Women in (European) Astronomy

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I am no expert on the status of women in European Astronomy, but I am an interested student of the status of women in science generally, since in Europe, in the U.S., and around the world, there is a dearth of women scientists, at least at the highest levels. As a graduate student, postdoc, young faculty member, and now tenured senior scientist, I have repeatedly seen women colleagues being undervalued or overlooked. But it wasn't until I became familiar with the social science literature that I could fit a viable theory to the data. In particular, my eyes were opened by Virginia Valian's influential book summarizing this research, entitled "Why So Slow? The Advancement of Women." Here I describe, much as she does in her book, social science experiments that illuminate how present-day society projects its unconscious biases into the workplace. But first, a few words about why this issue is so important:

Everyone agrees there are too few women and minorities in science. But then opinions diverge. Many scientists believe that increasing diversity is a matter of social engineering, done for the greater good of society, but requiring a lowering of standards and thus conflicting with excellence. Among this group are very well-meaning people who genuinely wish to increase the number of women colleagues. Yet they may be doing more harm than good.

Others understand that there are deep reasons for the dearth of women (discussed below)—wholly unrelated to the intrinsic abilities of women scientists—which lead to extra obstacles to their success. Once one understands the bias against women in male-dominated fields (which has been substantiated in thousands of research studies, though usually in a literature that few natural scientists read), one must conclude that diversity in fact enhances excellence. In other words, the playing field is not level, so we have been dipping more deeply into the pool of men than of women, and thus have been unknowingly lowering our standards. Returning to a level playing field (compensating for bias) will therefore raise standards and improve our field. Diversity and excellence are fully aligned.

What Data Show

There are many studies documenting the differential progress of women. Long (2001) reviewed the gender dependence of salary, rank and tenure in science and engineering, using NSF data for a synthetic cohort (correcting for time since degree, type of institution, specialty, and family status). Women lag behind, in advancing and in getting tenure (see other similar studies by Sonnert and Holton in the 1990s). Having children has the effect of removing women from the full-time workforce, but differences for women who remain full-time are minimal (see Mason and Goulden 2002).

Differential attrition in physics & astronomy (figures)

In a study of U.S. professionals in internationally-oriented business, Egan & Bendick (1994) studied how 17 factors—such as type of degree, years of experience, number of hours worked, etc.—affected the salaries of men and women very differently. Fourteen of the 17 factors helped men more than women. For example, having a BA degree added $28,000 on average to a man's salary but only $9,000 to a woman's. Not constraining one's career because of a spouse added $21,900 to the average male salary but only $1,700 to women. Being on the "fast track" added $10,900 for men, $200 for women.

Some factors that enhanced men's salaries actually subtracted from women's. For example, living outside the U.S. added $9,200 to a man's salary, on average, but subtracted $7,700 from a woman's. Speaking a second language added $2,600 for men and subtracted $5,500 for women. Deliberately choosing international work added $5,300 for men and subtracted $4,400 for women.

Two factors helped women's salaries more than men's: negotiating for one's salary subtracted $5,600 from men's salaries and added $3,500 to women's. Traveling for more than 10 days per year added $3,200 to men's salaries and $6,300 to women's.

In a study of academic medicine, Tesch et al. (1995) showed that newly hired men get more lab and office space, more funding and more research time than women. A well-known study at MIT (1999) showed the same disparities for women and men faculty in the School of Science.

In hundreds of studies across many fields, using many measures, the advancement of women lags that of men with the same qualifications.

Why Are Women Scarce in Science?

Some of my colleagues believe women are simply not interested in science—at least, not in the physical sciences—and the loss of talent does not seem to worry them. That is, if women are not interested, they must not be any good. Yet Xie & Shauman (2003) showed that interest in the sciences does not correlate with ability. Furthermore, they found that sex disparities in productivity (e.g., publication rates) were decreasing, and that productivity depends most strongly on access to resources (e.g., funding for postdoctoral associates) and is independent of family status (see discussion in Chapter 4 of the NRC study, *Beyond Bias and Barriers*, and references therein). Childbirth has the effect of removing women from full-time work, to the long-term detriment of their careers.

It is certainly true that there are too few high quality childcare options available, and that women do more family care than men do. But women without children still do not advance at the rate men do. And countries with excellent maternity and childcare benefits (e.g., Nordic countries) have some of the lowest participation of women in Physics. And finally, women with families do participate in extremely demanding careers (e.g., medicine).

If it is not ability or interest, what is it? There is plenty of evidence that the playing field is not level for women and men. In 1997 Wenneras and Wold published a study in Nature about applications for a prestigious Swedish postdoctoral fellowship in medicine. They showed that although 46% of the applications were from women, only 20% of the fellowships were awarded to women. Reviewers of the proposals consistently gave women lower scores for the same level of productivity, and women applicants had to be 2.5 times better than men to succeed. An earlier study of peer review (Paludi and Bauer 1983) showed that psychology papers were rated lower if the author's name was female than if it was male (initials were rated nearly as low as the female name, and subsequent interviews suggested initials were taken as a hidden indication of a female author). A recent study (Budden et al. 2008) showed that the fraction of papers having a woman as first author increased significantly when a biology journal went to double-blind refereeing. (Single-blind refereeing is when the referee knows the identity of the author but the author does not know the identity of the referee. Double-blind refereeing is when neither knows the identity of the other.) Studies of prizes or honors show that men receive a disproportionate number, even when one corrects for pipeline issues (Astronomy, Physics, Psychology).

There is much talk lately about “innate ability”—perhaps women are simply not as good at science as men? This suggestion is contradicted by almost all available evidence. First of all, gender gaps in performance (for example, on math exams) are decreasing in the U.S.; if they were due to physiology, they should not change dramatically on time scales of decades. Moreover, gender gaps vary enormously by country, arguing against a genetic origin. Japanese women score better in math than U.S. men. (See Chapter 2 of the National Academy’s *Beyond Bias and Barriers* report.)

At the same time, gender gaps *can* be explained by culture. Research into “stereotype threat” shows that culture affects test results. A class is told they will be given a difficult math test. Men do poorly, scoring 25 of a possible 100, and women do worse, with an average grade of 10. This is the kind of gender gap that makes a front-page page New York Times story: that at the extremes of performance, men substantially outscore women. However, another class is told the same story about a difficult math test, with the added information that the test has been designed to be “gender neutral.” Now the women's score doubles, to 20. Interestingly, the men's score decreases, to 20. In other words, men and women score the same. These tests have been repeated many times with the same results, and have also been done to probe other stereotypes (e.g., black students perform less well than white students, when in a stereotype-threat situation, regardless of educational or socio-economic background). When the stereotype threat is activated, people under stress conform to it.

"Gender Schemas"

We are a biased society. There is no getting away from it. It is not overt: most of us think we are—and try hard to be—unbiased. It is also not men discriminating against women, it is all of us discriminating against women (and minorities). Try taking the online "implicit bias" test of Mahzarin Banaji (implicit.harvard.edu)—it is a real education. In her book "Why So Slow? The Advancement of Women," Virginia Valian describes the origin of this bias with "gender schemas" —namely, a set of expectations of women and of men, embedded in our culture, that influence how women and men are judged.

A large body of research describes the effect of gender schemas:

- *Heights of men and women (Biernat, Manis & Nelson 1991)* – Subjects are asked to estimate an objective quantity, namely the heights of men and women in photographs, all of which include some physical object like a doorway or desk to offer scale. Even though the subjects were chosen so that each gender has the same height distribution, the average height estimated for men is greater than the average height estimated for the women. We expect men to be taller—we are sure this is true (indeed, it is true at present in our society as a whole)—and so this is what we measure, even when it is not true in the particular data set.
- *Leader at table (Porter & Geis 1981)* – Undergraduate students are shown photographs of people sitting around a table, and asked to identify the leader. Where all the people pictured are men, the leader is nearly always identified as the person at the head of the table. The same is true when only women are pictured. When both men and women are pictured and a man sits at the head, he is identified as the leader. However, in the mixed gender case with a woman at the head, half the time a random man is identified as the leader.
- *Leaders talking (Butler & Geis 1990)* – Undergraduate subjects are shown a film of male or female students leading a discussion; the subjects are observed during the film and are asked questions about it afterward. The men in the film generate more positive facial reactions when speaking than the women, unless the women have been validated as a leader prior to the talk (e.g., with a thorough introduction covering her qualifications).
- *Eye gaze (Dovidio et al. 1988)* – First the experimenters establish that in a conversation between a superior and a subordinate (same gender), the superior looks at the subordinate while talking, but looks away when listening. The subordinate spends roughly equal amounts of time looking and listening, regardless of who is speaking. Then the experimenters showed that in conversations between men and women, men look while talking and women look while listening. This reinforces the assumption that the man is more powerful than the woman. (Note to women: make eye contact while talking; not sure whether to look away while listening, though.)

- *Rating managers (Heilman et al. 2004)* – Subjects are asked to rate two assistant vice-presidents in a fictitious (but heavily documented) aircraft company (a “male” environment). Men are rated higher than women, despite randomized resumes, but both are deemed likeable. In a second experiment, in which women are validated prior to the evaluation (e.g., subjects are told “both managers have been rated outstanding”), then men and women are rated equally competent but the woman is not likeable and is judged hostile or difficult. That is, women can be competent or likeable but not both.
- *Rating resumes for a “male” job (Norton, Vandello & Darley 2004)* – Subjects are asked to rate 5 job applicants for a job in construction, based on resumes. By design, only 2 are really competent; one of the two has more education (an advanced degree in engineering and a certification from a construction industry group), and the other has more work experience (9 years compared to 5 years). In one experimental condition, the resumes are labeled with initials only; in another, the resumes are labeled with names of both genders. If initials, then education was judged more important than experience, and most highly educated person was ranked highest. If man’s name on resume with more education, he is ranked number one. If woman's name is on the “educated” resume, the “more experienced” man more likely to be ranked highest and experience is subsequently described as more important in making the decision.
- *Mismatched credentials for gender-identified jobs (Uhlmann & Cohen 2005)* – Subjects fill out a questionnaire asking about the most important criteria for a gender-identified position, either a police chief (“male”) or a nursing supervisor (“female”). For example, a masculine job like police chief generally elicits more emphasis on presumptively male characteristics like physical strength, authoritative voice, and experience in law enforcement, rather than female characteristics (nurturing, feeling) such as “caring” or “has a family.” The subjects then rate applicants according to resumes that have predominately (by stereotype) “male” or “female” characteristics. When a man’s name is on the resume with the male characteristics, he is ranked highest for the job of police chief. However, when the woman’s name is on

the resume with the male characteristics, the man is still ranked highest. In other words, the criteria change in response to the gender of the applicants. Interestingly, the subjects who identified themselves in the initial questionnaire as “objective” were far more likely to change criteria (i.e., act according to gender schemas) than those who labeled themselves “not objective.” *So, when someone tells you they are objective, beware.* When the same experiment was carried out for the stereotypically female job of nursing supervisor, the results were similar. That is, the woman was ranked highest for the job regardless of whether her qualifications aligned with those deemed most important in the initial questionnaire.

- *Sanbonmatsu, Akimoto & Gibson (1994)* – Evaluators are given an array of facts about 8 students, of whom four pass and four fail a welding course (a stereotypical male activity). The salient fact is that the students who passed had a light course load, while those who failed had a heavy course load. In the first experimental condition, in which gender is assigned such that four men pass and four women fail the course (i.e., the women had the heavier course load), the evaluators identify gender as the reason the women failed. In the second experimental condition, gender is distributed evenly, i.e., two men and two women pass, and two men and two women fail. In this case, the evaluators correctly identify course load as the reason for failure. That is, the expectation that women will not perform well in a stereotypically male activity can serve to confirm our prejudices, even if an objective appraisal would identify another cause.

Gender bias can play an important role in evaluation. For example, letters of recommendation and personal nominations are enormously important for academics—in hiring, promotion, invitations to speak, fellowships, grants, and other honors and awards. Yet there are systematic differences in the letters of recommendation for women and for men (Trix & Penska 2003). This is not widely known among science and engineering faculties. Letters for women are shorter and contain fewer standout words (like “outstanding” or “ground-breaking” or “superstar”). Letters for women express more doubt and contain more “grindstone” adjectives (“works hard,” “diligent,” etc.). They are more likely to mention women's personal lives and, in most cases, the mention of gender is explicit. Women are more likely to be compared to other women (a sure sign that this process is not gender blind). In my own experience, women get asked to write tenure letters for women more often, and their letters are more likely to be discounted or ignored—unless, that is, they are negative, in which case they are given extra weight. That is, women are not reliable if they support other women (it is interpreted as solidarity), but if critical, women are seen as more discerning since naturally they should be supporting other women. (In other words, women scientists are women first, scientists second.)

The presence of only a few women guarantees that bias will kick in. In studies of hiring practices, with artificial and matched resumes (Heilman 1980), it was found that women can succeed when they are more than 30% of the applicant pool, and that they are unlikely to succeed when less than 25%. This has obvious ramifications for job searches or tenure letters that include only one woman as a token on the short list.

As Virginia Valian describes in her book, “Why So Slow? The Advancement of Women,” expectations of men and women in our society are different, and those expectations—“gender schemas” —color our judgments, even those supposedly based on objective criteria. Schemas are expectations, often based on real characteristics, that help us interpret our surroundings. In this society, men are seen as capable of independent action, well suited to the task at hand, and acting on the basis of reason. Women are seen as nurturing, feeling, and prone to expressing feeling. Men *act*, women *feel and express feeling.* In the presence of schemas (e.g., in a profession dominated by men, like physics), gender schemas lead many to overrate men and underrate women.

Valian also describes how the “accumulation of disadvantage”—even small, seemingly minor disadvantages—can accumulate over a career to leave women in a decidedly inferior position (conforming to the data). She illustrates this with a simulation (Martell, Lane & Emrich 1996) of a company with an 8-level hierarchy; even starting from 50/50 gender equity at the base level, a promotion system biased only 1% in favor of men quickly results in a top management tier that is 65% men.

Gender schemas, and perhaps other factors in socialization, contribute to a lower self-image and lesser sense of entitlement among women relative to men. Sonnert and Holton (1996) described how women tend to rate themselves lower than men; women tend to believe they are below the average while men believe they are above average. Major (1987) described an experiment showing that women are willing to work harder and longer than men for the same pay, and that they will accept as fair a lower pay. Take a very public example: when Monica Seles suggested women should receive the same pay as men when competing in tennis tournaments, Steffi Graf responded, “We make enough, we don't need more,” and her highly ranked colleague, Mary Joe Fernandez agreed, “I'm happy with what we have. I don't think we should be greedy.” (June 3, 1991, Washington Post) It was not until 2007 that Wimbledon and the French Open awarded equal prizes to women’s and men’s tennis champions—some 34 years after the US Open.

Perhaps because of early socialization, women appear to act more altruistically, for the greater good of the community, while men expect rewards directly tied to their actions. Babcock and Laschever (2003) point out that women are less likely to negotiate for higher pay or other resources—and if they do, they pay a bigger price. In a hiring situation, both men and women who ask about money are perceived negatively, but women more so. A woman who asks for more money is less likely to be hired (Bowles, Babcock & Lai 2007).

This has been a very brief review of what is known from the sociology and psychology research, but enough, I hope, to show that this is not a mysterious problem. Rather, it is a well-understood and tractable problem. There are known remedies. But the first, critical step is to recognize the uneven playing field. Only then can we compensate fairly, and thus have truly objective evaluation of quality.

Remedies

Gender schemas resist change (and follow change). Change requires education, action, and further research.

The first step toward change is to ***educate*** our colleagues about the impact of gender on evaluation and career progress. The National Academy of Science's *Beyond Bias and Barriers* study summarizes the relevant research and interventions. Many NSF *ADVANCE* projects[1] have online resources, and universities can develop effective methods to teach scientists the (social) scientific literature. Virginia Valian maintains a very useful annotated bibliography of relevant research (www.hunter.cuny.edu/genderequity/equityMaterials/Feb2008/annobib.pdf).

Each of us can assess our own comfort with gender equity at the web site implicit.harvard.edu. *ADVANCE* groups have also developed very effective advice concerning job searches[2]. It is essential to actually *search* for candidates rather than simply reviewing incoming resumes, and to be prepared to deal creatively with the dual career issue.

You can educate your colleagues about, for example, how to write letters of recommendation (Trix & Penska 2003). You can teach students about teaching evaluations, which are more negative for women faculty (see www.crlt.umich.edu/multiteaching/gsebibliography.pdf).

Avoid facile solutions like adding a token woman to every committee. For one thing, women are vastly overworked. For another, successful women may compete with rather than support younger women. In their book on affirmative action, Clayton and Crosby (1992) suggested that some successful women avoid advocacy for other women because they are deeply invested in the idea of a gender-blind meritocracy—if evaluations are not objective, their own success is invalidated. (In fact, this paper suggests the opposite: that these women have succeeded despite the odds.)

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[1] *ADVANCE* is an NSF program intended to transform academic institutions with respect to women in science. Nineteen institutions and consortia have been given *ADVANCE* grants.
[2] For example, www.washington.edu/admin/eoo/forms/ftk_01.html .

To make progress, ***leaders must lead***. Most leaders in our field (today) are men. Men therefore have to play a key role (and indeed have played a key role) in advancing progress of women in science. And leaders (department chairs, committee chairs, agency heads) must be held accountable for developing excellent staffs – which we argue cannot be excellent if they are not gender balanced.

What kind of ***action*** can leaders take? First, establish norms. Make sure that colloquia, meetings, prizes, job interviews, etc., involve the appropriate fraction of women. Be articulate in explaining this issue and hold others accountable for their performance. If needed, arrange for training and education.

“Pre-validate” women in your organization. Brown and Geis (1984) showed that differential expectations by gender can be minimized if leaders establish women’s credentials. (See also Heilman et al. 2004.) For example, a woman speaker should be introduced with a thorough review of her accomplishments, in order to establish without doubt her expertise. A woman promoted to a new position can be pre-validated in a similar way, by describing explicitly the reasons for her success.

Learn to be effective (from organizational development literature) in taking the message forward.

Information and mentoring are essential. A mentoring program at the Johns Hopkins Medical Institutions dramatically improved the tenure rate for women assistant professors (Fried et al. 1996), and incidentally, also for who took part in the program——just one example of what's better for women is often better for men.

The style of mentoring may also be important. Here, a news story from the world of sports (*Boston Globe*, June 18, 1999) offers a useful case in point. Tony DeCicco, before he coached the U.S. women’s soccer team to a world championship, had coached men’s teams. When he moved to the U.S. women’s team, he saw the same tough, competitive, superb athletes, and he coached them just as he had their male counterparts. Then he began to notice that the women reacted differently. Where the men had brushed off criticism, the women stewed over it, to the point where it detracted from their performance. He gradually changed the mix, emphasizing compliments – i.e., positive reinforcement – over criticism, and the women played better. The analogy to "coaching" and mentoring graduate students and postdocs is obvious. Despite sharing a talent for and interest in science, men and women may need very different mentoring.

Other issues are more subtle. In many fields, the climate for women is inhospitable. Cultural values unrelated to ability or performance nonetheless dominate perceptions of quality (e.g., arrogance, assertiveness, aggressiveness), and indeed may repel women from the profession. The University of Michigan *ADVANCE* project has developed theatre performances that address this very effectively, and have been presented to national meetings of physicists, chemists, the National Science Foundation, Harvard University, and many others (sitemaker.umich.edu/advance/crlt_players).

Given the common timing for building careers or building families, it is not surprising that many people assume family issues are the reason for the dearth of women in science. Unquestionably, the academic world was not designed for people with family obligations. After all, the European academic system was originally designed for monks. Appropriate accommodations – for both men and women – such as on-site childcare, sick child care, elder care, delay of tenure clocks for family obligations, travel support for caregivers helping during professional meetings, etc., can go a long way toward humanizing the modern workplace.

Nonetheless, I argue there are at least three reasons family issues cannot explain there are not more women in physics or astronomy. First, women without children who remain full-time in the workplace are not more successful than women without children. (The well-known study by Mason & Goulden 2003 is often cited as showing that women's careers are harmed by having children, but this is because those women are more likely to go to part-time status – which indeed is a negative factor, perhaps wrongly, in their subsequent career advancement.) Second, there are many women in other demanding fields, like law and medicine. The training of medical students (at least in the U.S.) requires 24-, 36-, even 48-hour stretches "on call" yet half the medical students completing this training are women, some of them with young families. Third, countries with very strong family support systems, such as the Scandinavian countries, have extremely low numbers of women in physics – just a few percent in 2002.

We women in academia often complain about how hard we work and how difficult it is to raise a family under those circumstances. Certainly most astronomers have pulled "all-nighters" to complete a proposal or have traveled for days or weeks on end to give talks or attend meetings. It is no wonder that young people listen to us and decide they can't reasonably balance career and family. Yet I would argue that academic careers are better than most for this purpose. Our hours are extraordinarily flexible and in many countries salaries are better than the average citizen's, so we have the resources to get help with childcare, household tasks, etc. Having a family is hard, no matter who you are or where you work, but it's much harder if you work at a low-wage job with inflexible hours. But we don't see Walmart employees deciding not to have families because it's too difficult! (Even though it is.) I think we should tell young women that the academic life is great for raising a family: the work is fun (so parents are happy), the rewards are great, and we have a lot of control over our lives. My new mantra: *Become a professor, have a family!* And with more young women and men astronomers having families, perhaps the academic workplace will become less medieval and more supportive of those families.

Finally, advancing in our profession requires passing through an endless series of selection processes: graduate school admissions, hiring, invited talks, prizes, promotions and tenure. It is unlikely, given our societal biases, that these processes are gender-blind. Indeed, when an actual gender-blind selection process is instituted – for example, when auditions for modern orchestras began to require candidates to perform behind a screen – the percentage of women who "pass" increases dramatically. Of course, it is hard to imagine how job talks could be done behind a screen.

In any case, each of these selection steps requires two things: finding candidates and evaluating them fairly. To find a suitable, gender-balanced group of job candidates, it is not sufficient to wait for applications to arrive in the mailbox. A proper job search is just that – a search. One should solicit names from colleagues or by attending lots of talks by junior people. If the list of possibilities contains the names of too few women (fewer, say, than the percentage of women in the relevant pool), then one has to redouble one's efforts, and ask specifically for names of women, or use community bulletin boards (e.g., the list compiled by the American Astronomical Society's Committee on the Status of Women) to find and investigate possible women candidates. Many a search has turned up outstanding – but somehow overlooked – scientists.

The second step is to evaluate all candidates fairly. As the research described above shows, this cannot be done by declaring oneself or one's colleagues gender blind. Indeed, as Uhlmann & Cohen (2005) showed, only those who familiarize themselves with the issues of gender bias – unequal teaching evaluations, differential letters of recommendation, differences in the frequency of invited talks – are likely to evaluate others objectively.

Taking these issues into account and actively promoting the advancement of the talented women scientists we need in the modern world, will lead to a stronger, better, healthier, fairer scientific community.

Summary

Data illustrate the dearth of women in physics. The theory of gender schemas goes most of the way toward explaining why this is a difficult, persistent problem. Good intentions are not enough. The status quo will not repair itself. It will take concerted, conscious action on the part of enlightened leaders.

We need to transition from a "fix the woman" strategy, toward a "fix the system" strategy. The main problem is our perception of women being less good than men, when objective (gender-blind) review says otherwise (e.g., orchestra auditions, resumes, etc.). Women are not automatically seen as leaders, or in some cases, even as competent. Yet even this can be changed, by external validation by accepted authorities (often men). For example, introducing a speaker with a well-thought out review of their status establishes that status in the audience's mind. Similarly, appointing suitable women to positions of leadership can have the effect of educating the community that they are deserving of those positions.

What can women do for themselves and others? Gain success outside your institution. Take on highly visible jobs. Gather information on what is needed for success. Find effective mentors (and mentor others). Negotiate for the resources you need to succeed (see Babcock and Laschever 2003). Make allies. Most of all, work to improve the system for other women.

The key point is that change—toward greater equity and thus a higher level of excellence—takes positive intervention. It will not happen without action.

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