STATUS

A REPORT ON WOMEN IN ASTRONOMY

JUNE 2014

CONTENTS

CSWA Survey: Two-Body Careers in Astronomy

Erica Rodgers, Space Science Institute

Introduction

Dual-career couples may experience what is commonly referred to as the "two-body problem" when they pursue employment or education in the same geographic location. While the two-body problem in orbital mechanics has an elegant, closed mathematical solution if the two bodies are isolated, real-world perturbations can cause complexity. In the lives of people who do science, solutions to the two-body problem may be messy, take years to solve, or need to be repeated several times. Some couples continue to live apart. In other couples, one or both partners may change career activities or change careers. Or one partner may quit paid employment altogether.

As they ascend the career ladder, members of the astronomical community (hereafter, astronomers) find themselves changing jobs frequently – generally, but not exclusively, early in their careers. These changes may entail geographical moves, making astronomers prone to living apart from their dual-career partners. Those who complete a Ph.D. are likely to seek a temporary postdoctoral position afterwards. This is generally followed by a long-term research or university faculty position, but the goal of a permanent position may be elusive, leading to further changes in job status.

American Astronomical Society (AAS) Job Register data from 1992-2008 indicate that the number of astronomy postdoctoral positions is on the rise, while available faculty and research positions are in decline.[1] As of 2008, postdoctoral positions outnumbered tenure track and nontenure track faculty positions by a factor of three and permanent research and research support positions by a factor of five.[1] For this reason, astronomers are likely to hold multiple or longer than normal postdoctoral positions. The average time to achieve a faculty position is six years after receiving a Ph.D. for women and seven years for men.[2] Moreover, for every two postdoctoral positions, only one position is available in research or academia.[3] This limits people's choice of geographic location when considering and obtaining positions, not to mention that up to 50% of astronomy postdocs may have to seek employment outside of research and academia due to lack of permanent positions.

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A recent study by Stanford University's Clayman Institute for Gender Research[4] highlights the reality that 72% of full-time faculty members have employed partners, and 36% of those employed partners also work in academia. Women in academia (40%) are more likely than men (34%) to have a partner within academia. The same report also states that 83% of women scientists are in a scientific couple, compared with 54% of men scientists. Similarly, in a recent survey of planetary scientists,[5] 70% of women respondents report having partners in planetary science or in another science/engineering field, compared to less than 30% of men. Thus, women in science are impacted disproportionately, and, as this report will demonstrate, women astronomers are no exception.

An informal show of hands at the Committee on the Status of Women in Astronomy (CSWA) Town Hall at the AAS 222nd meeting indicated that approximately 30% of the attendees identified themselves as one member of a dual-career couple living apart from their partner. Therefore, the CSWA conducted a survey of partnered and un-partnered astronomers, in order to gain information on the prevalence of the "two-body problem."

Survey Design and Sample Definition

The 14-question survey was administered electronically via the *Survey Monkey* website from October 11, 2013 to January 31, 2014. Survey respondents are asked to identify the geographic location of their home and place of employment, their career activities, current job position, and gender. If the respondent is partnered, then the partner's corresponding geographic information is also requested, as well as the partner's career activities and gender. Respondents are asked whether they and their partner have dependent children, whether they are satisfied with their current living arrangement, and how long they anticipate being geographically separated from their partner if they are currently living apart. The survey concludes with a series of questions regarding what career changes (if any) the respondent or their partner would make in the future or have made in the past to remain co-located or to become co-located. The complete questionnaire is available as supplemental on-line material.[6]

All 598 survey respondents are self-selected volunteers. Respondents were recruited mostly through electronic media such as the CSWA, AAS, and Astrobetter websites, the *AASWomen* and Space Science Institute newsletters, the AAS News Digest, the *Women In Astronomy* blog, and the CSWA Facebook group. Additional advertising was done at the AAS 223rd meeting during the CSWA's Town Hall and by means of posters and business cards displaying the survey website.

It is reasonable to assume that respondents to the survey are more likely than non-respondents to be geographically separated from their partners (now or in the past), or more concerned with future geographic separations. The survey is not likely to include people who have left astronomy, whether because of the two-body problem or for other reasons. Thus, these results represent only astronomers who volunteered their time and personal data.

The data presented here are a snapshot in the lives of respondents and their partners, dealing with only their current living and working locations. However, through open-ended survey questions, several respondents graciously contributed additional information about past geographic separations from their partners, as well as many other useful data points, such as telecommuting information.

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Note from the Editor, Nancy Morrison

Like the previous issue of *Status*, this one leads off with a report on the results of an important demographic survey sponsored by the CSWA. Community surveys are an important part of CSWA's mission. This one sought information on the problems of dual-career couples. With input from the committee, Erica Rodgers designed the survey, implemented it on the Web, and analyzed the results. Nick Murphy served as her liaison with the CSWA. We thank them both for their excellent work.

The other contributions in this issue are also timely. Meg Urry's insights on workplace climate are germane to the CSWA's program of site visits that will begin this fall. Jedidah Isler's discussion of the nonlinear interaction between race and gender and my summary of recent research on gender differences in math and verbal test performance both pertain to topics that are under active discussion in our community. I hope you enjoy them all.

Survey Results

Survey respondents are grouped into three categories: those living with their partner (co-located group = 431, 72%), those living apart from their partner (non co-located group = 130, 22%), and those who are not partnered (single group = 37, 6%). Respondents and partners are placed in the non co-located group if the respondents identify either or both of the following situations: their partner lives in a different city/metropolitan area, or they report a remaining period of time for which they will be geographically separated from their partner. The rest of the respondents with partners are placed in the co-located group.

Respondents in the non co-located group indicate, on average, that they have already lived apart from their partner for 2.5 years and expect to live apart for at least another 2.5 years. The reported minimum expected time apart is 1 month, and the maximum time apart is expected to be 25 years. Several respondents (15%) report they plan to live apart from their partner for an undetermined amount of time. Three percent (3%) of the co-located respondents (11 couples) describe previous geographic separations from their partners, even though they currently live together.

Geography

Figure 1 shows the worldwide geographic distribution of respondents and their partners in the co-located group plus the respondents in the single group. Most of these respondents reside in the United States and in Europe. Figure 2 shows the rather similar geographic distribution of the respondents in the non co-located group. Table 1 lists the five metropolitan areas where these groups of respondents are most highly concentrated and the institutions where the bulk of them work.

Similar percentages of co-located plus single respondents and non co-located respondents generally work in the same geographic regions; however, Ann Arbor, MI is an area of high concentration for those in the co-located plus single groups (5%) but not for couples geographically separated (0.8%). Almost all (96%) of the co-located plus single respondents living in Ann Arbor work at or attend the University of Michigan as do 46% of their partners; 35% have partners that work elsewhere in the Ann Arbor area; and 19% are single. Most of the Ann Arbor partners do not work in astronomical sciences, but Ann Arbor does appear to be a place where couples successfully find jobs and educational opportunities both in and out of academia.

Figure 3 shows the location of the geographically separated partners in the non co-located group and highlights the locations where partners work in astronomy-related sciences. The partners of the non co-located respondents are more evenly geographically distributed than the non co-located respondents themselves, but there are two geographic regions of higher concentration (comprising 10%, 14 partners): greater Boston and greater Los Angeles. Most of the partners

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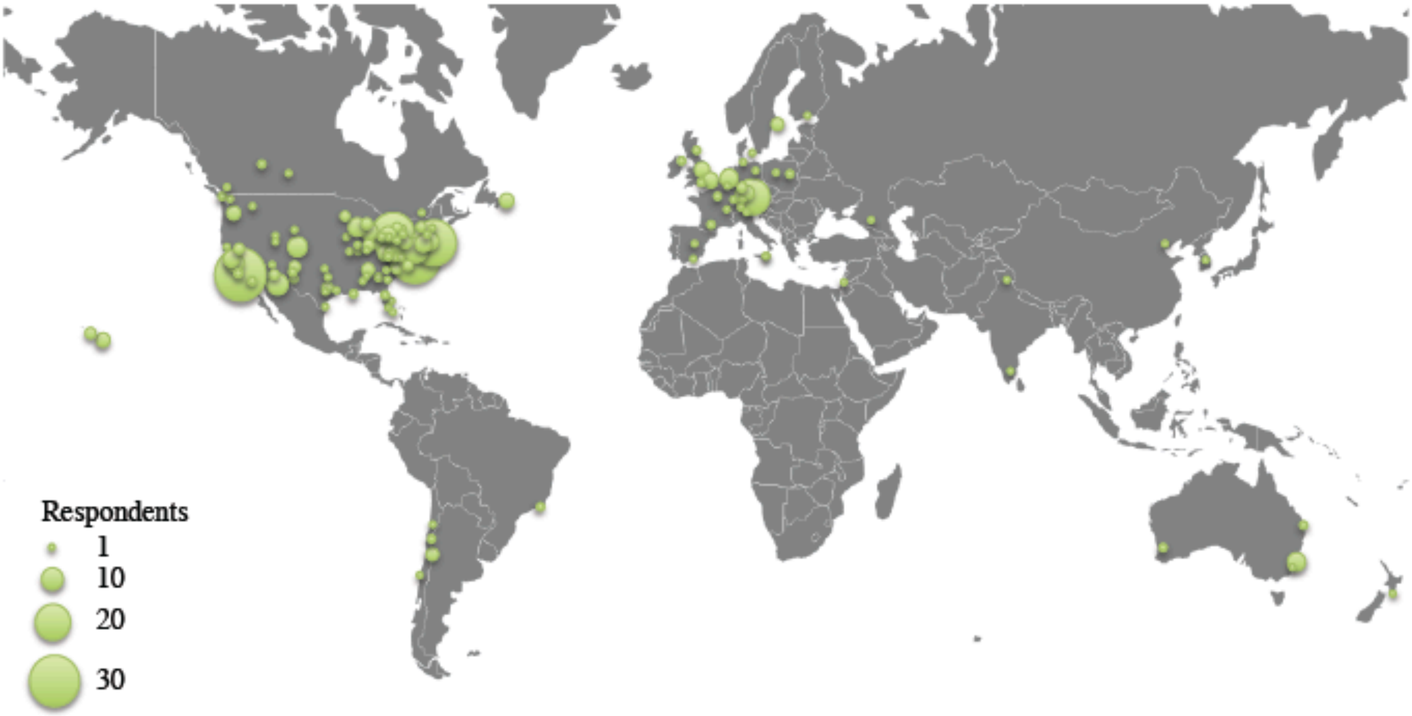

Figure 1. Worldwide distribution of respondents geographically co-located with their partners (co-located group) plus single respondents (single group).

Figure 2. Worldwide distribution of respondents who are geographically separated from their partners (non co-located group)

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Table 1: Locations and institutions where astronomers are concentrated

No.	%	Location	Institution(s)
Co-located plus single groups			
31	7	Greater Los Angeles, CA	Caltech and other universities
29	6	Greater Washington, DC & Baltimore, MD	NASA Goddard Spaceflight Center, Space Telescope Science Institute
27	6	Greater Boston, MA	Harvard-Smithsonian Center for Astrophysics
26	5	Ann Arbor, MI	University of Michigan
20	4	Greater Munich, Germany	European Southern Observatory
Non co-located group			
8	6	Greater Boston, MA	Harvard-Smithsonian Center for Astrophysics, Massachusetts Institute of Technology
7	5	Greater Munich, Germany	European Southern Observatory
7	5	Greater Washington, DC & Baltimore, MD	NASA Goddard Spaceflight Center
6	5	Greater Los Angeles, CA	Caltech and other universities
5	4	Tucson, AZ	University of Arizona, National Optical Astronomy Observatory
4	3	Madison, WI	University of Wisconsin

in these two areas work in a non-astronomy science job (36%, 5), in astronomy-related science (14%, 2), or in a non-science capacity at a facility where astronomical science takes place (14%, 2).

Non co-located respondents and partners commute shorter distances (7 and 10 miles, respectively) to work compared to couples living together. Co-located respondents commute 12 miles to work on average, and their partners commute 14 miles. These longer commutes likely allow more couples to live with their partner, as the maximum distance traveled is 108 miles for co-located respondents, and 70 miles for their partners. Non co-located respondents travel a maximum distance of only 33 miles and their partners travel 46 miles. Single respondents commute the shortest average distance (6 miles). Five percent (5%) of the respondents (20 couples) in the co-located group indicated that one member of the couple telecommutes to work.

Demographics

Respondents have the option to identify themselves and their partners as female, male, or non-binary. Women are the majority of survey respondents in the single group (57%), the co-located group (61%), and the non co-located group (69%). Non-binary respondents make up less than 1% of the co-located group and are not represented in the single or non co-located groups. Same-sex couples are a small minority, but they make up a larger percentage of the co-located group (2%) as compared to the non co-located group (<1%).

Overall, the majority of survey couples do not have dependent children, but there is a stark difference between couples that are co-located and non co-located. Couples who live apart are less likely to have dependent children (13%) than couples who live together (46%). All the demographic information is presented in Figure 4.

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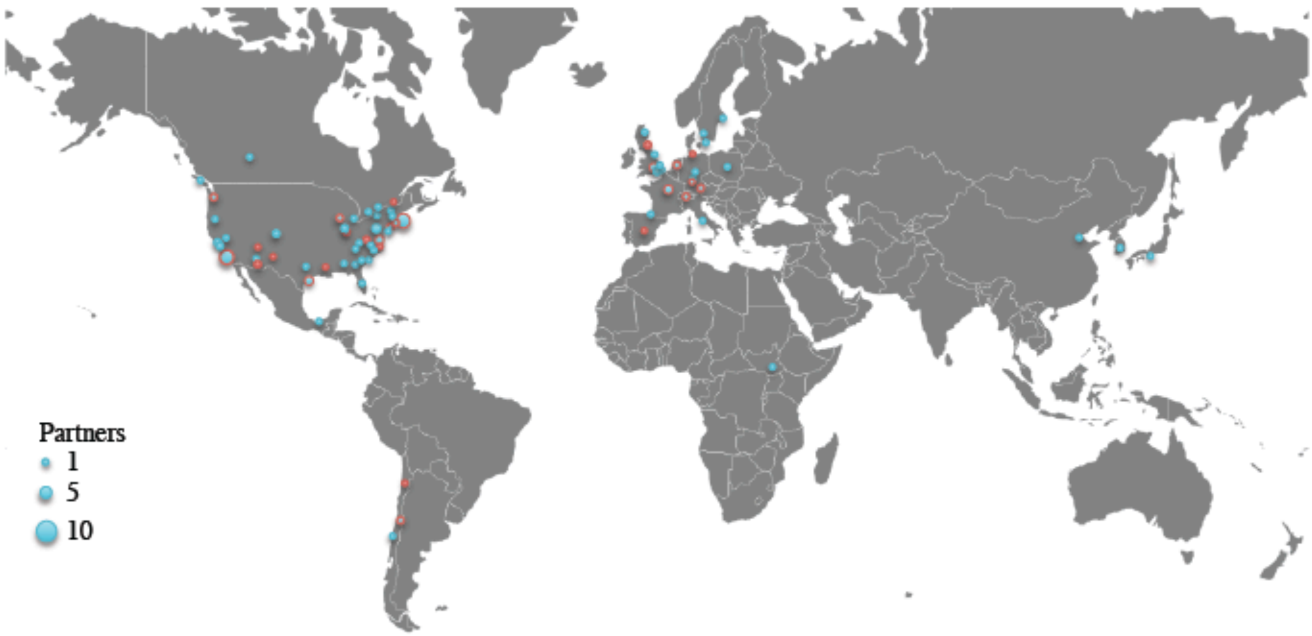

Figure 3. Worldwide distribution of partners in the non co-located group. Red symbols represent partners that work in astronomy-related sciences.

Careers

Respondents have the option to identify their career position as any combination of the following: undergraduate student, graduate student, postdoc, research scientist, senior research scientist, lecturer, adjunct faculty, pre-tenure professor, tenured professor, staff scientist, or other. Postdocs make up the highest percentage of respondents in all groups, comprising 26% of the co-located respondents. Tenured professors (19%) and graduate students (15%) round out the top 60%. Of the non co-located group, postdocs comprise 45% and graduate students 26%. Grad students and, even more, postdocs may be especially susceptible to geographic separations from their partners because they are at places in their careers where moving between locations can be the norm. Figure 5 shows the breakdown of all career positions with respect to group.

Respondents have the option to identify their career activities and those of their partner as any combination of research, industry, academic, management, or other. Research and academic activities dominate the career activities of all respondents, and, to a lesser extent, their partners (Figure 6). A higher percentage of non co-located respondents work in research (83%), compared to co-located plus single respondents (72%). Of geographically separated couples, 53% have both partners working in research, compared to 34% of couples living together. In the research couples, 72% of non co-located respondents are women, while 28% are men. A higher percentage of both partners working in academia is also reported for geographically separated couples, and women comprise over 70% of the academic couple respondents. Both cases suggest that it may be more difficult for couples to find employment in the same geographic location if they both pursue research or academic work, and women are impacted more than men.
Respondents have the additional option to specify their partner's career activity as science-based, either astronomy-related or non astronomy-related. In the co-located group, (34%) of partners have careers in science, and 20% work in an astronomy-related field. A higher percentage of non co-located partners work in science (43%) and 24% work in an astronomy-related field. This may suggest it is more difficult for couples with dual science careers, and specifically those who work in astronomy, to find employment in the same geographic location, as compared to couples where only one member of the couple works in any science or in astronomy. Disproportionately more than in the sample as a whole, women are the majority of respondents who have partners that work in astronomy (71%) and non astronomy-related (65%) sciences, compared to only 29% and 35% of men.

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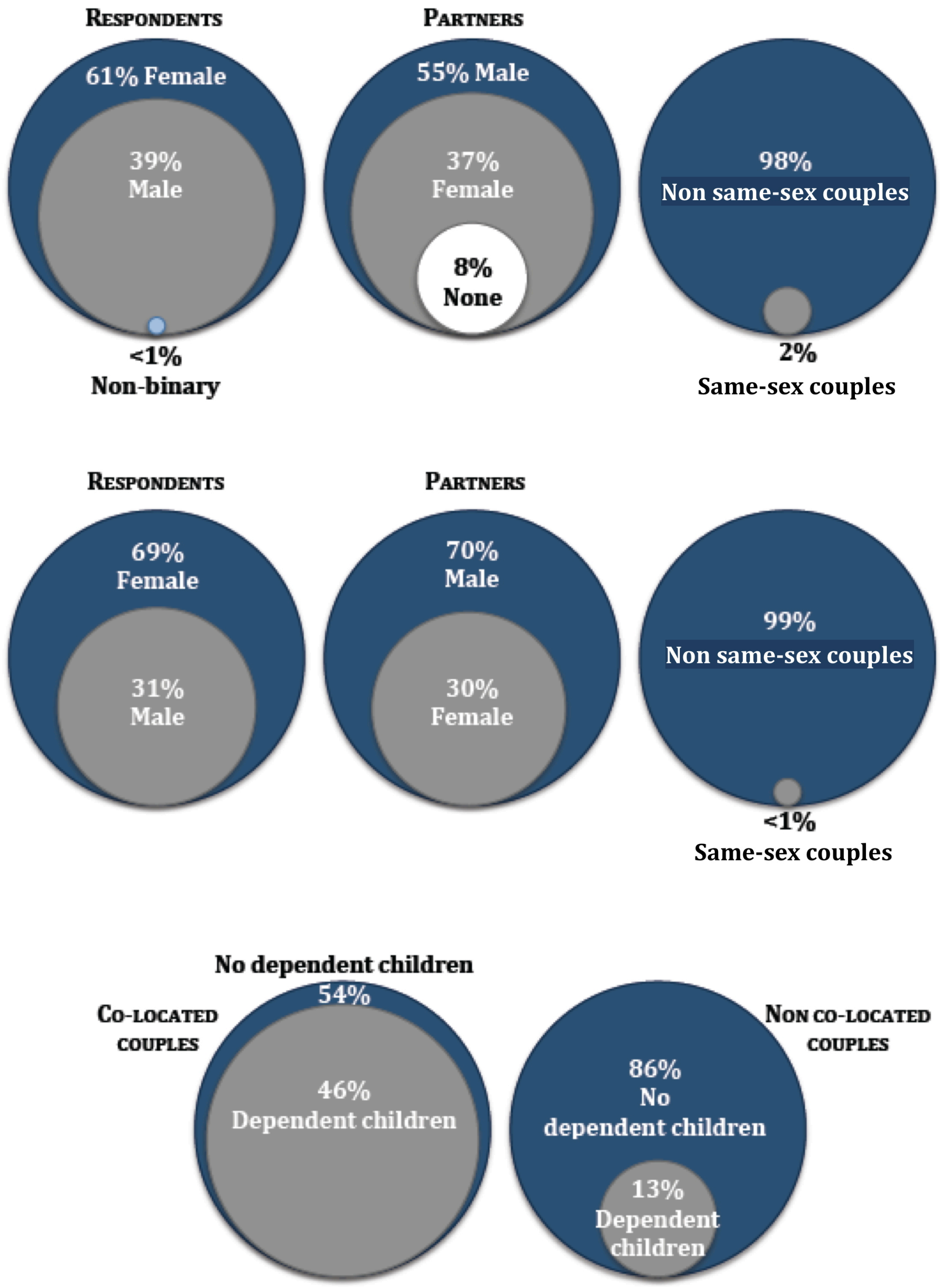

Figure 4: Demographic information for survey respondents. Top row: couples living together and single. Middle row: couples living apart (non co-located group. Bottom row: dependent children for the co-located group and the non co-located group. Percentages do not add to 100 because of roundoff error.

Satisfaction Levels

Respondents with partners are asked to rate the satisfaction level of their current living arrangement as very dissatisfied, dissatisfied, satisfied, or very satisfied. The results are presented in Figure 7. The majority of co-located respondents indicate they are very satisfied (53%) and satisfied (36%) living in the same geographic location as their partner. On the other hand, the majority of non co-located respondents reveal they are dissatisfied (46%) and very dissatisfied (37%) living apart from their partner.

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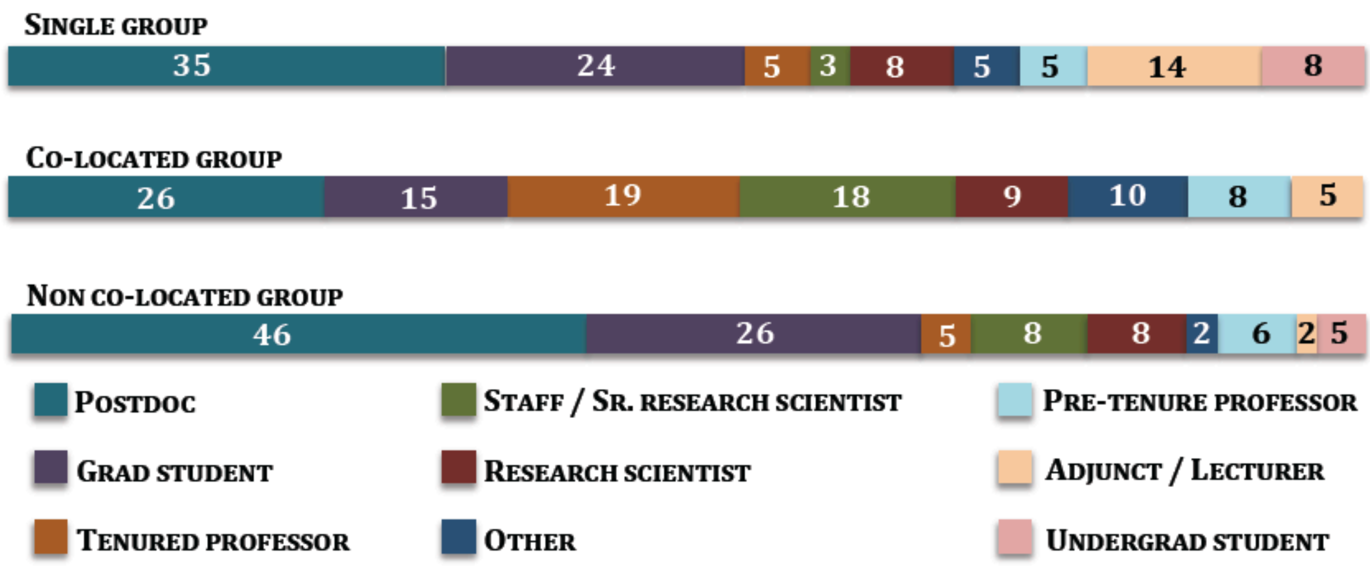

Figure 5: Professional status of respondents in all groups. All values are percentages. They do not add to 100 because of rounding or because respondents selected multiple categories.

Career Changes

Respondents with partners are asked to identify what types of career changes (if any) they or their partner are willing to make, or have made, in order to remain co-located or to become co-located. Most of the non co-located respondents indicate they would consider taking a new job, either similar to (89%) or different from (82%) their current position. In fact, 31% of non co-located respondents indicate they have already changed jobs so they could live with their partner,

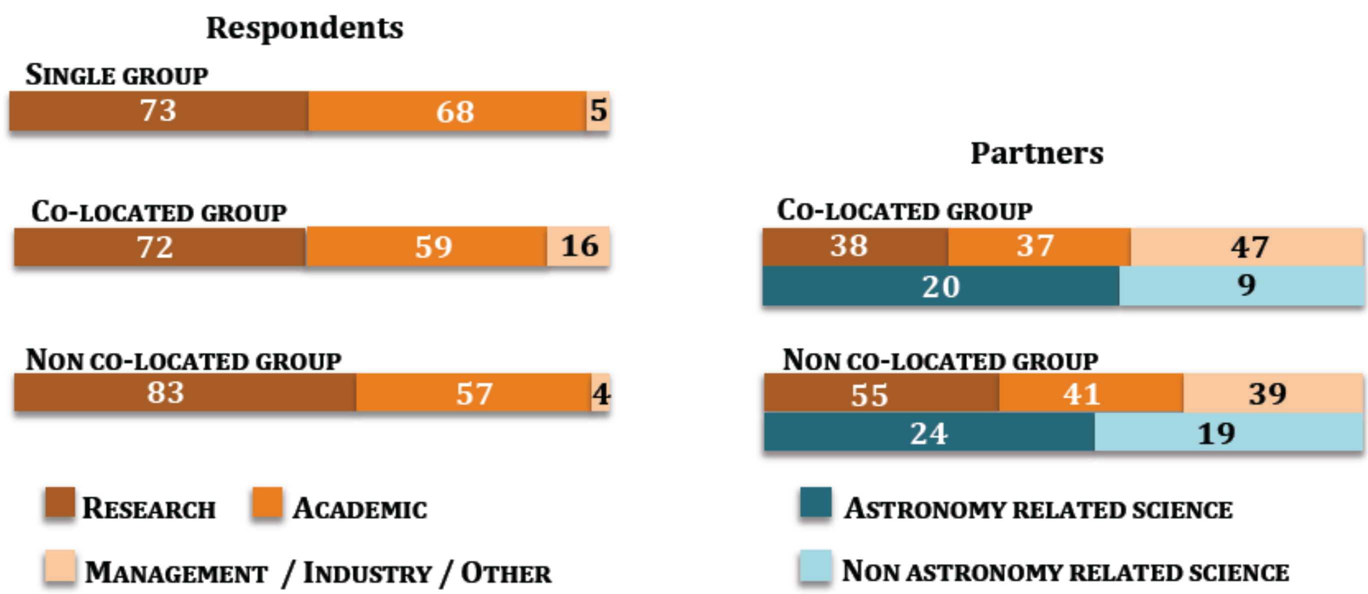

Figure 6: Professional activities of respondents and partners in all groups. Numerical values are as in Figure 5.

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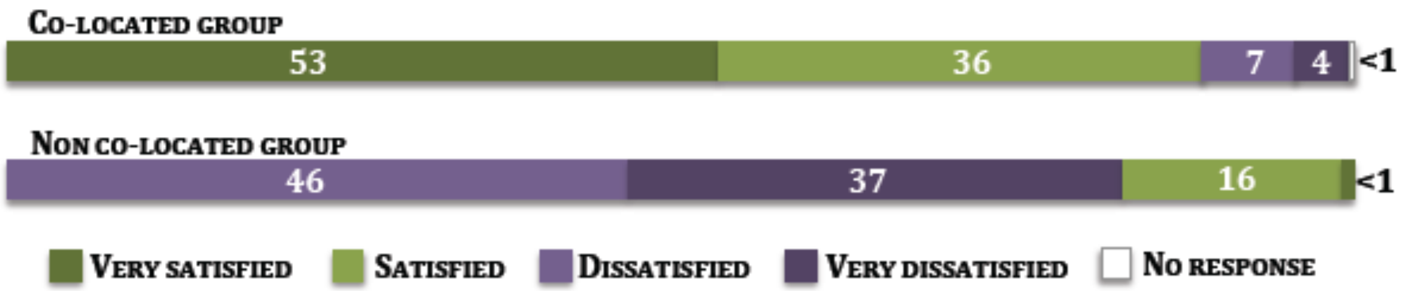

Figure 7. Respondents' satisfaction with their current living situation. Numerical values are as in Figure 5.

even though they currently are geographically separated. Most of the non co-located partners would also consider such adjustments to their careers, but a lower percentage followed through with changing jobs. Furthermore, 55% of non co-located respondents and 38% of partners indicate they would altogether change careers to be co-located, but only a small percentage (2% and 5%, respectively) actually have done this. Of those in the non co-located group that changed careers, the majority (67%) is female. Figure 8 presents all responses. The majority of respondents in the co-located group also indicate they would be willing to take a new position either similar to (61%) or different from (63%) their current position in order to remain living with their partner. Lower percentages of co-located respondents (50%) and partners

	Non co-located group				Co-located group			
	Respondents		Partners		Respondents		Partners	
	Would consider this	Have done this	Would consider this	Have done this	Would consider this	Have done this	Would consider this	Have done this
Remain in same position	39%	8%	39%	6%	46%	25%	41%	18%
New position (similar to current position)	89%	12%	73%	10%	61%	29%	51%	27%
New position (different than current position)	82%	31%	64%	6%	63%	15%	51%	17%
Change career	55%	2%	38%	5%	50%	7%	37%	15%

Figure 8. Matrix of responses regarding a couple's willingness to make career changes in order to be co-located.

continued

(37%) indicate they would consider a career change compared to those living apart. Compared to the non co-located group, higher percentages (7% and 15%, respectively) report that they have already changed careers to be co-located, perhaps a contributing factor to why they are geographically co-located. As with those living apart, the majority who changed careers are female (55%).

Of all the respondents and partners who reported they took a new position with different responsibilities, 49% are female and 50% are male in the co-located group, and 50% are female and male in the non co-located group. The percentages are mixed when it comes to lateral career moves (changing position to one with similar responsibilities). For those living together, 52% of females and 47% of males report such a career move, while 39% of females and 61% of males report the same in the non co-located group. Overall, higher percentages of women report changing careers, while higher percentages of men report lateral career changes.

Summary

The CSWA "Two-Body Careers in Astronomy" survey reveals that 22% of the respondents are geographically separated from their partner, with an average time apart of 5 years. Of respondents, 70% report currently living in the same geographic region as their partner and 8% are single.

The geographic distributions are similar for all respondents, with areas of higher concentration presumably reflecting the distribution of astronomical science jobs. However, partners of respondents who live and work in one of these regions do not necessarily also live and work in the same region, even if the partner also works in astronomy-related science.

Couples living together endure longer commutes than those who live apart. In addition, 5% of couples living together report that one member telecommutes to work.

Women are the majority of respondents (over 60%), while partners are mostly male. Same-sex couples comprise a small percentage of respondents: 2% in the co-located group and <1% in the non co-located group. Overall, the majority of survey couples do not have dependent children, but couples who live apart are less likely to have dependent children (13%) than couples who live together (46%).

Postdocs are the highest percentage of all respondents, possibly because extended or multiple temporary postdoctoral positions predispose people to frequent geographical moves as they pursue a permanent position. Postdocs are also the most numerous group other than graduate students, who might be less likely to be partnered.

In most cases, both respondents and partners are involved in research and academia, with non co-located couples reporting higher percentages of both partners working in either research or academia, as compared to couples living together. The reason may be that couples have more difficulty finding employment in the same geographic location if they both pursue research or academic work. Women are impacted more than men because the majority of respondents in these dual-research and dual-academic couples are overwhelmingly women (over 70%).

Furthermore, we find it may be more difficult for couples with dual-science careers or dual-astronomy careers to find employment in the same geographic location, as compared to couples where only one member of the couple works in any science or in astronomy. Again, women are disproportionately affected because they are the majority of respondents who have partners that work in astronomy (71%) and non astronomy-related (65%) sciences, compared to only 29% and 35% of men. These percentages are similar to those found in a survey of planetary scientists,[7] where more than 70% of women respondents reported having partners in planetary science or in another science/engineering field, compared to less than 30% of men. Our findings also corroborate the finding[4] that women are more likely than men to have a partner in academia and to be partnered with another scientist.

More than 80% of the respondents who live apart from their partner report they would consider taking a new job position, either similar to or different from their current position, and 55% report they would change careers in order to live in the same geographic region as their partner. These percentages are slightly higher (more than 60% and 50%) than for their co-located counterparts, possibly because the issue of modifying one's career becomes less significant when couples live together and not apart. These high percentages are not surprising, since the majority of non co-located respondents identify as dissatisfied and very dissatisfied with respect to living apart from their partner. Of all the respondents and partners who have actually changed careers in order to become or to remain co-located, 56% are women and 43% are men. According to White et al. (2011),[6] 31% of women and 17% of men have relocated because of their partner's job or have turned down a job because their partner could not find work in the same geographic location. Thus, more women than men have made career sacrifices for the sake of their partner.

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This survey, although limited in size and not designed to be a representative sample of all astronomers, effectively highlighted the difficulties faced by couples in astronomy. While it is beyond the scope of this research to propose solutions, solutions will be needed for the better health of our field.

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[1] D. Elmegreen 2014, "The Importance of Demographic Data in Astronomy," AAS 223rd Meeting, #304.01, http://adsabs.harvard.edu/abs/2014AAS...22330401E

[2] R. Ivie and N. K. Ray 2005, "Women in Physics and Astronomy, 2005," Statistical Research Center, AIP Report R-430.02, https://www.aip.org/statistics/reports/women-physics-and-astronomy-2005

[3] AAS Job Register, http://jobregister.aas.org/

[4] L. Schiebinger, A. Davies Henderson, and S. K. Gilmartin 2008, "Dual-Career Academic Couples: What Universities Need to Know", The Clayman Institute for Gender Research, Stanford University, http://gender.stanford.edu/sites/default/files/DualCareerFinal_0.pdf

[5] 5 S. White, R.Y. Chu, and R. Ivie 2011, "2011 Survey of the Planetary Science Workforce," http://lasp.colorado.edu/mop/resources/links/PlanetaryScienceWorkForceSurvey2011/Report.pdf

[6] http://www.aas.org/cswa/status/2body_questions_jun14rodgers.pdf

How Workplace Climate Changes the Knowledge We Generate

Meg Urry, Yale University, Department of Physics and Department of Astronomy

Based on a keynote address given at the University of California ADVANCE Roundtable in April 2014, at UC Davis.

Some years ago, at a major US university, a visiting faculty candidate was told by a senior colleague – an influential, Nobel prize-winning director of a major institute at that university – that she would not be welcome to work with him, that he would not allocate his institute's resources to her, and that his research group would be reluctant to talk to her because they were basically in competition with her.

She wisely decided to build her career elsewhere, but not before describing the problem and leaking his email to others at the university. The ensuing scandal created a classic conflict between bad behavior and first-rate science.

Nobel Prize winners are important to universities; their presence conveys prestige and their work inspires the next generations of researchers. So the president of that university had to be thinking: maybe the guy acted stupidly but he's a Nobel Prize winner! He's done amazing science, and he is incredibly valuable to us. I know few university presidents would have wanted to penalize this high flyer because he impeded diversity or young scholarship. If you did nothing but subtract him from the picture, the intellectual life of the university would certainly be poorer.

But I had quite a different reaction to this dilemma: What if the senior faculty member had been a different kind of person – specifically, someone less focused on beating the other guy, someone who saw his role as supporting the next generation, someone who welcomed a talented young scholar in his own area of research. Would not the achievements of that person's institute ultimately be greater?

Conduct – climate – has a strong influence on the generation of new knowledge. That is my theme in this piece.

I don't suggest that competition is bad or that level of scholarship is not the most important criterion for assessing the value of a faculty member to an institution. Rather, scholarship *is* the most important thing; universities are in the business of generating new knowledge. It is our responsibility to foster the best research we possibly can.

One of the problems with making change at universities is that many faculty members feel the current research enterprise is as good as it possibly could be – and therefore change is bad, a step backwards. What I *am* suggesting is that the atmosphere in many science departments – where aggressive behavior is often seen as a proxy for ability – does not lead to the best science, and that institutional change leading to an improved climate would enhance intellectual accomplishments.

Many of us have worked in unpleasant environments. What happens? You spend a lot of time thinking about the sources of friction, complaining to yourself and to others about the bad things that have happened, trying to calm distraught colleagues so they won't leave. In such places, a lot of energy is dissipated rather than channeled into productive research. In the worst case, the scientific productivity of apparent "misfits" can be badly affected by a toxic atmosphere, confirming preconceptions that some group just isn't up to the task.

Humanity can't afford this kind of waste. Major problems confronting the world are increasingly rooted in STEM issues, including climate change, economic growth, energy, water, pollution, education, and cyber security. We must have a workforce that can respond to these many challenges.

Excellence is diminished when scientists are not at their best. Think about the best research you have ever done. Chances are it was done in a collegial environment, where people spoke openly of their work, without worrying too much about who would get the credit. Quite likely the work was stimulated by a free exchange of ideas, especially with people who think differently from you.

The myth of the lone genius working in the customs office has little relevance to most scientific research today. When I worked at the Space Telescope Science Institute, mostly I saw teams of people working together to build the *Hubble Space*

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Telescope (a six-billion-dollar project), to calibrate its instruments, and to interpret its data. Almost never did lone geniuses come up with valuable results – although plenty of individuals were rewarded for "solo" contributions that were actually the work of teams. After one meeting of a tenure committee, a colleague muttered under his breath, "That's the third person we've tenured" for that particular achievement. That was the culture (in those days – it's changed a lot since then). Being called a "team player" was basically a negative.

The importance of teamwork is also seen at the ten-billion-dollar Large Hadron Collider; my physics colleagues in the 2000-person ATLAS experiment do science in a highly collaborative and coordinated way. Although only three or fewer people can be named as Nobel Prize recipients, it is often large teams – or large informal groups of colleagues – who make breakthroughs.

So, while increasing diversity is surely about excellence, and improving our hiring and promotion processes is essential, it is not sufficient. To get the most out of a community of scholars – to enable them to be maximally brilliant and creative and productive – we have to provide a good workplace.

The faculty candidate from my opening anecdote was quoted as saying, after she accepted a job elsewhere, that she looked forward to the "unprecedented opportunity to just focus on science" and having "a lot of fun being in a highly collaborative environment." She voted with her feet.

Research shows that diversity stimulates innovation[1] – indeed, this is one of the virtues of a diverse workplace. But the research *also* shows that diversity leads to increased conflict. If that conflict is well managed, innovation ensues, but if the conflict is left to fester, diverse groups do worse than homogeneous groups. One of the worst things we can do is hire women and minorities into STEM departments and leave them to sink or swim in toxic environments. This helps neither the young faculty members nor the STEM enterprise.

So let's focus on collegiality. What is the climate like in academic science departments? Clearly it varies a great deal from one place to the next, and from one discipline to the next, but there are some common themes.

My own experience has been in physics departments, in which the percentages of women and minorities are as low as in any STEM discipline. We have been among the slowest to change, so we are perhaps at the far end of the climate spectrum, where the symptoms are most obvious.

Tolstoy said, in Anna Karenina, "All happy families are alike; each unhappy family is unhappy in its own way." Actually, I think the site visit teams sponsored by the Committee on the Status of Women in Physics (CSWP) of the American Physical Society (APS) would say the opposite: all unhappy departments have a lot in common. In general, the undergraduates are fine: eager, happy, and excited about physics. The first- and second-year graduate students are the same, albeit slightly more stressed by qualifying exams and the pressure of finding an advisor.

The senior graduate students and postdocs are different, particularly the women. Most of the women are discouraged and unhappy, they feel they've made a mistake in pursuing physics, and they see no way to move forward. One young woman we talked to, who was known by one of the site visit committee members (someone in her field) as an up-and-coming young scientist with an excellent reputation, told us she had made a terrible mistake going into physics, that she had no good ideas, that she could not write a grant proposal to save her life, and that she was just hoping to finish her degree and get out of physics. In my experience on site visit committees, this kind of attitude was far more prevalent among the women than the men.

We saw this kind of thing in most physics departments we visited. The women faculty members were sometimes the saddest part of the story. They were often on the sidelines, marginalized and often seen – or at least treated – by their colleagues as unproductive or of lesser ability. Even the women who were held in high regard by their colleagues were often the most overworked, highly stressed faculty members in the department.

One time, as Chair of a CSWP Visiting Committee, I was debriefing the Physics Department Chair at a highly ranked physics department in a highly ranked university. He is a terrific leader on the issue of diversity – he understands the biases that have kept physics so male dominated – but he was taken aback when I described one female faculty member, in particular, as a rising superstar back when I was in graduate school. I remembered when his university hired her away from another highly ranked department – this had been seen as a major coup. Yet years later, her colleagues treated her more like furniture – when they weren't being rude and belittling. I think our conversation was the first time the Chair thought about the scientific cost of a bad climate, as opposed to the social good of having a good climate.

I have one foot in the astronomy world, which requires the same skill set as physics yet for many decades has had twice as

continued

many women (percentage-wise) as physics. In my experience, the climate in astronomy departments is frequently friendlier, less over-the-top elitist, less dominated by super-egos. Of course, a relaxed atmosphere doesn't guarantee first-rate scholarship – for that, one also needs ambitious ideas, hard work, and clever analysis.

In departments with troublesome climates, a good fraction of the faculty think the same way on a lot of matters. They easily reach consensus in back-room discussions, and they have difficulty appreciating other views. To the extent that the minority views belong to women and/or minorities, this can exacerbate the tensions of a newly diverse faculty and suppress innovation.

Of course, the majority don't see themselves as I have described them – and this is my last point. Many years ago, I was complaining (naturally!) to Sheila Tobias, who has written extensively about gender and STEM. I was bemoaning the tough conditions for women in these male-dominated fields, and her reply really stuck with me. She wouldn't trade places with them for anything, she said. In fact, she felt sorry for majority men. They never had any reason to examine themselves and thus they had far less self-knowledge than we who were fighting to get into the castle. This is a natural, human thing.

I remember vividly the first meeting of the organizing committee for the first meeting on Women in Astronomy, which we held in Baltimore in 1992. That meeting resulted in a document called the Baltimore Charter, outlining how change could happen. It was considered a radical document that only a few institutions were eager to endorse. Today it looks sweetly old-fashioned and almost toothless. I thought the conference should be about the extra obstacles women face in building a career, but a senior male colleagues insisted we talk about whether women face extra obstacles at all.

I was initially annoyed and disbelieving, but later I realized this was one of the most useful lessons of all. A clear lesson in diversity: we all prefer to associate with people who are like us and listen to people who agree with us. I'd been discussing these issues for years with people whose attitudes and sympathies were close to mine, and therefore I had zero understanding of different views. This guy had never thought there was anything unusual about a modern institute with less than 5% women faculty and no under-represented minorities. Now I always start my talks on women in science with demographic data and review the social science data on unconscious bias.

I am convinced that most white male scientists don't see anything off-kilter in the typical unbalanced department. When I arrived at Yale in 2001, I was the only woman in the Physics Department and the first woman they had ever tenured. (A few years earlier, Karin Rabe had been the first woman tenured by Yale's Applied Physics Department.) It's the same everywhere in the academy but perhaps particularly in science, because being objective is so central to our scientific identity. Other people might be biased, but we fancy ourselves gender blind and color blind, or so we would really, really like to believe. (Those who have visited implicit.harvard.edu usually know better.)

A story illustrates the problem: I was a member of the organizing committee for the 2007 APS-sponsored meeting of Physics Department Chairs, which was focused on diversity and equity. We arranged for the University of Michigan CRLT Players[2] to present one of their skits just before the opening reception. This theater troupe uses extensive interviews to develop scripts depicting key moments in academic life. Every incident depicted is based on reality and the words are often direct quotations.

We saw the "faculty meeting" skit, which I have seen three times now. Six faculty members discuss minor business and then which of two faculty candidates (one woman, one man) to hire. This last part is really the meat of the piece, but here I want to focus on the beginning. The department chair raises an issue about the Xerox machine and suggests a solution that he and another senior faculty member appear to have agreed on in advance. The senior woman objects, with detailed reasons, and is supported by a junior male. The remaining faculty members, all male, dismiss her concerns and support the Chair. He closes the Xerox machine discussion by saying, "We're all agreed, then. We'll do [what I suggested]."

At the 2007 Chairs' meeting, only one or two of the roughly fifty department chairs were female, but the dozen or so women attending the meeting (mostly members of the organizing committee) sat together in the front row and laughed through the choicest parts. We all thought, "This is my life." But the reaction of the male chairs was quite different. At the reception following the skit, one person after the next said the skit was terribly exaggerated, that no one would behave that boorishly, it simply wasn't realistic.

The next day (bear with me, this leads to the punch line), the meeting began with plenary talks followed by breakout

continued

sessions in which each group was asked to discuss how to deal with a particular scenario. A good friend who is a senior woman in physics later told me what happened in her group. Their scenario concerned a group grant, such as is common in nuclear and particle physics. The PI of the grant, a senior man, wanted to repurpose the funding allocated to a junior woman, over her objections, and she had brought the issue to the department chair.

The convener of this group started the discussion by saying, “First, let’s all agree that this has nothing to do with gender, it’s simply bad behavior.” Several men in the group agreed. Then my friend said, “I don’t agree, I think it has everything to do with gender, and how power intersects with gender.” The only other woman present, much younger, agreed with her. Then several men explained why they thought this view was wrong and the discussion moved on.

When the full conference reconvened, each breakout discussion was summarized by its convener. The man leading the group described above began his presentation by saying, “First, we all agreed that this scenario had nothing to do with gender.” It was precisely the situation depicted in the CRLT Players skit – behavior that the physics chairs believed was greatly exaggerated. This man also said the scenario simply described bad behavior, implying no one would ever do such a thing.

The point is, we do not always see ourselves as others do. Our challenges are to hold up the mirror in a way that does not offend and to inspire our colleagues to consider diverse points of view.

Let me close with two pieces of good news.

Twenty years ago, astronomy departments looked a lot like physics departments today – the same percentages of women (10%) and minorities (near 0%), the same attitudes, the same resistance to change. Now, astronomy appears to have hit the tipping point. About half the Ph. D.s over the past 5 years have gone to women, and it appears (small number statistics) that women are getting their share of the top faculty positions and are starting to win some of the prestigious prizes. This means change is possible.

Second, there are some really outstanding women professors out there who have been marginalized at their current institutions. If your university can get ahead of the pack, you can make some excellent acquisitions.

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[1] S. E. Page 2008, *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies* (Princeton University Press, Kindle Edition) chapter 12

[2] http://www.crlt.umich.edu/crltplayers

On Planck's Law, Blackbodies and the Physics of Diversity

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Diversity and inclusion are important, yet vexing, issues that we struggle with in every arena. Academia and, more specifically, astronomy are not exempt. Many interpretations of the experiences of diverse people have been offered, but unfortunately, many have fallen short in pivotal ways.

As an astrophysicist, I see the beauty and logic that physics allows us to impose on the cosmos, but also on a broader array of issues. Sociophysics, for example, "uses concepts from the physics of disordered matter to describe some aspects of social and political behavior."[1] I would like, then, to describe a few diversity issues in terms of a physical concept that astronomers are familiar with, namely Planck's Law. This analogy is not perfect, but it affords us a mechanism to address some of the complexity of diversity conversations and direct us towards more globally beneficial diversity practices.

Even before I begin, I acknowledge that I cannot address all aspects of diversity, which includes the full spectrum of ethnicity, class and sexual expression. I focus on the diverse experiences of women (broadly defined), but these principles can generally be extended to other dimensions of diversity. Still, I encourage expansion of our colloquial definitions of diversity, even as social psychologists grapple with characterizing our behavior surrounding it. My goal is not to establish who suffers most, but to suggest that different groups suffer differently and in profoundly complicated ways. Thus, this article is for all of us. It is an attempt to provide a familiar framework for this complex issue.

Perhaps the best place to begin this conversation is with blackbody radiation. Blackbodies are thermodynamic idealizations that are uniquely defined by their temperature. We describe the spectrum of blackbody radiation with Planck's law, which predicts the intensity of radiation as a function of wavelength. Therefore, Planck's law will immediately tell us the surface brightness of a blackbody at any wavelength. We can also determine its peak wavelength of emission, which is inversely proportional to the temperature, via Wien's Law.

Armed with the temperature and these laws, one can determine which filter is best suited to observe the peak of blackbody radiation. Using the wrong filter for a blackbody of a given temperature is a sure-fire way to accumulate non-detections. For example, an object with T=5,000 K has its peak emission at 5,796 Â and is not likely to have *detectable* emission at 300 GeV with the Fermi Gamma-Ray Space Telescope. Planck's Law tells us that there is non-zero emission from such a source at that energy, but it is far below instrument sensitivity limits. An exception is the Sun, which has had detections with Fermi/LAT of radiation associated with flares due to non-thermal processes.[2]

Social psychological research about diversity can offer us some interesting parallels with astrophysical observations. I suggest that the filter we use to observe a blackbody is analogous to our lived experiences and sensitivities. The farther removed the lived experiences of the observer from the peak wavelength of source emission, the more difficult it is to understand and accurately interpret or even perceive the 'signal' of another's experience. Let's now reinterpret the idea of a non-detection. We can clearly see that in a given situation, language like "that doesn't really happen" or "it's all in your head" is unproductive (and generally inaccurate). The nontrivial displacement between the filter and the peak source emission suggests lack of filter sensitivity, not necessarily lack of true signal.

Another point we can unearth here is that members of various groups must endeavor to understand their similarities and respect their differences. We can relate this to another fundamental principle of blackbodies: Planck curves for distinct temperatures never intersect. In a similar way, even for apparently single-identity groups, such as White women, individual experiences are not identical and do not overlap, like a group of blackbody sources with similar temperatures. A single filter may not be able to distinguish between these slightly different signals.

A second way to interpret this lack of overlap among different temperature blackbodies is to consider Planck's Law

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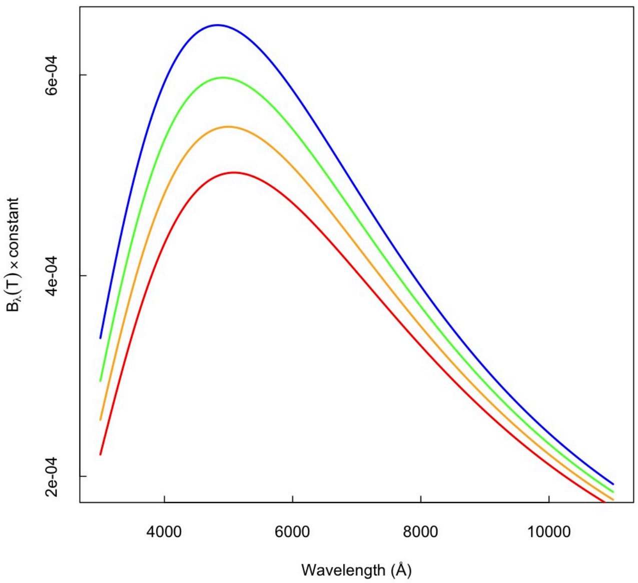

Figure 1. Blackbody curves in wavelength units, to within a constant factor. From top to bottom, *T* = 6000, 5900, 5800, and 5700 K. (Illustration by Nancy Morrison)

across the entire spectrum as shown, for example, in Figure 1. The behavior of surface brightness with respect to temperature is significantly different at shorter wavelengths (where the surface brightness at a given wavelength is approximately proportional to a high power of the temperature) than at longer wavelengths (Rayleigh-Jeans limit, where the surface brightness is only linear with temperature). For example, White women experience privileges that women of color do not, afforded them by being a part of the dominant race in the United States. When considering the oft-discussed pay wage gap between women and men, it is instructive to note that Black and Latina women also experience a pay gap with respect to White women.[3] Thus, the situation is disconcerting for women in general, but becomes even more dire as we consider the effects of race and gender. We come face to face with the fact that one can not escape racialized gender. In addition, the use of 'women' in terms of gender diversity without a qualifying statement of race reifies White women as the normative example of the female gender in America.[4,5]

On the other hand, persons with intersectional identities (e.g. Black women, Latina women, and those of mixed heritage) may not be sufficiently well-represented by a single parameter. Simply stated, a Black woman is neither just Black or just a woman. She is Black + woman,[5,6] and the concerns, prejudices, stereotypes, disadvantages and advantages she faces are unique. Further, she will encounter disproportionately more prejudice and discrimination than would a member of a single identifying group.[7] In the framework we are constructing, multiple identity groups are analogous to multi-temperature blackbodies, like accretion disks,[8] which require more parameters to characterize fully. While the spectral energy distribution of a multi-temperature blackbody has a different shape from that of a classical blackbody, the overarching necessity of adjusting the filter used for best evaluation remains germane. In fact, the need for multiple filters is underscored, as the broadband behavior of the curve may not be known *a priori*.

Women of color accrue some advantages due to their relative invisibility with respect to race and gender. Studies have shown that Black women are allowed to show more aggressive behavior in the workplace without repercussions than Black men or White women, due to their intersectionality.[9] However, the same study also showed that this leeway did not extend to situations when Black women made mistakes. In those cases, they were more heavily sanctioned than either of the other groups considered. Therefore, while each group has parameter spaces within which they can operate with relative advantage, none of these advantages are absolute.

So how do we address the biases that arise from the interconnectedness of race and gender in our research groups? As professional scientists, we are accustomed to referring to the experts, so we look to the extant research on diversity. The problem is that the relevant literature has largely ignored intersectionality. "[Empirical social psychology] research into the intersections of diversity did not arise until 2008 with Robert Livingston," says Erin Thomas, Gender Diversity Coordinator of STEM Initiatives at Argonne National Labs and Ph.D. in Psychology. She continues, "until that point, race and gender studies were characterized mostly by Black men and White women."[10]

Black women were the first group to be considered intersectional, but now many psychologists are expanding their investigations to other women of color, and are also considering class and sexual expression. For example, the new book by Joan C. Williams and Rachel Dempsey, *What Works for Women at Work,*[11] identifies similarities and differences between the work experience of White women and women of color. Williams also has an NSF-supported initiative called the Gender Bias Learning Project, where she has developed a Gender Bias Bingo[12] and worked extensively on the subject of 'double jeopardy'[13] at the University of California, Hastings Center for WorkLife Law.

Diversity is a complex subject. There is no panacea that we can sprinkle around the telescope to achieve an unbiased

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interaction with people whose life experiences are different from ours. As participants in a diverse world, we must do our part on many fronts. We must continue to push for scientific honesty, integrity and inclusion in the investigation of diversity as a research topic, as well as insist on responsive implementation of best practices unearthed from that research. Given the history of oppression and silencing of 'others' in this country, there is no reason to assume that the problem will fix itself. Moreover, the evidence suggests [14] that our scientific community has suffered due to loss of talent, uneven playing fields, and hostile work spaces. We have an individual responsibility to constantly assess our filters, and evaluate the resultant detections or non-detections thereof, to determine whether our perception sensitivity is high enough to make an informed statement on a given matter.

As an astrophysical community, we can sharpen our discernment of different lived experiences. First, in connection with the need for attention to our own sensitivities, I highlight the written testimony AAS submitted at the National Research Council's Women of Color in Academia Conference.[15] This work addressed barriers and recommendations for improvement at the departmental, institutional, and organizational level. (Full disclosure: I was a co-author of this work.) Second, we can incorporate evidence-based diversity trainings into the curriculum for graduate schools, into research grants, and at our very own AAS. As the world and our field are becoming increasingly diverse, significant gains in research, insight and innovation can be realized by making our discipline more welcoming to all, by recognizing and appreciating the filters and peak wavelengths of all who wish to participate.

I would like to thank Erin Thomas, Ph.D. for her help identifying relevant research studies and Joan Williams, Esq. for sharing her research with me before her book became available. In addition, many thanks are owed to Nancy Morrison and Joan Schmelz for their patience and keen eye in editing this work.

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[1] S. Galam 2012, *Sociophysics: A Physicist's Modeling of Psycho-political Phenomena* (Springer), http://www.springer.com/social+sciences/book/978-1-4614-2031-6

[2] http://fermi.gsfc.nasa.gov/science/mtgs/symposia/2012/program/mon/NOmodei.pdf

[3] R. Dozier 2010, "The declining relative status of black women workers, 1980-2002," *Social Forces*, **88**, 4, 1833–1857, http://sf.oxfordjournals.org/content/88/4/1833.abstract

[4] P. T. Reid and L. Comas-Diaz 1990, "Gender and ethnicity: Perspectives on dual status," *Sex Roles,* **22**, 397–408, http://link.springer.com/article/10.1007/BF00288160

[5] K. L. Johnson, J. B. Freeman, and K. Pauker 2012, "Race is gendered: How covarying phenotypes and stereotypes bias sex categorization," *Journal of personality and social psychology*, **102**, 1, 116, http://psycnet.apa.org/journals/psp/102/1/116/

[6] A. K. Sesko and M. Biernat 2010, "Prototypes of race and gender: The invisibility of Black women," *Journal of Experimental Social Psychology*, **46**, 2, 356-360, http://www.sciencedirect.com/science/article/pii/S0022103109002698

[7] V. Purdie-Vaughns and R. P. Eibach 2008, "Intersectional Invisibility: The Distinctive Advantages and Disadvantages of Multiple Subordinate-Group Identities," *Sex Roles*, **59**, 377-391, http://link.springer.com/article/10.1007/s11199-008-9424-4

[8] L. X. Li, E. R. Zimmerman, R. Narayan, and J. E. McClintock 2005, "Multitemperature blackbody spectrum of a thin accretion disk around a Kerr black hole: model computations and comparison with observations," *The Astrophysical Journal Supplement Series*, **157**, 335, http://iopscience.iop.org/0067-0049/157/2/335/

[9] Rosette, A.S., and Livingston, R.W. 2012, "Failure is not an option for Black women: Effects of organizational performance on leaders with single versus dual-subordinate identities," *Journal of Experimental Social Psychology,* **48**, 5, 1162–1167, http://www.sciencedirect.com/science/article/pii/S0022103112000832

[10] Thomas, E. 2013, personal communication

[11] J. C. Williams and R. Dempsey 2014, *What Works for Women at Work: Four Patterns Working Women Need to Know* (New York University Press, forward by Anne-Marie Slaughter)

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

[13] F. Beal 1969, *Double Jeopardy: To Be Black and Female*, http://www.hartford-hwp.com/archives/45a/196.html

[14] National Research Council 2009, *Gender Differences at Critical Transitions in the Careers of Science, Engineering, and Mathematics Faculty* (The National Academies Press, Washington, D.C.), p. 255

[15] D. Norman et al. 2012, "Women of Color in Astronomy and Astrophysics," The National Academies, http://sites.nas.edu/wocconference/files/2012/03/6.3.-American-Astronomical-Society.pdf

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Math and Verbal Performance of Men and Women Under Competition and Time Pressure

Nancy D. Morrison, The University of Toledo, Department of Physics and Astronomy (retired)

Recently, we've heard a lot about the gender gap in wages: the full-time median salary for women is lower than that of men in almost all occupations,[1] and a gap persists in many occupations when age and skill level are controlled for. Explanations can be grouped broadly into three categories: bias, whether conscious or unconscious; entry of women into lower-wage occupations because of skills or preferences; and less competitiveness among women than among men.

There are many ways to slice the data. It is commonplace to say that workers in female-dominated occupations generally earn less than those in male-dominated ones. Women being less willing to negotiate is another point;[2] all are aspects of self-selection by women. Discrimination is still a factor.[1] Another recent finding[3] is that the salary gap is greatest in business and law, where per-hour pay for employees working longer hours is greatest, and thus reflects the culture and the structure of the occupation.

In science, we confront all these issues. In addition, the early stages of our careers are strongly affected by math-based tests such as the GRE, both the quantitative general test and the physics subject test, on which women tend to score lower than men. For example, on the quantitative general test in 2006-2007, the median score for women was more than 50 points lower than that for men, and the 75th percentile score was about 30 points lower.[4] This difference is enough to disqualify a significant number of women and minorities from graduate admission if a hard cutoff score of 700 is used, as it often is in elite programs. If we assume that women are just as good at math as men, then why the difference?

Interesting research on the performance of women and men on math-based tests has been carried out by Olga Shurchkov, Assistant Professor of Economics at Wellesley College.[5] In lab experiments, she assessed the performance of male and female students who were paid to solve verbal and math puzzles, in competitive and noncompetitive environments and with high and low time pressure. In her analysis, she took care to tease out various effects on the students' performance. She also carried out a labor market analysis to investigate whether her findings on time presssure and competition carry over into the workplace. Her paper provides background on the research area. The rest of this article discusses her methodology and findings, which bear on several aspects of the gender gap outlined above.

Experimental Research

The verbal task was a "Words-in-a-Word" puzzle, which was based on an on-line game.[6] Subjects had to form as many shorter words as possible out of a longer word. The math puzzle was designed to be a comparable task: out of a string of digits, subjects had to find as many as possible sets of numbers that add to a target number. For example, in the string 1034582614 with a target number of 117, the correct solutions include 103 + 14, 54 + 63, and 14 + 43 + 60. For both the math and the verbal puzzle, precautions were taken to ensure that the difficulty of the puzzles was constant from trial to trial. In both puzzles, points were deducted for mistakes, such as illegal words, using a digit more times than it appeared in the numerical sequence, and so forth. Therefore, negative scores were possible.

In each verbal and each math session, there were three rounds in which the subjects had two minutes to solve each puzzle (high time pressure or short duration) and three rounds in which they had ten minutes (low time pressure or long duration). After each round, the subjects guessed their rank within their group of four, with payment for a correct guess.

Within each time pressure regime, different payment schemes were used to test the subjects' performance under, and preference for, competition. In a noncompetitive piece-rate treatment, no winner was announced, and each subject was paid in proportion to the number of points earned. In the competitive treatment, or "tournament," only the top scorer in each foursome was paid.

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After completing the piece-rate and the tournament rounds, subjects were invited to choose which scheme to use for the later rounds, and their preference for competition was analyzed.

In the verbal sessions, the subjects comprised 27 groups of two men and two women and five groups of all men. Taking part in the math sessions were 84 people, 21 groups of two men and two women and three all-female groups. All the subjects were undergraduate and graduate students at Boston-area universities, mainly Harvard, who were not otherwise selected for scholastic ability. Gender was the only demographic characteristic discussed in the study. It was not emphasized at any point in the experiments, but the subjects could see the gender of the members of their group. After completing each puzzle, the subjects saw their own scores but not those of the others in their group, and they were given no information about their ranking within their group. At the end of the experiment, subjects were asked demographic questions and questions about their strategies during the experiment. They were also asked whether they thought men or women would be better at the math and verbal tasks.

Experimental Results

In the noncompetitive setting, the mean math scores for men and women were virtually identical, and the distributions were not very different, as Figure 1 shows. While one or two male subjects scored very high, several of the men obtained negative scores by making mistakes. Thus, the men's and women's overall math abilities, as measured by their mean scores on this task, were similar. Stereotype threat was present: only 31% of male and female subjects thought that women would be better at the math task. In the tournament setting, the men did a bit better, while the women did significantly worse, showing a significant increase in the number of negative scores and a statistically significant drop in mean score. In the choice setting, significantly more men than women selected the tournament, in which the potential payoff was four times higher. This result holds up when performance in the previous rounds was controlled for, important since the highest scorers were all male. Confidence, as measured by rank guess, was also a predictor of a subject's likelihood of entering the tournament.

The next variations were designed to determine how the women would perform relative to the men when the stereotype threat and the time pressure were relaxed. In the verbal puzzles, stereotype threat, if anything, favored the

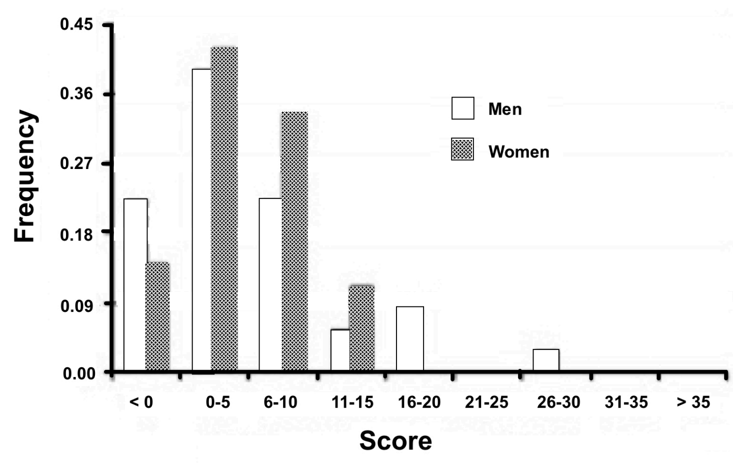

Figure 1. Distribution of math scores by gender in the noncompetitive (piece-rate) setting. Redrawn from Shurchkov's[5] Figure 1(a). Frequency is proportional to the number of occurrences of each score, such that all frequencies add to 1.

women, since a majority of both genders said they expected women to be better at the verbal puzzles than men. In this setting there was no significant difference between the women and the men in either the noncompetitive or the competitive setting. In addition, men and women were equally likely to choose the tournament when offered the choice in the later round.

When the time pressure was relaxed, both genders improved their scores significantly in the math task, and now there was no significant difference between the genders in either the piece-rate or the tournament setting. There was a high peak at the right-hand end of the score distribution for both genders, in both settings. Interestingly, in the tournament, the male subjects showed a high frequency of negative scores, indicating a high share of mistakes. Figure 2 compares the score distributions from the short- and long-duration math competitions. In the choice rounds, women were nearly twice as likely to select the tournament as they were in the high-pressure setting, while the men's choices remained the same.

In the verbal task, the men and women did about equally well in the piece-rate setting; the score distributions are almost identical. In the tournament setting, both genders improved, but the women improved dramatically. In the choice setting, there was little difference between women and men in likelihood of choosing the tournament, once confidence (rank guess) and prior performance were controlled for.

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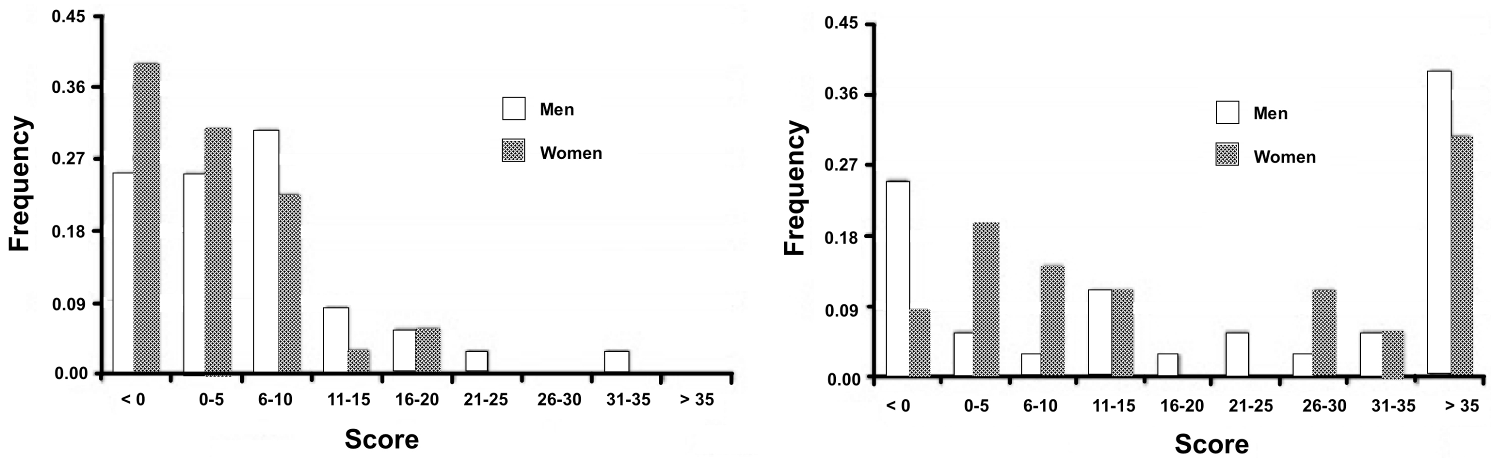

Figure 2. Distribution of math scores by gender under competition with high (left) and low (right) time pressure, redrawn from Shurchkov's[5] Figures 1(b) and 3(b) (left and right, respectively).

Also analyzed was mistake share, the number of points lost due to invalid solutions divided by the total possible number of points. In the math task, women's mistake share in the tournament setting decreased significantly when the time pressure was reduced. In the verbal task, on the other hand, the women's mistake share was unchanged, but the men's mistake share *increased* when time pressure was reduced. The hypothesis that this rise in mistake share might be due to men's greater preference for risk was explored and found wanting. More likely, the men used the extra time to increase the number of solutions they found, rather than their quality.

In the long-duration games, subjects had the option of quitting before the time expired. In the math tournament, women were significantly more likely than men to quit early, but there was no gender difference in the verbal tournament. Both genders were less likely to quit in the tournament than in the piece-rate setting, a result showing that competition has benefits.

Table 1 gives a brief summary of the results: the men and women performed about equally well in all but two of the settings: in the short-duration (high-pressure) math test, the men did much better, and in the long-duration (low-pressure) verbal test, the women did much better.

Labor Market Analysis

In short, Shurchkov found that differences in math test scores between men and women were greatly diminished when stereotype threat, time pressure, and competition were removed from the setting. To see whether these findings are reflected in the labor market, she examined individual-level labor market data from the years 2003 through 2009. She grouped occupations into low- and high- pressure and math and verbal categories based on classifications from CareerCast.com.

Examples of high-pressure jobs that emphasize mathematical skills include financial analysis and management, while mathematicians, actuaries and accountants fall into a lower-pressure category. High-pressure jobs with a verbal emphasis include journalism, while people in low-pressure jobs in the verbal category include librarians, novelists and poets. Admittedly, few jobs are purely mathematical or verbal; rather, they combine these attributes in varying amounts.

Regression analysis of real earnings against demographic variables and controlled for gender revealed a significant (at the 1% level) salary gap in high-pressure math jobs, smaller gaps in high-pressure verbal jobs, and little if any gap in lower-pressure verbal jobs. The high-pressure math jobs are also the ones with a lower share of women: "... a woman is almost 20% less likely to work at a high-pressure math job than a man of similar characteristics." Those probability differences are reversed in sign for the low-pressure jobs, both the math and the verbal.

continued

Table 1. Results of piece-rate (noncompetitive) and tournament (competitive) math and verbal games. M = men superior, W = women superior, E = men and women roughly equal.

	Piece-rate	**Tournament**
	Math	
High-pressure	E	M
Low-pressure	E	E
	Verbal	
High-pressure	E	E
Low-pressure	E	W

Conclusions

Shurchkov designed her experiments well to separate competing effects. She provided objective evidence that the women in the study have similar basic math ability to the men, but she confirmed conventional wisdom that women perform less well than men on mathematical tasks – where stereotype threat may be in force – in competition and under time pressure. Removing either stereotype threat or competition enabled women to perform as well as men, and removing both sources or pressure enabled women to perform better than men: they excelled in the verbal competition, earning a higher average payout than the men. Part of the reason was that the women used the extra time to improve the quality of their work, while the men appeared to aim for increased quantity, thereby increasing their mistake share.

What do these results tell us about how we ought to be preparing future scientists? Although some argue that science is more competitive than it needs to be, some competition is inherent in the process. Nor are graduate admissions procedures likely to become less competitive. Therefore, the disadvantage that accrues to women from competition is unlikely to change, unless women learn to overcome it.

Unlike competition, time pressure is not usually an essential feature of solving scientific problems. The most typical situations involving time pressure are answering tough questions in oral exams or after a talk and writing proposals to deadlines. In the former, we have to "think on our feet," a skill that we can learn in graduate school and beyond. In the latter, we use verbal skills at least as much as mathematical skills.

An essential feature of both the Math General and the Physics Subject GRE is solving numerous problems under time pressure, a skill that is minimally related to career success. The experimental research described here, showing that time pressure is a significant barrier to women's demonstrating their math skills, suggests yet another reason to "ditch," or at least down-weight, the GRE.[7] Indeed, research shows[4,8,9] that students' GRE scores are poor predictors of any measure of success in graduate school. The same research shows that alternative methods – "noncognitive measures" of personal characteristics and professional skills – are much better predictors. Properly applied, they are free of gender and racial bias. Noncognitive assessment will be reviewed in a future issue of *Status*.

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[1] http://www.iwpr.org/initiatives/pay-equity-and-discrimination

[2] R. Simmons and J. Bacal 2012, "How to Repair the Gender Pay Gap? Teach Negotiation Skills in College," in *Huff Post Women*, November 8, 2012, http://www.huffingtonpost.com/rachel-simmons/wage-gap_b_2084150.html?utm_hp_ref=women&ir=Women&ncid=edlinkusaolp00000008

[3] C. Goldin 2014, "A Grand Gender Convergence: Its Last Chapter," *American Economic Review* 2014, 104(4): 1–30, http://dx.doi.org/10.1257/aer.104.4.1

[4] C. Miller 2014, "Using Minimum Acceptable GRE Scores for Graduate Admissions Suppresses Diversity," presentation in Special Session 337 at the American Astronomical Society's 223rd meeting, http://csma.aas.org/AAS223/miller.pdf

[5] O. Shurchkov 2012, "Under Pressure: Gender Differences in Output Quality and Quantity under Competition and Time Constraints," *Journal of the European Economic Association*, 10(5):1189–1213, http://dx.doi.org/10.1111/j.1542-4774.2012.01084.x

[6] http://www.wordplays.com/help/words-in-a-word-game/

[7] See also J. A. Johnson 2014, "Increasing diversity by ditching the GRE," http://womeninastronomy.blogspot.com/2014/06/increasing-diversity-by-ditching-gre.html

[8] W. Sedlacek 2014, "Why Doesn't the GRE or GPA Work in Selecting Graduate Students & What Alternatives Are There?" http://csma.aas.org/AAS223/sedlacek.pdf

[9] C. Miller and K. Stassun 2014, "A test that fails," *Nature*, **510**, 303-304, http://www.nature.com/naturejobs/science/articles/10.1038/nj7504-303a