STATUS

A REPORT ON WOMEN IN ASTRONOMY

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CONTENTS

Using Non-Cognitive Assessments in Graduate Admissions to Select Better Students and Increase Diversity

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When I became the director of the APS's Bridge Program at the University of South Florida, I leveraged that position to raise awareness about diversity issues in physics. Thanks to many people's appreciation of this topic, I have given physics colloquia to about a dozen departments across the country and presented invited talks at numerous conferences. Recently, I teamed up with Prof. Keivan Stassun from Vanderbilt to bring this issue even more visibility with an article in *Nature* [1]. The present article is intended as a brief review/resource letter, summarizing what I would present in a colloquium.

Exercise I

Please write down the two or three attributes of your very best graduate student. It is often helpful to write that person's name down first. Write down a few thoughts about what it was like to work with that student. Take about one minute to complete this exercise, then move on to the next exercise.

Exercise II

Assuming you've played along, you're now in a position to think about a student who really didn't work out. What are the top two or three attributes that you feel led to that situation? Take another minute to write down a few thoughts about what that experience was like for you.

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Non-Cognitive Assessments continued

Debriefing Exercises I and II

If you're like most people, you said something along the lines of, "Student I was in the lab all the time taking data and writing papers, asked questions I hadn't thought of — then answered them. I was always excited to get to the lab." And for Exercise II you said something along the lines of, "Student II was smart, but gave up easily. He came running to me with questions on those days that he was actually on campus. His demeanor made being around him a drag for everyone; things got so much better when he left."

What part of your admissions process selects for I and selects against II? If yours is like most processes, the answer to this question is "it doesn't," or maybe you try to squirm around this by saying that you try to read between the lines in letters of recommendation and personal statements, when necessary. Good luck with that.

Some Problems

Figure 1 shows that racial/ethnic/gender groups have relatively large differences in average GRE Quantitative (GRE-Q) scores. These data come from ETS, the company that makes the GRE, and are in line with existing research in both education and work settings. The performance disparities of Figure 1 are: the same for the Physics GRE [2]; independent of intended graduate field; the same when controlling for undergraduate GPA; the same for the SAT; the same for 8th grade math achievement tests; and the same for fourth grade math achievement tests. ETS claims these differences are related to educational opportunity/access.

The significant problem facing our community is not necessarily with these scores per se, but rather with how these scores are misused during admissions. Of the roughly 180 Ph. D. programs in the AIP Graduate Programs book, ≈96% require the General GRE. One quarter of these have an explicitly stated minimum GRE-Q score for admission, with the median stated cut-off being 700 (64th–70th percentile, depending on year; 155 on the new test). With respect to the figure, such "minimum acceptable" policies can have a major impact on diversity: no one under the red line would be admitted to graduate school. Any admissions system that relies solely or predominantly on the GRE will result in an admitted class that is relatively homogeneous in both gender and race/ethnicity.

Non-Cognitive Assessments continued

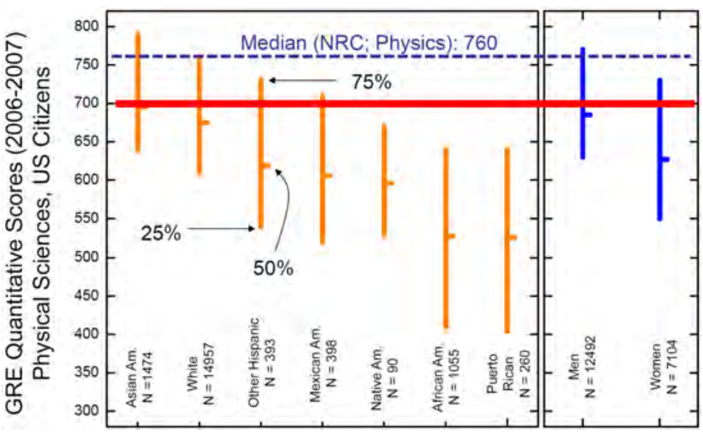

Figure 1: GRE Quantitative score quartile ranges from 2006–2007 [3] by race/ethnicity and gender for US citizens whose self-identified intended graduate major was "physical sciences." The top and bottom of the marker lines are the 75th and 25th percentiles of the score distributions, respectively; the tick is the median. The solid red line represents a typical "minimum acceptable" score posted by Physics Ph. D. programs; the dashed blue line indicates the average GRE-Q score of matriculants reported by departments to the National Research Council. [4,5]

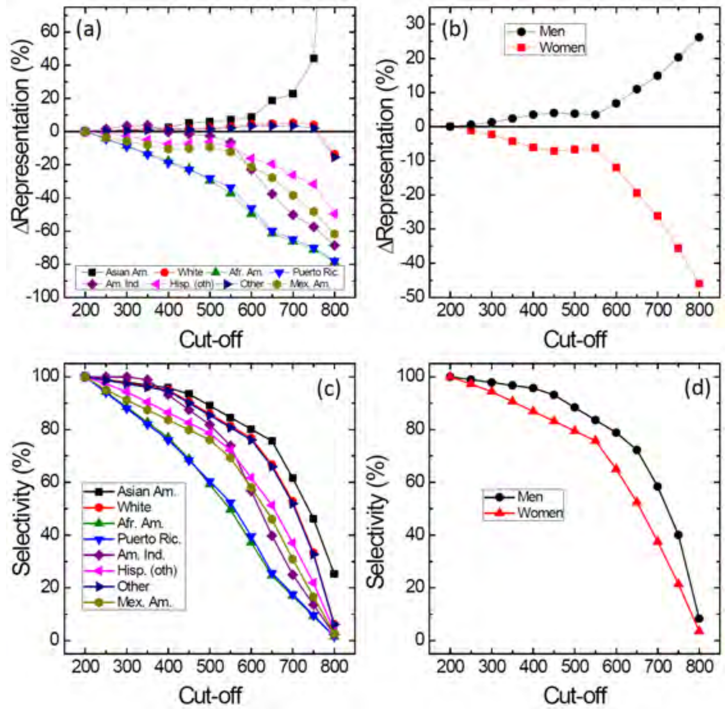

Figure 2: Cut-off scores change the representation of the "acceptable" applicant pool's composition by (a) race/ethnicity and (b) gender. Cut-off scores also lead to variable selectivity for the different groups based on (c) race/ethnicity and (d) gender.

Using the GRE-Q score distributions summarized in Figure 1, we can calculate the impact of cutoff scores on graduate student diversity. If we integrate the distributions from the cutoff score up to a perfect score, the result is the number of individuals within each group who make it through the cutoff. The representation of a group is then defined as the number for that group making it through the cutoff normalized by all individuals making it through the cutoff.

Thus, we are able to estimate the race and gender composition of the eligible applicant pool for an arbitrary cut-off score. The effect of the cut-off score on representation is shown in Figure 2(a) and (b). Whites, Asians, and men are over-represented when using a cut-off score, while Hispanics, African Americans, and Native Americans are under-represented. Throughout this article, the term "women" means all women, irrespective of race/ethnicity.

Another metric is what I call selectivity: the percentage of test takers making over the cut-off for each group (Figure 2(c) and (d)). For example, the percentage of women making it through a cut-off of 700 (64th percentile) is 26%, but only 5.2% of all under-represented minorities meet or exceed this cut-off. While not claiming causality, we note here that the actual proportions of physics Ph. D.'s granted to female and minority US citizens are ≈22% and ≈6%, respectively [6,7].

Compounding these race/ethnicity/gender issues is the fact that the standard admissions approach has not been successful in identifying students who will graduate. Indeed, the US Ph. D. completion rate in STEM fields is only 50%, slightly higher in physics [8]. So the standard admissions procedure is no better a predictor of success than a coin flip.

Non-Cognitive Constructs

Non-Cognitive Constructs are a set of measurable psychological and social attributes we use to navigate life. I first happened upon the concept of "non-cogs" when my wife and I took a Coursera MOOC entitled *Inspiring Leadership Through Emotional Intelligence*. The course was taught by Richard Boyatzis, a distinguished university professor of Organizational

From the Editor, Nancy Morrison

In this issue of *Status*, we are honored to include articles by two distinguished guest authors. Casey Miller of RIT has been involved in the highly successful APS Bridge program, and he has been among the pioneers in developing alternatives to traditional methods of evaluating applications for graduate school. He was an organizer and a presenter at the AAS 223rd meeting special session, cosponsored by CSWA and CSMA, "The Proper Use of GRE Scores for Enhancing Diversity and Excellence in Astronomy and Physics Graduate Programs." His article describes reliable methods for identifying students whose personality traits, along with GPA and GRE scores, indicate a high probability of success in Ph. D. programs.

Sue V. Rosser is Provost and Vice President for Academic Affairs at San Francisco State University. Her CV includes service as: Dean of Ivan Allen College, the liberal arts college at Georgia Institute of Technology; Director of Women's Studies at the University of South Carolina; and Senior Program Officer for Women's Programs at the National Science Foundation. She is noted for her research on the modern history of American women in science. Her article, which is based on a presentation in a special session at the 225th AAS meeting, describes recent findings that junior and senior women face different challenges in academia.

For a lighter touch, check out the book review and author interview by CSWA member Nicolle Zellner (page 30). I hope you enjoy the magazine.

Behavior at Case Western Reserve University's School of Management; I highly recommend it. Non-cogs are too numerous to list but include things like personality, motivation, and grit. Many of these terms have technical meanings in social science that differ from common usage.

Decades of educational and industrial-organizational psychology research conclude that non-cogs can simultaneously enhance validity and diversity in selection processes [9, 10, 11]. In contrast to cognitive ability measures (e.g., Figure 1), non-cognitive assessments typically show negligible differences between majority and minority groups [12, 13, 14]. What's more, non-cognitive assessments predict academic and job performance in their own right, and do so above and beyond cognitive ability measures. (In case you start reading psychology literature, this is known as "incremental" validity; "incremental" has a positive connotation in psychology.) [15].

Non-cogs have been used successfully in dental admissions by Buyse [16], and were shown by Lievens and Sackett to have validity beyond cognitive measures for long term performance of medical students [17]. In fact, the latter study showed that the correlation of non-cognitive competencies with long-term success increased with time, while the correlation with cognitive tests decreased with time. Sternberg famously showed the same result in psychology, concluding that the correlation of GRE scores with graduate grades decreased to the level of noise by the second year [18]. Lievens, Ones, and Dilchert also showed that the correlation between non-cogs and performance in medical school increases with time [19]. Along these same lines, a study of lawyering effectiveness concludes that non-cogs have such strong potential that they may transform law school admissions [20].

The body of work devoted to studying the validity of non-cognitive constructs in selection is enormous, but has not tunnelled into academia. The dilemma I run into is that most of these studies are too far afield for many STEM faculty to deem the conclusions valid for their specific discipline. Among the most palatable examples is work by Richard Boyatzis [21] that determined the correlation between didactic and

Non-Cognitive Assessments continued

clinical performance of dental students as functions of cognitive and non-cognitive variables at the admissions stage. The cognitive variables were undergraduate grades and performance on the Dental Admissions Test. The non-cognitive variables spanned twenty-two emotional intelligence competencies grouped into four clusters: Self-Awareness, Self-Management, Social Awareness, and Relationship Management. Of all the variables, cognitive and non-cognitive, the Self-Management cluster was the only significant predictor of clinical performance. The variables within this cluster are emotional self-control, achievement orientation, initiative, trustworthiness, conscientiousness, adaptability, and optimism—all qualities I would love to maximize in my students (and my colleagues! (and myself!)).

Boyatzis and others have applied non-cognitive assessments in fields as disparate as the military and mid-level corporate management; in each case, they find strong evidence that these tools are essential for identifying superior performers. They also found that these emotional and social intelligence competencies cut across cultural and language boundaries [22]. Through all of these studies, the most significant conclusion is that content-specific knowledge is necessary, but not sufficient, for outstanding professional performance. They also found that these essential non-cognitive skills can be learned [23]. What if yours was the first department to incorporate this sort of professional development and training into a graduate or undergraduate program?

Bill Sedlacek has assembled reasonable arguments for the use of non-cognitive variables with graduate and professional students [24, 25]. He has identified a handful of non-cognitive variables that have been useful in predicting the success of students from underrepresented groups. This is important because validity studies of things like the GRE are done with predominantly white test populations. Sedlacek's methods are used by numerous institutions and by the Gates Millennium Scholars program. Among his variables, four appear to be rising to the top: Positive Self Concept (exhibits confidence, character, determination, independence), Realistic Self-Appraisal (recognizes personal strengths and weaknesses, aspires to self-improvement), Long Range Goals (defers gratification, plans ahead, sets goals), and Leadership (demonstrated in any arena, academic or not). He has most recently applied his work to dental school admissions by augmenting the typical application materials with essay questions targeting non-cog variables, along with structured interviews of top applicants to probe additional non-cognitive variables [26]. While the initial cohorts in this study have not graduated yet, the early conclusions are that the non-cognitive metrics were strongly correlated with the final admission decisions, even though they were not explicitly incorporated into a decision algorithm. Assessing applicants' levels of non-cognitive competencies may thus provide a pathway to more efficient admissions processes.

The Fisk-Vanderbilt Masters-Ph. D. Bridge Program testifies to what is possible for next-generation graduate admissions. Together with social scientists, the program's leaders have developed means to identify "unrealized or unrecognized potential." The program has been wildly successful, with about a 90% rate of success, defined by earning a Ph. D., getting a job in STEM, or making normal progress toward the degree. Markers for success include "Passion, strong motivation to succeed, intense drive, hard worker, willingness to take risks, ability to overcome hardship, leadership capabilities, collaboration skills, and the ability to succeed in the classes that serve as gatekeepers to the Ph. D." [27]. Many of these markers can assessed by means of a guiding rubric when reviewing the personal statement and letters of recommendation. The program's *American Journal of Physics* article [27] includes appendices with tools that can help translation to your program; additional tools can be found at their website [28]. Their efforts and selflessness are worthy of recognition.

Conscientiousness

The work being highlighted here shows that non-cognitive constructs improve our ability to select high-quality students because graduate student performance is a more nuanced multidimensional space than can be reasonably assessed by purely cognitive measures. The magnitude of that improvement depends on which non-cognitive construct is assessed and its correlation with cognitive ability. *Conscientiousness* and cognitive ability are not only known to be orthogonal variables, but they have been shown time and time again to be of equal importance in predicting academic performance [15, 29, 30].

Non-Cognitive Assessments continued

Conscientiousness is a personality trait describing a person's tendency to be industrious, orderly, responsible, virtuous, and dutiful, and to act with self-control [31]. Conscientiousness is one of the "big five factors" of personality [32, 33]. Many of the characteristics that may be needed to succeed in STEM fields can be subsumed under conscientiousness. For example, in interviews with graduate deans and faculty, persistence was cited as an important predictor of success [34]. Similarly, motivation, planning, and self-organization are important [35]. Stassun et al. argue that strong motivation to succeed, intense drive, and diligence—all closely tied to conscientiousness—are critical for success in Ph. D. programs [27].

Conscientiousness robustly predicts job performance across all jobs and occupations assessed [36], and it predicts academic performance [30]. This is not surprising, since conscientious individuals are more likely to engage in effortful strategies (i.e., more organized, prepared) and set "performance-approach" goals (i.e., seek opportunities to prove themselves), which result in better performance [37].

Conscientiousness shows relatively small gender (mean difference, $d = -0.07$ [13]) and race/ethnicity differences ($d = 0.07$ for White-Black differences, 0.11 for White-Asian differences, 0.08 for White-Hispanic differences [14]). Thus, if conscientiousness is given comparable weight with cognitive ability in selecting applicants, the result should be a more diverse matriculating class with more potential to succeed than is the case in current practice.

Given this robust evidence for its universal utility, conscientiousness may be the most solid and straightforward construct to employ in admissions. Other non-cognitive constructs are less well established at this moment. For example, faculty and deans often cite communication as an important non-cognitive skill needed for success [34, 38]. Similarly, previous research has argued that emotional stability, resilience, and ability to overcome hardship are important predictors of academic performance in graduate school [38, 27], likely because graduate school is stressful and challenging. Others have argued that leadership capabilities should be assessed to ensure that we are training scientists who are capable of becoming educational and research leaders [27].

ETS itself has acknowledged the importance of measuring non-cogs at the admissions stage [10]. In fact, it has developed a new tool, the Personal Potential Index, that attempts to assess certain aspects of personality. This is basically a standardized reference letter filed by a handful of evaluators (chosen by the student), including questions related to non-cogs evaluated on a Likert scale. Many graduate schools now require this type of questionnaire in on-line applications before allowing the referee to upload the recommendation letter. Unfortunately, ETS reports that a surprising number of students are in the top 10% of all categories. This is probably a reflection of the evaluators' lack of ability to gauge, or interest in gauging, items related to personality.

How Social Scientists Measure Things We Consider "Intangibles"

When I first started talking to social scientists about using non-cogs in admissions, I was shocked at their claims. Assuming the applicant answers truthfully, industrial-organizational psychologists can obtain solid measures of personality with a dozen or so multiple choice questions. I still don't fully believe it, but they also don't believe I can grow films that are ten atoms thick (I can).

The following sections are an attempt to convey at least a taste of the available evaluation methods. Whatever variables you choose to include, don't get fancy with mathematical assembly of parameters. Apgar [39] got it right: pick important variables, assign them very coarse grades (0,1,2,3), then sum (normalization is tacit). This is summarized in the great popular book *Thinking, Fast and Slow* by Daniel Kahneman [40] (a Nobel prize winner in economics [41]). Additional research has shown that "clinical" prediction (e.g., interviews) is a weaker method than "mechanical" prediction (e.g., Apgar) [42]. In essence, anything that has a subjective component (recommendation letters, personal statements) should be scored coarsely by multiple raters, then added to the mix of quantitative parameters (which should also be coarsely graded and normalized). Since we know the non-cogs are largely orthogonal to cognitive things like GPA and GRE scores (all of which are strongly intercorrelated), it makes most sense, given the research outlined above, to give equal weight to the non-cog and cognitive components. Involve a social scientist if you want to do it right.

Non-Cognitive Assessments continued

Rubrics

The most palatable technique may be simply to use a coarse-grained rubric to guide the evaluation of application materials. Rubrics increase fairness by making sure each factor is assessed for each individual, and that the impact of raters' expectations is mitigated (e.g., see Figure 3). Coarse graining (e.g., high, medium, low, none) within the rubric is important because the resolution of every tool available is poor (why waste time bickering over a 3.4 vs. a 3.6?), and a single element is not crucial if you use multiple components.

Figure 3: Playing cards; see the text. (Incidentally, the odds of getting a full house in Texas Hold'em are orders of magnitude better than those of successfully navigating an asteroid field.) [43]

By now you've likely wondered what Figure 3 has to do with expectations and rubrics. How could this tell us anything about expectations? Your brain simply can't do all calculations all the time, so it relies on expectations for many things. Your brain expected the ten of diamonds to red, and it didn't even bother to get excited when it saw that it was black. Actually, it didn't even bother to check the color because it knows diamonds are red. Rubrics help make sure your brain checks the color of all the cards in each hand you're dealt.

Your social science collaborator can help with the difficult task of constructing a rubric and learning how to use it. You would then scour the letters of recommendation and personal statements for these predetermined features. You may already be doing this, but probably not as systematically as would be recommended by practitioners in selection. We used this technique to screen applications for the APS Bridge Program, and it does a decent job, but with approximately the same amount of effort used in traditional admissions (not all faculty in the traditional admissions committee were willing to adopt this systematization, a topic that I address below). The main issue with rubrics is inter-rater reliability, especially if the components are more subjective (e.g., "demonstrates leadership") than objective (e.g., "coauthored a peer-reviewed article"); a social scientist will be able to help refine the rubric and train the application reviewers. The folks at the Fisk-Vanderbilt program have developed a toolkit that includes an example non-cogs rubric based on Sedlacek's work [28].

SJTs

Situation Judgment Tests (SJTs) ask the test taker to describe how they would act in a hypothetical scenario or to rank the efficacy of several potential responses to the scenario. SJTs can be tailored to probe whatever qualities are of interest. The questions of course should be designed by a professional (i.e., not you). One issue is that SJTs are susceptible to "faking" (that's a technical term), though this can be limited by proper design.

360° Assessment

360° assessment is among the most comprehensive and reliable methods, but this comes at the cost of time and money, so it will probably only be a research tool. This technique assesses non-cogs through individuals surrounding the applicant; self-reports can be used, but are often flawed. An example is a 72-item questionnaire known as the Emotional Competence Inventory–University version [44], which was developed specifically for academic settings and used for admissions in research studies by Boyatzis.

Adoption

The strongest students are those with the largest volume in some n-dimensional space. Most programs don't measure applicants along all dimensions, which means that your program will have a competitive advantage if it does. Indeed, many students will be completely overlooked by many graduate programs because their test scores are not perfect; this is an opportunity for you, if you're able and willing to probe along the orthogonal axes.

Non-Cognitive Assessments continued

Apprehension about adopting new techniques in admissions is a phenomenon that has been studied by psychologists with the aim of designing interventions to enable adoption [45]. Perhaps the most common implicit obstacle to adoption in STEM fields is the belief that experience increases one's predictive prowess. This probably describes at least one of the reader's colleagues with comical accuracy. The expertise the veteran committee members proclaim is a myth that causes them to over-rely on faulty, irrelevant, and often unconsciously biased intuition. There are ways to reduce this overconfidence [46], but most of your colleagues won't change, since psychologists have shown that self-efficacy beliefs are negatively correlated with readiness to change [47].

The best way to proceed at the beginning of the admissions cycle is for each committee member independently to score each application package on each component, then discuss the results as a group. The latter step is crucial to help committee members calibrate themselves, which increases reliability. This can only be accomplished if discrepancies are discussed and rationalized in a training session. This may be worth repeating periodically, as reviewer fatigue and drift can undermine the utility of these protocols.

Concluding Thoughts

With this article, I hope to have communicated important things about graduate admissions. Using GRE scores in the usual way adversely impacts important groups and does not select for eventual Ph. D. attainment much better than a coin toss. Non-cognitive competencies are orthogonal to cognitive variables and can thus add significant value to admissions by identifying students with the necessary non-science skills to make it through rigorous graduate programs. Many non-cognitive constructs are available, but the most widely studied is conscientiousness. Psychologists have determined that non-cognitive factors are not only valid in their own right, but help to identify individuals with the potential to become exemplars. The striking thing is that these non-cognitive constructs do not appear to depend on discipline, race, culture, or gender. Consequently, they can simultaneously enhance validity and diversity in graduate admissions. I hope that some of you will find these arguments compelling enough to help astronomy and physics move forward ... with the help of a social scientist.

Acknowledgements

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Senior Women Moving into Leadership Positions: Has ADVANCE Affected Junior and Senior Women Scientists Differently?

Sue V. Rosser, San Francisco State University, Provost And Vice President for Academic Affairs

Portions of this article are taken from previous publications by the author [1,2]

During the last forty years, women in science have made documented progress on many fronts. The numbers and percentages of women have increased dramatically in STEM fields and reached parity in degree attainment in the life sciences as well as many of the social sciences ([3], Table 1). In chemistry, physics, geosciences, and mathematics, the numbers and percentages have increased considerably, although in engineering and computer science the percentages remain below 20 percent at the bachelor's level; in computer science, this represents a substantial drop from the level of 37 percent in 1984 [4].

Although there are a few fields, such as computer science, where the percentage of women at the master's and Ph. D. levels exceed those at the bachelor's level, attrition usually occurs at higher degree levels. More than thirty years of data [1] from the National Science Foundation (NSF) reveal that increasing numbers and percentages of women at the lower degree levels will not automatically translate over time into the same percentages at the higher degree levels in many fields that remain predominately male. Similarly, in the STEM workforce, loss of women occurs at each higher level on the career ladder [6].

Women in the academic STEM professoriate also become fewer at each rung of the career ladder. Women represent more than 30 percent of STEM faculty at four-year institutions, ranging from 42.8% at the level of assistant professor to 20.8% of full professors. Just as with degree recipients, considerable disciplinary variation exists, from 58.3% of psychology faculty through 37.6% of biology/life science faculty and 23.9% of physical science faculty to 15.5% of engineering faculty being women (see Table 2). The number of women faculty also varies with institutional type. At elite research institutions, where women constitute about 10% at the rank of full professor, the report from the National Academy of Sciences (2009) [7] found improving opportunities nationally for women in tenure-track positions.

Table 1: Percentage of degrees received by women in 2012 by major discipline and group [5]

	All Fields	All S&E*	Psychology	Social Sciences	Biology	Physical Sciences	Geosciences	Math/ Statistics	Engineering	Computer Science
Bachelor	57.4	50.5	76.7	54.7	59.3	40.6	39.1	43.1	19.2	18.2
Master	60.1	45.6	79.1	55.9	57.5	35.9	42.7	40.6	22.9	27.8
Ph. D.	49.6	41.1	72.6	48.7	53.1	31.5	43.3	28.2	22.6	21.4

*Science and engineering

Junior and Senior Women continued

Many of the institutional changes heralded as significant for attracting and retaining women in science and adopted by both prestigious private institutions [9,10,11,12] and institutions funded through the NSF ADVANCE program [13] focus on issues that are particularly significant for junior women. Although the original intent of ADVANCE was to move women to senior and leadership positions, a recognition of insufficient women in many fields at the levels of assistant and associate professor required many institutions to center their efforts on recruitment and retention at the junior level. From one point of view, this focus on junior women remains critical, particularly in light of the study conducted at Penn State documenting the significant difference in the percentage of women faculty (48%) achieving tenure at 10 top research institutions relative to their male peers (56%) [14]. If institutions do not evolve policies to attract and retain women, especially in STEM, there will be no issues for senior women, because there will be few or no senior women.

Population Studied and Methods

Responses of almost 400 NSF Professional Opportunities for Women in Research and Education (POWRE) awardees to e-mail questionnaires administered from 1997 to 2000 revealed some of the major issues and opportunities academic women scientists and engineers faced and the impact of laboratory climate on their careers [15,16,17]. In 2012, we re-administered the questionnaire to the original respondents. Our analysis then gave us a better understanding of their perceptions of these issues for academic women scientists some ten to fifteen years after their initial responses and yielded insights about senior, compared to junior, women scientists. In the e-mail questionnaire, the precise definition of the transition from junior to senior was left open. The items focused on junior compared to senior women were:

1. Do you think that the issues and/or climate differ for junior compared to senior women? If so, how?
2. In your opinion, what changes in institutional policies and practices are most useful for facilitating careers of academic women scientists or engineers at the junior level? Would these be the same for women at the senior level?

The questionnaire was e-mailed to all of the almost 400 awardees who responded to the initial (1997–2000) questionnaire and for whom a valid e-mail address could be found in 2012. The response rates were as follows: 63.0% of the 1997 awardees, 53.2% of the 1998 awardees, 50.6% of the 1999 awardees and 50.0% of the 2000 awardees. It is ironic that the highest response rate came from the earliest (1997) cohort.

As was the case with the sample responding to the initial survey, the sample responding to the 2011–2012 e-mail questionnaire in all four cohorts appeared to be representative of the population of awardees with regard to discipline, and the non-respondents did not cluster in any particular discipline. The 2012 responses were distributed among the NSF directorates in

Table 2: Percentage of women doctoral scientists and engineers in academic institutions by field and rank in 2013 [8]

Professorial rank	All S&E	Psychology	Social Sciences	Biology/ Life Sciences	Physical Sciences	Engineering	Math/ Statistics	Computer Science
Assistant	42.8	68.5	49.5	46.0	32.1	22.8	38.5	21.0
Associate	34.0	57.6	46.7	31.3	25.3	19.0	22.2	25.0
Full	20.8	41.2	26.6	23.4	15.2	7.5	16.2	12.5
Total*	33.5	58.3	40.5	37.6	23.9	15.5	26.6	16.5

*Includes Instructor/Lecturer

Junior and Senior Women continued

proportion to the number of awardees. Since directorates group similar disciplines together, the distribution among directorates eliminates the possibility that respondents from one discipline dominated the survey responses. The limited data available from the e-mail responses revealed no other respondent or non-respondent bias.

Results

The 2011–20112 responses from all four cohorts of POWRE awardees to question 1 overwhelmingly affirm their belief that junior and senior women face different issues/challenges/opportunities (see Table 3).

How strongly the four cohorts thought the issues differed for the two groups varied considerably. While in the 2000 cohort three and one-half times as many respondents thought the issues differed as thought they remained the same, in the 1997 cohort more than eight times as many felt they differed.

Similar or different?

Table 4 shows the responses separated by directorate of awardee. Respondents from all directorates in all cohorts believed issues faced by senior and junior women differed. A minority (14.1%) of respondents indicated that they felt the issues remained similar. Although some just said, “no difference,” others spelled out why they thought the issues remained the same:

> I do not think that the issues or climate differs that much for junior compared to senior women. The perception and potential negative impacts of the issues and climate may change some after one obtains tenure but the issues are pretty much the same. (2012 respondent from 2000 cohort)

> In a general way the main issue is the same, that there is a single ideal model for a scientist’s work/life balance of activities. That model does not allow much flexibility for dealing with family issues, whether it be raising a family or caring for an elderly parent. For dual-career couples at my institution, the negative climate towards the trailing spouse does not seem very different for junior and senior women. (2012 respondent from 1999 cohort)

In contrast, the overwhelming majority (78.5%) believe that senior and junior women face different challenges. The following quotations suggest some of the differences respondents observe:

> Very different. Issues for junior women are about harnessing respect from senior male colleagues within whatever social expectations of “feminine” behavior they have while asserting their personalities and their scientific identities, visibility (unless one has an exceptional mentor, which some do), and graduate student access. The climate issues for senior women are about equitable access to resources financial and otherwise, access to critical budget information, space allocation, access to prestigious positions, access to leadership positions that involve making budget and resource allocation decisions, access to large research grants/facilities, support for large initiatives. My experience suggests life is easier if husbands/partners work in academia. People’s behavior and attitudes tend to reflect whether they need to worry about the “other” or not. (2012 respondent from 1997 cohort)

> Yes, I think junior women are still tightly connected to their former mentors’ networks. With time, they need to form their own but that doesn’t work for all women. Some women in science end up pretty isolated except for students and former students. Junior women also are good at ignoring slights and acting like there is no problem. Sometimes older men are very lenient with attractive young women compared to how they will treat them when they are a bit older. Junior women get invited to speak much more, as best I can tell, and are nominated for awards, because of their network connections. (2012 respondent from 1998 cohort)

Junior and Senior Women continued

Table 3: POWRE cohorts' responses on issues and/or climate for junior vs. senior women [8]

	Year Cohort									
	1997		1998		1999		2000		Total	
	N	%	N	%	N	%	N	%	N	%
Different	26	79%	41	82%	37	82%	35	71%	139	78%
Same	3	9%	6	12%	6	13%	10	20%	25	14%
Don't know	4	12%	3	6%	2	4%	4	8%	13	8%

N: number of responses; %: percentage giving response

Yes, senior women are nearing or at the "glass ceiling". Thus the impact of the "good ol' boys" committees, etc. has more impact. (2012 respondent from 2000 cohort)

Ironically, I think that the climate for junior female scientists is better than for senior. Junior male scientists are less biased against their female counterparts than are more senior scientists. (2012 respondent from 1998 cohort)

Policies

Tables 5 and 6 document respondents' suggestions of policies and practices that would be useful for facilitating the careers of academic women scientists or engineers at the junior and senior levels, respectively. The categories used to group the 2012 responses in these tables were the same as those used for grouping responses for policies for junior and senior women in a study of Association for Women in Science (AWIS) Fellows ([1], tables 4.3 and 4.4). Using these categories from the AWIS study meant that some categories had no responses in them from POWRE awardees in 2012.

Table 4: POWRE awardees' responses on issues and/or climate for junior vs. senior women, sorted by directorate

	SBE		ENG		EHR		MPS		GEO		BIO		CISE	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Different	17	68%	26	76%	4	80%	33	87%	15	88%	30	75%	10	71%
Same	5	20%	4	12%	1	20%	3	8%	1	6%	8	20%	3	21%
Don't know	3	12%	4	12%	0	0%	2	5%	1	6%	2	5%	1	7%
Total	25	100%	34	100%	5	100%	38	100%	17	100%	40	100%	14	99%

N: number of responses; %: percentage giving response

NSF directorate names:

SBE = Social Behavioral and Economic Sciences
ENG = Engineering
EHR = Education and Human Resources
MPS = Math and Physical Sciences
GEO = Geosciences
BIO = Biology
CISE = Computer and Information Sciences

Junior and Senior Women continued

Family-friendly policies

Most respondents identified a number of changes in institutional policies and practices that they find most useful for facilitating careers and laboratory climates for junior women. As Table 5 shows, family-friendly issues, when grouped together (responses 1, 2, 3, 4, and 21) could be seen as junior women's highest priority for institutional policies.

> Family-friendly policies, such as scheduling departmental seminars at mid-day rather than late in the afternoon or in the evening. University-based child care for employees, which is still quite rare. More flexibility in hiring academic partners of recruited candidates; this is a major reason we lost our best attempted hires. (2012 respondent from 1997 cohort)

> Extending a tenure clock if a woman has a child is a must. Acceptance of such extension by all members of a department is also a must. (2012 respondent from 2000 cohort)

Although family-friendly policies such as childcare or extension of the tenure clock at the time of childbirth are more likely to benefit junior women, other family-friendly policies such as eldercare might be more relevant for senior women. Others, such as dual-career hires or reduction in time base to accommodate family and personal time needs, might be beneficial for either junior or senior women.

> The partner hire program would benefit women at any level. (2012 respondent from 1999 cohort)

> One of the most far-reaching changes in institutional policies and practices would be to incorporate a comprehensive win-win solution that would benefit both the institution and all dual-career couples who requested consideration for appointments. This would include factoring into the institution's funding pool the frequency of hires who bring with them a talented spouse or significant other. (2012 respondent from 1997 cohort)

Policies for senior women

In contrast to policies for junior women, respondents gave relatively few suggestions for senior women, as demonstrated in Table 6. Although the 177 awardees could provide more than one response, in total only 42 responses were given to the question: What changes in institutional policies and practices are most useful for facilitating careers of academic women scientists or engineers at the senior level? This contrasted with the 236 responses given to the same question when the word "junior" replaced the word "senior" (Table 5). These results reinforce findings from an earlier study of the AWIS population [18] that little is known about the issues facing senior women or what policies institutions might use to facilitate careers for senior women.

"Training for leadership" (#1) ranked as the most frequent response for policies for senior women, with nine responses, while several underlined the importance (in responses 6 and 8 in Table 6) of having women in key decision-making positions:

> Provide leadership opportunities and mentor women in leadership positions. Same for all — men and women! (2012 respondent from 2000 cohort)

> The Dean at the College level has a lot to say about how women move through the system, how they are supported. We need more women to serve as Deans (2012 respondent from 1998 cohort)

> Senior: having women in key administrative roles, such as President and/or Provost (2012 respondent from 1999 cohort)

Table 5: Responses to "In your opinion, what changes in institutional policies and pratices are most useful for facilitating careers of academic women scientists or engineers at the junior level?"

		Year Cohort					
	Category	1997	1998	1999	2000	Total	Percentage
	Number of responses	33	50	45	49	177	
1	Family-friendly policies	12	14	15	15	56	32%
2	Extension of tenure clock	10	14	13	12	49	28%
3	Mentoring for junior faculty	5	17	10	13	45	28%
4	Daycare	2	15	7	1	25	14%
5	Transparent expectations, especially for tenure and promotion	3	8	3	5	19	11%
6	Don't overload with excess of committee work	5	3	7	3	18	11%
7	Monitor infrastructure issues — start-up, salaries, space	3	5	4	5	17	10%
8	Career partner positions	4	2	7	4	17	10%
9	Train faculty and administrators for nondiscrimination	1	0	7	9	16	9%
10	Change 24/7 expectations for academics in science	3	5	3	5	16	9%
11	Leadership training	0	3	4	6	13	7%
12	Availability of Federal money	3	3	3	4	13	7%
13	Opt-out policies available to everyone	4	4	1	2	11	6%
14	Network/support group for women	2	5	1	3	11	6%
15	Hire more senior women	3	1	2	3	9	5%
16	Value service more	2	5	1	1	9	5%
17	Seed money for women	1	5	1	1	8	4%
18	Establish rainy day fund — unanticipated emergencies	1	2	0	3	6	3%
19	Incentives to value diversity	2	2	0	1	5	3%
20	Workshops on negotiation	1	1	1	1	4	2%
21	Sick daycare	0	0	1	2	3	2%
22	Woman president, provost	0	2	1	0	3	2%
23	Access to graduate students	1	1	1	0	3	2%
24	More women on search, admissions, and tenure committees	1	1	0	0	2	1%
25	Rethink tenure	0	0	2	0	2	3%
26	Best practices in recruitment	0	0	0	1	1	1%
27	No response	0	0	0	0	0	0%
28	Train graduate students/postdocs in career management	0	0	0	0	0	0%
29	Train promotion and tenure committees	0	0	0	0	0	0%
30	Encourage postdocs to aim high	0	0	0	0	0	0%

Respondents could give more than one response.

Table 6: Responses to "In your opinion, what changes in institutional policies and pratices are most useful for facilitating careers of academic women scientists or engineers at the senior level?"

	Category	1997	1998	1999	2000	Total	Percentage
		Year Cohort					
	Number of responses	33	50	45	49	177	
1	Training for leadership	3	3	3	0	9	5%
2	Eldercare	1	2	1	1	5	3%
3	Bridge/seed funding	1	2	1	0	4	2%
4	Same as for junior	1	2	1	0	4	2%
5	Granting agencies need to hold institutions acountable for equity	1	1	1	0	3	2%
6	Making sure women are in key decision-making positions	1	1	1	0	3	2%
7	Provide male colleagues a safe way to discuss their gender biases and learn how to overcome them	1	1	0	0	2	1%
8	Have women in highest levels of power	2	0	0	0	2	1%
9	Awards and honors not based on old boys network	1	0	1	0	2	1%
10	Value human impact and impact on community	1	0	1	0	2	1%
11	Monitor equity in space, salaries, travel, students etc.	2	0	0	0	2	1%
12	No response or inappropriate	1	0	0	0	1	1%
13	Reward service	1	0	0	0	1	1%
14	Ways to overcome isolation such as networking	1	0	0	0	1	1%
15	Targeted recruitment for senior women	1	0	0	0	1	1%
16	Can't think of anything	0	0	0	0	0	0%
17	Commitment to women from top administration - not the Larry Summers approach	0	0	0	0	0	0%
18	Don't base salary on outside offers	0	0	0	0	0	0%
19	Transition to retirement roles	0	0	0	0	0	0%
20	Recognition that diversity improves creativity and research	0	0	0	0	0	0%
21	Get rid of all age limits	0	0	0	0	0	0%
22	Committee to examine situation of senior women	0	0	0	0	0	0%
23	Talent-scouting	0	0	0	0	0	0%

Respondents could give more than one response.

Discussion

Although they acknowledge that issues differ for junior and senior women, relatively few respondents have ideas about how to improve the situation for senior STEM academic women compared to their junior colleagues. Since both junior women themselves [1] and senior women [18] seem to agree on what the issues are for junior women, it is not surprising that some consensus has also emerged about effective institutional policies and strategies to address those issues. ADVANCE projects have been helpful in raising national awareness of best practices and institutionalizing effective policies. Family-friendly policies, dual-career hires, equitable start-up packages and space, and monitoring the data to ensure that women receive tenure, promotion, and awards at the same rates as their male colleagues constitute institutional practices and policies significant for success for junior women. Administrators have key roles in communicating policies and implementing them equitably. Leadership of senior women can be crucial.

Junior and Senior Women continued

Attention also needs to be given to the environment for senior women. These women represent a group of successful scientists who have survived and thrived, despite obstacles and barriers that deterred others. They have made significant contributions to STEM, the institution, and the broader profession. Yet, as the MIT Report [19] documented, these very successful women scientists and engineers do not have the same access to space, awards, students, and perks as their male peers.

An initial impetus for ADVANCE also came from the recognition of a glass ceiling [20, 21] and problems for senior women [22] even in the life sciences, where there are a substantial percentage of women. Most of the implemented ADVANCE efforts either centered directly on junior women or included senior women as role models, mentors, and institutional leaders to facilitate the attraction and retention of junior women STEM faculty, rather than focusing on the needs of the senior women themselves.

Recent data such as the Fidelity Investments study of higher education faculty showing that 74% of professors aged 49–67 plan to delay retirement past age 65 or never retire [23] suggest that more academics, including senior women, postpone retirement, remaining in their tenure-track positions, teaching in the classroom, and conducting research in their laboratories. They choose to delay retirement or not retire, partially because of changing personal fiscal circumstances in light of the recession that began in 2008 and because of the increasing life span statistics, but most particularly because of their commitment to their students, research, and institution. Failure to recognize the issues facing these senior women scientists and to address them with appropriate policies and practices risks undercutting the productivity and professional contributions built over a lifetime of these women, who, earlier in their careers, overcame many obstacles to become successful.

Recommendations

Recommendations for Institutions to Retain Senior Women Scientists and Engineers

1. Monitor space, salaries, travel funds, and graduate students to ensure equity between men and women faculty
2. Reward service
3. Provide a safe way for male colleagues to discuss their gender biases and learn how to overcome them
4. Have individuals in top leadership positions with a demonstrated commitment to advancing women
5. Have women at the highest levels of power and in key decision-making positions in the institution
6. Do not make responses to outside offers the primary means to increase salaries
7. Provide some mechanisms such as working part-time as a transition to retirement
8. Provide networking and other means to overcome isolation
9. Recognize that diversity improves creativity and research
10. Establish targeted recruitment for senior women
11. Ensure that the old boys' network does not control the distribution of awards and honors
12. Provide bridge and/or seed funding as a transition between research projects
13. Establish a committee to examine the situation of senior women
14. Include eldercare among family-friendly policies

Junior and Senior Women continued

Recommendations for Both Institutions and the Profession to Address for Senior Women

1. Remove all age limits for funding and for administrative positions
2. Require granting agencies to hold institutions that receive awards accountable for equity at all levels throughout the institution, from students through faculty to administration
3. Incorporate the value of the impact of the science and scientist upon the community as part of the prestige and recognition received

Notes

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Junior and Senior Women continued

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Women of Color in Academia: A Conference

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AAS photo © Joson Images [2]

In the spring of 2012, the AAS was invited to contribute a supporting document, or "testimony," in preparation for a conference, *Seeking Solutions: Maximizing American Talent by Advancing Women of Color in Academia* [1], which was organized by an *ad hoc* committee of the National Academies. We were asked: to provide statistics on the education and employment of women of color in astronomy; to describe the barriers and difficulties facing women of color in our profession; and to recommend policies for professional societies and funding agencies.

In response to the invitation, the AAS convened representives of the CSWA and the CSMA to prepare a document. From the CSMA, the authors were Dara Norman, Jedidah Isler, and Hakeem Oluseyi, who were mainly responsible for the content. The CSWA authors — Caroline Simpson, Laura Trouille, and myself — played mainly a supporting/editorial role. Our document was posted on line before the conference [3], along with testimonies from 27 other scientific, engineering, and professional societies and federal agencies. It has also been reproduced in the CSMA's *Spectrum* newsletter [4] and most recently on the Women in Astronomy Blog [5]. The conference was held on June 7–8, 2012, in Washington, DC.

Afterwards, I wondered about the outcome of the conference. The rewarding experience of working on the document whetted my appetite to learn more. Indeed a report has been published [6], including the 28 society testimonials and two commissioned research articles as well as a summary of the conference itself. The report and the rich array of reference materials on the conference web site are a great starting point for learning about women of color in science, technology, engineering, and mathematics (STEM). In this article, I'll summarize the research reports that were commissioned in preparation for the conference and then the conference report itself.

Educational Experiences and Academic Careers of Women of Color

The article, "Education and Academic Career Outcomes for Women of Color in Science and Engineering," by Donna K. Ginther (University of Kansas) and Shulamit Kahn (Boston University) quantifies the underrepresentation of women of color in academia. It covers educational and career transitions all the way from high school to full-professor status, in order to identify where women of color most often leave academic STEM careers. Previous studies by Ginther and Kahn have shown that career trajectories in social science differ from those in life science, physical science, and engineering. Therefore, this paper concentrates on the latter fields (abbreviated S&E) in order to avoid masking important trends.

The principal data source was the National Science Foundation (NSF) Survey of Doctorate Recipients (SDR), a biennial, longitudinal survey of respondents to the NSF's annual Survey of Earned Doctorates. Even though the SDR tends to oversample members of underrepresented groups, the number of women of color in the data set is very small, especially for higher levels of education. To avoid violating anonymity, it was often necessary to lump together (US-born) African-American, Hispanic, and Native American/Pacific Islander women into the single category of women of color. From the 2008 SDR (the latest round of the data), a picture of the current demographic state of tenure-track and tenured faculty in S&E fields is derived. The estimated numbers are

Women of Color in Academia continued

about 2,700 women of color and 4,000 men of color, out of an estimated total of about 100,000 people in these positions in the US. Of all full professors, only 1.2% are women of color and 3.8% are men of color. Thus, women of color are grossly underrepresented, relative both to the general population (12.5%) and to men of color.

The current demographics are also broken down by whether the employers are underrepresented minority universities and colleges (URM universities) or not. According to Ginther and Kahn, "URM-universities are defined as Historically Black Colleges or Universities (HBCU), minority-serving institutions (where more than 25 percent of the student body comes from under-represented groups including African-Americans, Hispanics, and Native Americans), or Tribal Colleges or Universities (TCU)." The data show a strong tendency for women of color to be employed at URM universities: only 1.1% of tenured or tenure-track faculty at non-URM universities are women of color, while women of color comprise 9.6% of comparable faculty members at URM universities. In absolute numbers, more women of color are employed at URM universities than not, even though URM universities employ only 11% of all tenure-track and tenured academics. Men of color show a similar but less pronounced tendency. The data are not sufficient to show whether people of color gravitate toward URM universities by choice or by necessity.

The next section of the article examines education outcomes as a function of gender and race/ethnicity, employing as a data source the Current Population Survey (CPS) of the US Census. In this survey, about 50,000 representative households are interviewed regarding demographic and employment characteristics on four monthly occasions in each of two consecutive years. Examined were the representation of women of color among high-school and college graduates as well as in the population as a whole. From 1994 to 2010, all three percentages grew slowly. The representation of women of color among high-school graduates is about the same as that in the general population, but that among college graduates is only about half as large, although growing slightly faster in relation to the general population.

In 2008, according to the *Digest of Education Statistics*, nearly 17% of undergraduate students at two- and four-year colleges were women of color, about the same as their representation among high-school graduates. Averaged over the years 2006 through 2010, however, women of color high-school graduates were only about 60% as likely to graduate from college as white women.

None of the foregoing addresses field of study. Information on S&E majors was gathered from the *Integrated Postsecondary Education Data System* for the period 2005 to 2009, the most recent available. The results show that women of color are only slightly less likely to graduate with S&E degrees than white women, 19% vs. 22%. It follows that the most significant factor contributing to the underrepresentation of women of color among S&E graduates is their overall lower rate of graduation from college.

In a more complex analysis, Ginther and Kahn went on to calculate the probability that a S&E college graduate would go on to obtain a Ph. D. in S&E. Specifically, they compared the number of S&E college graduates averaged over the years 2000 to 2002 with the number of S&E Ph. D.'s awarded seven years later according to the NSF doctoral survey. Both men and women of color were only about 60% as likely as white women to attain the Ph. D. The probability of Ph. D. attainment was slightly higher for white women than for white men, mainly beause of the increasing numbers of women in the biomedical sciences. In contrast, it is interesting that a higher percentage of S&E majors who are people of color obtained M. D. degrees than of those who are white. In summary, the path to the Ph. D. is another exit zone for women of color. What is not known is whether the attrition occurs before or during graduate school, because statistics on entry of women of color to graduate school are not currently available.

Finally, the longitudinal data set from the NSF's Survey of Doctoral Recipients was used to study tenure-track career trajectories, starting with the likelihood of obtaining a tenure-track position within six years of the Ph. D. The tendency of women of color to obtain tenure-track positions at URM universities reappears in the longitudinal data. Slicing the data a different way, Ginther and Kahn found that white women and women of color are hired at Carnegie R1 universities in similar proportions. Thus, a major dearth of women of color exists at non-URM, non-R1 universities.

Women of Color in Academia continued

Once in a tenure-track position, the probability of being awarded tenure 11 years post-Ph. D. differs little among gender and ethnic groups and among types of university. The only statistically significant difference found by Ginther and Kahn is that women of color are more likely (81% vs. 67%) to obtain tenure at R1 universities than white women. Whatever one makes of these small-number statistics, the upshot is that the tenure process is not in itself a major barrier for women of color.

The final rung in the academic career ladder is promotion to full professor. Ginther and Kahn examined the percentages of those who, having obtained tenure, are full professors within seven years. Because of the length of the time span involved, only those who received Ph. D.'s between 1983 and 1995 are included. Small sample sizes precluded finding a significant difference between white women and women of color. However, at both URM universities and non-URM universities, men attain the rank of full professor at significantly higher rates than women, for all races/ethnicities.

In their final calculation, Ginther and Kahn multiplied the probabilities of progressing from each stage to the next, thus estimating the probability of an S&E Ph. D. reaching full professor status at non-URM universities. The probability of a women of color obtaining a tenure-track position at such a university is lower to begin with, and the lower probabilities at each stage are compounded, even though the probabilities at the individual stages do not differ significantly among the groups. Table 7 shows the results (error estimates not given).

In contrast to this gradual accumulation of small disadvantages, major drops in numbers of women of color in S&E occur at two career transitions: between entry to and graduation from college; and between college graduation and earning the Ph. D. Once armed with a Ph. D., women of color are about as likely to obtain a tenure-track position as white women, although the nature of the academic employer tends to be quite different. Therefore, these authors suggest that the most critical policy interventions on behalf of women of color would be during their student years.

Table 7: Probability of proceeding from Ph. D. to full professor at non-URM universities

Group	Probability
Women of color	0.079
Men of color	0.096
White women	0.124
White men	0.141

Research Paper on Experiences of Faculty Members in Academia

The second of the two commissioned papers was authored by Sylvia Hurtado and Tanya Figueroa (UCLA) and entitled, "Women of Color among STEM Faculty: Experiences in Academia." The importance of this topic is highlighted by earlier research, which found that individuals' sense of belonging or "fit" in their departments is the single most important climate-related predictor of job satisfaction. While members of underrepresented minority groups are known to be less satisfied and more likely to leave the academy early in their careers than white males, it is not known how women of color compare with either white women or minority men in this respect. Some previous research has suggested that women of color face a "double bind," or double disadvantage, while other research has found that the interaction between gender and race is nonlinear, leading to unique experiences of academic life, and indeed that different aspects of the identities of women of color dominate in different situations.

These considerations motivated the research by Hurtado and Figueroa. As their data source, they used faculty surveys that are administered triennially by the Cooperative Institutional Research Program at the Higher Education Research Institute (HERI) at UCLA, of which Hurtado is a research director. Over the years, hundreds of colleges and universities have been invited to take the survey. Four-year institutions are divided into twenty classifications, and then random sampling is done within each classification. To augment certain small samples, Hurtado and Figueroa sent supplemental surveys to selected groups. In all, the sample consisted of about 11,000 STEM faculty members at 673 institutions; 272 were women of color. Known limitations of this study include sampling bias toward full-time undergraduate teaching faculty, with

Women of Color in Academia continued

less representation of research faculty and part-time faculty. A more serious issue arises from these authors' experience: a lower rate of response or withholding of identifying information from "vulnerable populations." For this reason, the survey results may underreport climate issues and work-related difficulties for such individuals. In this study, Asian men and women were listed as distinct groups, while Hispanics, African Americans, and Native Americans were aggregated and categorized as "underrepresented minorities (URM)." In this analysis, no distinction was made between native- and foreign-born respondents.

Sylvia Hurtado [7]

First, the respondents were enumerated by rank, race, and gender. Women of all ethnicities are concentrated toward the lower academic ranks, Asian more than white women and URM women most of all. Inequalities of power and status must be acknowledged when considering the experiences of women of color in academia.

Women, especially women of color, experience a lack of role models and mentors, which lead to, among other things, limited awareness of unwritten policies on promotion and tenure. Previous research has found that all women are less satisfied than white male colleagues with their relationships with their seniors. Women, even at the senior ranks, report marginalization and exclusion.

Related issues arise in the results from the HERI survey. For example, respondents were asked whether they felt their research was valued within their departments. A positive sign is that 70% of URM women felt their research was valued, but this percentage was the smallest one reported by any group; compared with white and with Asian men, the difference is significant at the $p < 0.01$ level. When asked whether they have to "work harder than their colleagues to be perceived as a legitimate scholar," nearly 80% of URM and of Asian women answered "yes," significantly larger at the $p < 0.01$ level than for both white and Asian men. Finally, women in all ethnic groups reported subtle discrimination as a source of stress significantly more often than men; of all groups, URM women had the largest percentage giving this response.

However, the survey of STEM faculty unearthed many sources of stress even more significant than subtle discrimination: lack of personal time, self-imposed high expectations, managing household responsibilities, and so forth. On many of these, women score higher than men, but the differences between URM women and white women are not large. Self-imposed high expectations is an area in which white women report even more stress than URM women (significant at the $p < 0.05$ level).

Survey respondents were asked to estimate the number of hours per week they spent on various responsibilities. Results that stand out include the fact that significantly fewer white men reported spending five or more hours per week on advising students and on committee work compared to other groups, while significantly more men — especially Asian and URM men — reported spending five or more hours per week on research and scholarly writing.

Responses to questions regarding satisfaction with salary, retirement benefits, teaching load, and other job characteristics were combined into a unified scale. URM women at the full professor level were the least satisfied group by a significant margin.

An underlying theme of this research is underrepresentation — the fact that URM women often have "solo status" in their departments and even in their institutions. Solo status is known to reinforce stereotyping and to lead to isolation and job dissatisfaction. Citing previous research, Hurtado and Figueroa pointed out that women of color tend to be more involved with extended family and with community than white women. Although work-life balance is an issue, engagement with the community may, according to other research, be a source of strength.

Continued ...

Women of Color in Academia continued

The Conference: Summary

With this statistical background, the conference looked at the people behind the statistics and then moved on to key roles that can be played by professional societies, by institutions, and by funding agencies to help the academic profession make the most of the underutilized talent represented by women of color. Here is a summary of the conference report, which was written by Karin Matchett.

A panel discussion among four women of color at different stages of their careers put faces on the statistics. Tamisha Vaughn, a postdoctoral fellow at Emory University, had been active in programs that support minorities throughout her student years, but, after she obtained her Ph. D., she found that these sources of support had vanished. With colleagues, she tried to remedy this lack by forming a Minority Postdoctoral Council, with the aim of facilitating mentoring for the transition from postdoc to faculty position. Patricia Taboada-Serrano, an assistant professor at the Rochester Institute of Technology, reinforced the importance of mentoring during this period and advocated an online network where experienced women of color could offer guidance to younger ones in selecting a tenure-track position. Gilda Barabino, a professor at the Georgia Institute of Technology, discussed the importance of context throughout a person's career, particularly the interaction between the individual and the institution. Among the common themes of importance to women of color is a choice of research area aimed at helping their own community, such as her own decision to study sicke-cell anemia. Barabino co-leads an NSF-sponsored program, Cross-Disciplinary Initiative for Minority Women Faculty, which engages social scientists who study women of color in the sciences and engineering, and also helps educate women of color about the unspoken norms of academia. Finally, Evelynn Hammonds, dean of Harvard College, spoke about the importance of institutional culture for retention of outstanding women of color in science and argued for better analysis of the experiences of women of color.

The panel was followed by a plenary talk entitled, "Double Jeopardy? How Gender Bias Differs by Race," by Joan C. Williams, Founding Director of the Center for WorkLife Law, UC Hastings. Williams's work is familiar from her center's web site [8], and much of the research she described in her talk has been published in book form [9] and discussed previously in *Status* [10]. Her recent work concerns implicit bias as applied to African-American, Latina, and Asian-American women, and she described some damaging stereotypes that adhere to them. In a separate breakout session on multiple marginalities, Williams discussed how institutions might modify their policies to mitigate implicit bias. Her organization [11] has developed a set of best practices in areas such as workload negotiations, start-up agreements, performance reviews, and family-related policies and has recently issued a report on bias against women of color in science [12].

Following the breakout sessions was a panel discussion by representatives of professional societies, who reported on exemplary strategies. The Society for Advancement of Hispanics, Chicanos, and Native Americans in Science (SACNAS) hosts an annual conference that includes a session on "Coaching Strong Skills," which aims to teach women to walk the fine line between assertiveness and overaggressiveness. The American Psychological Association has a diversity implementation plan and has formal relationships with several minority-serving professional societies [13]. It is also a member of the Collaborative for Enhancing Diversity in Science [14]. The American Society for Microbiology has a Committee on Microbiological Issues Impacting Minorities and, in general, it makes a point of recognizing contributions to science by underrepresented groups. Interestingly, the Annual Biomedical Research Conference for Minority Students has slightly more female attendees than male. The American Chemical Society has four "diversity committees," and it has recently formed the Women Chemists of Color Initiative, whose activities include networking, advocacy, and support. Subsequent discussion highlighted the importance of collaboration among societies.

Matchett's summary proceeds to the next session of the conference, which concentrated on the activities of federal agencies. For me, the most interesting and useful material was presented by Janine Clayton, director of the Office of Research on Women's Health at NIH. She described the activities of the NIH Working Group on Women in Biomedical Careers, which include formation of the Women of Color Committee and the Women of Color Research Network [15]. The network has a website with a blog and an

Women of Color in Academia continued

extensive resource list, and it encourages the formation of regional chapters. Clayton's summary of the working group's extensive list of activities on behalf of all women in biomedical science [16] — including improvements to the agency's policies regarding child care and career interruption — is impressive.

There followed a panel discussion on best practices and successful strategies, including representatives of both URM and non-URM universities. James Wayne Jones decribed some of the results of the NSF-ADVANCE program at the University of Michigan. Its reforms were made part of the university administrative structure after the 2002 NSF grant expired. In 2001, 15% of all faculty searches resulted in a female hire; by 2007, that number had risen to 32% in the STEM disciplines. The university has implemented launch committees, which are mentoring committees assigned to each new faculty hire and include "the department chair, a senior faculty member from the department, an ADVANCE faculty member, and a senior faculty member from another department." Experience with the ADVANCE program has taught leaders at Michigan how to prepare the faculty for cultural change.

Harvard Medical School, represented by Joan Reede, is "working to embed diversity and inclusion into the institution's operations," noting that diversity issues include disability, sexual orientation, and socioeconomic status. Reede noted that the need for change will continue indefinitely, and part of her task is to train the leaders who will follow her.

Jackson State University is a minority-serving institution, where the ADVANCE program (begun in 2010) is designed to advance the careers of all women faculty but focuses specifically on women of color. Activities include: summer writing retreats; international group travel, including opportunities to present research results and form collaborations; mentoring; administrative internships; education on unconscious bias; and research on culture and climate.

The Conference: Conclusions and Action Agenda

Here are some highlights from the conference's conclusions about what will be needed to make progress. For more details, see the report's many helpful boxed lists of resources.

Data

Some participants stated that enough data on women of color in STEM are in hand and what is now needed is action, while others felt that more data are needed. There are gaps in qualitative data about individuals' career choices and about institutional climate and policies. For example, while there is a clear drop in the representation of women of color between the bachelor's degree and the Ph. D., it is not known whether women of color simply do not enter graduate programs or whether they enter and then drop out. Conference participants and written testimonies alike called for data that are better disaggregated by gender and by race/ethnicity and for better longitudinal data. The conference developed a detailed wish list for data on institutions and on students, including: information on departments' track records in supporting doctoral students; identification of strategies that work across disciplines for involving women of color in professional societies and supporting them in their careers; what makes for successful mentoring; and the causes of faculty attrition.

As outlined above, the research papers commissioned for the conference identified points during the student years where women of color tend to go missing. Suggestions for intervention at these points included: customized training for better success in undergraduate school and better preparation for graduate programs; better support from faculty (that is, equivalent to that for white male students); more exposure to suitable role models; more opportunities for undergraduate research; and better awareness of various career paths in STEM. Also identified was a need for stronger and more equitable (i.e., not involving "poaching" of the strongest minority students) partnerships between URM universities and Ph. D.-granting institutions. The APS Bridge Program (e.g., [17]) was not mentioned, but it comes to mind as a successful example of such programs.

Mentoring, Unconscious Bias, and Institutional Transformation

Next, the conference identified strategies for addressing unconscious bias. As Williams and other participants attested, making people aware of their biases goes a long way toward mitigating the effects of those biases.

Women of Color in Academia continued

Incorporating bias awareness training into every university procedure that makes decisions about people's careers would be very helpful, and university policies should be compared against exemplary practices to check for inadvertent biases. Universities should elicit the help of experts on organizational change.

Mentoring and sponsorship are crucial for success. While they are a matter of course for white males, women of color and their potential mentors need to bond more proactively. Universities should provide more structured mentoring opportunities, and senior women of color should be aware of opportunities to sponsor outstanding junior faculty. The report lists exemplary programs from universities and from national online networks.

Institutions can enable progress by: establishing transparency in their policies on promotion and tenure; making new policies highly visible; mitigating the stigma connected with use of exemplary practices such as tenure-clock stoppage; and increasing the number of women of color in their applicant pools. Policies at the departmental level are key, since that is where decisions are made in most faculty careers. Needs for research on institutional policies include: approaches to work-life balance, especially at the departmental level; institution-wide salary equity studies; and studies of faculty who are considering leaving or who have left their institutions.

Proof-of-concept programs at the departmental level can be helpful because a small scale is conducive to experimentation. It is important that department chairs have ownership of improvements to personnel policies. The presence of faculty champions — recognized leaders in a department — is crucial, especially if they are white men and women. Departments need to be made accountable to the central university administration, and in turn they need commitment from it. For example, a department that hires a solo member of an underrepresented group may need special guidance to avoid inadvertent discrimination against that person. It is also important to recognize the special needs of institutions, including URM universities, where faculty may have to spend extra time supporting underprepared students, so that the reward structure needs to be different.

Proposals for Action by Professional Societies and Federal Agencies

Here is a selection from an extensive bullet list of recommended courses of action. For professional societies: offer professional development funding for tenure-track faculty members at resource-constrained institutions; use social media to build networks; host a symposium or a governance session about the results of this conference; promote improvement in K–12 STEM education in various ways; and highlight and reward exemplary programs in support of women of color.

For funding agencies: withhold a portion of grant funding until grantees report on their accomplishments in the "broadening participation" component; establish or strengthen civil rights compliance programs; require federally funded initatives to interact directly with university personnel who are women of color; grant fundig for protected time for mentoring; offer more family-friendly policies; and other successful strategies that are already in place. For example, in the setting of peer review, the NIH has an Early Career Reviewer Program [18] to help train new reviewers and to diversify the pool of reviewers.


Shirley Malcom [20]

Individual conference participants made many interesting suggestions, too numerous to list here, for action by federal agencies [19]. Several participants asked that funding agencies conduct randomized pilot programs at different institutions in order to learn which practices improve inclusion and under what conditions. Suggestions along the lines of using federal funding to support graduate students included: support for mentoring in manuscript preparation; funding for one-year bridge programs between undergraduate and graduate school for bright but poorly prepared students; and training grants that would support tutoring of junior graduate students by senior ones.

The closing plenary talk was given by Shirley Malcom, head of the Directorate for Education and Human

Women of Color in Academia continued

Resource Programs at the American Association for the Advancement of Science and co-author of a noted book [21]. As institutions address barriers faced by underrepresented minorities, she called for them to progress from piecemeal actions to an overall strategy. She praised the NSF-funded ADVANCE program precisely because it requires a holistic approach to institutional transformation. Reiterating many of the points made already, she emphasized: the need for disaggregated data; the necessity for mentors, sponsors, coaches, and individuals to nurture professional connections; and transparency and equity in institutional personnel procedures. There is an immediate need for a "toolkit" for change that can be adapted to the needs of each individual and institution.

Malcom finished by advocating that individuals and communities move past their natural tendencies to see one another as different and focus on their similarities. Toward this end, she called on women of color to be even more visible and committed, and she called on organizations to ensure that outstanding women of color are appropriately acknowledged and supported.

This conference was not the last word on women of color in STEM. For example, the following year, the Institute for Women's Policy Research convened a meeting on women of color in STEM entitled, "Accelerating Change for Women Faculty of Color in STEM: Policy, Action, and Collaboration" [22]. Its web page lists many additional interesting resources on this topic. Now that some paths forward have been illuminated, we can strive for progress in the academic community.

Notes

[1] http://sites.nas.edu/wocconference/

[2] Used with permission

[3] http://sites.nas.edu/wocconference/files/2012/03/6.3.-American-Astronomical-Society.pdf

[4] Committee on the Status of Minorities in Astronomy, *Spectrum*, January 2014, p. 11, http://csma.aas.org/spectrum_files/spectrum_Jan14.pdf

[5] http://womeninastronomy.blogspot.com/2015/01/women-of-color-in-astronomy-and.html

[6] http://www.nap.edu/catalog/18556/seeking-solutions-maximizing-american-talent-by-advancing-women-of-color [Report available as free, downloadable PDF]

[7] http://www.heri.ucla.edu/research_directors.php#SYLVIA%20HURTADO

[8] http://www.genderbiasbingo.com/

[9] J. C. Williams and R. Dempsey 2014, *What Works for Women at Work: Four Patterns Working Women Need to Know* (New York: NYU Press).

[10] J. C. Isler 2014 June, *Status*, p. 16, http://www.aas.org/cswa/status/Status_2014_Jun.pdf

[11] http://worklifelaw.org/

[12] J. C. Williams, K. W. Philips, and E. V. Hall 2014, "Double Jeopardy? Gender Bias Against Women of Color in Science," http://www.toolsforchangeinstem.org/tools/double-jeopardy-report

Continued . . .

Women of Color in Academia continued

[13] The Association of Black Psychologists, the Asian-American Psychological Association, the National Latina/Latino Psychological Association, and the Society of Indian Psychologists

[14] http://www.cossa.org/diversity/diversity.html

[15] https://www.wocrn.nih.gov/

[16] [6], p. 35

[17] C. W. Miller 2015 January, *Status* (this issue), p. 5

[18] http://public.csr.nih.gov/ReviewerResources/BecomeAReviewer/ECR/Pages/default.aspx

[19] [6], pp. 78–79

[20] S. M. Malcom, P. Q. Hall, and J. W. Brown 1976, *The Double Bind: The Price of Being a Minority Woman in Science* (Washington, DC: American Association for the Advancement of Science), http://archives.aaas.org/docs/1975-Double%20Bind.pdf

[21] http://blog.stemconnector.org/stem-woman-leader-day-shirley-malcom-aaas

[22] http://www.iwpr.org/initiatives/women-of-color-in-stem/

The Falling Sky (Pippa Goldschmidt), a Review

Nicolle Zellner, Albion College, Department of Physics

> *Jeanette works at night. It's better that way. Now it's dusk and she can hear her colleagues leaving the Observatory, going home. She is not going anywhere. She is going to work tonight, as she does most nights. She likes the Observatory in the dark and the silence. There's more room to breathe out, she feels an easing in her chest and she relaxes.*
> — Pippa Goldschmidt, *The Falling Sky*

Sound familiar? *The Falling Sky* is the fictitious story of an astronomer. An astronomer! When was the last time you read a book with an astronomer as the protagonist? My guess is, not lately. The title and main character alone prompted me to order the book; when I found out that the author has a Ph. D. in astronomy, I had to read it. The first few lines sucked me in:

> *Jeanette . . . [is] standing on the stage in the auditorium in front of about two hundred other astronomers . . . she can tell no one's listening . . . Some of them are working on their laptops, others are talking to each other. Several people are fiddling with their phones, reading the conference programme, even reading the paper . . .*
>
> *[It's] not enough to give the talk . . . the experience isn't complete without the ritual of questions afterwards, to allow the (mostly male) audience to do the verbal equivalent of showing their tail feathers off to each other.*

Wow. I've been to talks like this.

In her debut novel, author Pippa Goldschmidt tells the story of Jeanette, an early-career astronomer whose observations of distant galaxies cause her to question well-established cosmological theories. Are her data real, though? Have she and her colleague, on a mountain top in Chile, really observed galactic structure that could turn the Big Bang theory on its end?

Soon, the observations of Jeanette and her colleague become known and, as her colleague's interest in continuing the study fades after well-intentioned media coverage goes awry, Jeanette alone is forced to learn how to deal with people's reactions to both her work and her. Throughout the book, Goldschmidt engages the reader with a back-and-forth "NOW" and "THEN" dialogue that takes us from Jeanette's adult life back to her childhood. As she interacts with her parents and tries to reconcile childhood trauma with upheaval in her career, as well as learn from her mistakes, we see her reality start to dissipate. In the mix, of course, are conflicts in her personal life — even fictitious characters struggle with work-life balance — all of which cause her to question her place in her professional and personal communities.

This book is easy to read: the topic, the format, the characters are all interesting (and somewhat familiar), and the character development was such that I could overlook the one scientific mistake I noticed and the ending that left me wanting more. I learned that it was the author's intent to convey some of the uncertain aspects of doing science, but it wasn't a very satisfactory ending for me. Still, science doesn't always present answers, so this seems to be an appropriate ending for a book about a scientist searching for answers and not always being able to resolve professional and personal conflicts.

I reached out to Pippa, and she warmly responded to my request to ask a few questions.

Continued . . .

The Falling Sky, a Review continued

Q. Is this book autobiographical, at least at some level?

Pippa Goldschmidt

It depends on what you mean by autobiographical. With respect to the book's plot, I was a post-doc in an astronomy group for several years, but I never made any discoveries that appeared to contradict the Big Bang theory!

Neither did I suffer a bereavement as a child. But I did draw upon my experience of the death of my mother a few years ago, and I did draw on my professional life to ensure that the atmosphere of the observatory depicted in the book was as accurate as possible. But I am not the main character.

Q. What made you decide to leave astronomy and pursue writing as a career?

I was a post-doc for 5 years and that felt to me to be long enough. I stopped enjoying the day-to-day work and I felt the need for other challenges. So I joined the UK civil service to work as a science policy advisor for the Government. My first job was working on outer space policy, which I loved. Alongside this job I started to write seriously, and I did a Master's degree in creative writing at Glasgow University. The writing slowly became more and more central to my life and I realised that I really wanted to write about science. There is very little fiction about real science (although see www.lablit.com for some examples) and I wanted to create more.

I'm currently on a career break from the civil service so I can write full-time. I've worked as a writer in residence at the Royal Observatory Edinburgh (the real-life model for the observatory in the book) and also at an institute called the Genomics Forum which existed at the University of Edinburgh. Its purpose was to encourage debate about genetics in society, and the people there thought that writing fiction about genetics was a good way of doing this. I think that's great. Writing fiction about science is a great way of opening up that science to people and helping to demystify it.

Q. What are/were the most difficult and most fun aspects of both of your careers (astronomy, writing)?

The most fun aspect of being an astronomer was coming up with the initial ideas for experiments — I used to enjoy putting together telescope time applications. And I loved speculating wildly on data!

Similarly, the most fun aspect of writing is writing the initial draft of a story — that's when I get to write anything and delve deep into my subconscious. The tougher part is redrafting it and editing, and making it work for the readers. Surprisingly, it can be tough to see my work in print. I don't like reading my work after it's been published, in case I spot things I want to change.

The most difficult aspect of being an astronomer was the competitive aspect — constantly competing with other astronomers for grant funding and jobs. I think it takes a certain amount of self-belief to interact in that way, self-belief which I couldn't always summon up.

Q. Any advice for Ph. D. astronomers or aspiring writers?

I don't think anyone should come to me for advice on being an astronomer [because] I think it's essential to find more senior people who can be your mentor, and give you advice when things get tough.

[B]eing a writer can be tough. It's very difficult to get published and when you are published it's very difficult to make a living from it. So it's good to have another career up your sleeve to keep you going. But if you want to do it — do it! The process of creating a good story is incredibly satisfying. On a practical level, getting good-quality feedback on your work is essential — don't ask your friends or family (because they will invariably say that they love your work), but join a writers' group or attend a course.

And you can't be a good writer without being a good reader. Read — and think about why you love what you love. Learn from great writing.

Continued . . .

The Falling Sky, a Review continued

The Falling Sky was short-listed for the Dundee International Book Prize in 2012 and long-listed for the Polari First Book Prize 2014. More about Pippa Goldschmidt can be found at http://www.pippagoldschmidt.co.uk/about, which is the source for the picture of Goldschmidt on page 31.