note 2 and accompanying text, while feminists who seek to overcome a history of gender stereotyping and prejudice are driven to emphasize the potentially harmful nature of unrestrained inquiry. Feminism seeks concrete and immediate political change and—like administrative decision-makers—must be ever

resources, or whether certain evidence demonstrates gender discrimination, must always act without complete information.[158] University presidents like Summers have to determine the amount and type of resources to devote to altering the male/female ratio in STEM fields.[159] Foundations need to determine whether to undertake or fund programs to increase young women's participation in the sciences. Judges have to resolve disputes under Titles VII and IX of the Civil Rights Act (or the Constitution). Not to act, or to decline to accept certain evidence, is itself a decision to perpetuate a status quo which may be, and likely is, discriminatory, and deeply harmful not only to girls and women (as well as boys and men), but also to a society seeking to compete globally in STEM fields or, more importantly, to join in collaborative STEM efforts across national boundaries.

Ben Barres wrote that, despite the blatant discrimination he faced, he did not turn away from science because he experienced himself as male, and hence did not internalize the self-doubt a female repeatedly sent an ego-battering message of inferiority likely would.[160] Today, assumptions that women are less qualified, able, or eager to become STEM scientists are daily damaging women who might, like Madame Curie and numerous others before and after her, contribute greatly to social progress and enjoy fulfilling lives.

But, as Kimura argues, there is more than one way to skin a cat, and we might spare women the pain of rejection and ego-battering by simply accepting that women not only make better biologists than physicists, but also that they are happier working with people and solving concrete problems than they would be if they were immersed in lonely, more abstract problems in mathematics, physics, or engineering.[161] The trouble with such presumptions is

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sensitive to the ways in which science's tentative hypotheses are likely to play out in public consciousness. Unlike feminists, however, administrators who face the pressure of competing demands may, like Summers, run with the superficial expression of a scientific hypothesis and ignore the harm a tentative suggestion may cause. Carefully cabined suggestions do not good headlines make, and they do not frequently help resolve controversial policy issues. The harm caused by merely purporting to "follow the data" may far outweigh the value of the study, and the hypothesis may even take on a life of its own. *See supra* Part V. Administrators who act on conjecture—or use it as a basis not to act—enact the very harm that feminists seek to prevent.

There are, of course, times when the evidence is nearly conclusive—as with the theory of evolution—yet public controversy remains. But apart from these (usually faith-generated) controversies, most controversies are due to a lack of factual certainty.

158. Scientists, too, must make decisions about what research studies to undertake. I take for granted that because there are differences in the pattern of development in XY and XX generated brains (as well, of course, as those with atypical sex chromosomes), Haier, *supra* note 33, is correct that studying such differences is likely to be helpful in understanding the human brain.

159. After *Grutter v. Bollinger*, 539 U.S. 506 (2003), public universities may be limited in the manner and degree to which they do this if there is a lack of evidence that the institution historically discriminated against women, or women in STEM fields.

160. Barres, *supra* note 113; *see also* Dweck, *supra* note 80 (describing the effects of stereotyping on girls' math performance).

161. Another version of this argument is that women's superior social intelligence leads them to shy away from occupations which seem to aim primarily at increasing the deadliness of war-making. Although I am not partial to this cultural feminist view, a friend who now does bio-medical research at

not only that they tend rapidly to become self-fulfilling prophecies, but also that they generate further searches for gender difference which are used to justify the result of what we know to be centuries of junk science about—and flat-out discrimination against—women.

One thing cognitive science has taught us is that people understand the world by categorizing it. People, rather than genes or hormones, create categories like "gender," "ability," and "merit," and determine how to structure education, evaluate skills, and organize fields and occupations. And, unfortunately, people have a historically well-documented tendency to attribute innate and cognitive difference to those who appear, talk, or act differently than themselves.[162] Given all of this, the best course to take when all the evidence will never be in, and would not in any case likely offer definitive answers, is to assume relatively equal gender capacity and to err on the side of presuming discrimination as the strongest explanation for the dearth of women in science, as in Congress and in high-level positions almost everywhere. For the sciences, this means devoting extra resources to ensure full female participation in STEM subjects (especially computer science and engineering) from early in girls' lives, and doing so for far longer than a few generations (after all, women were excluded from equal education in most, if not all, parts of the globe for many generations).[163] It means redesigning curricula so that they appeal to females. It means subsidizing private efforts to create math and science computer games that are appealing to girls, and making them readily available to girls at early ages and at low cost.

Additionally, it means demanding of those who suggest that scoring at the top 0.01% of the SAT-M curve is the primary skill necessary to succeed in STEM professions whether advancement might rest more on cooperative and collaborative capabilities that combine the problem-solving capabilities of numerous individuals across wide expanses of geographic and cultural space. If so, it might be time to rethink hiring criteria to take these skills into account, and to design brain-imaging and other studies to investigate cooperative problem-solving. Such research might uncover regions of the human brain as yet insufficiently tapped.

Harvard quit her theoretical physics post-graduate position because the uses of her work seem to be entirely aimed at war-making.

162. *See* ANIKA K. WARREN, CASCADING GENDER BIASES, COMPOUNDING EFFECTS: AN ASSESSMENT OF TALENT MANAGEMENT SYSTEMS (2009) (describing the tendency of talent-management systems to look for traits like those of the white males who already hold top management positions).

163. *See, e.g.*, MICHAEL L. PENN & RAHEL NARDOS, OVERCOMING VIOLENCE AGAINST WOMEN AND GIRLS: THE INTERNATIONAL CAMPAIGN TO ERADICATE A WORLDWIDE PROBLEM 25 (2003) (framing the Indian proverb, "Investing in a girl is like watering a plant in a neighbor's garden," in the context of girls' contemporary lack of education relative to boys throughout the developing world); BARBARA MILLER SOLOMON, IN THE COMPANY OF EDUCATED WOMEN: A HISTORY OF WOMEN AND HIGHER EDUCATION IN AMERICA (1985) (describing several centuries of struggle to gain access to higher education by women in the United States).

Several of *Women in Science*'s contributors have useful suggestions: Dweck proposes curricula aimed at instilling in women the understanding that ability can be "grown" and is not natural and innate;[164] Spelke and Grace propose a "grand experiment" focusing on overcoming social stereotyping about female ability and interest;[165] and Hines implies that devoting resources to overcoming teacher biases about the relative abilities of girls and boys might dramatically change female performance.[166] Halpern reminds us that the simple step of making science and math more hospitable to women by creating more flexible career options is important as well;[167] Hyde reminds us that important components of assuring female success are "family, neighborhood, peer and school influences";[168] and Berenbaum and Resnick add that it may be equally important to value women's contributions outside the sciences precisely to ensure that those who truly want them have access to science and math careers.[169] (Eccles also makes this point in a different way.[170])

All these societal interventions are important and there are many other possibilities. The important point is that, for the sake of science as well as individual women, we cannot collectively rest on seductive explanations of gender difference; we must shoulder the burden to prove that we collectively, along with the particular institutions that "do science," have devoted significant resources to recruiting and training women and to making the environment (including the timing of tenure clocks and the distribution of lab space) hospitable to them. We need to reassess our definition of "success" so that collective achievement and the abilities that underlie it—the ability to share and give credit and the ability to subordinate individual ego to collective good—are valued equally to risk-taking and single-minded study. We also need to place the political and judicial burden of disproving discrimination on institutions, such that, if they cannot demonstrate by clear and convincing evidence that they have instituted meaningful measures to overcome bias against and offer supports for women, they must try harder and do more. For the sake of science and of society, they can do no less.

164. Dweck, *supra* note 80, at 50-52.
165. Spelke & Grace, *supra* note 55, at 65.
166. Hines, *supra* note 83, at 109-10.
167. Halpern, *supra* note 29, at 129.
168. Hyde, *supra* note 3, at 135.
169. Berenbaum & Resnick, *supra* note 43, at 155.
170. Eccles, *supra* note 49, at 208-09.