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Recognition through awards: a source of gender inequality in science?

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ABSTRACT
Drawing from Acker's gendered organizations perspective, this study analyzes the gender distribution of research and non-research awards in STEM (Science, Technology, Engineering, Mathematics) colleges at a mid-size public doctoral university in the western U.S. This analysis is complemented with a faculty survey (2016) elucidating faculty perceptions of the nomination process and their standing within their department and college. Despite an increase in the number of women among STEM faculty over time, women remain underrepresented among research award recipients, especially at the university level. The ratio of research to non-research awards for men is 3 to 6 times that of women faculty. Differences in productivity cannot be invoked as a mechanism for this gendered awards distribution. Women report being overlooked in the nomination process for all awards. This study suggests that the nomination and selection processes put women at an evaluative disadvantage with respect to high-status research awards. Social proximity tends to neutralize some of the evaluation bias at the college level.

KEYWORDS
academic STEM, gendered organizations, bias, awards, glass ceiling, status

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INTRODUCTION

Women have entered careers in academic STEM (Science, Technology, Engineering, Mathematics) disciplines in increasing numbers since the 1980s (Burelli, 2008), yet remain underrepresented at senior ranks (Long & Fox, 1995; Mason, Wolfinger & Goulden, 2013; Valian, 1999). Women in STEM encounter male-dominated work environments marked by intense competition for and uneven distribution of available scientific resources (Preston, 1995), and a pronounced "winner-take-all" ethos based on reputation and prestige of institutions and individual faculty (Frank & Cook, 1995). Women scientists advance more slowly than men (Long & Fox, 1995; Mason *et al.*, 2013; Valian, 1999) and leave science at double the rates of their male colleagues (Preston, 1995). Scholars continue to debate the causes for these phenomena. This study explores the gendered distribution of awards over time at a mid-size public doctoral university in the western U.S. and investigates whether recognition through awards is a source of gender inequality in career attainment.

Some scholars attribute the declining representation of women up the academic STEM ladder to supply-side factors, positing that academia is meritocratic and unequal career attainment between men and women largely reflects personal traits or choices (Ceci & Williams, 2011; Ceci, Ginther, Kahn, & Williams, 2014). This is without considering the institutional context or structural barriers that may impact the productivity, visibility of accomplishments, or relative career success of women. An alternative perspective focuses on gendered organizational practices (Acker, 1990; Acker, 2006), especially in the assessment of scientific achievement, that systematically disadvantage women relative to their male counterparts (Valian, 1999). Some scholars argue that the construction of academic excellence – key in the definition of success and critical for career advancement within academic institutions that espouse objectivity, gender neutrality and meritocracy – masks a complex structure of interconnected processes that are highly gendered and infused with subjectivity (Coate & Howson, 2016; Roos & Gatta, 2009; van den Brink & Benschop, 2011).

Visibility and reputation – based on the perception of others not necessarily reflecting objective measures of skill or productivity by the individual – frequently emerge as cornerstones in the construction of excellence (e.g., Fox & Colatrella, 2006; van den Brink & Benschop, 2011). The bestowing of awards is one mechanism that signals status and prestige within the scientific community. Granting and receipt of awards have potentially significant career consequences, as a positive feedback exists between recognition, resource access, and future productivity (Zuckerman, 1996; DiPrete & Eirich, 2006). While there is a significant body of literature concerning gender inequality in the material rewards systems within organizations outside academia (e.g., wages, promotion) that influence professional status and career advancement (e.g., Abendroth, Melzer, Kalev, & Tomaskovic-Devey, 2017; Hultin & Szulkin, 2003; Tomaskovic-Devey & Skaggs, 2002), awards are, for the most part, intended as symbolic tokens. Bourdieu (1988; 1989) posits that academics wield very little economic power and the world of science and academia – more so than society at large – presents itself as a symbolic system of difference, derived from prestige and status (Bourdieu, 1988). Merton (1973) similarly argues that science as a social institution utilizes an elaborate reward system for varying grades of scientific performance that invariably creates prestige strata of scientists. The very notion of an upper stratum is inherently restrictive and exclusionary, such that some with the prerequisite scientific credentials may nevertheless be excluded from recognition and elite status. This selectivity of awards recognition and the inequality that may arise in the nomination and allocation process, can thus stifle the upward career mobility of low-status individuals; either directly, when it is used as a metric of excellence (van den Brink & Benschop, 2011); or indirectly, when it results in uneven access to resources (Zuckerman, 1996; DiPrete & Eirich, 2006) that underpin research output and thus suitability for promotion or career advancement.

Only within the last decade have scholars begun to analyze the role of gender bias in formal recognition within discipline-specific professional STEM societies (Holmes *et al.* 2011; Lincoln, Pincus, & Leboy 2011; Lincoln, Pincus, Koster, & Leboy, 2012; Popejoy & Leboy, 2012; Popejoy, Leboy, Crowley, & Cook, 2011). This empirical research suggests that in the absence of structured guidelines, national awards committees tend to access gender stereotypes such that men are considered inherently more competent, high-status and deserving of praise for their scientific accomplishments (e.g., research), while women are rewarded for activities that are congruent with feminine nurturing and care labor (e.g., teaching, mentoring and service). Comparatively, little or no information is available on the internal awards process within academic institutions. While some posit that gender bias may influence faculty recognition as well, very few studies have documented this empirically.

Substantial evidence suggests that women in STEM face a number of barriers that limit their visibility and recognition in academia (e.g., Cech & Blair-Loy, 2010; Coate & Howson 2016; Dutt, Pfaff, Bernstein, Dillard, & Block, 2016; Valian, 1999). Scholarship on institutional climate and leadership finds that these barriers can be most acute in academics' home institutions (e.g., Callister, 2006; Van Miegroet, Glass, Callister, & Sullivan, 2019). However, within the scholarship on institutional climate, very few scholars have analyzed awards recognition specifically. The current study aims to build upon this scholarship by focusing on awards processes and outcomes at a single institution. Specifically, this study combines quantitative institution-level awards data with a faculty survey into perceptions of individual productivity and institutional practices, to assess whether gender gaps emerge in the awards process. We intend to answer the following research questions: (1) do women receive proportionally fewer awards than their male colleagues? (2) are there gender differences in the type of awards granted? and (3) what factors account for these potential differences? Specifically, do women receive proportionally more awards in recognition of (lower-status) non-research activities and fewer awards for highly valued research accomplishments, while men are more dominant as recipients of research awards? Survey responses of tenured faculty are further used to elucidate the factors and underlying mechanisms that drive these disparities.

This study is novel in that it focuses on the awards process within a single university and will provide empirical verification of patterns observed at the national level within STEM organizations. This analysis will advance the field of gender inequality in academia by unpacking one specific aspect in the construction of excellence that lies outside the control of the recipient. It intends to make visible institutional patterns in the recognition of success and achievement, which are typically construed as positive acts, yet by their selective and exclusive nature, advantage some while disadvantaging others. Ultimately, this process can affect career success in divergent ways. This study can thus inform changes in institutional practices at other institutions that foster greater gender equality and create a supportive work environment for a diverse faculty corps.

LITERATURE REVIEW

Status & Prestige Hierarchies in Science

The world of scholarly and intellectual pursuits essentially functions as a prestige economy that is highly stratified. Rather than economic power, reputation and prestige are the coin of the realm, and the uneven distribution of symbolic capital creates and maintains a class of high-status elites whose reputation as valuable and distinct is produced and reproduced through the perception of others (Bourdieu 1988; 1989). Status and rank imparts greater weight to their judgments and grants those endowed with symbolic capital (i.e., high status scientists) the power to impose their views on what is valuable (Bourdieu, 1989), effectively contributing to the reproduction of a class hierarchy in the absence of "a genuine institutional criterion of scientific value….in a field that claims to recognize only scientific value" (Bourdieu, 1988: 297).

Merton (1973) similarly argues that science as a social institution utilizes an elaborate (often symbolic) reward system for outstanding scientific performance that enhances individual prestige and creates an upper stratum that is inherently selective, numerically restrictive, and exclusionary. He further notes the so-called Matthew effect at work, i.e., when eminent scientists accrue disproportionately more recognition for their scientific contributions than lower-status individuals. This phenomenon increases inequality, ultimately leading to the emergence of a scientific class structure that distinguishes and privileges high-status, highly visible scientific elites from so-called "artisans of science." This selective dynamic is active in scientific citation, for example, when only the work of a few highly cited, high-status scientists is highlighted, effectively increasing the gap between the symbolically rich and symbolically poor (Small, 2004). Thus, the rich and famous become richer, more famous, and more scientifically influential; and the gap between the scientific elites and the lower strata increases over time, a trend that has not gone unnoticed in the recent scientific literature (e.g., Xie, 2014).

While neither Bourdieu nor Merton dispute that high-status elites are deserving of their recognition, equally meritorious individuals may nevertheless be excluded from such recognition and the benefits it entails, based on the judgment of others.

However, neither theory explicitly considers gender as a dimension of scientific class stratification and the emergence of scientific elites.

Gender Hierarchies in STEM

Scientific organizations and academic institutions espouse objectivity, gender neutrality and meritocracy; yet, the reliance on seemingly "objective" criteria in the evaluations of a scientist's cumulative accomplishments does not, by itself, guarantee gender-neutral decisions (Acker, 2006; O'Connor and O'Hagan, 2016). Acker's theory of gendered organizations (Acker, 1990; 2006) offers valuable insights into how gender differences can emerge within organizations that overtly espouse meritocracy. Since STEM was until recently dominated by male scientists, it follows that male hegemonic norms of success still permeate the evaluation processes, as scientists are socialized to view masculine behavior as more professional (Rhoton, 2011). Acker (1990) identifies several processes that reproduce gender bias in organizations. Here we discuss some that are pertinent to scientific recognition in STEM and are supported through empirical evidence in the STEM literature.

Division of labor along gender lines grants more weight or status to tasks and responsibilities performed by men (Acker, 2006). Eveline (2004) coined the term "elasticity of merit" to signify the subjectivity in what is judged significant and important scientifically, based for example, on choice of fields, methods utilized, or theoretical approach to science (Roos & Gatta 2009; Rosser, 2004). There is evidence that women concentrate in certain fields or subfields within STEM that are considered less prestigious (e.g., life sciences, biology) (Blickenstaff, 2005; Burelli, 2008) and tend to specialize less compared to men who are more often active in high-value fields or specialty areas (Leahey, 2007).

In most doctoral universities, research-related activities receive high priority and are often given more status than teaching and student mentoring (Eveline, 2004; Monroe, Ozurt, Wrigley, & Alexander, 2008; Rosser, 2004). Befitting the cultural gender norms of women as caring and nurturing, women faculty frequently take on a considerable service and teaching load in their academic institution (Burke & Lauenroth, 1997), especially when few women are present (Rosser, 2004), and these activities are considered lower-status (Coate & Howson, 2016; Mason *et al.*, 2013; Misra, Lundquist, Holmes, & Agiovritis, 2011; Monroe *et al.*, 2008). Consequently, men accrue relative professional advantage by spending significantly more time on research (Ceci *et al.*, 2014). Furthermore, women, may experience reduced work-time flexibility or structural constraints on their mobility due to additional domestic responsibilities, while men can more freely pursue heightened visibility and networking opportunities as they are less burdened by family obligations that impinge on the job (Dean & Koster, 2014).

Norms of success further augment gender bias in that we often unconsciously evoke images of success and competence in masculine terms. As the normative standard for success, male scientists are often judged on their potential for success. They receive micro-advantages earlier in their career (Roos & Gatta 2009; Steinpreis, Anders, & Ritzke, 1999), such as negotiated access to more institutional resources and support (Duch *et al.*, 2012; Rosser, 2004) or higher rank at hire (Van Miegroet *et al.*, 2019) that benefit productive capacity (DiPrete & Eirich, 2006), further enhancing their status as successful scientists. By contrast, similarly situated women must continually prove their accomplishments are deserving of recognition (Roos & Gatta, 2009; Rosser, 2004) or must work harder to be invited (Nittrouer *et al*., 2018) or appointed to prestigious positions (Coate & Howson, 2016). The perception of men as more competent is further augmented by a greater tendency of men to self-promote (Coate & Howson, 2016; Rudman, 1998), also expressed through greater self-citation of their published work (Cameron, White, & Gray, 2016; King *et al.*, 2016). By contrast, women tend to underplay their achievements (Valian, 1999), show a reluctance to assert themselves and their achievements (Coate & Howson, 2016; Rudman, 1998), or tend not to negotiate their academic start-up package with the same vigor as men (Williams & Dempsey, 2014) lest they be perceived negatively (Rudman & Glick, 2001). Consequently, they may be considered less competent, even if equally qualified (Coate & Howson, 2016; Ridgeway, 1991), and their accomplishments may go unnoticed when research awards are bestowed (Lincoln *et al.*, 2012).

Institutional logic that appears gender neutral reflects the historical dominance of men in STEM fields, in that the notion of the ideal scientist continues to be framed around largely masculine traits. Successful scientists are presented as unemotional, decisive, objective, aggressive, competitive, and fully dedicated to their work at the expense of other obligations (Rhoton, 2011). Women are considered more emotional, a trait that aligns better with their service role (Monroe *et al.*, 2008) but is perceived by some as irreconcilable with the notion of a successful scientist (Cech & Blair-Loy, 2010; Rhoton, 2011). Any deviation from these hidden masculine norms (e.g., part time work, interruption in career path, inability to put in long hours, visible commitments to teaching, mentoring or service-related activities) result in negative judgments of women's professional commitment and scientific acumen (Acker, 2006; Ridgeway, 1991; Risman, 2004; Valian, 1999).

Membership in scientific networks allows accumulation of symbolic and social capital that is critical in gaining visibility and recognition of achievement, both in direct and indirect ways (Cech & Blair-Loy, 2010; van den Brink & Benschop, 2011). The density and range of professional network connections directly augment the metrics of success by increasing the number of co-authored publications (Ceci *et al.*, 2014; van den Brink & Benschop, 2011) and citations (Johnson & Oppenheim, 2007; Nielsen, 2016; van den Brink & Benschop, 2011). STEM networks remain highly gendered (Lincoln *et al.*, 2012; Rhoton, 2011) and women often find themselves excluded from information-rich professional networks (Rosser, 2004). In selecting potential collaborators, colleagues, students or protégés, dominant males show a cognitive preference for their own gender or people who are otherwise similar to them (homophily) (McPherson, Smith-Lovin, & Cook, 2001; Rosser, 2004; Sheltzer & Smith, 2014; Valian, 1999; van den Brink & Benschop, 2011), thereby limiting women's opportunities to access these network benefits (Rosser, 2004; van den Brink & Benschop, 2011). A recent quantitative analysis of biology labs in the US, for example, found that high-status elite male faculty employ and mentor fewer women as PhD and postdocs than their female counterparts or lesser-known male colleagues (Sheltzer & Smith, 2014). Affiliation with high-status elites can also bestow indirect benefits in terms of heightened status (Merton, 1973; Zuckerman, 1996), access to critical information (Rosser, 2004), or opportunities for career advancement (Zuckerman, 1996; van den Brink & Benschop, 2011). Scientists with network connections to eminent academics frequently accrue more favorable ratings in evaluations (van den Brink & Benschop, 2011), effectively misrepresenting prestige and status, or the proximity to it, as an indicator of competence.

Gendered Differences in Recognition and Awards

When gendered processes shape organizational norms and discourse, they may result in unequal access by men and women to symbols of success. The subjective becomes objectified and officially sanctioned – with scientific prizes one of the most objectified indices of symbolic capital in academia – and reputation and status are transformed into authority and mistaken for legitimate competence (Bourdieu 1988: 76).

In her treatise on scientific elites, Zuckerman (1996) examines the role of prestigious awards and recognition (such as the Nobel Prize and induction into the National Academy of Sciences) in creating and reproducing social stratification within science that entails the accumulation of advantage by a selected few. Based on their elite status, they are bestowed greater access to resources that directly benefit their career and progressively widen the gap relative to equally meritorious scientists that miss out on such recognition, and are unintentionally demoted to lower status. The Matthew effect also operates in the skewed distribution of honors and awards, as those who already have them, tend to receive more (Cole & Cole, 1967; Zuckerman, 1996). Furthermore, scientific elites serve as gatekeepers and status-judges of scientific role performance and worthiness of recognition, resources, or access to means of scientific production, thereby perpetuating the prestige hierarchy. Zuckerman's research further elaborates on the critical importance in scientific upward mobility towards elite status of processes such as early recruitment by eminent scientists, grooming and sponsorship of young talent by these mentors, and status by proxy and networking benefits to protégés resulting from these collaborations. These mechanisms, in part, explain the existence of distinct genealogies among Nobel laureates (Zuckerman, 1996).

Importantly, Zuckerman's work provides an important link between theories of symbolic status hierarchies and gender inequality in scientific organizations. She noted distinct gender stratification at work in scientific recognition and the often unwarranted exclusion of women among Nobel laureates (Zuckerman & Cole, 1975; Zuckerman, 1996). Even now, underrepresentation of women in the elite ranks is still an issue, as out of 592 Nobel prize winners between 1901 and 2018, only 19 (3%) were women, one-third of whom were during the last 10 years (6, 8% of total 2009-20018). Rossiter (1993) coined the term "Mathilda effect" as the flipside to Merton's Matthew effect, to signify the exclusion of women or lack of recognition of the scientific achievements by women when awards are bestowed (Lincoln *et al.*, 2012). This phenomenon can be directly linked to some of the gendered processes described in the previous section, such as lack of recruitment, exclusion from critical collaborative networks, and gender stereotyping with regards to scientific aptitude and career commitment.

A comprehensive analysis by the Association for Women in Science (AWIS) found that while the number of women receiving scholarly awards has increased over time in some STEM societies, the proportion of women recipients is still well below the expected rates based on their academic rank, their seniority within societies, or even the composition of the nomination pool (Holmes *et al.,* 2011; Lincoln, Pincus & Leboy, 2011; Lincoln *et al*., 2012; Popejoy & Leboy, 2012; Popejoy *et al*, 2011). Several studies have further shown how evaluations reflect and reinforce seemingly gender neutral processes built around hegemonic male standards that result in hyperscrutiny and the devaluation of women's achievements in all critical aspects of the construction of excellence, including the selection for national awards (e.g., Holmes *et al.*, 2011; Lincoln *et al.*, 2012; Monroe *et al.,* 2008).

Homosocial reproduction by men, still the dominant group in STEM, is thought to contribute to the lower nomination rates of women in many science organizations (e.g., Holmes *et al.,* 2011; Hurley, 2014) that can, in part, be linked to the underrepresentation of women among the nominators (Ball, 2014; Holmes *et al.*, 2011). In other words, lack of representation at decision-making levels reinforces and reproduces gender imbalance in bestowing status within these organizations.

Without formal guidelines and transparent rules in the decision making process, evaluators (irrespective of gender) tend to activate cognitive shortcuts that favor men (Holmes *et al.*, 2011; Lincoln *et al.*, 2011). Heavy reliance on letters of recommendation, rather than portfolio analysis or use of structured evaluation forms, further exacerbates this gender bias (Holmes *et al.*, 2011). Content analysis of letters recommendations reveals longer letters for male nominees containing more status terms and standout adjectives speaking to professional aptitude, whereas letters for women tend to be significantly shorter and highlight personal traits rather than scientific achievement (Holmes *et al.*, 2011; Schmader, Whitehead, & Wysocki, 2007; Trix & Psenka, 2003) or describe women in more communal than agentic terms, implying lower leadership fitness (Madera, Hebl, & Martin, 2009). Overall, women are less likely to receive excellent letters (Dutt *et al.*, 2016). Thus, if the selection committee is looking for clear indicators of scientific excellence in letters of recommendation, they are less likely to find it among women nominees.

Implicit gender bias does not only influence nomination and selection for a given award, but also affects whether candidates are considered suitable for some but not other types of awards. As a result of institutional division between high- and low-status labor, and congruent with female role stereotyping, women tend to receive external recognition for service and teaching more often than for scientific achievement in their professional societies (Holmes *et al.*, 2011). Consequently, the number of female recipients of education and service awards is more in line with the membership demographics of STEM societies (Holmes *et al.*, 2011; Lincoln *et al.*, 2011).

Bourdieu's concept of symbolic power and Merton's Mathew effect illuminate the ways in which symbolic recognition, including awards, can reproduce inequalities within academia. Acker's theory of gendered organization and Zuckerman's work on gendered scientific stratification elucidate the gendered nature of these processes. A gendered division of labor and women's unequal access to prestigious networks, combined with organizational gendered norms of success and institutional logics, limit the visibility of women's contributions and inhibits their ability to be recognized for their research achievements. We hypothesize that this bias will also be reflected at the meso-scale by a lower proportion of women receiving awards and in a skewed distribution of the type of awards by gender, with men receiving more recognition for scientific achievement and women receiving proportionally more awards for non-research activities.

DATA AND METHODS

To meet our objectives, i.e., analyze gender patterns in award distribution by type and elucidate drivers underlying potential gender disparities, this study adopted a mixed-methods approach. Quantitative analysis of available data on research and non-research awards at a public doctoral research university in the western U.S. was combined with a survey of tenured faculty in three STEM colleges at that institution to glean whether supply-side (productivity) and/or organizational practices contributed to gender differences in recognition.

Awards data

In this analysis we used all available awards data from 1958 through 2014 (n= 591) at the level of the university and for four STEM colleges (Agriculture, Engineering, Natural Resources, and Science), representing a total of eight award types. Some activities were recognized both at the university level and in all STEM colleges (e.g., Researcher of the Year, Teacher of the Year, and Undergraduate Advisor of the Year); some awards existed only at the university level (Research Career Award, Carnegie Professor) or at the college level (Undergraduate Mentor of the Year), and one award was given at the university level and in a single college (Graduate Mentor of the Year). Based on the nomination criteria, awards were coded as research or non-research recognition. In one college, the "Distinguished Professor" award recognized both teaching and research and was assigned 0.5 unit to research and 0.5 unit to the non-research category. Recognition for service was inconsistent among colleges, and only recently initiated at university-level; therefore, that data was not included in this analysis. Awards were coded for gender of the recipients, and for those years where a particular award was shared between a male and female faculty member, the recipient gender was coded as female. For university-level awards, which are open to all colleges, a distinction was further made between recipients from STEM or non-STEM colleges. The length of the data record differed among awards, among STEM colleges, and between college and university-level awards, with the longest record for the "University Teacher of the Year" (1958-2014) and the shortest for "University Researcher of the Year" (2008-2014). To glean patterns over time, data were aggregated across three time periods: prior to 1995, 1995-2004 and 2005-2014, reflecting changes in faculty demographics and gender awareness at this university. In the earliest period, women in STEM were largely in token positions; 1995-2004 coincides with a significant increase in the number of women among STEM faculty; and the most recent period reflects a change in faculty demographics and the impact of climate and policy changes in the wake of the NSF-funded ADVANCE project (2003-2008) towards the recruitment and retention of women in STEM (Van Miegroet *et al.*, 2019).

The ratio of research to non-research awards for male and female recipients was calculated for each calendar year across STEM colleges and then averaged by time period. Due to the limited number of awards received by women at the university level, research-to-non-research ratios were calculated for each of the three time periods only.

Faculty Survey

In Fall 2016, an e-mail invitation for an online Qualtrics Survey was sent to all faculty (total 299: 221 men and 78 women) from the colleges of Engineering, Natural Resources and Science, with a follow up reminder prior to the deadline. The survey was broadly structured based on climate surveys conducted earlier by the ADVANCE team into the perceived barriers to career attainment among all STEM faculty (Callister, 2006; Van Miegroet *et al.*, 2019). It contained closed-ended questions on demographics, career advancement, and professional activities. The overall survey response rate was 33% (23.5% for men and 39.7% for women), but only completed surveys with gender information were used for further analysis, reducing the response rate somewhat (to 85 individuals, or 28% of all invited faculty). Our survey population was comprised of 19% non-tenure track faculty, 25% untenured faculty, 17% associate professors, and 39% full professors (Table 1). In addition, we queried tenured faculty on their perception of institutional policies and processes, including those pertaining to recognition and productivity. This survey subgroup consisted of 16 women and 30 men, representing respectively 61.5% and 21.3% of women and men in tenured ranks in those three colleges. Demographic composition of the survey population is summarized in Table 1.

Because little or no information is available on past nomination pools nor on deliberations with regard to nomination or award selection, we opted for an indirect approach. In this paper we use the survey responses from tenured faculty (n=46) related to the awards process and perception of standing by leadership and peers, as well as self-reported metrics of productivity, to gain insight into institutional practices. Questions pertaining to productivity and achievement included: "In a typical week, how many hours do you work?"; "Thinking about the last 3 years, (i) approximately how many peer-reviewed journal articles have you published per year? (ii) approximately how many graduate students do you mentor and/or supervise per year? (iii) please estimate the number of grants you have received, (iv) estimate the amount of money received from these grants"; "On average how many department, college and campus-wide committees do you serve on per year?"; "On average, how many professional non-university committees and/or boards have you been invited or selected to serve on per year?"; and "How many invited talks do you give on average per year outside of the university?" To capture faculty perception with regard to university awards practices, the survey included the following questions: "Have you ever been nominated for an award at any of the following levels: Department; College; University?" (3 separate questions); "Which of the following best describe the reason for your nomination(s) for university awards: Teaching; Research; Service; Advising/Mentoring; Other?"; "Have you ever been nominated for a non-university professional award?"; "In your opinion, have your colleagues or administrators ever failed to nominate you for an award for which you felt you were deserving?"; "In your opinion, are you or have you been viewed as outstanding by your department head / by your peers / by your dean in the following areas: Teaching; Research; Service?" (9 separate questions).

Table 1: *Composition of the Survey Population by rank, gender and college (expressed % of tenured respondents in this study)*

Original Survey population				
	Men	Women	Other	Total
Faculty respondents by *Rank*				
Non-tenure track Faculty	8	8	0	16
Assistant Professors	14	7	0	21
Associate Professors	9	5	1	15
Full Professors	21	11	1	33
Total Valid Survey Responses	52	31	2	85
Survey Population used in this study				
	Men	Women	Other	Total
Tenured Faculty respondents by *College and Rank*				
Associate Professors	9 (19%)	5 (10%)	1 (2%)	15 (31%)
Engineering	4 (8%)	0	0	4 (8%)
Natural Resources	3 (6%)	3 (6%)	0	6 (13%)
Science	2 (4%)	2 (4%)	1 (2%)	5 (10%)
Full Professors	21 (44%)	11 (23%)	1 (2%)	33 (69%)
Engineering	3 (6%)	1 (2%)	0	4 (8%)
Natural Resources	5 (10%)	4 (8%)	0	9 (19%)
Science	13 (27%)	6 (13%)	1 (2%)	20 (42%)
Total Tenured Faculty Responses	30 (63%)	16 (33%)	2 (4%)	48 (100%)

Data analysis
Differences in scientific achievement and productivity are often invoked as reasons for gender inequality in recognition and advancement (e.g., Ceci *et al*., 2014), but to the best of our knowledge there is no unifying metric that captures scientific achievement and standing adequately. In this study we intended to provide a broader and more comprehensive evaluation of productivity beyond simple bibliometrics, to better capture the complexity and interplay among factors underlying scientific achievement. All metrics were characterized by a 5-categorical scale. Using the raw data, there was a positive correlation between all metrics used, except hours worked, which was excluded from further analysis. Based on scree plot and test for sample adequacy (KMO=0.776), exploratory factor analysis with oblique rotation extracted 2 factors that collectively explained 64% of the variability in productivity among the respondents. Factor 1 comprised of grant metrics (number and funding level), number of graduate students and external invites (talks and committees) (Cronbach $\alpha = 0.779$) was considered indicative of resource availability and status, and was combined into single "resource and status" score; Factor 2 comprised of, in relative order, number of publications, number of invited talks and external committees, and number of graduate students (Cronbach $\alpha = 0.729$) reflected tangible outputs and was combined into an "output" score. T-tests were used to detect gender differences in the original and combined productivity metrics. Logistic regression analysis was used to discern gender influences on the distribution of research vs. non-research awards within STEM colleges and at the university level. All data analysis was done with SPSS (Version 21).

RESULTS

STEM College awards
Across all STEM colleges and dates, women received a total of 66 out of 429 (~15%) awards. Prior to 1995, women received < 4% of the STEM college awards (research or non-research awards), with 1989 marking the first year for a woman in STEM to receive a college-level award. This pattern likely reflects the underrepresentation of women among STEM faculty, especially at the mid-career and senior level. The 2008 university faculty census data confirm that prior to 1990, the STEM colleges combined counted fewer than 10 women among their faculty. The number of women faculty in STEM colleges has steadily increased since then, and in 2014, 27% of all STEM faculty and 23% of tenured and tenure-track STEM faculty were women (Van Miegroet *et al.*, 2019). The relative proportion of women receiving awards also increased over time, but more so for non-research than research awards (Figure 1; Table 2). Over the last 10 years, almost 26% of the non-research awards have gone to women faculty, approaching their demographic representation in STEM. The rate of increase has been slower for research awards (16% for 2005-2014) and has not kept pace with growing number of women in the STEM faculty ranks (Figure 1).

Table 2: *Relative distribution of research vs. non-research awards received by STEM women and men faculty in the STEM colleges and at university-level prior to 1995, between 1995-2004, and between 2005-2014.*

Period	Men Research	Men Non-Research	Ratio R/nonR	Women Research	Women Non-Research	Ratio R/nonR	Gender differences in research awards $\chi^2_{(1)}$	p <	Odds ratio (95 % CI)	p <
STEM Colleges Awards										
2005-2014	42	87	0.57	8	30	0.20	2.238	0.135	1.95 (0.78 , 4.83)	0.151
1995-2004	22	72	0.31	3	20	0.16	1.638	0.201	2.52 (0.54 , 11.81)	0.243
Prior to 1995	35	107	0.48	1	4	*	0.005	0.946	1.08 (0.12 , 10.07)	0.946
Total	98	265	0	12	54	0	2.487	0.115	1.74 (0.85 , 3.58)	0.132
University Awards - STEM Recipients										
2005-2014	17	11	1.55	0	7	0.00	**10.971**	0.001	NA	
1995-2004	11	9	1.22	1	3	0.33	1.247	0.264	NA	
Prior to 1995	12	15	0.80	1	1	1.00	0.023	0.879	NA	
Total	40	35	1.14	2	11	0.18	**7.011**	0.008	**6.29** (1.30 , 30.32)	0.008

* insufficient data to calculate average
NA = not available due to limited data

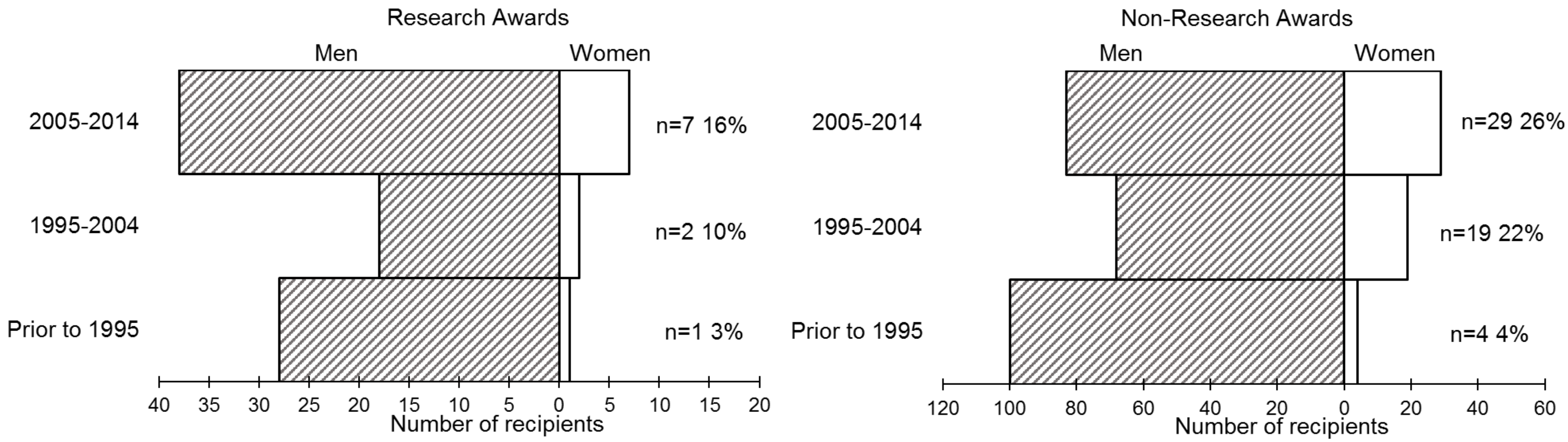


Figure 1: *Number of men and women in STEM colleges receiving research vs. non-research awards over time (excludes mixed-designation awards).*

For both men and women faculty, the ratio of research to non-research awards was less than 1, indicating a greater number of non-research honors in the STEM colleges (Table 2). Men received research to non-research awards in a 1:2 ratio. That ratio always remained lower for women faculty, ranging from 1:6 to 1:5 over the last 20 years. While the χ^2 tests and logistical regression by period and across the entire data set does not support a statistically significant gender influence on the type of awards received, residual error (z) of -1.2 for women faculty across the entire data record nevertheless suggests that women received research awards at slightly lower than expected rates, while odds ratios suggest that men were nearly twice as likely than women to receive research awards (Table 2). By contrast, women were recognized as undergraduate mentor of the year significantly more frequently than expected across the entire period of record [z = +3.5 and $\chi^2_{(1)}=17.62$ ($p<0.003$); data not shown].

University awards

Of the 160 university faculty awards, 19% went to women and 55% to STEM faculty, slightly above the proportion of STEM faculty at the university (46% of all faculty). Consistent with the college awards data and university demographics, women comprised an increasing percentage of the STEM faculty recipients over time: 7% (prior to 1995), 17% (1995-2004) and 20% (2005-2014). This is lower than for non-STEM disciplines where 12% (prior to 1995), 43% (1995-2004) and 22% (2005-2014) of the faculty award recipients have been women. At the university level and among the STEM recipients, men received research and non-research awards in almost equal proportion (40 research vs. 35 non-research awards; average ratio of 1.14), with the ratio of research over non-research even increasing over the last 10 years (17 research vs. 11 non-research awards; average ratio of 1.55). While the proportion of STEM women receiving non-research awards has significantly increased over time [6% (prior to 1995), 25% (1995-2004) and 39% (2005-2014)], women have remained markedly under-represented as recipients of research awards (Table 2). Across the entire historic data record, only 2 STEM and 2 non-STEM faculty women have been recognized for their research achievements at the university level[1]. This suggests that the under-recognition of research achievements of women faculty is not solely an issue in STEM disciplines, but may indeed be more systemic[2]. There was a statistically significant gender effect on the awards distribution at the university level with women receiving research awards at rates lower than expected [residual error (z) of -2.2 over the entire period] and non-research awards at rates higher than expected [z of +1.7 over the entire period]. This pattern was even more pronounced among STEM faculty recipients for the entire period and was driven mostly by statistically significant gender differences in the last 10 years. Overall, men in STEM on average had six times greater odds than women of receiving a research award (Table 2). Women faculty in STEM received proportionally more non-research awards (n=11) at the university level, yielding a ratio of research to non-research awards of 1:5, similar to the ratio in STEM college awards (Table 2).

Table 3: *Pearson Correlation matrix of survey-based productivity metrics (p value) considered in factor analysis and factor loading of variables after oblique rotation (n=37).*

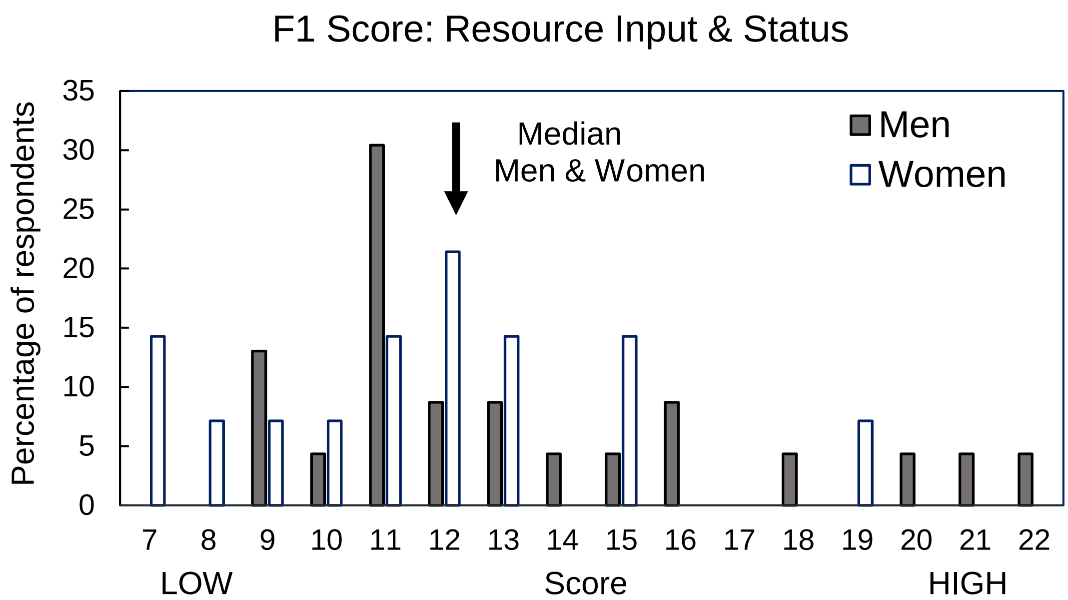
	Variable	V1	V2	V3	V4	V5	V6	V7	Factor Loading 1	2
V1	Number of Grants	1	**0.571**[a] (0.000)	**0.429** (0.004)	**0.385** (0.010)	**0.455** (0.002)	**0.311** (0.043)	-0.054 (0.744)	0.627	
V2	Grant Funding		1	**0.434** (0.007)	**0.378** (0.021)	**0.503** (0.002)	0.089 (0.601)	0.148 (0.397)	0.971	
V3	Number of Graduate Students			1	**0.299** (0.049)	**0.490** (0.001)	**0.413** (0.006)	-0.074 (0.656)	0.336	0.294
V4	Invites to External Boards/Committees				1	**0.543** (0.000)	0.243 (0.117)	0.310 (0.30.55)	0.348	0.318
V5	Number of Invited Talks					1	**0.455** (0.002)	0.089 (0.590)	0.374	0.579
V6	Number of Journal Articles						1	-0.092 (0.579)		0.61
V7	Hours worked							1		

[a] Pearson correlation coefficients in bold are statistically significant ($p<0.05$)

Source of gender differences

Survey responses by tenured faculty in three STEM colleges yielded further information on the role of supply-side (productivity) vs. organizational practices in the observed gendered allocation of awards. As to potential supply-side drivers, analysis of self-reported productivity metrics (Table 3, Figure 2) did not indicate substantial differences in individual metrics of research productivity between tenured men and women, except for a slightly higher number of invited talks reported by male faculty (p=0.043, data not shown). Combined status and output scores obtained after factor analysis (Table 3) indicated similar relative distributions (and median values) in productivity (p=0.195 for factor 1 and p=0.108 for factor 2), irrespective of gender (Figure 2). It is interesting to note that in this analysis, grant size (i.e., resource input) and publication output were poorly correlated (Table 3). On the other hand, the survey data did not allow us to specifically assess whether women faculty were engaged in more teaching, mentoring or service activities. Faculty perception of the nomination process, however, provided some insight into structural (institution-level) mechanisms underlying the uneven awards distribution between men and women in STEM. In general, a lower proportion of tenured women compared to men reported being nominated for an award within the institution (gender difference of around 15-27% depending on whether award was at the departmental, college or university level) (Figure 3). This gender difference in reported award nominations held across all types of awards, except for service awards, where both men and women reported equally low nomination rates (10% and 13%, respectively) (Figure 4). Almost two-thirds of male faculty vs. 40% of women reported being nominated for research-related awards, in line with actual awards data showing the preponderance of men as research award recipients. Women also consistently reported lower nominations rates for non-research activities such as teaching (48% of men vs. 33 % of women) and mentoring (38% of men vs. 7% of women). There was also a greater perception among women that they had been overlooked by colleagues and administrators in the nomination process (33% of women vs. 18% of men).

When queried about whether they were considered outstanding by their peers and leadership in research, teaching or service, no consistent gender patterns emerged. Overall approval rating of faculty accomplishments progressively declined from department head (70% for men and 56% for women), to peers (50% for men and 47% for women) to college deans (26% for men and 33% for women), and a substantial portion of the faculty reported that they were unsure how their dean rated their performance in these three areas. Men reported higher positive ratings by their peers in the area of research (66 % vs. 47% of women) and by their department head for service (71% vs. 47% of women), while a higher proportion of women indicated recognition for teaching by their dean (33 % vs. 14% of men). None of the observed gender differences in response rates were statistically significant.



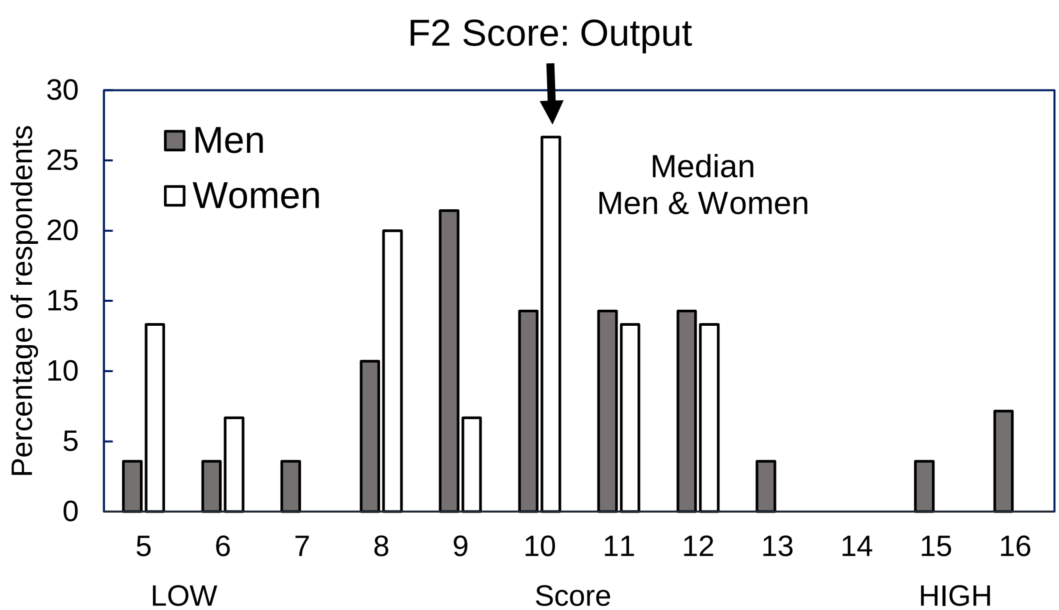


Figure 2: *Distribution of productivity scores for male (n=30) and female (n=16) tenured faculty respondents.*

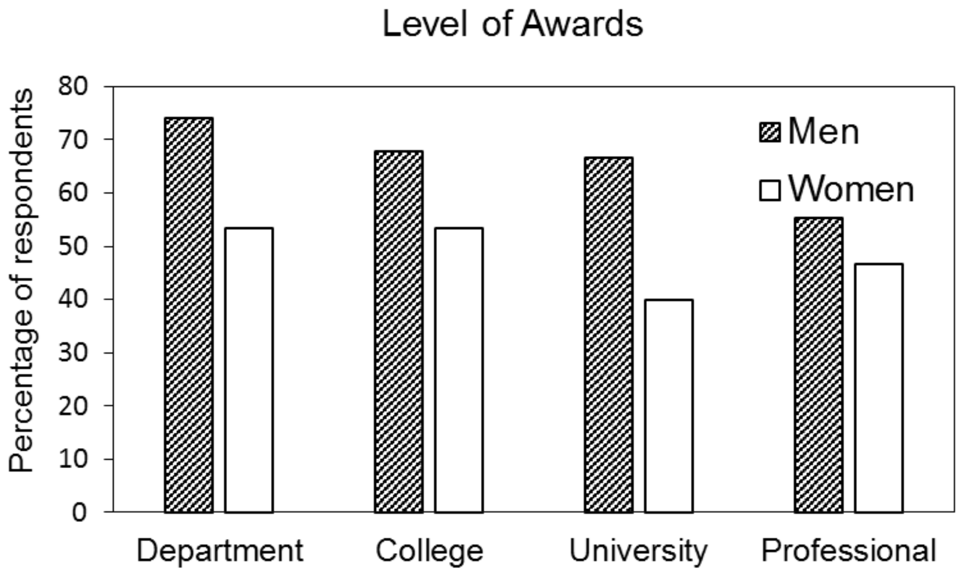


Figure 3: *Percentage of tenured male and female faculty (n=46; 30 men, 16 women) who report being nominated for awards at different levels inside and outside the university.*

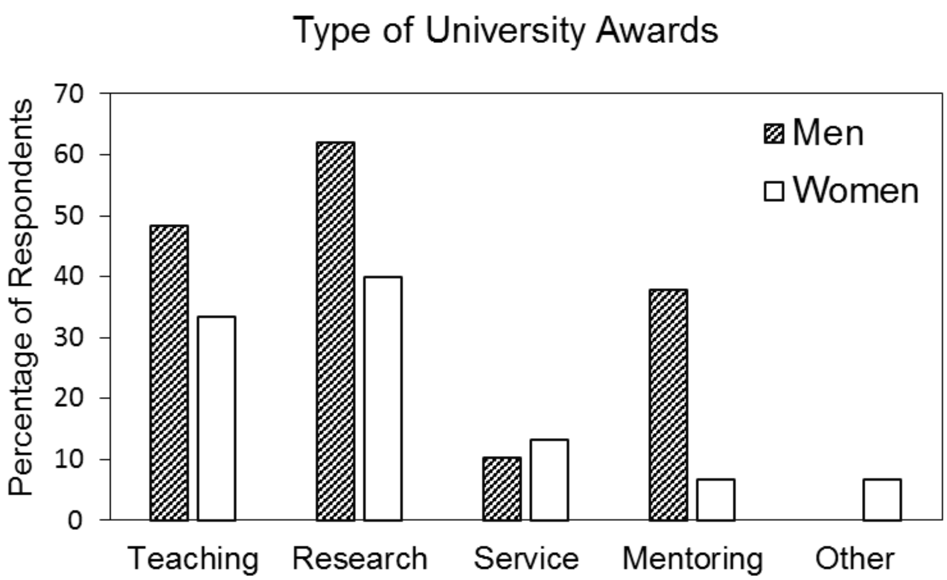


Figure 4: *Percentage of male and female tenured faculty (n=46; 30 men, 16 women) who report being nominated for different types of university awards.*

DISCUSSION AND IMPLICATIONS

The awards data at this doctoral research university mimic trends observed at the national level in professional and scientific organizations as documented by the AWIS project (Lincoln *et al.*, 2011; 2012). The granting of awards and honors remains a highly gendered process, and in spite of a proliferation of awards over time at this institution, women are still underrepresented as awards recipients, especially in recognition of research accomplishments. The number of women receiving research awards in the STEM colleges has increased significantly in recent years (2005-2014), but these changes are not commensurate with the increased representation of women among (senior) faculty. Men consistently receive research awards at higher than expected rates, and gender discrepancies are especially pronounced at the university level, where men continue to dominate as research award recipients. As hypothesized, women are more likely to be recognized for their non-research activities such as teaching and undergraduate student mentoring, consistent with the caring and nurturing female stereotype. While this analysis primarily focused on STEM faculty, women are underrepresented as university-level research awardees in the non-STEM disciplines also, suggesting a highly gendered process that is systemic rather than discipline-specific.

The survey provides insights into institutional practices that may contribute to these divergent outcomes for men and women. Unlike previous research (e.g., Ceci *et al.*, 2014; van den Besselaar & Sandström, 2016) that alludes to gender-based productivity differences in mid-career, the productivity metrics used in this study do not support substantial gender differences in the research productivity among tenured faculty. The survey responses further suggest that gender inequality starts at the nomination process, and that women, unlike men, feel their scientific achievements are frequently overlooked.

From our quantitative and qualitative lines of investigation, we can also infer the role of social proximity in mitigating implicit bias: (1) by more pronounced gender differences in awards distribution at the university compared to the college level; and (2) by the observation that both men and women are more uncertain about whether and how college deans value their research, teaching and service activities compared to their department heads. This would suggest that the more distant evaluators are from actual faculty being evaluated, the more likely they are to access biased gender perceptions in their evaluations. This is consistent with research on cognitive processes in decision making (Goodwin, Operario, & Fiske, 1998) demonstrating that those granted the ability to judge and control the outcome of others (e.g., selection of nominee or awards recipient) tend to activate stereotype bias unless they have a stake in the outcome or are held accountable especially to higher levels of power. Contact theory of intergroup interactions further suggests close and sustained contact, interdependence and the sharing of common goals among people (e.g., within the context of an academic department) are factors likely to promote reliance on individuating information rather than stereotype expectations by those who judge (Reskin, 2000). Department heads are more likely to have more frequent contact with and better understanding of faculty and their achievements than college deans. This is substantiated by faculty members' perceived differences in approval ratings from department heads vs.

deans, irrespective of gender. Likewise, colleagues within the same department or college are more likely to have intimate knowledge of the accomplishments of their colleagues and may even collaborate with them compared to university-level selection committees, which may account for the somewhat more gender balanced awards distribution at college-level awards compared to the university-level awards.

Collectively, the quantitative awards data combined with the survey responses suggest gender bias in the awards process that tends to preferentially reward the research accomplishments of men. While there are limitations to the inferences that can be drawn from this data as to causation, the results are nevertheless in line with patterns observed at the level of national professional STEM societies. They are consistent with theory on power as a source of inequality (Goodwin *et al.*, 1998; Reskin, 2000), which states that in the absence of deliberate counter measures, groups with the power to judge tend to utilize cognitive shortcuts and access stereotypical role expectations, such that male faculty are more likely to be considered scientifically more competent and worthy of recognition, while women's accomplishments are more in line with a stereotypical nurturing role.

The first step towards institutional change is to acknowledge the possibility of cognitive bias in the decision-making process and to implement counter measures to prevent (unintended) gender inequality (Reskin, 2000). This research points at best practices that can alleviate the effect of gender bias at all levels of the awards process at this institution that are consistent with the existing literature. First, the nomination process itself needs greater consistency, transparency, and time and resource allocation such that it is clear to all who can nominate (including self-nomination), nominations are not made in haste (to counter stereotype-driven assessments; Reskin, 2000), and nominators are incentivized by real support (to counter potential negative consequence of loss of individual productivity). The composition of evaluation committees is also critically important in terms of gender composition, disciplinary representation, position within the institution, and overall status, to break the cycle of homo-social reproduction or ingroup preference (Hurley, 2014). Especially at the university level, over-reliance on the input of past award recipients and/or high-status individuals at the exclusion of various other constituencies is counter to achieving diversity among future awardees. Finally, to avoid cognitive distortions along gender lines, evaluations should be based on clear and objective performance criteria and decision matrices, and those making the decisions should be held accountable (Reskin, 2000). In short, the awards process can become truly meritocratic and objective only if it relies on individuating information and minimizes the influence of stereotype bias. This requires deliberate actions at all levels within the institution that engender transparency, achieve diverse participation in the nomination and selection process, and hold decision-makers accountable for the criteria and the accuracy of the information utilized in selecting awards recipients. As a first step, data collection and dissemination is a powerful tool in facilitating institutional change, as it makes the gender gap visible and can serve as a mechanism of accountability and "nudge" decision makers to adopt fairer and more equitable practices (Castilla, 2015; Thaler and Sunstein, 2009). However, long-term institutional change can only be achieved through sustained implementation of best practices and continued monitoring of progress towards institutional gender equity goals, as progress tends to stall when issues fall out of focus and attention within the organization is distracted (van den Brink & Benschop, 2012).

LIMITATIONS AND CONCLUSIONS

Though our findings suggest gender bias in the granting of university awards – in line with national trends at the level of scientific societies – there are several limitations to this study that may provide fruitful avenues for future research on this topic. First, since the current study is based on analysis of a single institution over time, generalization on the role of awards as a source of gender inequality in career achievements within STEM requires a more extensive analysis and synthesis of similar awards data records across a larger number of universities. A comparative study of the gendered nature of awards recognition at different types of institutions may reveal important insights into the mechanisms that drive inequity. Second, based on available census and survey data, it was not possible to fully explore all factors contributing to the divergent outcomes for men and women in STEM. A further exploration of supply-side and institutional factors might shed light on the critical nexus points where gender gaps emerge. A useful direction for future research would be to include quantification of the relative time commitment by men vs. women towards research vs. non-research activities; a critical evaluation of transparency and consistency in criteria and procedures for the various awards at a given institution; and an analysis of the impact on awards outcomes of the gender, rank, discipline of those involved in nominating and selecting suitable candidates. Finally, our study suggests that social proximity influences the relative balance of gender stereotypic vs. individuating information in award decisions, but this topic definitely warrants a more thorough exploration. It might be of interest to investigate at what level within the organization individuating information is most effectively introduced into awards decisions. It might be especially useful to assess whether mid-level managers (such as department heads) in particular are crucial in creating a more gender-equitable workplace culture, as suggested by a recent study on the role of leadership (Bystydzienski, Thomas, Howe & Desai, 2017), or how gender diversity at this leadership level affects transformative changes in university practices.

In conclusion, this institutional analysis of awards distribution among STEM faculty supports the notion that academia remains a gendered prestige economy that is socially stratified and places women at a distinct evaluative disadvantage with respect to research awards, not because they are less productive, but because their accomplishments are overlooked or given more scrutiny. Such gender inequalities can only be addressed though conscious and sustained implementation of best practices that include greater transparency, formalization and accountability in the nomination and selection process, and diversification of the nomination pools and decision-making entities.

ENDNOTES

1. In 2017 and 2018, female faculty in Psychology and English, respectively, received D. Wynne Thorne Career Research Award.
2. Lack of awards data for non-STEM colleges does not allow extrapolation to the college-level.

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