

Differences in STEM Doctoral Publication at a Large Research University by Ethnicity, Gender and Academic Field



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Expectations of brilliance underlie gender distributions across academic disciplines

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The gender imbalance in STEM subjects dominates current debates about women's underrepresentation in academia. However, women are well represented at the Ph.D. level in some sciences and poorly represented in some humanities (e.g., in 2011, 54% of U.S. Ph.D.'s in molecular biology were women versus only 31% in philosophy). We hypothesize that, across the academic spectrum, women are underrepresented in fields whose practitioners believe that raw, innate talent is the main requirement for success, because women are stereotyped as not possessing such talent. This hypothesis extends to African Americans' underrepresentation as well, as this group is subject to similar stereotypes. Results from a nationwide survey of academics support our hypothesis (termed the field-specific ability beliefs hypothesis) over three competing hypotheses.

Laboratory, observational, and historical evidence reveals pervasive cultural associations linking men but not women with raw intellectual talent (1-4). Given these ambient stereotypes, women may be underrepresented in academic disciplines that are thought to require such inherent aptitude. We term this the field-specific ability beliefs hypothesis (fig. S1).

Current discourse about women in academia focuses mainly on women's underrepresentation in (natural) science, technology, engineering, and mathematics (STEM) (5). However, STEM disciplines vary in their female representation (fig. S2) (5, 6). Recently, women have earned approximately half of all Ph.D.'s in molecular

Individuals' beliefs about what is required for success in an activity vary in their emphasis on fixed, innate talent (9). Similarly, practitioners of different disciplines may vary in the extent to which they believe that success in their discipline requires such talent. Because women are often negatively stereotyped on this dimension (1-4), they may find the academic fields that emphasize such talent to be inhospitable. There are several mechanisms by which these field-specific ability beliefs might influence women's participation. The practitioners of disciplines that emphasize raw aptitude may doubt that women possess this sort of aptitude and may therefore exhibit biases against them (10). The emphasis on raw ap-

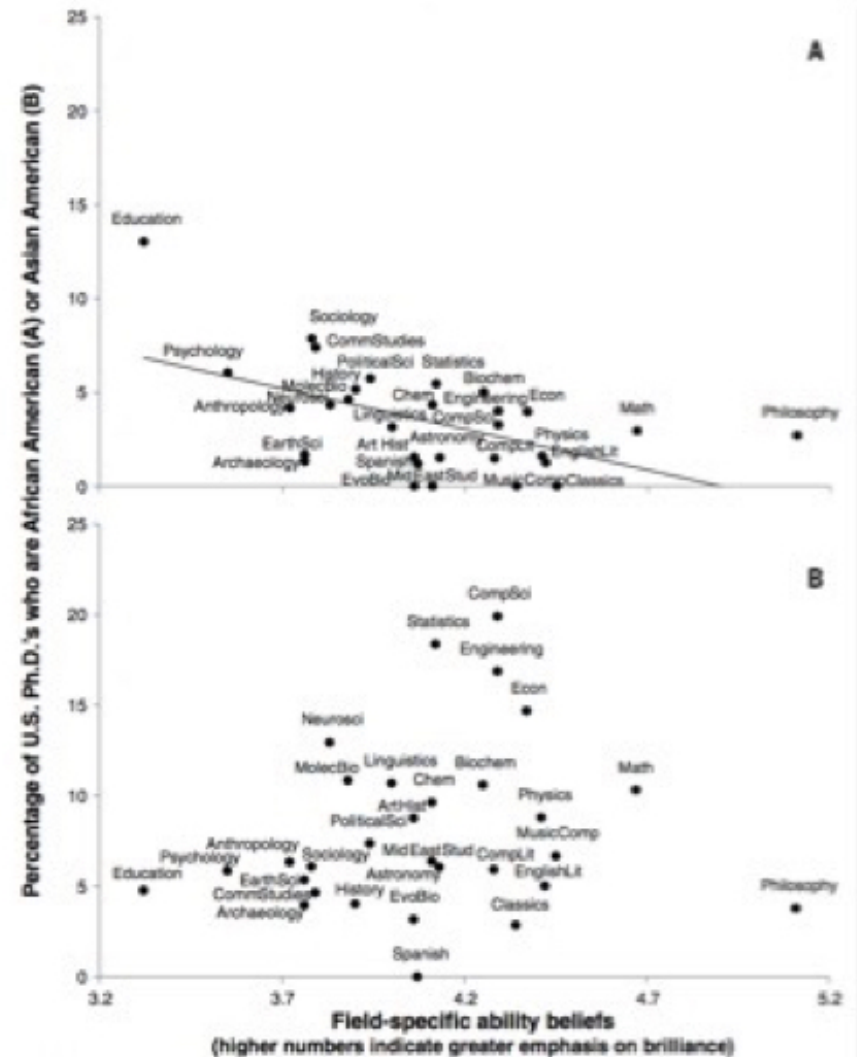


Fig. 2. Field-specific ability beliefs and the percentage of 2011 U.S. Ph.D.'s who are (A) African American and (B) Asian American.

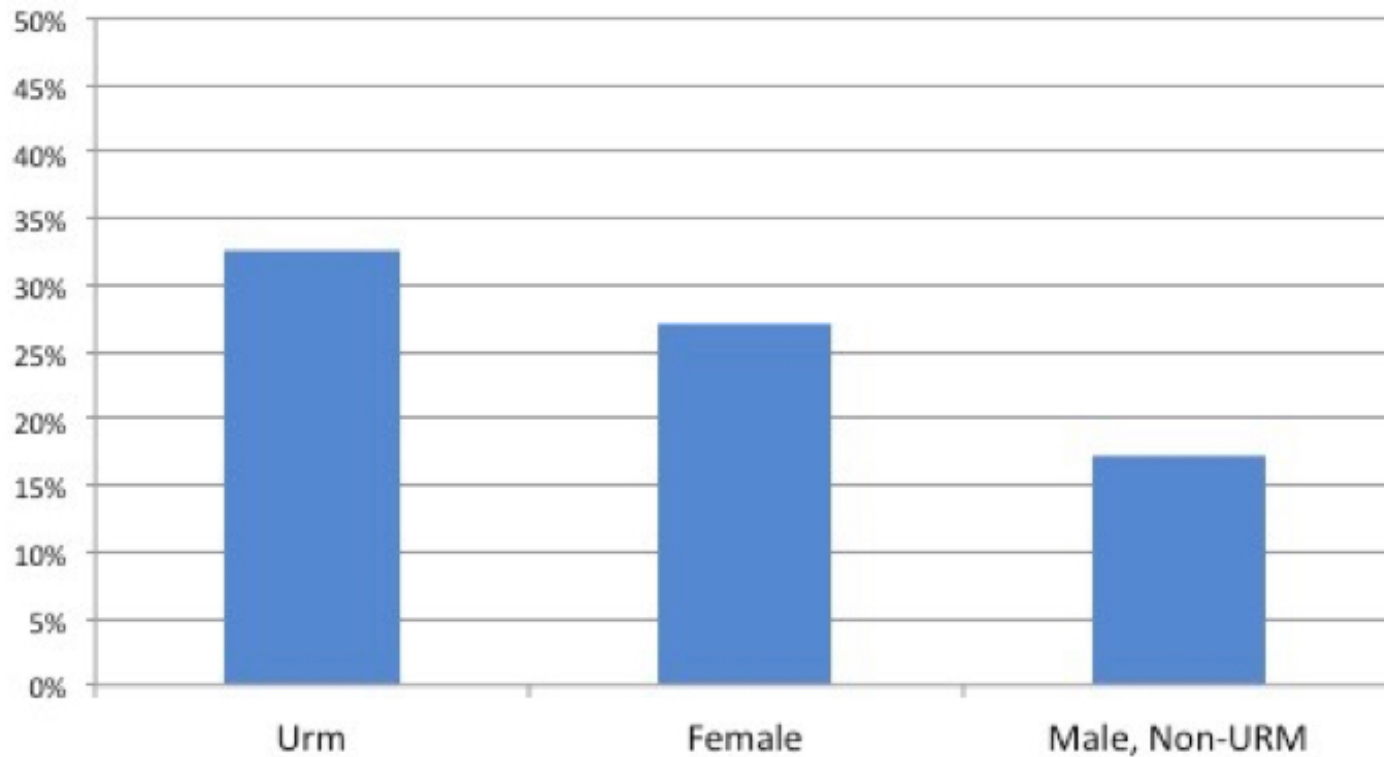
Berkeley Life in Science Survey (BLISS) Study (Winter-Spring 2013)

Mendoza-Denton, Patt, Fisher, Eppig, Young, Smith, & Richards (2017), *PLoS One*

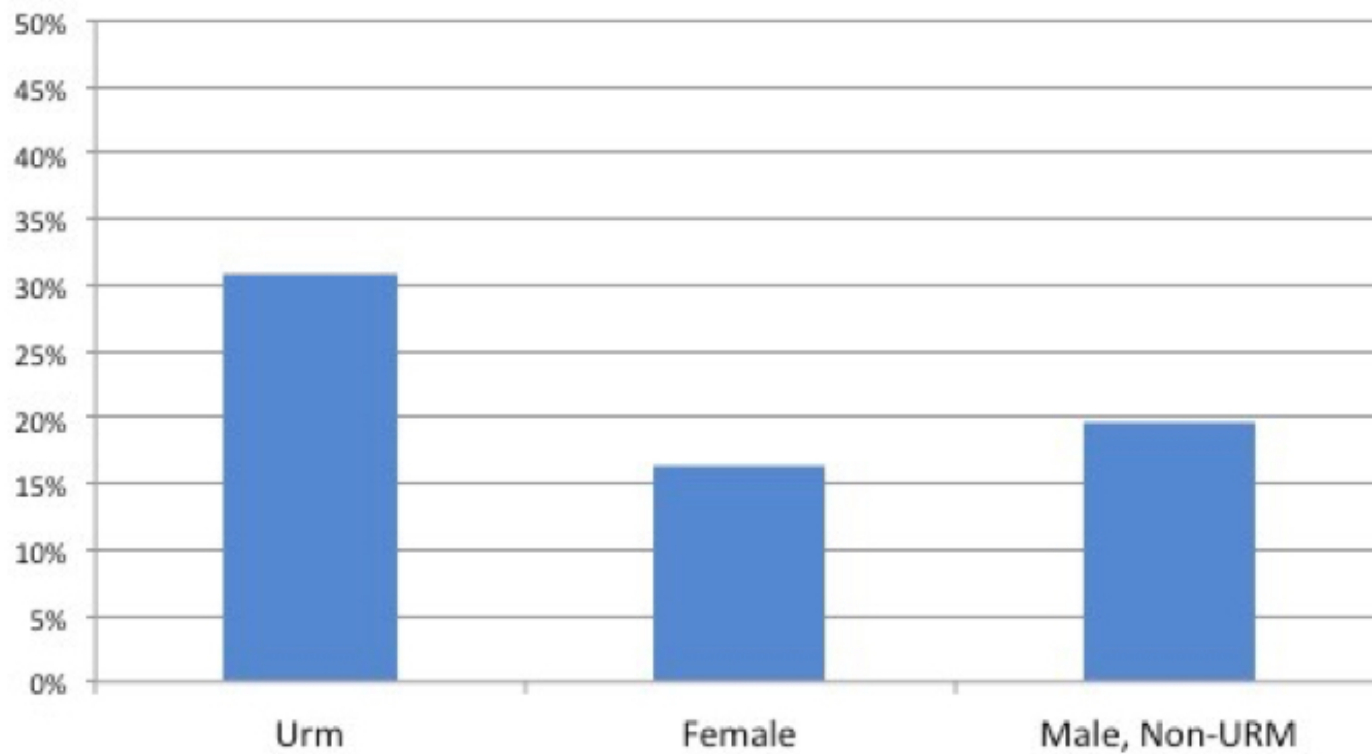
Participation rates (graduate students)

	Total	Completers	Percent
Non-URM men	555	218	39%
Women	383	204	53%
URM	109	55	50%
M&PS	398	165	41%
EECS	234	88	38%
Chemistry	381	199	52%

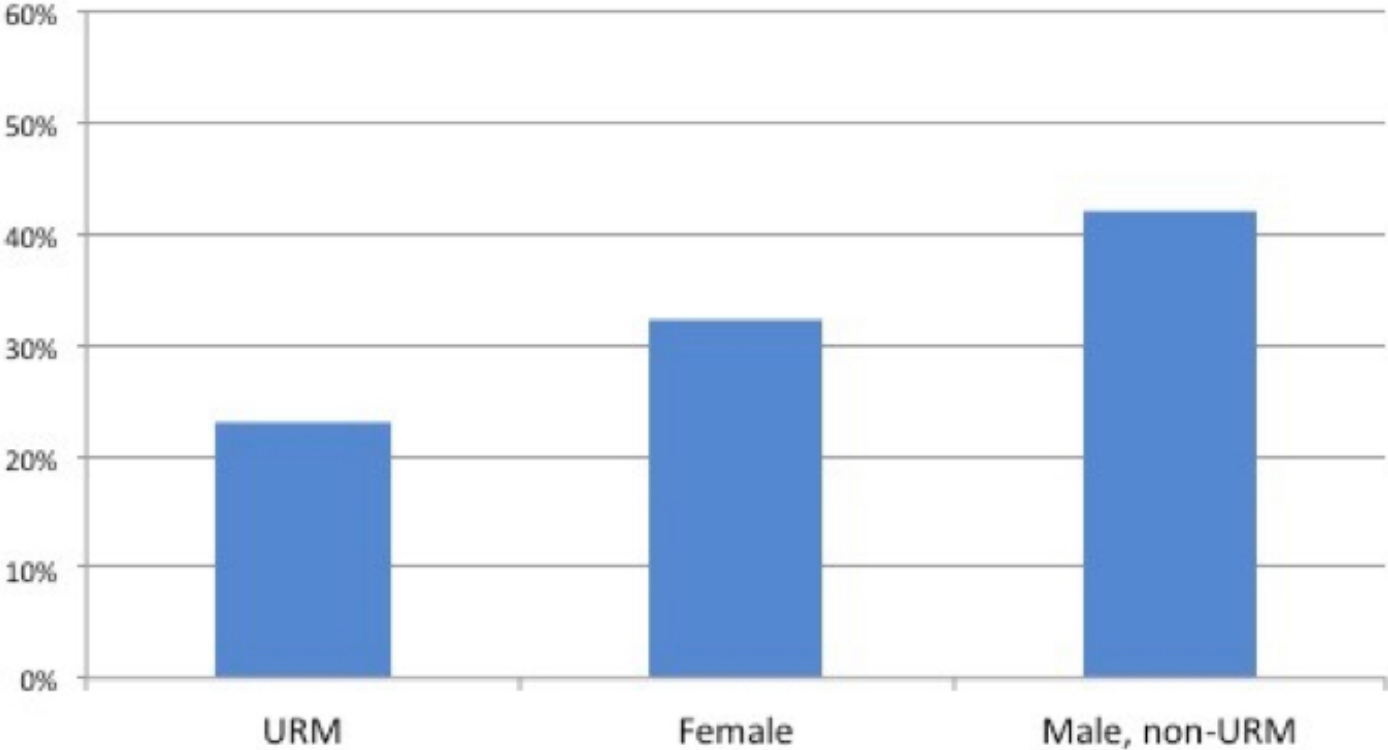
Won a fellowship or grant

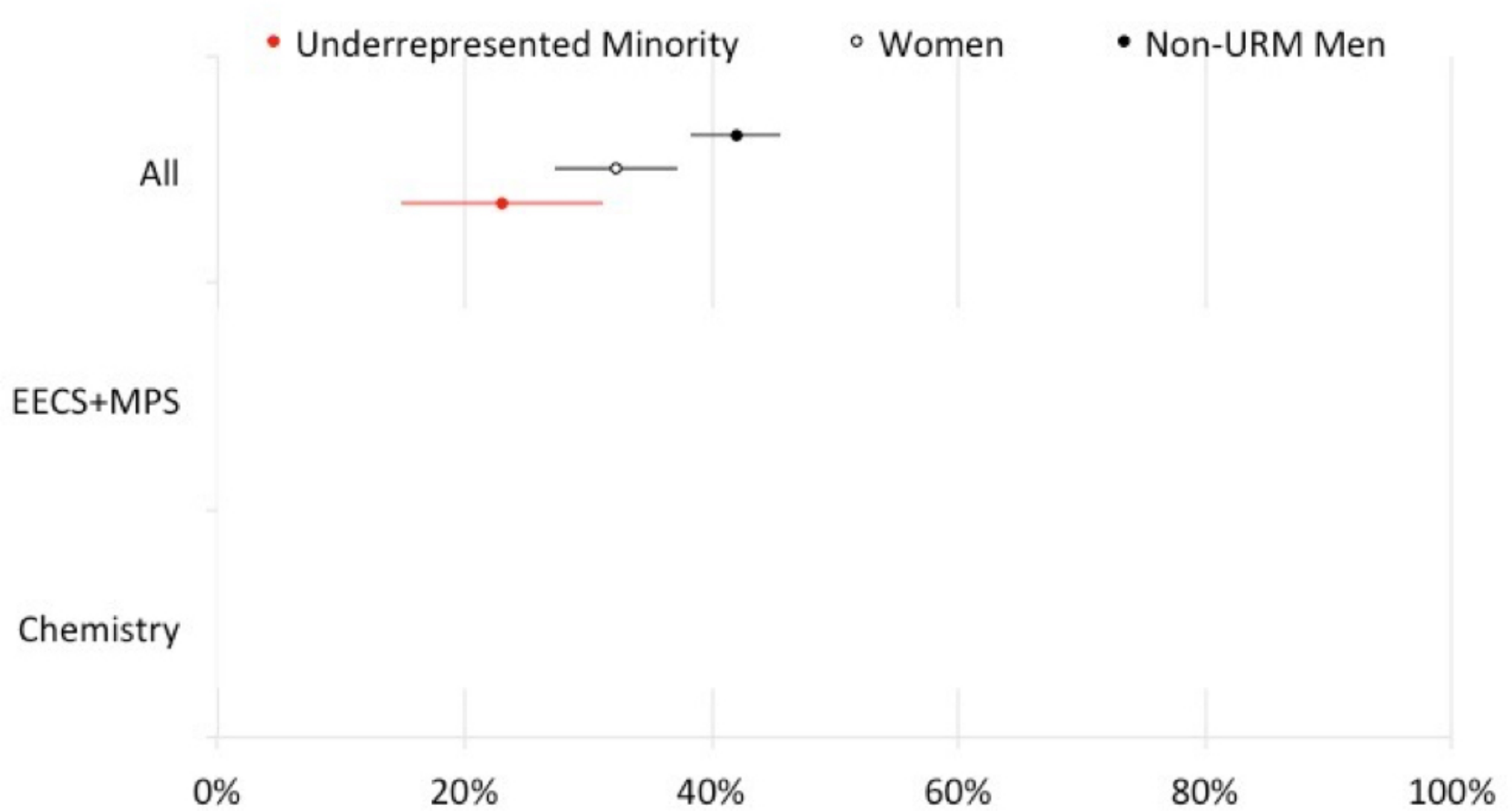


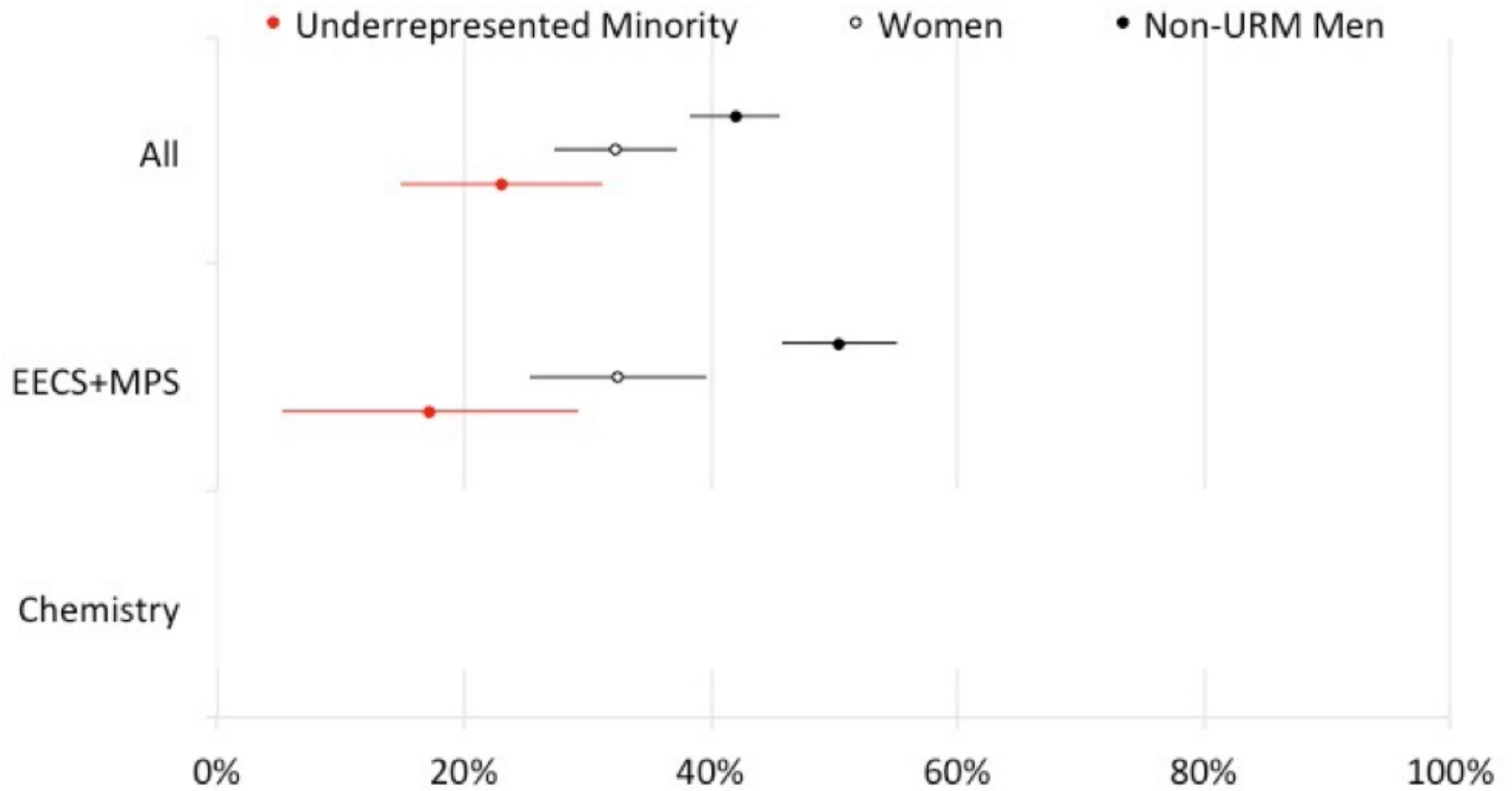
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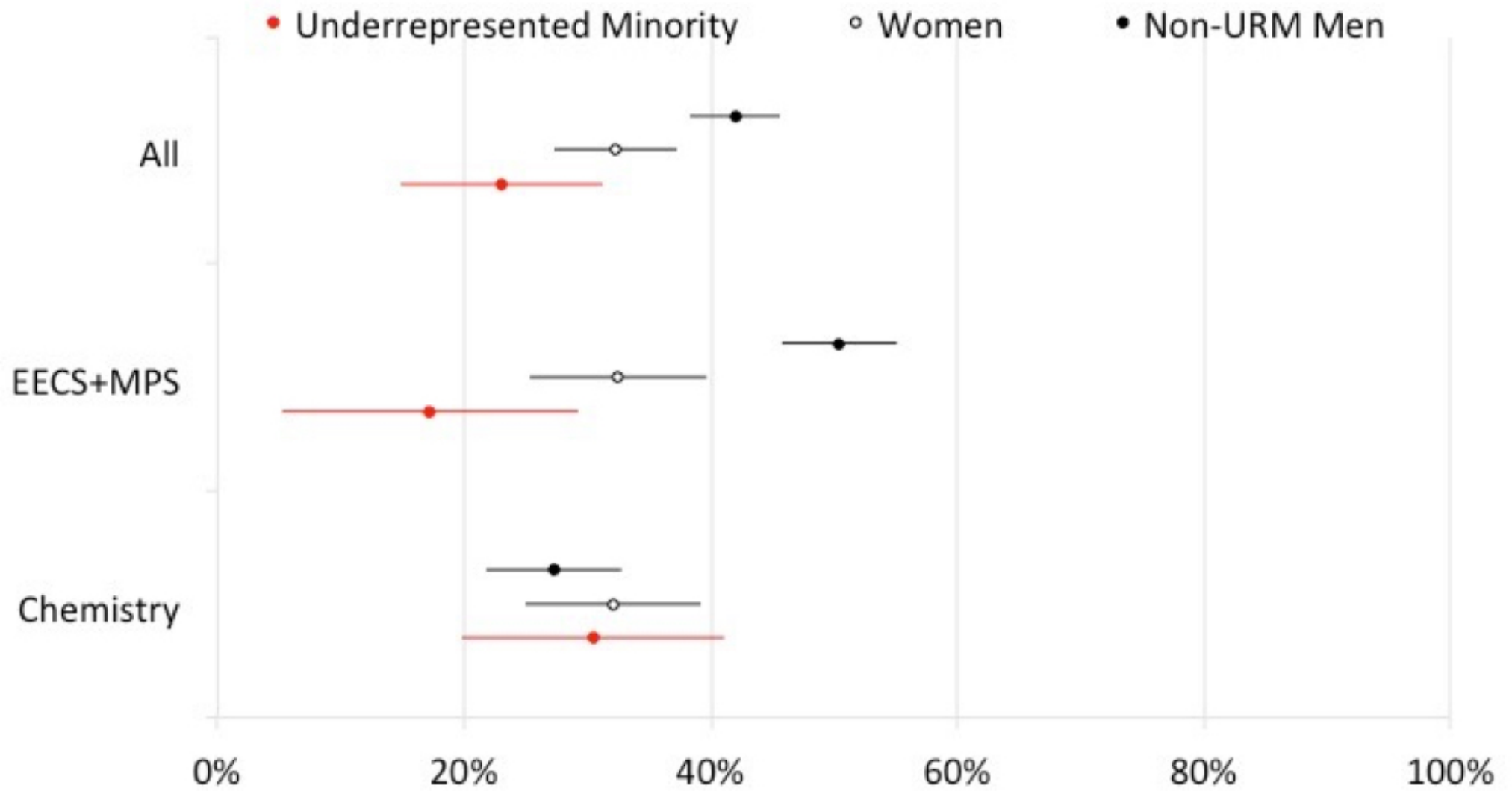


Submitted a Paper for Publication









- Statistical controls:
 - Time in PhD program
 - Research Assistantships
 - Teaching Assistantships
 - Fellowships

- But..
 - Snapshot survey
 - Limited sample

PhD Exit Survey (1998-2003)

Mendoza-Denton, Patt, Fisher, Eppig, Young, Smith, & Richards (2017), *PLoS One*

Respondent Headcount: PhD Exit Survey

Division	Total	Non-URM Men	Women	URM
Bio	1,563	690	812	103
Chemistry	1,273	814	415	66
EECS	692	559	107	22
MPS	1,242	939	244	59
Mathematics	377	298	55	26
Physics	502	408	65	23
All	4,770	3,002	1,578	250

PhD Exit Survey Questions

- “Did you deliver any papers at national scholarly meetings?”
- “Were you encouraged by faculty in your department to publish?”

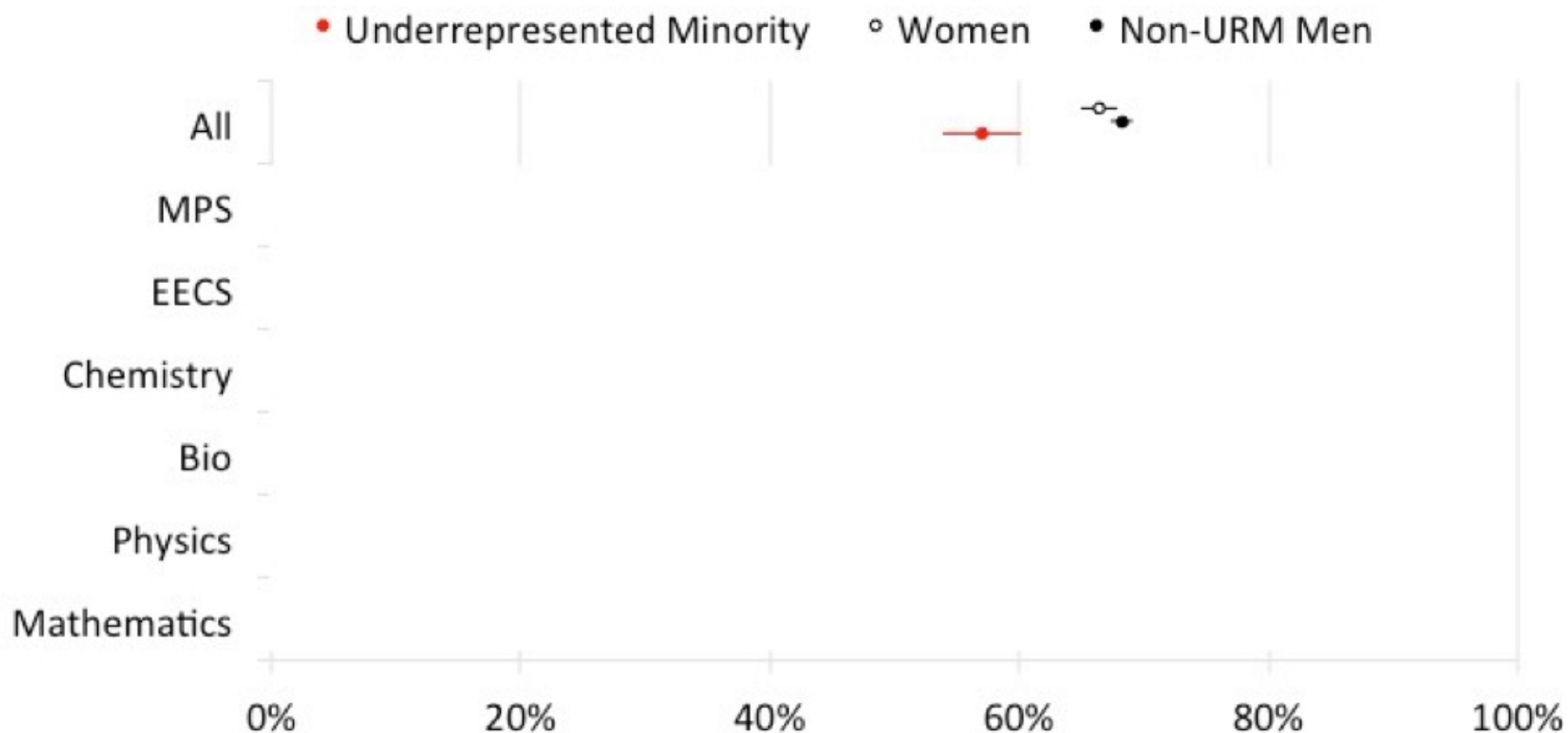
Fig. 2. Papers presented at national scholarly meetings (Ph.D. exit survey). Note: Error bars represent ± 1 SE.

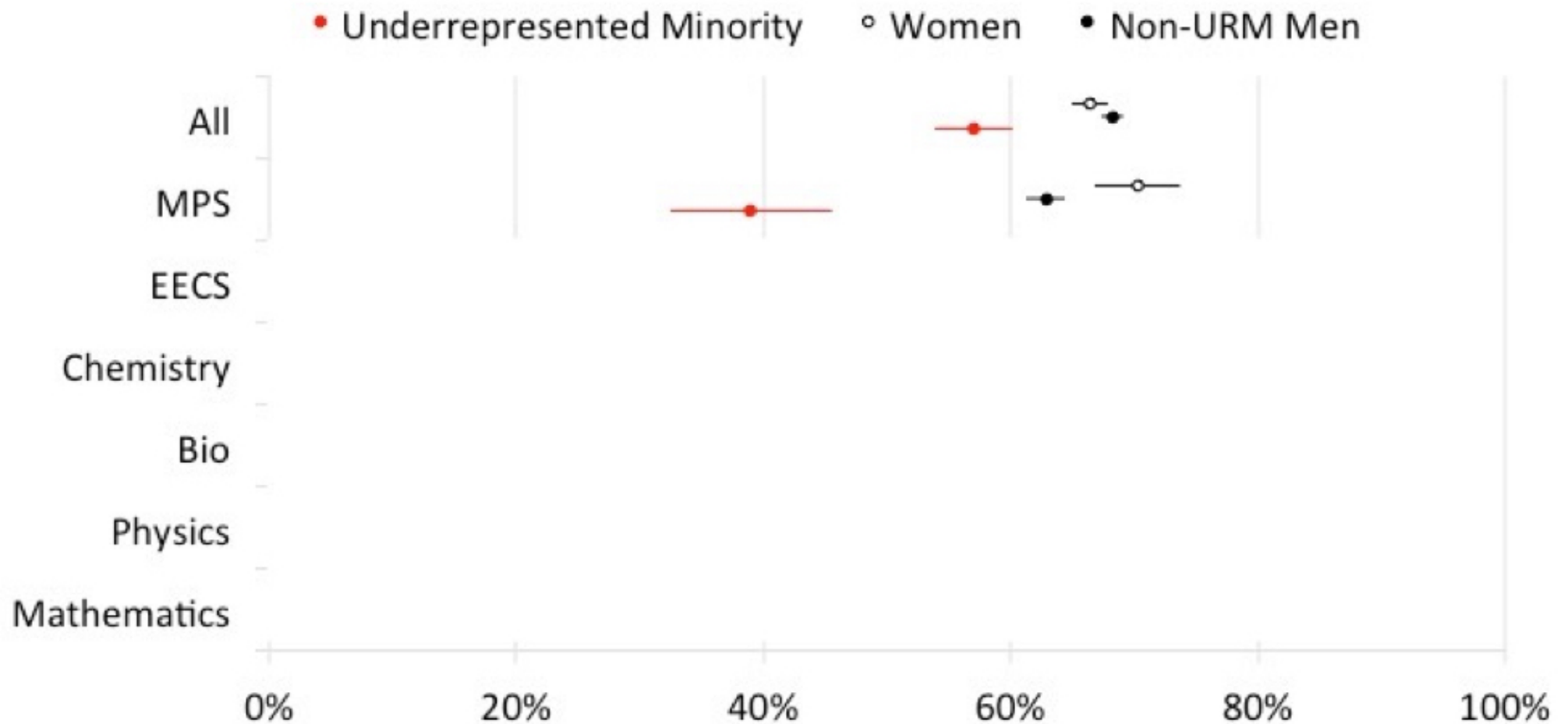
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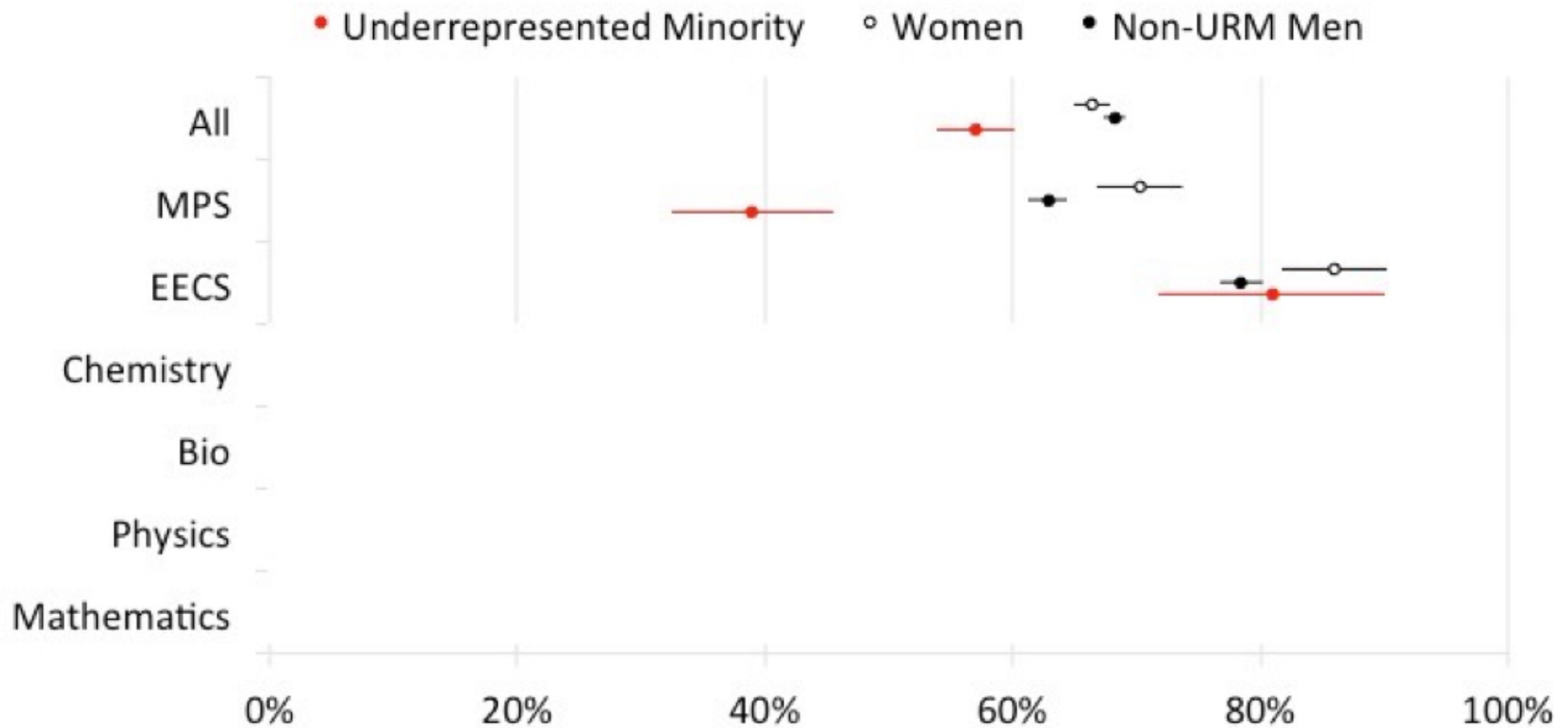
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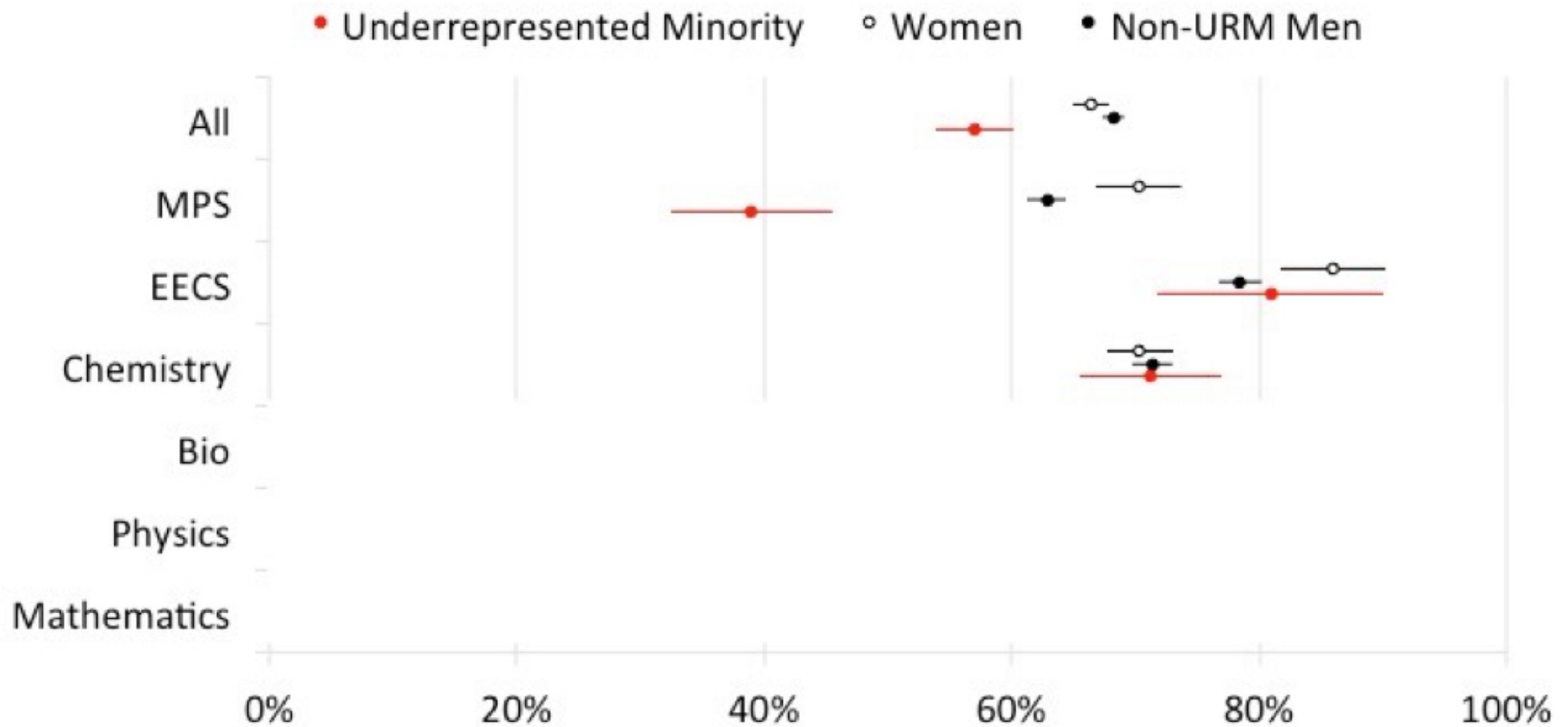
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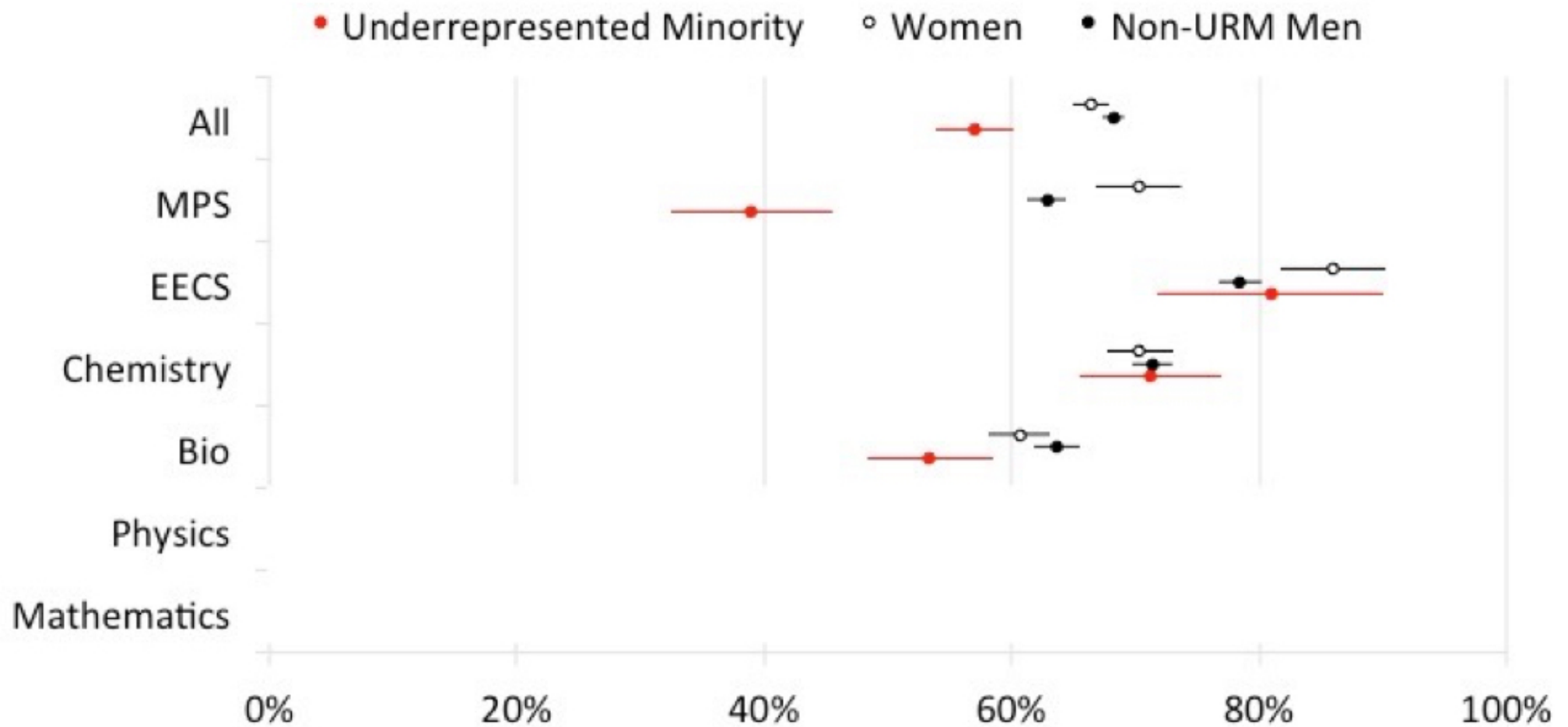
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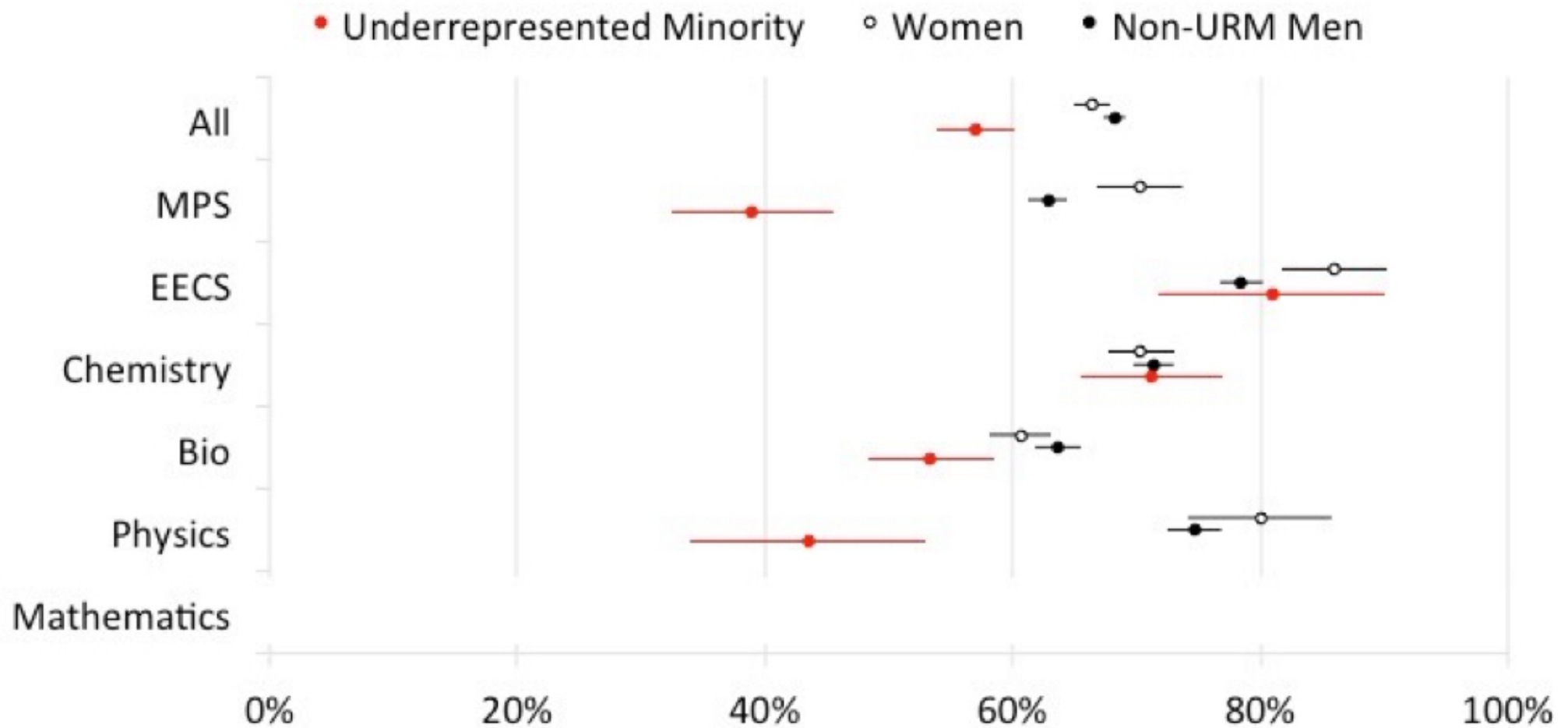
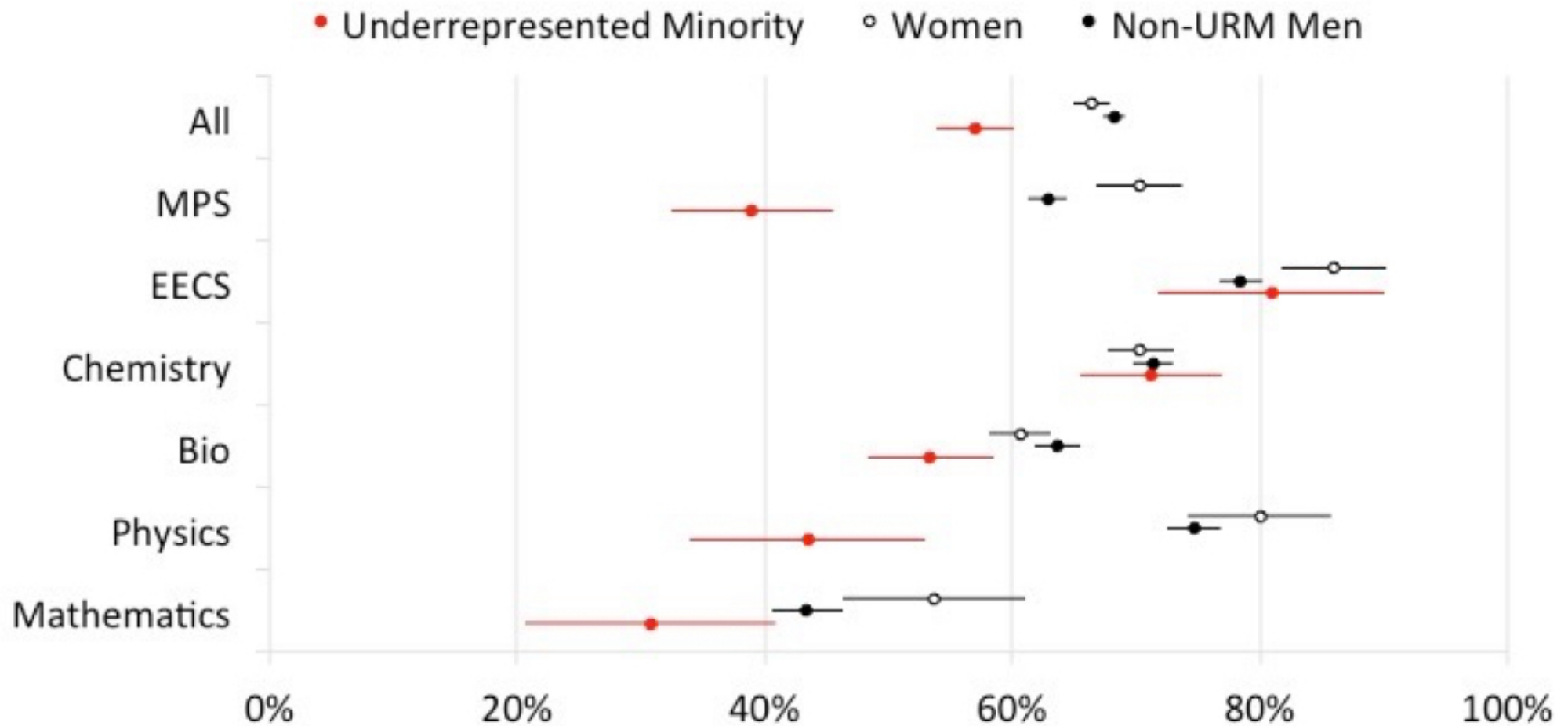
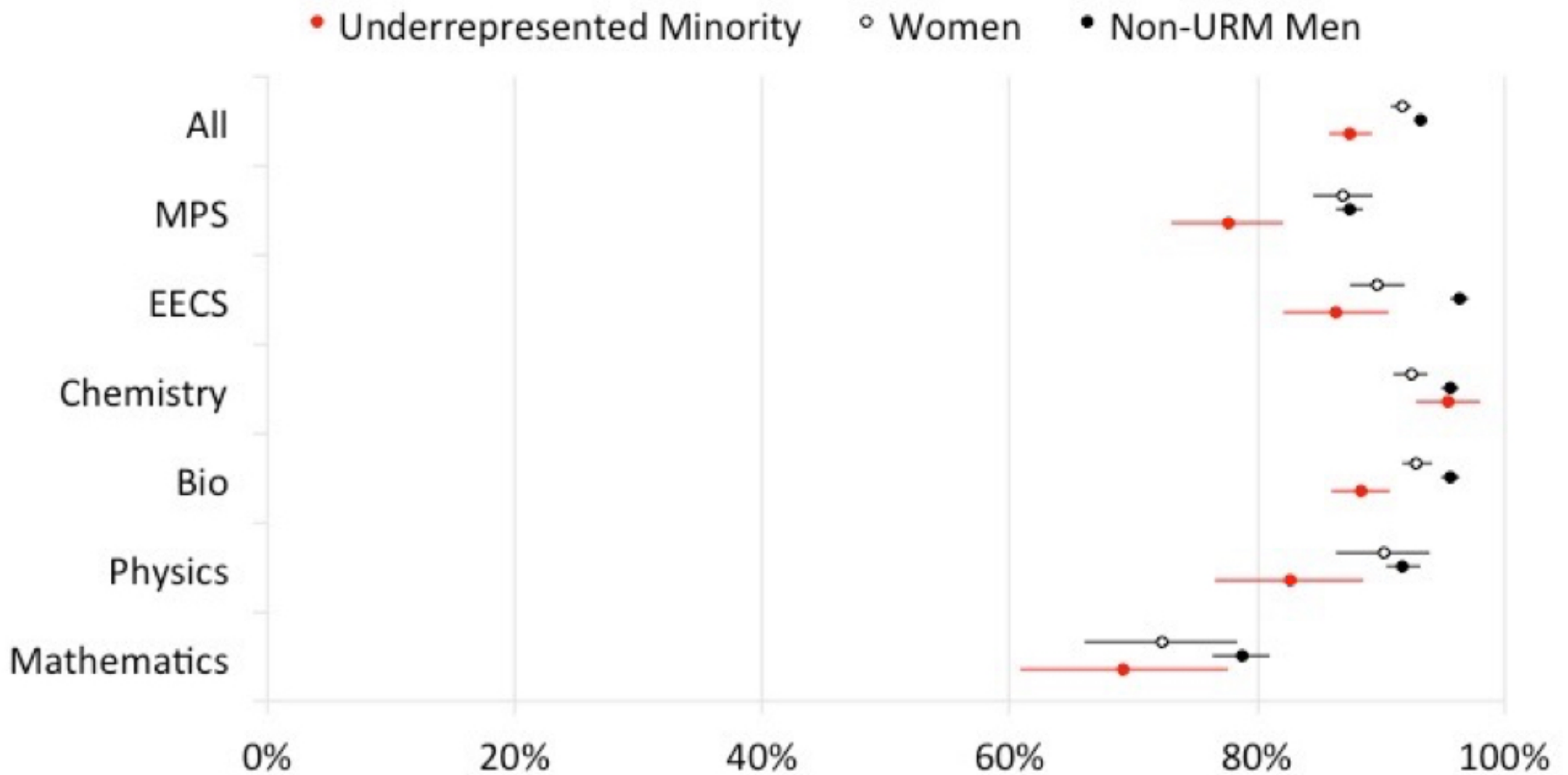
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PhD Exit Survey Questions

- “Did you deliver any papers at national scholarly meetings?”
- “Were you encouraged by faculty in your department to publish?”

Fig. 3. Encouragement by faculty to publish (Ph.D. Exit Survey).



What's happening at Chemistry at Berkeley?

What's happening at Chemistry at Berkeley?

Structure

Please return form to the Graduate Assistant in 419 Latimer Hall.

Please indicate whether you would like this evaluation to become a part of the Graduate Student Record, which is completely accessible to the graduate student. Otherwise this evaluation will be returned to you at the conclusion of the examination. I would like this evaluation to become a part of the Graduate Student Record. Yes / No (circle one)

PRE-QUALIFYING EXAM GRADUATE STUDENT EVALUATION

Student Name:

Research Director:

Please evaluate the above student in the following areas with regard to research capability (a possible scale might be superior, excellent, good, average, below average). Address your comments to the Chair of the Qualifying Exam committee.

Probable Creativity:

Innate Scientific Curiosity and Motivation:

Research Progress to Date:

Technical Ability:

Major Strengths:

Major Weaknesses:

Roughly when would you expect this student to submit a paper for publication?

Please rank this student (from 1.0 to 4.0, 1.0 being "the best") at this stage in their career:

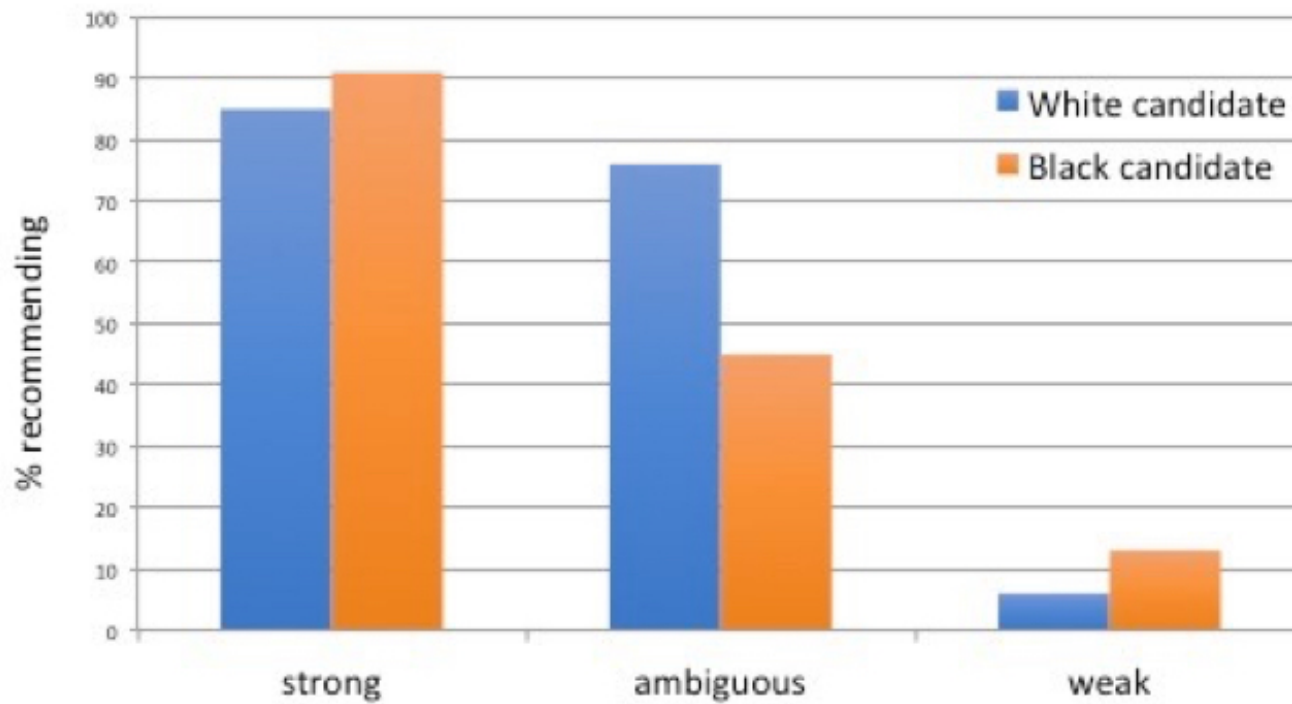
Signature:

Date:

The vague road to publication

- Ambiguity provides fertile ground for the expression of prejudice (Dovidio & Gaertner, 2000)
- Virtually all steps leading to publication involve judging ambiguous stimuli
 - Ideas
 - Methods
 - Findings
 - Writeups

Percentage of people recommending a job candidate for hire based on candidate race and strength of resume



Resume strength

Dovidio & Gaertner, 2000

Science faculty's subtle gender biases favor male students

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Edited* by Shirley Tilghman, Princeton University, Princeton, NJ, and approved August 21, 2012 (received for review July 3, 2012)

Despite efforts to recruit and retain more women, a stark gender disparity persists within academic science. Abundant research has demonstrated gender bias in many demographic groups, but has yet to experimentally investigate whether science faculty exhibit a bias against female students that could contribute to the gender disparity in academic science. In a randomized double-blind study ($n = 127$), science faculty from research-intensive universities rated the application materials of a student—who was randomly assigned either a male or female name—for a laboratory manager position. Faculty participants rated the male applicant as significantly more competent and hireable than the (identical) female applicant. These participants also selected a higher starting salary and offered more career mentoring to the male applicant. The gender of the faculty participants did not affect responses, such that female and male faculty were equally likely to exhibit bias against the female student. Mediation analyses indicated that the female student was less likely to be hired because she was viewed as less competent. We also assessed faculty participants' preexisting subtle bias against women using a standard instrument and found that preexisting subtle bias against women played a moderating role, such that subtle bias against women was associated with less support for the female student, but was unrelated to reactions to the male student. These results suggest that interventions addressing faculty gender bias might advance the goal of increasing the participation of women in science.

diversity | lifestyle choices | science education | science workforce

A 2012 report from the President's Council of Advisors on Science and Technology indicates that training scientists and engineers at current rates will result in a deficit of 1,000,000 workers to meet United States workforce demands over the next decade (1). To help close this formidable gap, the report calls for the increased training and retention of women, who are starkly underrepresented within many fields of science, especially among the professoriate (2–4). Although the proportion of science degrees granted to women has increased (5), there is a persistent disparity between the number of women receiving PhDs and those hired as junior faculty (1–4). This gap suggests that the problem will not resolve itself solely by more generations of women moving through the academic pipeline but that instead, women's advancement within academic science may be actively impeded.

With evidence suggesting that biological sex differences in inherent aptitude for math and science are small or nonexistent (6–8), the efforts of many researchers and academic leaders to identify causes of the science gender disparity have focused instead on the life choices that may compete with women's pursuit of the most demanding positions. Some research suggests that these lifestyle choices (whether free or constrained) likely con-

tribute to the gender disparity in science (9–11), and that it “is not caused by discrimination in these domains” (10). This assertion has received substantial attention and generated significant debate among the scientific community, leading some to conclude that gender discrimination indeed does not exist nor contribute to the gender disparity within academic science (e.g., refs. 12 and 13).

Despite this controversy, experimental research testing for the presence and magnitude of gender discrimination in the biological and physical sciences has yet to be conducted. Although acknowledging that various lifestyle choices likely contribute to the gender imbalance in science (9–11), the present research is unique in investigating whether faculty gender bias exists within academic biological and physical sciences, and whether it might exert an independent effect on the gender disparity as students progress through the pipeline to careers in science. Specifically, the present experiment examined whether, given an equally qualified male and female student, science faculty members would show preferential evaluation and treatment of the male student to work in their laboratory. Although the correlational and related laboratory studies discussed below suggest that such bias is likely (contrary to previous arguments) (9–11), we know of no previous experiments that have tested for faculty bias against female students within academic science.

If faculty express gender biases, we are not suggesting that these biases are intentional or stem from a conscious desire to impede the progress of women in science. Past studies indicate that people's behavior is shaped by implicit or unintended biases, stemming from repeated exposure to pervasive cultural stereotypes (14) that portray women as less competent but simultaneously emphasize their warmth and likeability compared with men (15). Despite significant decreases in overt sexism over the last few decades (particularly among highly educated people) (16), these subtle gender biases are often still held by even the most egalitarian individuals (17), and are exhibited by both men and women (18). Given this body of work, we expected that female faculty would be just as likely as male faculty to express an unintended bias against female undergraduate science students. The fact that these prevalent biases often remain undetected highlights the need for an experimental investigation to determine whether they may be present within academic science and, if so, raise awareness of their potential impact.

Whether these gender biases operate in academic sciences remains an open question. On the one hand, although considerable research demonstrates gender bias in a variety of other domains (19–23), science faculty members may not exhibit this

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National hiring experiments reveal 2:1 faculty preference for women on STEM tenure track

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Edited* by Richard E. Nisbett, University of Michigan, Ann Arbor, MI, and approved March 3, 2015 (received for review September 20, 2014)

National randomized experiments and validation studies were conducted on 873 tenure-track faculty (439 male, 434 female) from biology, engineering, economics, and psychology at 271 universities/colleges from 50 US states and the District of Columbia. In the main experiment, 363 faculty members evaluated narrative summaries describing hypothetical female and male applicants for tenure-track assistant professorships who shared the same lifestyle (e.g., single without children, married with children). Applicants' profiles were systematically varied to disguise identical rated scholarship; profiles were counterbalanced by gender across faculty to enable between-faculty comparisons of hiring preferences for identically qualified women versus men. Results revealed a 2:1 preference for women by faculty of both genders across both math-intensive and non-math-intensive fields, with the single exception of male economists, who showed no gender preference. Results were replicated using weighted analyses to control for national sample characteristics. In follow-up experiments, 144 faculty evaluated competing applicants with differing lifestyles (e.g., divorced mother vs. married father), and 204 faculty compared same-gender candidates with children, but differing in whether they took 1-y-parental leaves in graduate school. Women preferred divorced mothers to married fathers; men preferred mothers who took leaves to mothers who did not. In two validation studies, 35 engineering faculty provided rankings using full curricula vitae instead of narratives, and 127 faculty rated one applicant rather than choosing from a mixed-gender group; the same preference for women was shown by faculty of both genders. These results suggest it is a propitious time for women launching careers in academic science. Messages to the contrary may discourage women from applying for STEM (science, technology, engineering, mathematics) tenure-track assistant professorships.

gender bias | hiring bias | underrepresentation of women | faculty hiring | women in science

Women considering careers in academic science confront stark portrayals of the treacherous journey to becoming professors. Well-publicized research depicts a thicket of obstacles standing between female graduate students and tenure-track positions, including inadequate mentoring and networking (1); a chilly social climate (2); downgrading of work products such as manuscripts (3), grant proposals (4), and lectures (5); and gender bias in interviewing and hiring (6–9). Numerous blue ribbon panels and national reports have concluded that implicit, and sometimes explicit, attitudes pervade the hiring process and negatively influence evaluations of female candidates and their scholarship, contributing to women's underrepresentation within the academy (e.g., refs. 10–13).

Women's underrepresentation in academic science is hardly trivial. In life and social sciences, women now earn the majority of doctorates, but they make up a minority of assistant professors. In 1993–1995, 28.4% of assistant professors were women, but 41.6% of Ph.D.s awarded in the same cohort went to

controlling for demographics, degree characteristics, and field (15). [This winnowing of women in the STEM (science, technology, engineering, mathematics) tenure-track pipeline is a result of women Ph.D.s being far less likely than men to apply for tenure-track jobs, rather than to women applying but being rejected at higher rates than men (14).] Against this bleak backdrop, it is perhaps no surprise that talented young women opt out of the STEM tenure track either by not applying for assistant professorships at the same rate as men or, in some fields, by not majoring in them in college in the first place (14).

The point at which scientists choose to apply for tenure-track assistant professorships is a key juncture in understanding the problem of women's underrepresentation. Once hired, women prosper in the STEM professoriate (14, 16–18): They are remunerated, persist, and are promoted at rates roughly comparable to men's (14) after controlling for observable characteristics, including academic productivity. However, to be hired and eventually tenured, women must first apply. Unfortunately, despite their success once hired, women apply for tenure-track positions in far smaller percentages than their male graduate student counterparts (14, 16, 18). Why might this be?

One reason may be omnipresent discouraging messages about sexism in hiring, but does current evidence support such messages? Despite this question's centrality to any informed discussion about women's underrepresentation in academic science, only one experimental study (7) contrasted faculty ratings of the relative "hireability" of hypothetical identically qualified women and men. Results showed that both female and male psychology faculty members downgraded a hypothetical woman's academic record compared with an identical man's. However, this study

Significance

The underrepresentation of women in academic science is typically attributed, both in scientific literature and in the media, to sexist hiring. Here we report five hiring experiments in which faculty evaluated hypothetical female and male applicants, using systematically varied profiles disguising identical scholarship, for assistant professorships in biology, engineering, economics, and psychology. Contrary to prevailing assumptions, men and women faculty members from all four fields preferred female applicants 2:1 over identically qualified males with matching lifestyles (single, married, divorced), with the exception of male economists, who showed no gender preference. Comparing different lifestyles revealed that women preferred divorced mothers to married fathers and that men preferred mothers who took parental leaves to mothers who did not. Our findings, supported by real-world academic hiring data, suggest advantages for women launching academic science careers.

Author contributions: W.M.W. and S.J.C. designed research, performed research, analyzed data, and wrote the paper.

The authors declare no conflict of interest.

Investors prefer entrepreneurial ventures pitched by attractive men

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Entrepreneurship is a central path to job creation, economic growth, and prosperity. In the earliest stages of start-up business creation, the matching of entrepreneurial ventures to investors is critically important. The entrepreneur's business proposition and previous experience are regarded as the main criteria for investment decisions. Our research, however, documents other critical criteria that investors use to make these decisions: the gender and physical attractiveness of the entrepreneurs themselves. Across a field setting (three entrepreneurial pitch competitions in the United States) and two experiments, we identify a profound and consistent gender gap in entrepreneur persuasiveness. Investors prefer pitches presented by male entrepreneurs compared with pitches made by female entrepreneurs, even when the content of the pitch is the same. This effect is moderated by male physical attractiveness: attractive males were particularly persuasive, whereas physical attractiveness did not matter among female entrepreneurs.

Physical appearance | persuasion

Entrepreneurship, the creation and construction of new-to-the-world ventures by individuals and small teams, is a critical activity in modern economies (1). Although new ventures of all types have a role in the economy, the formation of high-potential, innovation-driven ventures is widely regarded as a central path to job creation (1), economic growth, and prosperity (2–4). For example, entrepreneurial start-up ventures contribute almost 20% of new job creation annually in the United States.

In the earliest stages of start-up business creation, the matching of entrepreneurial ventures to investors is important because new businesses need funding to survive, and high-potential ventures need capital to grow and succeed (5, 6). The fundamentals of the entrepreneur's business proposition and the previous experiences of the entrepreneurs themselves are regarded as the main criteria for investment decisions (7, 8). Our research, however, documents other criteria that investors use to make these decisions: the gender and physical attractiveness of the entrepreneurs themselves.

Around the world, there are more male entrepreneurs than female entrepreneurs, with total entrepreneurial activity led by men in the vast majority of countries (9). In the United States, men engage in entrepreneurial activity at almost twice the rate of women (10). Among high-growth-potential ventures, only 11% of US firms with venture-capital backing, past and present, have been founded or led by women (11), and women-led ventures have received only 7% of all venture funds (12).

The gender imbalance in entrepreneurship has been attributed to a persistent incongruence between personality attributes ascribed to women and personality attributes ascribed to entrepreneurs (13, 14). This perceived lack of fit makes women less likely to pursue and to be selected for male gender-typical roles such as that of entrepreneur (15, 16). Consistent with more

Although the gender imbalance is undesirable and challenging for female entrepreneurs, it remains unclear whether the gender imbalance is due to irrational investor behavior. If male entrepreneurs are inherently more talented or more likely to be at an advantage throughout their ventures or throughout their careers, then the gender gap in entrepreneurship may result from rational statistical discrimination by investors. In the same way that participants in the classic Keynesian beauty contest game were asked to choose the most popular (rather than the most beautiful) contestant, investors may rationally seek to invest in male-led ventures that other investors and future customers are most likely to prefer.

Across the broad landscape of entrepreneurial ventures, it is unclear whether men outperform women. Some prior work has found that, compared with men, women are likely to have fewer employees, lower growth projections, and lower levels of internationalization (9). On the other hand, recent work using 15 y of panel data from the Standard & Poor's Financial Services 1,500 firms suggests that female managers improve overall firm performance by bringing informational and social diversity benefits to the management team, curbing the behaviors exhibited by managers throughout the firm, and motivating lower-status women in the firm (26).

Answering the question about gender and entrepreneurial performance has been limited by two main challenges (26, 30). First, male- and female-led ventures tend to focus on different types of market opportunities with differing levels of underlying growth potential. Male entrepreneurs tend to pursue ventures across a broad spectrum of industries, whereas female entrepreneurs have predominantly pursued ventures that focus on the female consumer, such as fashion, cosmetics, and stocking. Notable examples of female-founded, female-focused companies include May Kay Inc., Estee Lauder Companies, Chanel S.A.,

Significance

We identify a profound and consistent gender gap in entrepreneurship, a central path to job creation, economic growth, and prosperity. Across a field setting (three entrepreneurial pitch competitions in the United States) and two controlled experiments, we find that investors prefer entrepreneurial pitches presented by male entrepreneurs compared with pitches presented by female entrepreneurs, even when the content of the pitch is the same. This effect is moderated by male physical attractiveness: attractive males are particularly persuasive, whereas physical attractiveness does not matter among female entrepreneurs. These findings fundamentally advance the science related to gender, physical attractiveness, psychological persuasion, bias, role expectations, and entrepreneurship.

Author contributions: A.W.B., L.H., S.W.K., and F.E.M. designed research; A.W.B., L.H., and S.W.K. performed research; A.W.B., L.H., and S.W.K. analyzed data; and A.W.B., L.H., S.W.K., and F.E.M. wrote the paper.

Female hurricanes are deadlier than male hurricanes

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Do people judge hurricane risks in the context of gender-based expectations? We use more than six decades of death rates from US hurricanes to show that feminine-named hurricanes cause significantly more deaths than do masculine-named hurricanes. Laboratory experiments indicate that this is because hurricane names lead to gender-based expectations about severity and this, in turn, guides respondents' preparedness to take protective action. This finding indicates an unfortunate and unintended consequence of the gendered naming of hurricanes, with important implications for policymakers, media practitioners, and the general public concerning hurricane communication and preparedness.

gender stereotypes | implicit bias | risk perception | natural hazard communication | bounded rationality

Estimates suggest that hurricanes kill more than 200 people in the United States annually, and severe hurricanes can cause fatalities in the thousands (1). As the global climate changes, the frequency and severity of such storms is expected to increase (2). However, motivating hurricane preparedness remains a major challenge for local and state authorities (3). Although natural hazards such as hurricanes represent both physical and social phenomena (4, 5), meteorologists and geoscientists point out that too little attention has been paid to findings from the social sciences about subjective risk perceptions (6, 7). Those findings highlight the importance of understanding how assessments of risk from threats in the environment are often influenced not only by environmental and social cues (8, 9), but also by irrelevant psychological factors (10–12).

We demonstrate that a natural disaster can, merely by being symbolically associated with a given sex through its assigned name, be judged in ways congruent with the corresponding social roles and expectations of that sex (13–16). In particular, analyses of archival data on actual fatalities caused by hurricanes in the United States (1950–2012) indicate that severe hurricanes with feminine names are associated with significantly higher death rates. An explanation for this unexpected finding is tested in six experiments. These experiments show that gender-congruent perceptions of intensity and strength are responsible for male-named hurricanes being perceived as riskier and more intense than female-named hurricanes. These findings have important implications for hurricane preparedness and public safety.

US hurricanes used to be given only female names, a practice that meteorologists of a different era considered appropriate due to such characteristics of hurricanes as unpredictability (17). This practice came to an end in the late 1970s with increasing societal awareness of sexism, and an alternating male-female naming system was adopted (17). Even though the gender of hurricanes is now preassigned and arbitrary, the question remains: do people judge hurricane risks in the context of gender-based expectations?

Research shows that women and men are socialized to have different social roles and self-schemas, in turn generating descriptive and prescriptive expectancies about women and men

violence and destruction (23, 24). We extend these findings to hypothesize that the anticipated severity of a hurricane with a masculine name (Victor) will be greater than that of a hurricane with a feminine name (Victoria). This expectation, in turn, will affect the protective actions that people take. As a result, a hurricane with a feminine vs. masculine name will lead to less protective action and more fatalities.

Archival Study

To test this hypothesis, we used archival data on actual fatalities caused by hurricanes in the United States (1950–2012). Ninety-four Atlantic hurricanes made landfall in the United States during this period (25). Nine independent coders who were blind to the hypothesis rated the masculinity vs. femininity of historical hurricane names on two items (1 = very masculine, 11 = very feminine, and 1 = very man-like, 11 = very woman-like), which were averaged to compute a masculinity-femininity index (MFI). A series of negative binomial regression analyses (26, 27) were performed to investigate effects of perceived masculinity-femininity of hurricane names (MFI), minimum pressure, normalized damage (NDAM) (28), and the interactions among them on the number of deaths caused by the hurricanes (see Materials and Methods for complete descriptions of models tested, Table S1 for descriptive statistics, and Table S2 for a statistical summary of models tested. See the full Dataset S1 available online.)

The analyses showed that the change in hurricane fatalities as a function of MFI was marginal for hurricanes lower in normalized damage, indicating no effect of masculinity-femininity of name for less severe storms. For hurricanes higher in normalized damage, however, this change was substantial, such that hurricanes with feminine names were much deadlier than those

Significance

Meteorologists and geoscientists have called for greater consideration of social science factors that predict responses to natural hazards. We answer this call by highlighting the influence of an unexplored social factor, gender-based expectations, on the human toll of hurricanes that are assigned gendered names. Feminine-named hurricanes (vs. masculine-named hurricanes) cause significantly more deaths, apparently because they lead to lower perceived risk and consequently less preparedness. Using names such as Eloise or Charlie for referencing hurricanes has been thought by meteorologists to enhance the clarity and recall of storm information. We show that this practice also taps into well-developed and widely held gender stereotypes, with potentially deadly consequences. Implications are discussed for understanding and shaping human responses to natural hazard warnings.

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