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STATUS

A REPORT ON WOMEN IN ASTRONOMY

CONTENTS

A Publication of The American Astronomical Society Committee on the Status of Women in Astronomy

The Status of STATUS

By Meg Urry and Lisa Frattare

STATUS was started in 1985 by Sue Simkin, then chair of the Committee on the Status of Women in Astronomy (CSWA), and was edited most recently by Kathy Mead. As the official newsletter of the CSWA, STATUS has provided a forum for the topic of women in astronomy, and has reached a broad audience through direct mail and distribution at national AAS meetings.

This issue marks our debut as editors of STATUS. We took on this assignment with two very specific goals:

(1) To investigate the status of women in astronomy. Few of us know the statistics, either for our field alone (there are few data) or for closely related fields, and it must be an evolving story. Do women have a harder (or easier) time advancing in the profession? Are there parallels to other fields? We will explore the data for astronomy and the physical sciences at all levels of interest to professional astronomers.

Meg Urry

Lisa Frattare

(2) To explore possible barriers to the progress of women in astronomy, and what can be done about them. For example, women can be affected disproportionately by concerns about physical safety and sexual harassment. Their progress may be slowed by micro-disadvantages relative to their male peers (a sort of "1% discount" cumulative effect) or by lesser access to mentoring and networking. We will include many relevant studies inside and outside the physical sciences.

The CSWA already has a very active and important electronic forum, AASWOMEN, which needs neither duplication nor replacement. Rather, we aim to be the "review paper" complementing the dialog of AASWOMEN, with statistical studies, topical interviews, illustrative anecdotes, and guest columns. We further aim for balance, comprehensiveness, and relevance. By distributing STATUS widely at each AAS meeting, we hope to reach a larger, broader audience than those who already follow CSWA issues.

We welcome your contributions either in area (1) or (2), as well as suggestions or criticisms. Because we publish only twice per year, letters might better be directed to AASWOMEN, but all submitted material will be considered for publication. We request that all submissions be signed, however, some contributions may be published anonymously, as appropriate, to preserve the privacy of those involved. ❖

A new feature of STATUS will be a guest column by a senior astronomer. For our first issue, we asked Steven Beckwith, until recently the director of the Max-Planck-Institut für Astronomie in Heidelberg, Germany, and now director of the Space Telescope Science Institute, to offer his thoughts on the status of women in astronomy.

Women, Culture, and Science

By Steven Beckwith

You are struck by it immediately upon entering a French institute for astronomy: a large fraction of the scientists are women. You even find them at the director's level, a situation somewhat different from that in the United States. Italy has also been favorable for the promotion of women in the sciences; I am told it is true for Spain as well. The Latin countries with the "macho male" mentality seem, nevertheless, to be comfortable with women in intellectual positions.

In Germany, you rarely see women in the physical sciences — although it varies among institutions — and there are almost none in prominent positions; the number of women directors in the CPT Sektion (physical sciences) of the Max-Planck-Society is for all practical

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purposes zero. There are not many in Holland, either, or in Great Britain. The United States is better than the Germanic and Anglo-Saxon countries and is approaching the Latin countries in representation. The Space Telescope Science Institute seems better than most American institutions. Interestingly, a remarkable fraction of its staff is Italian.

It is hard to avoid concluding that culture plays a dominant role in the integration of women into the physical sciences. This is good news for women, because cultural barriers can be changed by the application of social pressure and natural evolution, whereas it would be impossible for women to achieve equal status to men if they were inferior at doing science, as some of my male colleagues seem to believe. There is no doubt in my mind that women and men are equally equipped to solve the mysteries of nature.

Men in the Latin countries are evidently more comfortable working with successful women doing research[1] than their counterparts in other countries. I do not know why this is not so in all cultures. Personally, I like working with women, and I think of those I work with as being scientists of very high caliber. My two longest and closest collaborators are Anneila Sargent and Antonella Natta, and I have not had two more enjoyable research partners. Our collaborations have given me a chance to see first-hand the difficulties they had in their careers as a result of cultural barriers.

The author (left) and long-time scientific collaborator Anneila Sargent (right) began working together 20 years ago in sweatshirts and jeans. Today they can be found partying in fancy dress at high-level committee meetings and expensive dinners.

But these barriers are not what everyone may think. It is no doubt true that the attitudes of men serve as a powerful deterrent to women who want to do research, but I do not think that they are the most powerful deterrent. The most powerful deterrents are often structural aspects of society that deny particular individuals the opportunities to excel in endeavors of their choice.

The contrast between France and Germany, two countries sharing a common border, provides a good example. France has abundant day care at low cost available to families who wish to pursue dual careers. Rather than placing the burden on the family to decide who is the caregiver — the women have historically lost out in these family battles — France makes the argument moot from the beginning. France has found a way to put enough flexibility in its social institutions — supermarkets, shop closing hours, job security — to encourage women with

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[1]A French colleague of mine, a woman, recently suggested in all seriousness that French men were simply more sensual and understanding of a woman's needs than American men, and that is why they allowed women into research; keeping in character, I put virtue ahead of chivalry and declined to comment.

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For more information on subscribing to STATUS, submitting articles or obtaining back issues, please see the STATUS web site:
http://www.aas.org/~cswa/status

Harvard physicist Gerhard Sonnert is the author of an influential study (with Gerald Holton) comparing career advancement for women and for men in science, starting with recipients of prestigious postdoctoral fellowships — arguably the best and the brightest. Even in the modern era in which gender discrimination has been formally abolished, women fall systematically behind for what appear to be complex reasons.

Women in Science: The Project Access Study

By Gerhard Sonnert

Since the early 1970s, huge numbers of women have entered, and succeeded in, science careers — careers that in the preceding decades had been an almost exclusively male domain. Nevertheless, the influx of women has clearly been uneven by discipline and subdiscipline (Babco 1997), and a multitude of gender disparities still exist (Davis et al. 1996, Fox 1995, Zuckerman et al. 1991). It is rather obvious that pervasive gender discrimination kept women from pursuing science careers in the earlier period. Yet it is much less plausible to identify overt gender discrimination as the sole and sufficient cause of the more varied gender disparities that persist today. More complex explanatory models are needed to capture an ever more complex reality.

Gerhard Sonnert

A useful framework for understanding scientific career paths is the "kick-reaction" model (Cole and Singer 1991), according to which a career path in science is formed by a sequence of numerous (positive or negative) "kicks" from the environment, followed by "reactions" to these kicks by the individual.[1] When applied to today's science careers of women, the model posits that a multitude of relatively small and subtle disadvantages, both in terms of kicks and reactions, accumulates in women's career paths and thus makes less likely the full parity in career outcomes for women scientists as a group. This forms a picture consistent with Robert K. Merton's concept of the "Accumulation of Advantages and Disadvantages" over the course of a science career (Merton 1973, Zuckerman 1989).

The Project Access study

To disentangle the complex causal processes shaping scientific careers, our research project, called Project Access, controlled the effects of early career experiences by focusing exclusively on a group of female and male scientists[2] who started their careers from the same kind of auspicious position. All had received a prestigious postdoctoral fellowship. Furthermore, to illuminate the fine structure of our participants' career paths, Gerald Holton and I augmented a quantitative research approach with a qualitative one.

Our data included 699 replies to a structured questionnaire, as well as 200 open-ended, face-to-face interviews. The questionnaire respondents comprised 508 men and 191 women who had received a postdoctoral fellowship from the National Science Foundation (NSF) or the National Research Council (NRC). The years of their fellowship awards ranged from 1952 through 1986. Our sample thus included both women who began their scientific careers before the pivotal epoch of the early 1970s and women who entered theirs afterward. Face-to-face interviews, each lasting about two to three hours, were conducted with 92 men and 108 women who had received postdoctoral fellowships from NSF, NRC, or the Bunting Institute of Radcliffe College, or who had been Bunting finalists.

Selecting these scientists as our research subjects allowed us to investigate the merits of two antithetic hypotheses about gender differences in careers: "glass ceiling" and "threshold." The "glass ceiling" hypothesis postulates an invisible but real barrier that impedes women from reaching the top of their profession. Women scientists who have been awarded prestigious postdoctoral fellowships should have accumulated significant advantages up to that point, and should be highly qualified, as well as motivated, to pursue a successful research career in the sciences. If these promising women scientists as a group turn out to be less successful than comparable men in attaining high positions, they may

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[1]For a detailed presentation of our theoretical framework, which includes what we call the "deficit model" of gender disparities (corresponding to "kicks") and the "difference model" (corresponding to "reactions"), see Sonnert and Holton (1995a).

[2]The term "scientist" in our study includes scientists in all fields, as well as mathematicians and engineers.

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be said to have encountered a glass ceiling of gender-specific obstacles in the later stages of their professional careers.

The alternative hypothesis to the "glass ceiling" notion of career development is that of a "threshold." According to this model, the processes of professional stratification would be gender-neutral for those women who had succeeded in overcoming certain earlier barriers. These women would be said to have passed a threshold beyond which gender no longer matters in careers. Again, our choice in sample selection provided a research site for detecting such a phenomenon.

Average rank of former postdoctoral fellows in academic science

(Total number of respondents in parentheses)

Academic rank
1 Non-professorial positions
2 Assistant professor
3 Associate professor
4 Full professor

		Discipline		
		Bio	PSME	SocSc
Women	Pre-1978 Ph.D.	3.2 (23)	2.9 (19)	3.3 (14)
	1978+ Ph.D.	2.1 (28)	1.7 (16)	2.1 (8)
Men	Pre-1978 Ph.D.	3.4 (57)	3.6 (105)	3.8 (24)
	1978+ Ph.D.	1.9 (52)	2.6 (89)	2.9 (9)

Career outcomes of the former postdoctoral fellows

Before summarizing a few key results from Project Access (details in Sonnert and Holton 1995a,b, 1996; Sonnert 1995, 1995/96), I should emphasize that we did not find monolithic blocks of women scientists on the one side and men scientists on the other. Rather, we typically observed great variations within each gender group and a great deal of overlap between the genders. What we report are differences of degree, of statistical trends.

As for academic rank achievement, we found substantial differences by academic field. In biology, our group of women scientists appeared to have overcome a threshold. There were no statistically significant differences in their career progress through the academic ranks, compared with that of their male cohorts. However, great gender disparities were found in PSME (physical sciences, mathematics, and engineering), even in this "elite" sample, which thus conformed to the pattern that is well known for the population as a whole (see table, this page). Here a glass ceiling became clearly visible. Controlling for the level of publication productivity, women were still at a rank disadvantage — again with the exception of biology, where the situation was

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careers to pursue them regardless of their choice of personal lifestyle.

In Germany, daycare is essentially nonexistent. The legal barriers to establishing daycare centers probably make them unprofitable. I actually investigated the possibility of putting a small childcare facility at the Max-Planck-Institut für Astronomie in Heidelberg for young couples with children, but I was told it was not allowed unless we met a certain quota that, of course, we did not meet. In any case, school hours are so limited — typically 4 hours per day through high school, and the students go home for lunch — that someone has to be home most of the time even when the children are in school. The lack of substitute teachers exacerbated the problem. If a teacher is sick, the students are often sent home with no prior notice. The strict shop closing hours make it difficult for a working couple to cope with the normal problems of life. So great are these structural barriers that married women with children have no avenue to make choices about their career paths unless their husbands are unusually committed to helping them out. Most German men are not.

Removing these structural barriers should be the first priority not just for women but for men, too. By doing so, women, or any other group that feels unfairly treated, will at least have the opportunity to excel based on their merits, thus giving lie to the notion that they are incapable. This is not to say that the "old boy" networks and overt methods of discriminating against women should be tolerated; they should not, but I doubt that they are the biggest problem in the long run. Most men my age, even in Germany, are more accepting of professional women than our counterparts a decade or two older, and the older men are beginning to retire. A bigger problem is a societal structure that frustrates women from competing equally, even if they ignore prejudice.

The United States has made some progress along these lines. Life is convenient with our 24-hour supermarkets and abundant services for everyday chores. The schools are responsible for

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our children most of the day. Childcare, however, is still not readily available to everyone at an affordable price. Low unemployment may push the private sector to offer more than it has previously, but it may take some government aid. We need to make the workplace sufficiently family friendly so that working moms and dads can be judged on their performance, not on their ability to deal with the inevitable emergencies that arise. It will take some time and some dedication from those of us in prominent positions to support these values.

Men and women should be united in overcoming these structural barriers. It is as much in my interest as it is in my wife's to have ready childcare, convenient shopping, and a workplace understanding of the demands of family life. I am delighted when we can solve the problems of everyday life without having to worry about whose career suffers the most. I think most men now understand how important these factors are, even though not everyone will be equally ready to defeat them.

With these impediments removed, women could set their own culture for research. It may be better than the culture we have now. Who knows? The only way to find out is to foster an environment that makes it possible without destroying productive habits. It is these productive habits that we must retain while striving to give star performers, be they men or women, equal opportunities: hard work, constant learning, contact, challenge, competition, and (yes) support from our brightest colleagues. Women who want to succeed need support for developing and maintaining these habits without having the Hobson's choice of deciding between a career and a personal life. It seems to me that if men and women work as collaborators rather than adversaries, we will all be better off. ❖

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more favorable for women than that in other sciences. (The issue of publication productivity receives special attention below.)

The observed contrast between the disciplines is consistent with the view that rare representatives of a particular social group, called tokens, tend to face particular difficulties in obtaining career success in their fields (Kanter 1977). This appears still to be the case in the physical sciences, mathematics, and engineering, whereas for women biologists, who may have reached a "critical mass" some time ago, gender stratification within the discipline seems attenuated. One may speculate that the relatively long and strong tradition of women in biology, as compared with that in other natural sciences, has contributed to the reduction of the gender gap also in career success among those engaged in biological research.

In terms of institutional prestige, the women of our questionnaire sample were well represented at top-rated departments. Twenty-nine percent of the women working in academe, compared with 27% of the men, were located at institutions ranked among the top 15% in a large national survey (Jones et al. 1982). But women, as a group, "paid" for prestigious affiliation with disadvantages in rank achievement, whereas men did not experience such a tradeoff. There was a particular dearth of women full professors at the most prestigious institutions.

The attrition rate (proportion of former fellows who are no longer research scientists) was 10.5% for women and 8.5% for men in our questionnaire sample. This gender difference did not reach statistical significance. As a group, the female former fellows were remarkably persistent in their pursuit of a science career. A considerable gender difference, however, existed in the reasons given by those who had left science. As one might expect, leaving science was more strongly connected with family responsibilities for women than for men.

"There was a particular dearth of women full professors at the most prestigious institutions."

"Kicks"

Various kinds of potential obstacles contribute to differences in career outcomes. Among the "kick"-type of obstacles, we should note that gender discrimination has not vanished. Seventy-three percent of our women interviewees reported they had experienced some instance(s) of discrimination — whereas 13% of the men said they had been subject to reverse discrimination. There were reports of a few egregious cases, such as the denial of jobs and tenure for women who considered themselves well qualified for a positive decision. But in the interviews there were many more accounts of very subtle exclusions and marginalizations. The latter obstacles

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might be illustrated by the problems women scientists reported facing in the area of scientific collaboration. When asked for the degree of collaboration with other scientists during different stages of a scientist's career, women reported being slightly more collaborative than the men before the postdoctoral fellowship, i.e., during graduate school, whereas they collaborated less than the men both during and after the postdoctoral stage (see table, this page). Thus, compared with men, women, as a group, experienced less collaboration as an equal or senior partner, whereas they experienced more collaboration as a junior partner. It has been proposed that it may be harder for women to establish egalitarian, collegial collaborations (Reskin 1978). Comments in our interviews supported this suggestion. Several women said that their postdoctoral advisors ignored them, and others noted that their advisors treated them as subordinates.

Collaborative research style at different career stages

Average response on questionnaire; (total number of respondents in parentheses)

Questionnaire range:

1 = "I usually worked alone on my scientific problems."

5 = "My research was performed almost exclusively in collaboration with other scientists."

	Stage of fellowship		
	Before	During	After
Women	2.17 (189)	2.32 (190)	2.67 (184)
Men	2.10 (500)	2.55 (500)	2.89 (492)

"Reactions"

Even our group of women — "atypical" in that they were, at least initially, highly successful doctoral-level scientists — differed on average from their male cohorts in their own estimation of self-confidence, ambition, and related traits in ways that echo traditional gender patterns of socialization. For instance, substantially more men than women considered their scientific ability to be above average (men: 70%; women: 52%), whereas more women than men considered theirs to be average (men: 18%; women: 34%). When asked whether they should have handled their career obstacles in a different way, many more women than men thought they should have had more confidence or been more assertive (25% vs. 5%). In addition, many more women than men (16% vs. 4%) in our interview sample said they had had vague or unclear career aspirations when they started out in science.

Styles of doing science

Handicaps in the area of "kicks" and in the area of "reactions" are likely to interact and reinforce each other. One result of this interaction may be the tendency to develop gender-specific styles of doing science. A considerable group among our interviewees recognized such styles. Somewhat more women than men reported they believed in the existence of gender differences in the work of scientists in general (men: 49%; women: 61%). Moreover, substantially more women interviewees than men thought that their own gender influenced the way they pursued their work. The area in which such a gender influence was most commonly thought to play a role was the professional conduct and interaction among scientists (men: 26%; women: 51%). Fewer interviewees thought that their own gender influenced their choice of research subjects (men: 16%; women: 40%) and their ways of thinking in science (men: 20%; women: 36%). Still fewer interviewees thought there were gender influences on the methods they used in their scientific work (men: 10%; women: 35%).

Women's professional conduct: Less careerist

Here is a closer look at the different areas of perceived gender differences in scientific style. A common observation among the interviewees, both men and women, was that, in terms of professional conduct, men scientists were found to have more "entrepreneurial spunk," as a female interviewee called it. They are, in this view, more aggressive, combative, and self-promoting in their pursuit of career success, and so they achieve higher visibility — in short, they are better at playing the "political game" of career advancement. For instance, some women interviewees reported that men have a way of "showing off" at conferences that alienates women. The following comment by a female scientist illustrates this male behavior:

> "... the men showed off for each other, they took themselves terribly seriously and they said any kind of thing that came to their head. I call it 'professor talk,' and I can do it very well.... And I found that a waste of my time."

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Whereas "professor talk" may indeed be a waste of time in terms of exchanging research information or gaining scientific insights, it may be anything but wasteful in terms of its hidden agenda. Professor talk — or a "bull session" or "chatty self-promotion," as other women respondents called it — may have the function of a bonding ritual. The social bonds thus forged may then have some beneficial effects on a scientist's research and career.

Women's problem choice: The niche approach

With respect to choosing subfields and problems, a number of our male and female respondents agreed with a woman who noticed "fewer women in highly theoretical/ mathematical sub-fields." But gender differences appeared to go beyond differences in mathematics interest or training. In terms of problem selection, many women reported to be following what could be termed a "niche approach," creating their own area of research expertise. A good example is a female interviewee who liked "to sense that I had my own area, that I wasn't just a cog." Similarly, a woman respondent said that she was predisposed to selecting research problems that were completely her own, because "I very much dislike working on problems that I know other people are working on." Rather than competing with other researchers and research groups in a race toward the solution of the same problem, she carves out a niche for herself. Of course, following a niche approach was not exclusively female. And it is not necessarily disadvantageous for career success.

Women's methodology: Perfectionism

When our interviewees mentioned a specifically female methodologic approach or way of thinking, it hardly ever implied a belief in a "non-androcentric" science that has been occasionally discussed in the literature. Rather, the overriding theme that emerged from both men's and women's responses was that women were seen to be more cautious and careful in their methods, and to pay more attention to details, compared with men. A woman respondent believed that "women are often more careful in their research and more hesitant to make statements until they feel they can really 'prove' them." Numerous women acknowledged a tendency to be perfectionists in their scientific work. Another woman scientist stressed women's attention to detail: "Women are more meticulous … And so I think that does affect how you do science. I don't know why that is, it just seems that for me, and the other women scientists I've dealt with, we tend more to deal in the minute details, fine points." It does not follow, however, that women scientists exclusively concern themselves with details. On the contrary, next to the theme of women's greater thoroughness, the interviews also brought out the theme that women see the broader picture and do more comprehensive work. In the words of a woman scientist, "women tend to work longer on individual projects and take on projects that are broader in scope than do men. Women seem to find it more difficult to break projects into small parts."

> "Thus, compared with men, women, as a group, experienced less collaboration as an equal or senior partner, whereas they experienced more collaboration as a junior partner."

Publication productivity: Quantity and quality

These results suggest a reinterpretation of the often-observed publication productivity gap between the genders (e.g., Cole and Zuckerman 1984; Fox 1983; Long 1992) — a gap we also found in our group of scientists. The male questionnaire respondents who now work in academe produced an average of 2.8 publications per annum, compared with the women's 2.3 publications per annum. The tendencies toward thoroughness and comprehensiveness may combine to reduce women's quantitative publication output. If women scientists are more thorough and perfectionist than men, on average, and if they favor more comprehensive and synthetic work, the quantity of their publications per annum will tend to be lower. This can have a deleterious effect on careers whenever the sheer number of publications is taken to indicate excellence of a candidate for a position, for instance.

The lower-quantity-but-higher-quality claim that some women made could be just a self-serving justification of low productivity. However, some indirect factual evidence for the women scientists' tendency to publish articles containing

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more substantial or comprehensive work emerged from a small study in which, among other things, we examined the citations in the scientific literature to biologists' articles (Sonnert 1995). Among this study's subsample of 25 former NSF fellows in biology who are now academic scientists, women's articles received significantly more citations per article, on average, than men's articles did (24.4 vs. 14.4 citations). This greater citation impact might indicate that the women's articles tended to contain more noteworthy contents, on the whole. Because the sample of this citation study was rather small, we cannot place a great deal of confidence in this finding; but a gender difference in citations per article in the same direction was also found by Long (1992), in a much larger sample of biochemists. Results like these support current efforts in the reward system to shift from a mostly quantitative toward a more qualitative evaluation of scientists' publication productivity when important decisions about scientists' careers are made.

Gender socialization and the scientific environment

The reported gender-specific styles of doing science may have various roots. From the "reaction" perspective of the kick-reaction model, one could point to the observed differences in traits, such as self-confidence, and emphasize that females might be socialized in a way that they prefer their own research niche, for instance, rather than enter the fray with numerous competitors who all work on the same topic. They may take criticism more personally than men and therefore try harder to produce "perfect" work that is above any possibility of criticism. From a "kick" perspective, however, one could stress that the collegial environment may be particularly hostile to women who deviate from accepted standards. A woman scientist, for instance, reported that "there's always somebody watching for me to make a mistake." And another woman concurred that women scientists find themselves often "under the magnifying glass." In their view, the burden of proof is reversed: while male Ph.D.s are considered competent scientists until proven otherwise, their female counterparts have to demonstrate fully their competence before it is generally accepted.

"While male Ph.D.s are considered competent scientists until proven otherwise, their female counterparts have to demonstrate fully their competence before it is generally accepted."

Both types of obstacles surely apply to different women scientists' careers to different extents. What seems more important than gauging the relative weight of these explanations is to realize that they tend to combine in bringing about considerably worse overall career outcomes.

Marriage and parenthood

In addition to science-internal problems, many women scientists face the issue of combining a science career and a family. We investigated with our questionnaire sample whether current marital and/or parental status was related to some basic career outcomes (leaving science, employment area, academic rank, publication productivity). In general, we found that marital and parental statuses were unrelated to these career outcomes, both for men and — more surprising — for women. If these overall analyses failed to show any strong interrelationships between the family and the career spheres for women scientists, does this mean there are none? We believe that interactions between family and science career do exist, but that they have become too complex and idiosyncratic to be captured by such broad variables as marital or parental status.

Rather than thinking of marriage and parenthood as having a fixed effect on women scientists' careers, we should see marriage and parenthood as a set of opportunities and problems. Women scientists are faced with the dilemma of "synchronizing" the often conflicting demands of three clocks: their biological clock, their career (e.g., tenure) clock, and their spouses' career clock. On the other hand, as reported to us, a husband and a family can provide emotional security and financial stability, as well as possibly some scientific support if the spouse is a scientist in the same field. Largely depending on how the problems are resolved and the opportunities are utilized, the effect of marriage and parenthood on women scientists' careers may be positive or negative. Our respondents could make choices about how to deal with the structural constraints

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and opportunities. Some choices turned out to be more fortuitous than others.

Conclusion

In sum, the gender problem in science careers has not yet been solved. Even the women in our specially selected group faced gender-specific career-obstacles, as shown by collectively less successful career outcomes than for their male cohorts. The disparities were not uniform across the board; they were concentrated in the top ranks of achievement and in fields outside of biology. As the pattern of gender disparities becomes more complex, their causes become more subtle. It may nowadays be futile to search for "the big remaining obstacle" to women's career parity in the science. Rather, the accumulation of subtle structural disadvantages ("kicks") together with attitudinal and behavioral disadvantages ("reactions") may go far to explain gender disparities where they persist. Policymakers should keep this in mind when trying to influence the social system of science.

A number of policy suggestions of various scope emerged from our work. I shall mention only one of them in conclusion, one that does not require large funds or high-level policy decisions, yet is crucially important (for a comprehensive presentation of suggestions, see Sonnert 1995-6 and Sonnert and Holton 1995b). Students and beginning scientists need to be more aware of the social factors that determine scientific career outcomes. We must end the widespread naiveté among young scientists. Almost all the people we talked with simply loved what they were doing; clearly they would much rather think about science than strategize about their careers. The view that, if the scientific research works out, career advancement will automatically follow, was particularly prevalent among our female respondents. At a minimum, universities should offer real-world career counseling, perhaps including courses that provide some eye-opening advice on how careers work. ❖

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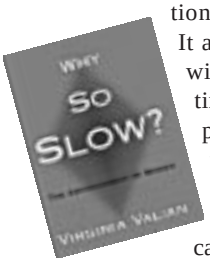
Sex, Schemas, and Success What's Keeping Women Back?

By Virginia Valian

The term glass ceiling has become popular as a way of referring to women's lack of representation at the top levels of organizations. The term suggests that invisible factors — as much as or more so than overt discrimination — keep women from rising to the top. It also suggests that those hidden factors will probably not simply disappear with time. It implies, moreover, that women's performance is at least equal to that of their male peers, for a ceiling keeps people down despite their competence.



Although disputes about the implications of the glass ceiling continue, solid data from social and cognitive psychology, sociology, and economics show that men and women receive unequal returns for equal investments. More important, the evidence reveals the perceptions and practices that create and maintain inequality. To move forward, we must understand how our cognitive processes unconsciously distort our judgments about men and women and thereby perpetuate the inequities that we have long been trying to overcome. Such an understanding will allow us to determine remedies for the present impasse, ranging from affirmative action to better methods for evaluating job applicants and employees.

Salary discrepancies

Discrepancies between men's and women's salaries occur both in business and in academia. In 1991 economists Mary Lou Egan and Marc Bendick conducted a survey of U.S. professionals working in occupations with an international focus. The men and women in the study resembled one another in many ways, such as years of work experience, range of specialties, and hours worked each week. But factors that benefited men did not help women to the same degree. Women's achievements and qualifications appeared to be worth less than men's.

For example, a bachelor's degree contributed $28,000 to a man's annual salary but only $9,000 to a woman's. And not constraining one's career for one's spouse added $21,900 to men's yearly income but only $1,700 to women's. Some factors that added to men's salaries subtracted from women's. Having lived outside the United States added $9,200 a year for men but subtracted $7,700 for women. Speaking a language other than English added $2,600 for men but cost women $5,100. Of the seventeen factors Egan and Bendick examined, fourteen helped men more than women (see table, next page).

This study is typical of others in the literature. Women tend to benefit less from their qualifications than men do. In many cases, women's human capital — their training, years of job experience, and so on — is less than men's. But even when men and women are equal in human capital, or when their differences are statistically equalized, men get more from their investments than women do.

Men's advantage above and beyond their greater human capital is often termed discrimination. Those who argue that the residual unexplained disparity between men and women is evidence of discrimination have been criticized for incorrectly assuming that all relevant factors have been measured and that the single variable of discrimination accounts for the remaining unexplained differences. Thus, the criticism continues, discrimination could appear to be taking place only because of a failure to specify all the relevant sex differences.

Others have made the opposite criticism, arguing that some economic studies have erred by including variables that may themselves be the consequence of discrimination. For example, lesser work skills may be the result of less opportunity to acquire skills. While both criticisms point out potential pitfalls, the studies to date appear neither to overlook major factors contributing to disparity nor systematically to under- or overestimate discrimination.

In academia men and women now start out with equal salaries, but they do not progress at the same pace. Data from the National Science Foundation (NSF) for 1993 showed that full-time academic male and female scientists were close to parity in their salaries one to two years after they received their Ph.D.s. But three to

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Salary discrepancies between men and women in business and academia

Factor analyzed	Contribution to men's salaries	Contribution to women's salaries
A bachelor's degree	$28,000	$9,000
Not holding back one's career for benefit of a spouse	$21,900	$1,700
Being designated "fast track"	$10,900	$200
A degree from a highly prestigious school	$11,500	–$2,400
Choosing international work	$5,300	–$4,200
Speaking another language	$2,600	–$5,100
Experience living outside the U.S.	$9,200	–$7,700

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eight years after completing the Ph.D., women earned 92 percent of men's salaries, and at nine to thirteen years afterward, women earned only 90 percent of their male counterparts' salaries (NSF, unpublished data). Similar data hold for male and female humanists.

In medicine, as well, the pattern is early parity followed by a gap. Income data for 1990 for physicians under forty-five years of age with two to five years of experience showed equal earnings (once human capital differences were controlled for). But for physicians with six to nine years of experience, women earned 96 percent as much as men. The story is the same in field after field; initial salaries are now close to equal for similarly trained young men and women. But disparities develop quickly.

Gender schemas

The data reveal that women rise too slowly through the professions, and their credentials appear to be worth less than men's. To understand why that is so, I developed an explanation that relies on two key concepts: gender schemas and the accumulation of advantage. Our unarticulated beliefs about men and women — gender schemas — make it harder for women (and easier for men) to accumulate advantage and rise to the top.

Schemas are hypotheses that we use to interpret social events. A schema resembles a stereotype, but is more inclusive and neutral. Gender schemas are hypotheses that we all share, men and women alike, about what it means to be male or female. Schemas assign different psychological traits to males and females. We see boys and men as capable of independent action, as agents; they are task-oriented and instrumental. We see girls and women as nurturing, communal, and expressive. In brief, men act; women feel and express their feelings.

Women have more trouble than men in reaching the top because our gender schemas skew our perceptions and evaluations, causing us to overrate men and underrate women. Experimental and theoretical work in social and cognitive psychology and sociology supports this thesis. People are not perceived as people but as males or females. Once gender schemas are invoked, they work to the disadvantage of women and the advantage of men by directing and skewing perception.

Laboratory experiments that control for variables that might affect people's judgments have illustrated how gender schemas operate. The findings from such experiments complement the statistical data offered in the preceding paragraphs. Despite their artificiality, the experiments allow us to isolate the factors that account for the lag in women's achievements.

Take, for example, a laboratory study conducted by New York University psychologist Madeline Heilman that asked different groups of students in an M.B.A. program to evaluate a female applicant for a managerial job. The number of other women candidates in a pool of eight people varied for each group of student evaluators. For one group, the female applicant was the only woman; for others, she was one of two women, one of three, one of four, or one of eight.

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Composition of pool

When women made up 25 percent or less of the applicant pool, the female candidate was

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evaluated more negatively than when women made up 37.5 percent or more of the pool. Being in a small minority made a female applicant appear less qualified and less worth hiring. Even more interesting were the assessments of the woman's personality. When women made up 25 percent or less of the applicant pool, the student judges perceived the female applicant as more stereotypically feminine — unambitious, emotional, indecisive, and soft — than when women accounted for 37.5 percent or more of the pool.

Such skewed perceptions pervade every evaluation of men and women. Even for objective characteristics such as height, people do not perceive males and females accurately. In a compelling laboratory experiment by University of Kansas psychologist Monica Biernat and her colleagues, college students were shown photographs of other students and were asked to estimate their height in feet and inches. The photos always contained a reference item, such as a desk or a doorway, so that height could be accurately estimated.

The experimenters matched the photographs so that for every photograph of a man of a given height, there was a woman of the same height. Here, then, was an easily visible characteristic to be measured in "objective" units. One might have expected accurate evaluations. But the evaluators' knowledge that men are on average taller than women affected their judgment. When exposed to a sample contrary to the general rule, they perceived the women as shorter and the men as taller than they really were. In this experiment, as is typical, there were no differences in how male and female observers perceived others.

> "In academia men and women now start out with equal salaries, but they do not progress at the same pace."

This experiment and others suggest that if someone has a schema about sex differences, that schema affects the person's judgments. Observers perceive individuals who diverge from schemas in light of their own gender hypotheses. If the schema is accurate, as it is for height differences, that will exacerbate errors made about individuals. Evaluators tend not to question their judgment, because it is supported by a real overall difference.

The implication of schemas for judgments of professional competence are clear. Evaluators may be faced with men and women who are matched on the qualities relevant to success. The evaluators may sincerely believe that they are judging the candidates objectively. Yet they are likely to overestimate the men's qualifications and underestimate the women's because of schemas that represent men as more capable than women.

Take, for example, data from a study of postdoctoral fellowships awarded by the Swedish Medical Research Council in 1995. Women made up 46 percent of the applicant pool but only 20 percent of the winners, because panels of senior scientists rated women as inferior to men in scientific competence. A subsequent analysis used an "impact" index to rate the candidates' productivity and the prestige of the journals in which they published. This analysis showed that women with a hundred or more impact points had been rated by the original panels as equal in scientific competence to men with twenty points. The evaluators no doubt considered themselves to be objective and impartial judges of scientific merit. But as these and other findings on gender schemas suggest, people tend to underestimate women and overestimate men in ways ranging from height to professional ability whenever they have antecedent beliefs about sex differences — even when those beliefs are unarticulated.

No credit for leadership

Gender schemas not only make it difficult for women to be evaluated accurately; they also make it difficult for women to reap the benefits of their achievements and be recognized as leaders. Consider a study in which college students viewed slides of five people seated around a table working together on a project. The students were asked to identify the leader of the group. In same-sex groups, the man or woman sitting at the head of the table was always selected as the leader. In mixed-sex groups, a man at the table's head was reliably picked out as the leader. But if a woman sat at the head, she was not always labeled as the leader; a man seated elsewhere was chosen as the leader about as often. As in other studies, there were no differences in the perceptions of female and male participants.

Failing to label a woman seated at the head of a table as a leader may have no discriminatory impetus behind it. But a woman leader is nevertheless prone to lose out compared with a man in the same position, because she is less likely to receive the automatic deference that subtle marks of leadership confer on men. As a result, the woman is objectively hurt even if observers intend no hurt. She has to work harder to be seen as a leader.

A real-life example from a prestigious university, circa 1990, shows gender schemas in

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action. A new female faculty member in a science department at a prestigious university has a conference with her department chair about what courses she will teach. She is eager to teach a large introductory lecture course. The chair refuses, saying that the students will not accept a woman in that format. The woman presses a bit, saying she thinks she can do it and would like to try. The chair doesn't want to take a chance and instead gives the lecture course to a new male faculty member.

We can ask two questions about his decision: why does he make it and how does it affect the woman's future? The chair makes that decision because gender schemas influence how he perceives and evaluates the scientist. He sees her not just as a scientist but as a female scientist. As such, she is probably unable to handle a large group of people. She lacks the authority a male automatically has by virtue of his sex.

We might be tempted to dismiss the incident. We might be tempted to tell the woman not to make a mountain out of a molehill. But the woman ends up teaching a laboratory course that requires much more work, giving her less time for research and publishing and putting her at a disadvantage relative to her male colleague who teaches the lecture course. She also has had a small failure she didn't deserve, giving her a small psychological disadvantage, because she has something to worry about that her male colleague does not.

Accumulation of advantage

Although a single course assignment is a small thing, small things add up. Success is largely the accumulation of advantage, the parlaying of small gains into larger ones. Mountains are molehills, piled one on top of the other.

A computer simulation demonstrates how the accumulation of advantage and disadvantage can work. Psychologist Richard Martell and his colleagues at Teachers College of Columbia University created a model eight-level hierarchical institution, staffed initially by equal numbers of men and women. Their model assumed that over time a certain percentage of incumbents would be promoted from one level to the next. It also assumed a tiny bias in favor of promoting men, a bias accounting for only 1 percent of the variability in promotion. The researchers ran the simulation through a series of promotions. After many runs, the highest level in the institution was 65 percent male. In the long run, a molehill of bias creates a mountain of disadvantage.

Our gender schemas cause us systematically to overrate men and underrate women. Our doing so culminates in lower salaries and slower rates of promotion for women. Knowing how these gender schemas work can help us understand why women in fields such as international business gain less advantage from their credentials than their male colleagues do. When men learn another language and live outside the United States, they are seen as preparing for their careers, engaging in those activities not because they enjoy them but because they expect an economic return. Women, in contrast, are perceived as choosing such activities for pleasure. Men accumulate advantage more easily than women because men are seen as more professional than women.

One school's success story

Fortunately, the situation is not hopeless. We can improve women's status in different ways, institutionally and personally. The Johns Hopkins University School of Medicine has shown what can be done to address the problem of lower salaries and slower promotion rates for women.

> "In the long run, a molehill of bias creates a mountain of disadvantage."

In 1990 the university's Department of Medicine had only four women associate professors. A task force found that women were put up for promotion later than their male peers, both because evaluators failed to identify qualified women and because women did not realize what was required for promotion. Each female faculty member (and later, each male faculty member) began to receive annual evaluations that gave her explicit information about her progress. The women also obtained concrete information in monthly meetings on how to develop their careers and how to handle different problems that would arise. On top of that, senior faculty members learned how to mentor their junior colleagues, so that disparities in treatment between junior men and women could be eliminated.

The monthly meetings and mentoring addressed serious problems in the department's treatment of junior faculty members. Mentors gave junior men more guidance and help than they gave junior women. For example, mentors invited junior men to serve as chairs at conferences six times as often as they invited junior women to do so. The junior men thus received more public exposure than their female colleagues.

Within five years, the program was a success. By 1995, with no change in the criteria for promotion, the department had twenty-six women associate professors. More subtle aspects of the women's experience also improved. In 1990, 38

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percent of the women said that the institution welcomed them, while 74 percent of the men said so. In 1993, 53 percent of the women felt welcome — a dramatic improvement within a short period of time, albeit one that fell short of equity. The Johns Hopkins experience demonstrates that institutions willing to dedicate resources to improving the status of their female employees can do so.

Affirmative action

Affirmative action is another institutional tool that can counteract the effects of gender schemas. Designed to guarantee representation of women and minorities in the work force according to their numbers and qualifications, affirmative action policies implicitly acknowledge the social and psychological realities that I have just described. Affirmative action recognizes that gender-blind policies are impossible to implement because there are no gender-blind evaluators.

"Affirmative action helps to counteract the continuing, if unwitting, overvaluation of white men."

Affirmative action procedures acknowledge that people are not hired simply on the basis of their qualifications. Those who have an unfair advantage because of their membership in a particular group receive preferential treatment according to characteristics irrelevant to the jobs they seek. Those irrelevant characteristics have prevented women and minorities from getting their fair share of good jobs.

Although affirmative action has been misperceived as making employers hire a woman or minority candidate over a more qualified white man, it in fact ensures the hiring of female and minority candidates who are more qualified than their white male competitors. It also gives hiring preference to female or minority candidates who are as qualified as white male applicants. The goal is a work force in which no group is overrepresented.

The misunderstanding about affirmative action stems in part from our belief that hiring procedures are meritocratic and that the best person gets the job. Even though we all have ample evidence that the "best person" (if such a notion can be sensibly defined) does not always get the job, we cling to the idea of a "just world" in which the deserving are rewarded and the unrewarded are undeserving. We rely on principles of meritocracy and fair play to justify decisions that we make about others. Our explicit commitment to equality makes it difficult for us to perceive the extent to which we make unfair, nonmeritocratic evaluations and decisions based on gender and race schemas.

Those schemas are themselves the other source of our misconceptions about affirmative action. From the outset, nonwhite, nonmale job candidates are perceived as having fewer qualifications than white male applicants. Such persons, it is assumed, need affirmative action to get a job. In reality, however, affirmative action helps to counteract the continuing, if unwitting, overvaluation of white males.

Better reasoning

Besides implementing institutional reforms to eliminate the inequities that gender schemas encourage, people can learn to reason better. The findings of cognitive psychology can help us avoid mistakes in judging other people. Even without the influence of schemas, evaluators are prone to errors in reasoning. They tend to give too much weight to extreme examples, ignore information about how frequently different events occur, and overestimate the value of their personal experience. Social schemas intensify those errors.

A common error is the failure to appreciate covariation, the phenomenon in which two factors vary together. For example, University of British Columbia psychologist Mark Schaller and his colleagues asked college students to assess the leadership potential of men and women in a fictitious company in which most executives were men and most office workers women. Within each group, the same percentages of men and women showed leadership ability. In this example, leadership ability and status within the company covaried. The covariation misled the male student judges, who erroneously inferred that the male workers had more leadership ability than the females. Those students saw only that, overall, more men than women showed high leadership ability; they neglected the fact that most executives were men. Follow-up studies demonstrated that students were less likely to make such gender errors after receiving training in the logic of covariation. People can be trained to reason in a way that will minimize the effects of gender schemas.

A similar reasoning error is the blocking of relevant hypotheses. If people have a hypothesis that explains a regularity, they tend not to entertain other valid hypotheses. That is, they often fail to perceive causes that might contribute to a person's performance if a prior hypothesis — such as a gender schema — independently predicts that performance.

An experiment by University of Utah psychologist David Sanbonmatsu and colleagues demonstrated how blocking works. Participants

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in the experiment learned a number of facts about fictitious students who had taken a welding course. Many of the facts were irrelevant to the students' success or failure, but one piece of information — about course load — was important. Students with a light course load passed, and those with a heavy course load failed. Participants also received information about the students' gender. One group learned that all the passing students were male and all the failing students were female. Another group learned that half the students who passed were male, and half the students who failed were male. Participants were asked to evaluate why some students had passed and others had failed.

The experimenters reasoned that participants would expect males to be more likely than females to pass a welding course. If the gender information supported such an expectation, they thought, the participants would not notice the other characteristic that predicted performance, namely course load. The division of success and failure along gender lines would block students from seeing that gender covaried with course load. In contrast, participants given information that did not support expectations based on gender schemas would tend to see that course load explained the students' performance. The results verified the predictions.

The welding experiment has obvious implications for judgments about women in professional settings. People who see a woman fail at a task they expect her to fail at because of the influence of gender schemas will probably not perceive other possible causes of her failure. They will attribute her failure to her sex instead of looking for other reasons, even if those other reasons actually caused her failure. They may even feel that a search for other causes is a search for excuses.

Evaluators can learn how to correct for blocking in the same way that they can learn to understand covariation. Once trained to reduce errors in their reasoning, these people may then be able to mitigate the effects of gender schemas in their own judgments. Understanding that their own gender-based expectations may affect their assessment of other people, these evaluators will thus judge others more fairly and accurately.

On balance, there is some reason for optimism. Although women's advancement is too slow, gender schemas operate covertly, bias evaluations show that small examples of bias add up, and people's reasoning is often flawed, we can understand how these processes work and do something about them. Relying on our knowledge of how schemas work and how advantage accumulates, we can make institutions genuinely fair. ❖

Sometimes the situation of women in astronomy can be illuminated by fields well outside academia. For example, top professional orchestras have long excluded women, but in recent years out-of-date prejudice has been overcome by novel audition strategies.

Behind the Scenes, Behind the Screens

by Lisa Frattare and Meg Urry

Apparently it is no secret that some famous male musicians doubt the abilities of their female colleagues. In a study from the National Bureau of Economic Research, entitled "Orchestrating Impartiality: the Impact of 'Blind' Auditions on Female Musicians," authors and economists Claudia Goldin of Harvard and Cecelia Rouse of Princeton document the low numbers of women in major orchestras and describe in vivid detail the common biases of male conductors against female performers.

The conductors expressed their opinions unapologetically and mostly anonymously, saying, "The more women, the poorer the sound," and "Women have smaller techniques than men," and "Women are more temperamental than men and more likely to demand special attention." Famous New York Philharmonic conductor Zubin Mehta was quoted as saying, without explanation, "I just don't think women should be in an orchestra."

Part cause, part effect, is that women are rare in the upper echelons of the classical music profession. As recently as 1980, the premiere "Big Five" musical ensembles — the Boston Symphony, Chicago Symphony, Cleveland Symphony, New York Philharmonic, and Philadelphia Orchestra — had only 10% women musicians even though the pool of well-qualified graduates from places like New York's Juilliard School of Music included 45% women.

At about this same time, the Musician's Union began pushing a new hiring strategy. Not only was there a movement away from the "inside-track" and "old boy network" and

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toward open auditions, but also to a new audition format, the "blind audition." Musicians either played behind a screen or the reviewers themselves sat behind such dividers. Audition areas were also carpeted and/or women musicians were asked to remove their shoes so that an escorting personnel manager could make male-sounding footsteps. These changes ensured that musicians were judged on sound, not gender.

The practice of blind auditions was sometimes done only in initial auditions, not necessarily in second or third auditions, yet the changes were still immediate and strikingly favorable to women. Even the New York Philharmonic, with Zubin Mehta at its head, hired women for an incredible 45% of new positions once blind auditions were instituted.

As with any dramatic reduction in bias, many factors are at work. Elizabeth Woodside, violinist for the Cleveland Orchestra, describes her role as one of 23 women in the 105-member highly competitive orchestra, which does not participate in blind auditions. She points out that besides variations in the numbers of women from orchestra to orchestra, there is also a definite gender distinction in choice of instrument. String sections are heavily dominated by women, whereas brass and percussion sections consist mainly of men. These inequalities may result not from biased hiring practices but from earlier, more subtle effects of initial training or pressure from parents or peers, steering girls and boys toward different instruments.

The world of astronomy/physics is not so different. Women remain a small minority, their attrition is higher, and they are noticeably more prevalent in some subfields than others. Although blind auditions are impractical in the scientific world — applicants for academic and research positions usually give talks, for example — there is evidence that gender influences supposedly objective review processes such as refereeing of papers or ranking of job applicants (Paludi and Bauer 1983, Wennerås and Wold 1997). The challenge for astronomy is to develop truly objective ways to evaluate scientific excellence, the analog of the blind audition. ❖

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