# The Female Penalty for Novelty and the Offsetting Effect of Alternate Status Characteristics

Denis Trapido, *University of Washington Bothell, USA*

Research has shown that audiences penalize novelty in women's work but also that such penalty may vary. This study builds on theories of uncertainty and status signaling to identify contingencies that may account for the variation in the female penalty for novelty, particularly in the production of technological and scientific knowledge. Drawing on theories of expectation states and gender status beliefs, I posit that peer audiences have a baseline bias against novelty in women's work and penalize novelty in female authors' contributions. However, when authors possess status characteristics that are more task-relevant than gender, this penalty erodes. I identify two academic status characteristics, prestigious graduate degrees and prestigious mentors, which offset the female penalty for novelty. Longitudinal multi-source data on the productivity of academic engineers show that female engineers who have these characteristics face no significant citation penalty for the novelty of their work. Implications of these findings for gender inequality and for policies that aim to reduce it are discussed.

## Introduction

Research has found recurrent evidence that audiences are biased against novel ideas contributed by women. Women receive less recognition than men for innovative contributions (Goldin and Rouse 2000; Schmutz and Faupel 2010), and this disadvantage increases as individuals' innovativeness increases (Luksyte, Unsworth, and Avery 2018; Proudfoot, Kay, and Koval 2015). The disadvantage impedes women's careers by lowering their performance evaluations (Luksyte, Unsworth, and Avery 2018) and by reducing organizations' support for women's creativity (Taylor et al. 2020). The findings, however, have not been uniform.

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Roca et al. (2016) found no difference favoring either men or women in the evaluation of creative contributions. Post et al. (2009) showed that women perceived by managers as highly innovative received higher evaluations of promotability than similarly perceived men.[1]

The prevailing finding and the occasional counterevidence have matching theoretical explanations. To explain the female penalty for novelty, studies invoked theories of gender status beliefs, which posit that women's skills and contributions are discounted because women are culturally viewed as less competent than men in general (Heilman 2001; Ridgeway 2011; Ridgeway and Correll 2004; Ridgeway and Erickson 2000) and as less competent at creative tasks in particular (Proudfoot, Kay, and Koval 2015). Expectancy violation theory has been used to explain bias in favor of women's novelty (Jussim, Coleman, and Lerch 1987; Post et al. 2009). The theory argues that individuals receive positive evaluations when they exhibit stereotypically non-expected desired traits or behaviors (e.g., women are not expected to generate highly novel ideas). However, this theory has an explanatory edge only when audiences desire novelty, which innovation research has shown is often not the case (Boudreau et al. 2016; Mueller, Melwani, and Goncalo 2012; Sgourev and Althuizen 2014; Staw 1995).

While evidence suggests that audiences' reactions to female novelty vary and theories are available to explain both discriminatory and nondiscriminatory reactions, we lack a theoretical framework to understand why these reactions may vary. This study takes early steps toward developing this understanding. It takes guidance from the growing awareness in discrimination research that bias based on individual traits is not unconditional but rather dependent on the context in which potential discriminators perceive these traits (Foschi 2000; Lynn et al. 2019; Pugh and Wahrman 1983; Sauer, Thomas-Hunt, and Morris 2010). Unlike past studies of the female penalty for novelty, whose different findings may reflect unknown differences between empirical settings and their respective audiences, the study explores how the penalty may vary within the same audience. With a better understanding of the determinants of within-audience variation, policymakers and managers may leverage these determinants to reduce gender discrimination and inequality.

To examine factors that affect the female penalty for novelty, I use scientific and technological novelty as a case in point. The argument builds on insights from three theoretical traditions: (1) research attesting that audiences are uncertain about the quality or, synonymously, merit of highly novel work (Boudreau et al. 2016; Fleming 2001; Mueller, Melwani, and Goncalo 2012; Rindova and Petkova 2007); (2) sociological and economic theories of status signaling which argue that, to the extent that audiences are uncertain about true quality, they rely on producers' status as a proxy for quality (Higgins, Stephan, and Thursby 2011; Podolny 1993, 2005; Sgourev and Althuizen 2014; Simcoe and Waguespack 2011; Spence 1974); and (3) expectation states and gender status beliefs theories, which posit that gender is one of a number of status characteristics that people use to infer others' competence and quality of work (Berger et al. 1992; Berger, Cohen, and Zelditch 1972; Ridgeway and Erickson 2000).

Theories of status signaling predict that peer audiences will be more reliant on authors' status characteristics in allocating recognition for their ideas to the extent that the merit of these ideas is uncertain. Because uncertainty about ideas' merit increases with novelty and social norms consider female gender as lower status, the baseline prediction is that peer audiences will penalize women for novelty. Specifically, women's contributions to knowledge will earn less peer recognition relative to men's contributions to the extent that the contributions are novel. I further argue that when authors possess status characteristics which are more relevant to the task of producing high-quality research than gender—such as prestigious professional training—these characteristics will erode the female penalty for novelty. They will close the gender gap in audiences' recognition, making high-status women's recognition for highly novel work comparable to that of high-status men. This argument was tested and supported using a unique dataset that combines data from nine sources, tracing three decades of publication and citation histories of academic electrical engineers.

This study makes three related contributions to innovation and gender inequality research. First, it demonstrates that peers penalize novelty in knowledge authored by women and theorizes uncertainty reduction as its underlying mechanism. Second, it shows that this penalty is contingent on other status characteristics, particularly on educational prestige. Third, the study shows that alternate status characteristics may fully offset the impact of individuals' gender on audience recognition of their contributions. While previous research showed that other status characteristics may attenuate the impact of gender on individuals' outcomes (Foschi 2000; Pugh and Wahrman 1983; Ridgeway and Correll 2004), it identified no conditions where such characteristics may entirely offset that impact (Ridgeway 2001, 638–39; Ridgeway 2011). Together, these conclusions highlight the role of the female penalty for novelty in reproducing gender inequality and the role of institutions of higher learning in countering this inequality.

## Background Theory and Hypotheses

### *Uncertainty About Merits of Highly Novel Knowledge*

The quality of highly novel ideas is difficult to know. Such ideas are unusual, unfamiliar to their audiences. The more novel the ideas are, the less prior exposure to them these audiences have had. The audiences are thus necessarily limited in their ability to discern the true merits of highly novel ideas.

Innovation research has recurrently highlighted the uncertainty about contributions' quality among audiences of highly novel work (Mueller, Melwani, and Goncalo 2012; Staw 1995). This uncertainty has been documented in peer audiences of technological innovation (Fleming 2001) and in audiences of scientific research (Boudreau et al. 2016). Commercial organizations and their customers similarly encounter difficulty in discerning the merits of highly novel products (Rindova and Petkova 2007). So do audiences of visual art

(Sgourev and Althuizen 2014) and expert panels evaluating R&D project proposals, particularly when opportunities to give novel ideas lengthy consideration are limited (Criscuolo et al. 2017).

This relationship between a product's novelty and its audiences' uncertainty about its merits underlies the argument of this study. When applied to the production of scientific and technological knowledge, the relationship implies that, other things being equal, the higher the novelty of a contribution to knowledge, the more uncertain its audiences are about its merits.

## Producer's Status Characteristics Proxy for Product Quality under Uncertainty

Lacking reliable quality markers, audiences rely on producer's status as a proxy for quality information. Most clearly articulated in signaling theory in economics (Spence 1974) and sociology (Podolny 1993, 2005), the tendency to infer quality from visible status markers when true quality is difficult to discern has been confirmed in a variety of settings. Prestigious scientists receive a recognition premium known as the Matthew effect (Merton 1968), which is larger when the quality of their work is uncertain (Azoulay, Stuart, and Wang 2014). Higgins, Stephan, and Thursby (2011) showed that a company's affiliation with star scientists is read by the investors as a signal of quality when the company goes public. Simcoe and Waguespack (2011) found that inclusion of high-status author names dramatically improved the publication chances of engineering proposals if the proposals had not been pre-screened by experts. The role of status as a surrogate for quality is particularly fitting in fine arts, where the objective quality criteria are elusive. Artists' high status predisposes art audiences to appreciate the stylistic novelty in their work (Sgourev and Althuizen 2014). High-status background also helps people enter creative careers by breeding the cultural capital which gatekeepers perceive as a signal of creative competence (Koppman 2016).

## Gender as a Status Characteristic

Status beliefs are "widely shared cultural beliefs that people who belong to one social group are more esteemed and competent than those who belong to another social group" (Ridgeway and Erickson 2000, 580; see also Berger et al. 1977). Among the multiple group distinctions that are subject to status beliefs, gender stands out in at least two ways. First, gender is what Ridgeway (2011) called a "primary frame" for organizing social relations—people can rarely have awareness of another person without being aware of the person's gender. Across cultures, people automatically and nearly instantly sex-categorize any person they encounter (Blair and Banaji 1996; Stangor et al. 1992), and gender status beliefs are activated concurrently (Ridgeway 2009). Second, gender status beliefs rank groups similarly across societies and time when compared to more varying status beliefs based on race, ethnicity, or occupation (Ridgeway 2011).

**Figure 1. Causal links in the emergence of the female penalty for novelty**


Expectation states theory posits that people rely on status beliefs when evaluating individuals' competence and the quality of their contributions (Berger et al. 1977; Berger, Cohen, and Zelditch 1972). Research has found extensive support for this general proposition across a variety of status characteristics (Berger, Rosenholtz, and Zelditch 1980). An instant and uniformly understood status marker, gender is expectedly among the most potent of these characteristics. Competence and quality inferences based on gender status beliefs create entrenched social inequalities that disadvantage women (Heilman 2001; Ridgeway 2011; Ridgeway and Correll 2004). Studies have shown that audiences' reliance on gender as a proxy signal of quality increases under uncertainty, resulting in an increased female disadvantage (Botelho and Abraham 2017; Gorman 2006).

Insofar as audiences' uncertainty about merits of contributions to knowledge increases with the contributions' novelty and as their reliance on gender status beliefs increases under uncertainty, female authors will be subject to a penalty for novelty. Women's novel contributions will receive less recognition than men's similar contributions, and this disadvantage will increase as novelty increases:

> *Hypothesis 1 (H1):* The higher the novelty of contributions to knowledge, the less peer recognition female authors earn for them relative to male authors.

The theoretical logic underlying this hypothesis is summarized in figure 1.

## *Alternate Status Characteristics*

The effect of gender may coexist with that of other status-granting differences. Therefore, even if audiences generally prize women's novel contributions below men's, not all women will be disadvantaged because of low status; high status on characteristics other than gender may eliminate the disadvantage for some women.

No alternate status characteristics, however, have been shown to eliminate the impact of gender in contexts where status beliefs generally disadvantage women. Studies of such contexts have shown that, even when women outrank some lower-status men in other salient status characteristics, such women will still be disadvantaged relative to men of equally high status (Foschi 2000; Pugh and Wahrman 1983; Ridgeway 2001, 638–39; Ridgeway and Correll 2004). Women need to surpass men on other statuses for their work or skills to be recognized equally with men's. For example, to attain equal recognition, a woman coder working on a coding relevant task would need to rank higher on at least one other status attribute (e.g., job title) than men working on the same task.

I propose that, under the condition of audiences' high uncertainty about the quality of highly novel contributions, outranking men on other status characteristics may not be necessary to attain equal recognition. Rather, ranking high on status characteristics more relevant to performance at producing knowledge than gender will be sufficient for women to be recognized for highly novel contributions equally with men of the same rank. In other words, women who rank high on performance-relevant alternate status characteristics will be subject to no detectable gender-based penalty for novelty.

I suggest that two parallel mechanisms may contribute to this outcome. First, high-status individuals of any gender are more likely to present highly novel knowledge in ways that minimize audiences' uncertainty about quality. This mechanism undermines the female penalty for novelty by weakening the causal link between novelty and uncertainty (the leftmost link in fig. 1). Echoing Bourdieu's (1984) analysis of esthetic hegemony, Rivera (2012) and Koppman (2016) argued that high-status individuals find ways to convey that they have cultural tastes favored by gatekeepers of creative careers, which eases their entry into such careers. Authors may also benefit from tacit subject knowledge needed to frame their novel ideas in ways favored by audiences. Thus, Darwin's careful use of methodological vocabulary and his nods to established knowledge about selective breeding increased the appeal of his theory of evolution within biology and the theory's cross-disciplinary influence (Cowles 2017). Similarly, Newton's use of accepted geometry to present his laws of gravitation in Principia, instead of his newly developed calculus, may have helped his ideas gain traction (Whiteside 1970). Status can help authors find such advantageous framing strategies by giving them early, nuanced understanding of audiences' reactions through easier access to social contacts and peer feedback.

The second mechanism undermines the female penalty for novelty by eroding the use of gender as a proxy for quality. While uncertainty makes audiences willing to fall back on gender as a proxy for creative quality, it may also make them more likely to abandon gender information for status characteristics which more reliably proxy for quality. Status characteristics research has long noted that evaluators may disregard previously considered status characteristics when other characteristics become available (Kramer 1991; Lenski 1966, 86–8) but did not specify what triggers such disregard. I suggest that contributions' high novelty is a likely trigger. Because novelty increases audiences' uncertainty about the true quality of a contribution, it highlights to them the defectiveness of the available information, including gender, for making the quality judgment. With the true quality of highly novel contributions uncertain and authors' gender being an unreliable proxy for it, the salience of authors' other characteristics, more pertinent to quality than gender, may increase in the eyes of the audiences to the extent that women's high status on those characteristics makes the audiences disregard their gender.

Research suggests that educational prestige is a status characteristic that may trigger both of these mechanisms. The cultural capital and tacit knowledge of graduates of prestigious, highly ranked academic programs are particularly likely to overlap with that of influential members of knowledge audiences.

Furthermore, knowledge gatekeepers are highly sensitive to peers' educational prestige. Such prestige has been consistently shown to determine their judgments of merit, particularly in hiring (e.g., Baldi 1995; Long, Allison, and McGinnis 1979). For example, Burris (2004) found that PhD graduates from five highest-ranked sociology departments were substantially overrepresented among new faculty hires, while faculty from programs ranked below top 20 were almost never hired at the top 5.

Because audiences' perception of knowledge is contingent on its authors' educational prestige, H1 is expected to hold generally but not among authors with high educational prestige:

> *Hypothesis 2a (H2a)*: The female penalty for novelty in knowledge is contingent on author's educational prestige such that, for authors with degrees from high-rank graduate programs, the relationship between the novelty of their published contributions and peer recognition does not differ between genders.

Relatedly, I expect that female penalty for novelty will be absent among authors who were trained by highly prestigious mentors. Latour (1987) and Camic (1992) both maintained that when uncertainty about scientific quality is high, peer regard for particular scientists and judgments of the quality of their work are based on the status of other professionals with whom the scientist is visibly associated. Mentorship is a highly salient association in science (Collins 1998; Malmgren, Ottino, and Nunes Amaral 2010; Zuckerman 1977). Scientists are keenly aware of mentoring relations, and academic mentors become their students' highly visible, career-long status markers. In mathematics-related disciplines, including information theory examined in this study, this visibility is embodied in the Mathematics Genealogy Project (genealogy.math.ndsu.nodak.edu). The project, run in association with the American Mathematical Society, has developed a public archive intended to include all mentor–student relations that ever existed in such disciplines. Thus, H1 is not expected to hold among authors mentored by the winners of prestigious professional awards:

> *Hypothesis 2b (H2b):* The female penalty for novelty in knowledge is contingent on the prestige of the author's mentors such that, for authors mentored by winners of prestigious professional awards, the relationship between novelty of their published contributions and peer recognition does not differ between genders.

Co-authorship is another salient association in knowledge production. However, co-authors' prestige does not extend to the focal author in the same way as academic mentors' prestige extends to their protégés. While being trained by an acclaimed expert is a marker of prestige, co-authoring with such a person may also signal that the focal author lacks intellectual independence and thus lowers the latter's professional prestige (Merton 1968, 57–8).

Finally, I expect the female penalty for novelty to weaken with the author's scholarly eminence, as reflected in their total citation counts. Because the total

citation count, alongside various measures derived from it, is a standard, widely used indicator of scholarly impact and prestige (Lynn et al. 2019; Meho 2007), I expect the relationship postulated in H1 to weaken as the authors' total citation count increases:

> *Hypothesis 2c (H2c):* The female penalty for novelty is contingent on the author's total citation count such that the gender difference in the relationship between the novelty of contributions to knowledge and their peer recognition decreases as the author's total citation count increases.

### Scope Conditions

The above argument and hypotheses are tailored to apply in knowledge creation. Although the precise scope of the argument cannot be determined a priori, sociological studies of gender bias suggest that the argument applies beyond this context. On the other hand, they also suggest that some contexts may fall beyond the argument's scope.

The argument can be reasonably applied to male-typed cultural markets in which the identity of individual authors is salient and gatekeepers need to resolve uncertainties about contributions' merits, including visual arts and music. Because the criteria of quality are more ambiguous in art than in research, gatekeepers in the arts must be more uncertain about quality and more prone to enact the uncertainty mechanisms that create or offset the female authors' penalty for novelty. On the other hand, studies have shown that audience evaluations do not disadvantage women when a domain is female-typed—that is, when audiences associate higher competence with female gender (Leung and Koppman 2018; Tak, Correll, and Soule 2019). Without evidence, it would therefore be wise to refrain from generalizing arguments about the female penalty for novelty to female-typed domains in academia (e.g., feminist theory) or beyond (e.g., cupcakes). Remarkably, however, high or increasing female representation in historically male-majority domains does not remove bias against women if the domain does not flip to become female-typed; increasing female representation may even reinforce this bias (Begeny et al. 2020). Thus, domains with high or increasing female representation are likely to remain susceptible to the female penalty for novelty.

## The Empirical Setting

To examine the hypotheses, I assembled comprehensive data on the creative output of academic engineers in the United States specializing in information theory.

Information theory is a sub-discipline of engineering focused on the mathematical representation of transmitted or stored information. Claude Shannon launched information theory almost single-handedly in 1948 by publishing his Mathematical Theory of Communication. Among other groundbreaking contributions, that article proposed the bit as a unit of information and developed the

notions of channel capacity, information redundancy, and information entropy. Information theory has since developed a distinct identity and has matured institutionally. Its main professional organization, founded in 1951, sponsors professional meetings and selects recipients of the field's prestigious awards. Its flagship journal, now monthly and named IEEE Transactions on Information Theory, has been published since 1953. Today's information theory has wide commercial applications, particularly in wireless communication, Internet technologies, and image and sound processing.

The choice of information theory as the empirical setting allows the collection of high-quality, relevant data. The well-developed identity and organization of the discipline help clearly demarcate the professional community of information theorists and the knowledge base relative to which the novelty of their contributions is defined. Using data from an entire field of knowledge vastly expands the empirical scope of the study of the female penalty for novelty, which in previous research was limited to specific organizations (Goldin and Rouse 2000; Post et al. 2009) and ad-hoc expert panels (Roca et al. 2016; Schmutz and Faupel 2010), sometimes in combination with experiments (Luksyte, Unsworth, and Avery 2018; Proudfoot, Kay, and Koval 2015). At the same time, the field of information theory is compact enough to code the scientists' gender, advising relations, and professional awards. Collecting systematic bibliographic data, a task that requires manual disambiguation of author identities, is also a manageable task for the field of such size. The technological relevance of information theory allows tapping into patent data to trace the practical applicability of contributions.

## Sample

The sample of information theorists was built in two steps. First, 343 information theory faculty members were distinguished, defined as any individuals who, in June 2010, (1) were employed as tenure-track or tenured professors in electrical engineering units (separate departments or combined with other disciplines, mostly computer science) in one of the 96 US institutions which the Carnegie Classification of Institutions of Higher Education classified as "very high research activity" and (2) mentioned information theory among professional interests on personal websites and/or had published in IEEE Transactions on Information Theory. Second, the initial sample of information theorists was expanded using the ProQuest Dissertations and Theses (D&T) database. Initial sample members' doctoral advisees, advisers, and advisers' advisees were added, bringing the number of individuals affiliated with information theory to 4,029. All sample members had doctoral degrees.

Articles authored or co-authored by information theorists were determined using the Web of Science. Articles and authors were matched by the author's last name and all initials. No articles were matched to a name if the Web of Science contained no publications under that name in any of the six subject categories where the information theory articles most commonly appear.

A disambiguation algorithm developed by Trapido (2015) was applied to remove articles with at least one ambiguous author identity from the sample. The resulting sample included 19,918 articles published by 1,946 authors. A check with a 1 percent random subsample showed that 98.5 percent of the articles were correctly matched to the authors. Attributes of articles and authors were gradually added from other sources as time, funding, and research assistance became available (see table 1).

## Measures

Because the dependent variable and the novelty variable vary in time, the unit of analysis in the data is the publication year: the variables are measured for each year between publication and the last year of the observation period. The dataset includes each publication year (not to be mistaken for the year of publication) once for each author. Table 1 shows the correlation matrix, descriptive statistics, and data sources for each variable.

### *Dependent Variable*

When academic work is cited, this is overwhelming because the citing authors recognize the work's usefulness rather than the flaws (Case and Higgins 2000; Shadish et al. 1995). The publication's yearly citation count, the dependent variable in the analysis, thus reflects the annual increment in the publication's peer audience recognition. The dependent variable is measured with a 3-yr. lag after the independent variables. This lag is an informed estimate of the delay between the perception of the cited piece by the citers and the eventual publication of the citation (see Trapido 2015, 1,492).

The observations of the dependent variable cover the period between the publication year (or 1980, whichever is later) and 2009. Due to the time lag, 2006 is the latest year in the analysis. The omission of the three latest publication years removed from the sample 4,545 publications published in those years.

### *Publication Novelty*

A long research tradition conceptualizes novelty as unusual recombination of the pre-existing elements. An early statement of the recombinant nature of novelty is sometimes credited to Joseph Schumpeter's work on business cycles (Schumpeter 1939). The conceptualization of novelty as unusual recombination of antecedents has since become the standard in the study of innovation (Fleming 2001; Fleming and Sorenson 2001; Henderson and Clark 1990; Kogut and Zander 1993; Nelson and Winter 1982; Weitzman 1996). The view of novelty as recombination is particularly apt in fields where authors typically contribute mathematical results, such as information theory, which this study examines. Unless a mathematical result involves new axioms, it is entirely derived from

**Table 1. Descriptive Statistics, Correlation Coefficients, and Sources of Data**

| Variable | Mean | SD | Min | Max | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Yearly citation count | 1.83 | 5.69 | 0 | 288 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 1 |
| 2. Degree centrality | 43.97 | 77.01 | 1 | 778 | .03 | — | — | — | — | — | — | — | — | — | — | — | — | — | 1, 2 |
| 3. Information theory faculty | .48 | .50 | 0 | 1 | .08 | −.01 | — | — | — | — | — | — | — | — | — | — | — | — | 2, 6, 7 |
| 4. Publication age | 6.94 | 5.24 | 1 | 27 | −.07 | .18 | −.04 | — | — | — | — | — | — | — | — | — | — | — | 1 |
| 5. (Publication age)$^2$ | 75.65 | 106.3 | 1 | 778 | −.07 | .21 | −.03 | .94 | — | — | — | — | — | — | — | — | — | — | 1 |
| 6. Years since PhD | 9.47 | 9.78 | −19 | 51 | −.01 | .16 | .29 | .01 | .01 | — | — | — | — | — | — | — | — | — | 2, 7 |
| 7. Publication's citations in patents | 26.00 | 58.33 | 0 | 556 | .09 | .07 | .58 | .04 | .04 | .34 | — | — | — | — | — | — | — | — | 1, 5 |
| 8. Number of authors | 2.83 | 2.16 | 1 | 24 | <.01 | .50 | −.09 | .03 | .06 | −.07 | −.06 | — | — | — | — | — | — | — | 1 |
| 9. First author | .39 | .49 | 0 | 1 | −.02 | −.11 | −.12 | .07 | .06 | −.27 | −.17 | −.26 | — | — | — | — | — | — | 1 |
| 10. IEEE TIT publication | .11 | .32 | 0 | 1 | .10 | −.03 | .17 | −.03 | −.03 | .06 | .12 | −.11 | .03 | — | — | — | — | — | 1 |
| 11. Female | .044 | .205 | 0 | 1 | <.01 | −.02 | −.01 | <.01 | <.01 | −.14 | −.04 | .03 | .03 | −.03 | — | — | — | — | 1, 2, 7 |
| 12. Publication novelty | .007 | .018 | 0 | .25 | −.08 | .13 | −.01 | .11 | .18 | <.01 | −.02 | .15 | .03 | −.05 | −.01 | — | — | — | 1 |
| 13. Top-five PhD department | .17 | .38 | 0 | 1 | .09 | .23 | .14 | −.02 | −.03 | −.34 | .14 | −.01 | .08 | .03 | −.05 | −.04 | — | — | 2, 3, 4 |
| 14. Award-winning mentor | .41 | .49 | 0 | 1 | <.01 | .12 | −.03 | .06 | .06 | .05 | −.03 | .04 | <.01 | −.01 | −.04 | −.04 | .05 | — | 2, 8, 9 |
| 15. ln (author's total citation count) | 4.56 | 2.15 | 0 | 8.63 | .09 | .43 | .17 | .27 | .23 | .55 | .31 | .11 | −.28 | .05 | −.04 | .01 | .17 | .05 | 1 |

**Note:** The sources of data are coded as follows: 1 = Web of Science; 2 = ProQuest D&T Database; 3 = Gourman Report (1980–97); 4 = U.S. News and World Report; 5 = United States Patent and Trademark Office; 6 = Carnegie Classification of Institutions of Higher Education; 7 = Google web search; 8 = Institute of Electrical and Electronics Engineers; 9 = IEEE Information Theory Society.

elements of prior knowledge. It may only diverge from prior knowledge by combining these elements in unusual ways.

Researchers have developed several recombination-based measures of novelty, which have been tailored to measure the unusualness of combinations of elements in artistic creation, science, and technology (Boudreau et al. 2016; Simonton 1980a, 1980b; Uzzi et al. 2013; Valentini 2012). I adopt the measure by Dahlin and Behrens (2005), which is designed to quantify the unusualness of recombination of knowledge elements in documents that reference pre-existing knowledge, such as research articles and patents. Because judgments of unusualness of recombinations tend to be domain-specific (Godart, Seong, and Phillips 2020), the measure captures how unusual the combinations of the referenced knowledge elements in the focal document are among the prior combinations in its domain of knowledge. The measure considers pairings between the focal publication $i$ and every pre-existing publication $j$ written by authors defined above as information theorists. Then, the overlap score between $i$ and $j$ is computed as the count of documents cited in $i$ and also cited in $j$ ($C_i \cap C_j$), divided by the total count of unique citations in $i$ or $j$ ($C_i \cup C_j$). To measure the usualness of the combination of knowledge elements in $i$ relative to anteceding combinations in the domain, the overlap score was summed over publications $j$, and the sum was divided by the total count of these publications ($J$):

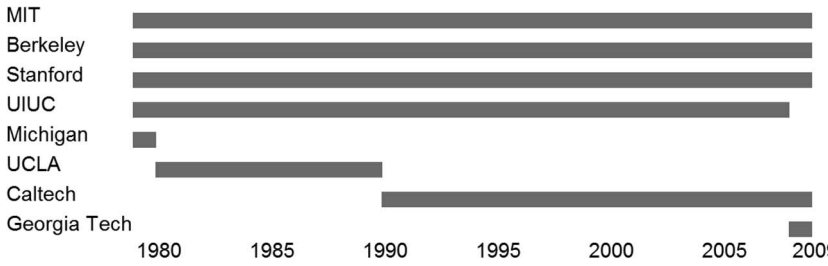
$$U_i = \frac{\left(\sum_{j=1}^{J} |C_i \cap C_j| / |C_i \cup C_j|\right)}{J}.$$

To convert the measure of usualness $U_i$ into a measure of unusualness, its scale was reversed by subtracting it from the maximum in the year of publication.

The resulting recombination-based novelty measure can range between 0 and 1. Publications score low on this measure when they cite only documents most frequently cited in pre-existing work. Such publications recombine the prior elements that have been most routinely, usually recombined by their authors' professional peers. The measure's high extreme marks publications that only cite prior work never cited before in the domain of knowledge. This attests that knowledge elements are recombined in a unique way, entirely novel in the field. The measure does not assume that authors literally recombine elements of knowledge which they cite but rather that recombination can be observed indirectly using citations.

Three PhD students in information theory were hired to check the validity of the novelty measure. All were advanced students at a leading research university and had multiple publications in the field's top journals. The PhD students independently assessed the novelty of the articles which they had cited in publications on a 4-point ordinal scale. For comparison with this scale, the novelty variable was recoded into quartile categories. Weighted Cohen's kappa, an indicator of the agreement between the recoded novelty variable and the raters' combined scores, was .50 (the individual kappas of the raters were .43, .50, and .53). The value falls short of the .75 threshold indicating "excellent

**Figure 2. Graduate engineering programs ranked within top five, 1980–2009**




agreement" but exceeds the .40 threshold of acceptability (Fleiss, Levin, and Paik 2003, 609), evidencing that the raters' subjective concept of novelty is consistent with the variable.[2]

This or possible other validity checks do not safeguard against all limitations of the measure. For example, the measure weighs all combinations of cited prior work equally, without considering that some antecedents had more impact on the citing publication than others. Such limitations must be balanced against the advantages of measuring novelty in knowledge with systematic quantitative data.

## Gender

Information theorists' gender was coded from the given names and photos found with web search. The gender of 67 authors could not be determined, and their publications were not used in multivariate analysis. Publication years have female authors in 4.4 percent of the cases, which is comparable to other contexts where bias against female authorship has been studied (Botelho and Abraham 2017, 709; Conley and Stadmark 2012).

## High-Rank Degree

Authors' PhD degree information was obtained from the ProQuest D&T database. Because information theory is an engineering discipline, the degrees were then ranked using rankings of graduate engineering programs. The Gourman Report was the only available source of such rankings until 1997; rankings by the US News and World Report were used for subsequent years. The Gourman Report was published at intervals ranging between 1 and 4 yrs. In years when the rankings were not published, the ranks from the edition closest to the PhD conferral year were assigned. Consistent with Burris (2004), top five departments, which had awarded PhD degrees to 29.4 percent of the authors in the data, were coded as high rank. There was a remarkable continuity in the top-five group between the two sources of rankings: MIT, Stanford, and Berkeley ranked within top five throughout the period, and the University of Illinois at Urbana-Champagne did so in all years except 2009 (see fig. 2).

### Award-Winning Mentors

The IEEE fellowship and the Shannon Award are two major professional accolades presented for long-term accomplishments in information theory. The IEEE Fellow status is conferred annually on individuals with "an extraordinary record of accomplishments in any of the IEEE fields of interest." The IEEE Information Theory Society gives the Shannon Award annually to one person "to honor consistent and profound contributions to the field of information theory."[3] Among the authors in the sample, 929 had PhD advisers who received one or both awards. Authors were coded as protégés of award-winning mentors only in years that followed the award. PhD advisers of 234 authors could not be identified in the ProQuest D&T database or in other sources; their status as a protégé of an award-winning mentor was coded as missing. Remarkably, neither award had been given to a female information theorist before Michelle Effros and Muriel Medard became IEEE fellows in 2009.

### Total Citation Count

Web of Science citation counts were summed over all author's publications prior to the focal year. The count had a strong positive skew. To reduce the skew, the variable was logged in the regression models.

### Control Variables

To ensure the robustness of the models, a set of author-level and publication-level control variables was included. First, the count of academic co-authorship and advising ties (degree centrality) captures the authors' involvement in peer networks, a factor that may potentially affect peer recognition (Uzzi et al. 2013) and is a common reproducer of gender inequality. The measure is the sum of all ties ever created before the focal year. Second, I controlled for employment by a research-intensive institution of higher learning, to remove its confounding effect on other status variables. Because the Web of Science did not record authors' institutional affiliation reliably in the examined period, I included a dummy variable marking publications by members of the initial sample of information theory faculty members, all 343 of whom had attained employment at top research institutions during the observation period. Third, I controlled for three kinds of time dependence. The year dummies control for any variation stemming from the specifics of the year. The count of years since PhD ensures that the results hold net of the authors' professional age. The age of the publication controls for the time that elapsed since it appeared in print. Because groundbreaking, highly cited work in information theory tends to date back to its earlier days when female authorship was rarer, this control is essential: it accounts for a potential source of spurious correlation between gender, novelty, and the dependent variable. I also included the quadratic term for the age of the publication because annual citation counts tend to peak and drop. Fourth, I controlled for the number of times the publication was cited in patents. This measure captures the technological relevance of the published

ideas, an important determinant of the audiences' recognition of contributions to knowledge (Boudreau et al. 2016). Fifth, I included the count of focal publication's co-authors, accounting for the citation premium enjoyed by co-authored work (Wuchty, Jones, and Uzzi 2007). Sixth, a dummy indicator of first authorship accounts for women's disadvantage in author ordering (West et al. 2013). Seventh, a dummy marks publications in IEEE Transactions on Information Theory, the field's main journal. The models may be biased without this variable because it is a major predictor of the publications' citation count; the variable is also negatively correlated with novelty, which is consistent with leading journals' tendency to avoid radical novelty (Siler, Lee, and Bero 2015). Eighth, to correct for heterogeneity across subfields, a full set of dummies for Web of Science subject categories was included. Of the 252 subject categories, 144 were represented in the data.

## Model

Poisson regression is a standard model for dependent count variables; the model assumes that the dependent variable's variance is equal to its mean. Because the dependent variable greatly exceeds this dispersion threshold, I used negative binomial regression, a generalization of Poisson regression not sensitive to over-dispersion. The Vuong test did not favor correcting the negative binomial models for zero inflation.

Two types of interdependence may potentially inflate the $p$ values of the model coefficients. First, multiple publications by the same author may violate the assumption of the mutual independence of observations. Second, inter-dependence may potentially exist between repeated observations of the same publication. The standard errors were therefore corrected for author- and publication-level clustering in all models reported below. Correction for clustering on multiple variables produces reliably unbiased standard errors (Cameron, Gelbach, and Miller 2011; Petersen 2009). The correction is implemented in the Stata ado-file clus_nway.ado.[4]

## Results

Table 2 reports the results of the tests of the hypotheses. Model 1 is the baseline model which includes only the controls, the author's gender, and the publication's novelty variable. Remarkably, the model shows no evidence of the overall citation bias against female authors; female-authored publications receive more citations, albeit insignificantly so. The effect of novelty on the publication's yearly citation count is likewise not significant.

The hypotheses are examined in models which include the full set of independent variables and the specific interaction effects that test the hypothesis at hand. Model 2 tests H1 by examining the interaction effect of female gender and novelty. This effect is negative and significant. Consistent with H1, this result attests that, relative to male authors' novelty, female authors' novelty receives less

**Table 2. Effects of Gender, Novelty, and Academic Status on Yearly Citation Counts of Information Theory Publications**

| | Negative binomial models of citation count in year $t + 3$ | | | | |
|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
| Author-level control variables | | | | | |
| Degree centrality | <.001 | −.001** | −.001** | −.001** | −.001** |
| | (.001) | (<.001) | (<.001) | (<.001) | (<.001) |
| Information theory faculty | .053 | −.046 | −.042 | −.047 | −.048 |
| | (.060) | (.055) | (.055) | (.058) | (.056) |
| Years since PhD | −.008* | −.013** | −.012* | −.013** | −.013** |
| | (.004) | (.005) | (.005) | (.005) | (.005) |
| First author of publication | −.061** | −.092** | −.092** | −.093** | −.090** |
| | (.009) | (.011) | (.011) | (.011) | (.011) |
| Publication-level control variables | | | | | |
| Publication age | −.001 | .001 | .001 | .001 | .001 |
| | (<.001) | (<.001) | (<.001) | (<.001) | (<.001) |
| (Publication age)$^2$ | .046 | .104* | .103* | .103* | .103* |
| | (.043) | (.045) | (.045) | (.045) | (.045) |
| Citations in patents | .003** | .002** | .002** | .002** | .002** |
| | (.001) | (.001) | (.001) | (.001) | (.001) |
| Number of authors | .017 | .027 | .027 | .026 | .027 |
| | (.014) | (.014) | (.014) | (.014) | (.014) |
| IEEE TIT publication | 1.217** | 1.139** | 1.145** | 1.142** | 1.140** |
| | (.134) | (.134) | (.133) | (.134) | (.133) |
| Year dummies included | Yes | Yes | Yes | Yes | Yes |
| Subject category dummies included | Yes | Yes | Yes | Yes | Yes |
| Female author | .018 | .172 | .467** | .254* | .445** |
| | (.106) | (.104) | (.130) | (.116) | (.166) |
| Publication novelty | 1.715 | 1.784 | 1.840 | 2.622 | .140 |
| | (2.720) | (2.667) | (2.725) | (3.055) | (1.956) |
| Female author × publication novelty | | −46.275** | −96.590** | −71.617** | −63.360* |
| | | (11.648) | (20.344) | (15.334) | (25.617) |
| Author's academic status characteristics | | | | | |
| PhD from top-5 departments (TOP5) | | .424** | .462** | .423** | .424** |
| | | (.078) | (.091) | (.079) | (.078) |

*(Continued)*

**Table 2. Continued.**

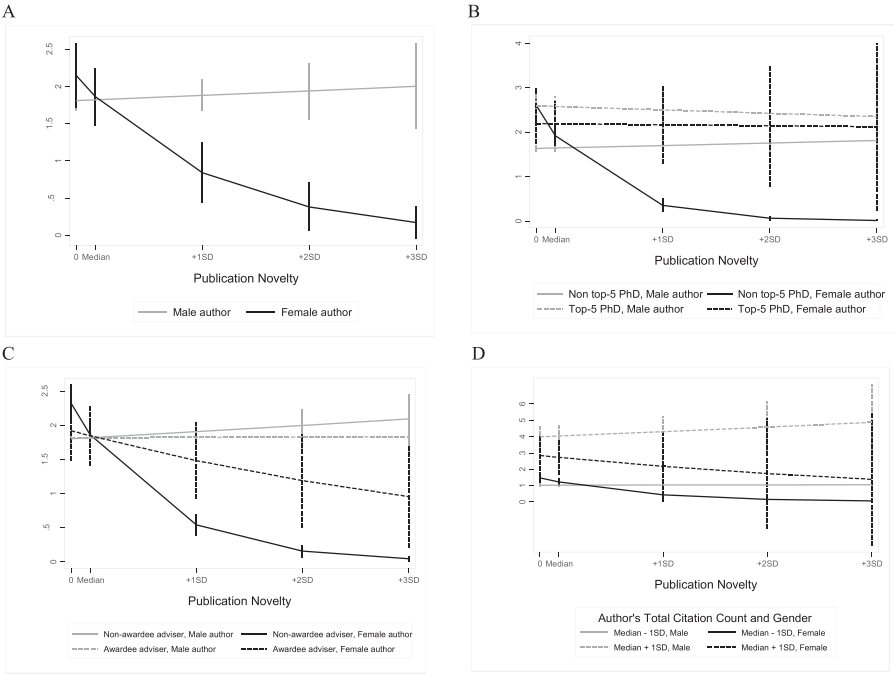
| | Negative binomial models of citation count in year $t + 3$ | | | | |
|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
| Award-winning PhD adviser (AAWARD) | | −.008 | −.003 | .007 | −.009 |
| | | (.055) | (.055) | (.061) | (.055) |
| Total citation count, logged (TOTCIT) | | .157** | .156** | .157** | .159** |
| | | (.020) | (.020) | (.020) | (.020) |
| Interaction of gender and novelty with academic status characteristics | | | TOP5 | AAWARD | TOTCIT |
| Female author × academic status characteristic | | | −.634** | −.197 | −.083 |
| | | | (.232) | (.241) | (.046) |
| Publication novelty × academic status characteristic | | | −3.563 | −2.455 | .358 |
| | | | (8.815) | (2.268) | (.698) |
| 3-way interaction | | | 97.737** | 59.156** | 4.982 |
| | | | (25.324) | (18.943) | (6.314) |
| Yearly observations | 140,158 | 119,717 | 119,717 | 119,717 | 119,717 |
| Publications | 13,674 | 12,014 | 12,014 | 12,014 | 12,014 |
| Authors | 1,554 | 1,361 | 1,361 | 1,361 | 1,361 |
| Log likelihood | −229,250 | −195,174 | −195,136 | −195,158 | −195,160 |

**Note:** The constants are omitted. Standard errors, adjusted for author-level and publication-level clustering, are in parentheses. The observation count reflects list-wise deletion due to missing variable values.
*$p < .05$; **$p < .01$.

peer recognition expressed in citation counts. The moderating effect of gender on peer recognition of publication novelty is visualized in panel A of figure 3. As novelty increases, female authors' publications receive fewer citations, while citation counts of publications authored by men change little. The marginal effect of novelty does not differ between genders at or below the median, but women's contributions are cited significantly less than men's when novelty is one or more standard deviations above the median. The gap between men's and women's lines, in this and other panels of the figure, is the gender difference in citations. The widening of the gap toward the right graphically represents the female penalty for novelty predicted in H1. Because citation is a publication-level outcome, the penalty is shared by all co-authors regardless of gender.

Models 3–5 examine how this penalty varies by academic status characteristics. To test the hypothesized effects of these characteristics, I proceed in two steps. First, for each characteristic, I estimate the full factorial model of its interaction with gender and novelty. A significant three-way interaction effect suggests that gender moderates the effect of novelty on publications' citation count differently, depending on the status characteristic. Second, I plot the

**Figure 3. Marginal effects of publication novelty on publications' citation count by author's gender and academic status characteristics**




three-way interaction to visualize the possible moderating effects. The respective hypothesis would be supported if the three-way interaction effect was significant and the visualization showed that the gap between men's and women's lines at high levels of novelty persists when authors have low status but is narrower and not significant when they have high status.

The three-way interaction effect for gender, novelty, and the top-five status of the author's PhD program in Model 3 is positive and significant. The effect is plotted in panel B of figure 3. The citation counts of male-authored publications vary little across the values of publication novelty or the top-five status of their PhD program. For female-authored publications, the relationship between novelty and citation count visibly depends on the ranking of the PhD program. For graduates of top-five PhD programs, publications' citation count does not significantly differ between female and male authors at all levels of novelty. For those who did not graduate from top-five PhD programs, the female citation penalty for novelty persists—the more novel the publication is, the fewer yearly citations women receive for it relative to men. This difference remains significant one, two, and three standard deviations above median novelty. These results support H2a. The signs and significance of all effects do not change if the top three PhD programs (Berkeley, MIT, Stanford) or the top ten are considered instead of the top five.

The findings are similar when the second status characteristic, being mentored by award-winning PhD advisers, is considered. Again, the three-way interaction effect is positive and significant (see Model 4). Publications' citation count does not significantly vary by novelty, except for women who had no award-winning PhD advisers. In this latter group, the citation count declines with increasing publication novelty, as shown in panel C of figure 3. A downward trend also shows among female authors advised by award winners, yet it is not significantly different from the trend among men. The gender gap in citations, graphically represented by the vertical distance between men's and women's lines, is larger and significant among those whose advisers won no awards (solid lines) and smaller and nonsignificant among those whose advisers won awards (broken lines). This pattern of results supports H2b.

Model 5 examined H2c. This hypothesis predicted that the gender difference in the relationship between novelty and publication citation count will be smaller for highly cited authors. The three-way interaction between novelty, gender, and author's total citation count was not significant, and the pattern of the relationship between novelty and the total citation count did not agree with the prediction in H2c. In panel D of figure 3, the gender gap is, again, represented by the vertical distance between men's and women's lines. The gap widens as novelty increases among the highly cited authors (those whose total citation count is at least one standard deviation above the median), more so than among the less-cited authors (total citation count is at least one standard deviation below the median).

## Conclusion

### *Summary*

This study built on theory and evidence suggesting that audiences are uncertain about merits of highly novel work and rely on producers' status, including gender, as a proxy for merit. Given that femininity is culturally associated with lower status, I hypothesized that female authors will earn less peer recognition relative to male authors for their contributions to knowledge to the extent that these contributions are highly novel. I further argued that female authors who possess high academic status characteristics will not be subject to such penalty for novelty due to two causal mechanisms. First, such authors are more prone to present their novelty in ways that minimize audiences' uncertainty. Second, the same uncertainty which makes audiences use gender as a proxy for quality also urges them to prioritize information—including status markers—which conveys quality more reliably than gender.

Evidence from publications by information theorists supported the first hypothesis: female authors received fewer citations for their published work to the extent that this work was novel; citation counts of male-authored publications did not significantly vary by novelty. As hypothesized, women with degrees from top-ranking PhD programs or mentored by award-winning advisers

were not subject to this novelty penalty. Contrary to the hypothesis, highly cited female authors were no less subject to the penalty than less-cited ones.

## Theoretical Implications for Gender Inequality

By offering evidence of the female penalty for novelty in knowledge, this study helps to clarify the double standards that reproduce gender inequality in academia and at its interface with commercial technology. Insofar as male producers of knowledge receive more positive reinforcement for pursuing intellectually divergent paths, they will tend to persevere on those risky paths which tend to lead to extreme, positive and negative, peer recognition outcomes. Because the distribution of academic prestige is highly unequal, with a select high-prestige tier at the top and the differences between others tiers compressed (Zuckerman 1977), men's tendency to get positive reinforcement while pursuing risky high-novelty paths will result in men's overrepresentation in the highest tier and a disproportionate accrual to these men of rewards, such as funding, publication in prestigious outlets, tenure, and professional awards. Likewise, the bias against women's novelty may contribute to firms' reluctance to solicit advice from female scientists (Ding, Murray, and Stuart 2013). In commercial innovation, the uncertainty about scientific ideas' merit is not a purely intellectual matter but also a matter of company performance. Faced with such two-fold uncertainty, decision makers may prefer male researchers' inputs over those of female researchers because the former convey more certainty about ideas' commercial potential.

The finding that women who have high status on salient characteristics may be immune to peer audiences' otherwise well-pronounced gender bias alters the familiar understanding of the robustness of gender status beliefs. Research has found that other status characteristics counteract the impact of gender on competence and quality evaluations; yet it showed that high status on these characteristics does not eliminate the double standards that disadvantage women relative to men of equally high status (Foschi 2000; Pugh and Wahrman 1983; Ridgeway 2001; Ridgeway and Correll 2004) and attributed the persistence of the double standards to the culturally entrenched gender status beliefs (Ridgeway 2009, 2011). This study provides early evidence that, when audiences allocate credit to highly novel contributions, high status on other salient characteristics may render gender bias inconsequential to credit allocation, even while the same audiences' judgment is generally biased against women's novelty. To explain this divergent finding, the study's argument points out that audiences of highly novel knowledge experience high uncertainty about quality. In both sociology and economics, theories have argued that uncertainty about the true quality makes audiences more reliant on the producer's status as a proxy for quality (Higgins, Stephan, and Thursby 2011; Podolny 1993, 2005; Sgourev and Althuizen 2014; Simcoe and Waguespack 2011; Spence 1974). I extended these theories, arguing that uncertainty also directs audiences' attention to the relative relevance of various status-based proxies, making them use more quality-relevant proxies in their assessments instead of less-relevant ones such as gender.

This study had no ambition to examine the overall bias against female authorship. Nevertheless, it found that overall citation counts did not differ between women's and men's publications. This finding was anticipated in prior research and may be explained by the irrelevance of self-selection and commitment, otherwise powerful mechanisms perpetuating gender inequality, in the case of citations (Lynn et al. 2019). The finding attests that the overall gender equality may belie continuing women's disadvantages when audiences are highly uncertain about the contributions' merits.

## Practical Implications for Countering Gender Inequality in Science and Technology

The finding that gender-biased audiences remain attuned to markers of women's status other than gender, to the extent that high-status women are subject to no disadvantage, points to practical ways of countering gender inequality. Insofar as this finding generalizes to rewards other than citations, it implies that whenever women's attainment of performance-relevant status characteristics is affirmed, such affirmation will help erode gender inequalities in careers. Much of the task of visibly affirming female scientists' and technologists' competence falls to educational institutions. To help erode the disadvantages that female scientists and technologists face because of prejudice against women's novelty, prestigious academic institutions and mentors should welcome and support aspiring female scholars. Because evaluators discount the prestigious educational credentials of members of low-status demographic groups when they perceive that such credentials were obtained due to preferential treatment (Sauer, Thomas-Hunt, and Morris 2010), universities will be well advised to support women without granting outright gender-based preferences.

By the same token, managers of technology, R&D, education, or in any domain where generation of novel knowledge is factored into individual performance evaluations may leverage the uncertainty-reducing effect of status characteristics to lower barriers to women's career advancement. Peers and superiors will be more likely to prize women's novel ideas on par with men's when women's credentials are salient. Although hiring alumnae of prestigious educational establishments or companies can be costly, within-organization ways of signaling women's status through prestigious mentorship, training, and recognition of past achievements may be similarly effective in countering the bias against women's novelty.

## Limitations and Future Research

The lack of support for H2c is an obvious loose end in this study. H2c predicted that, because total citation count is a salient marker of academic status, it would, similarly to cues of academic pedigree, counteract the female penalty for novelty. A possible reason why this prediction failed—consistent with the pronounced effects of doctoral training in the tests of H2a and H2b—is that authors in information theory are relatively recent graduates and their typical

citation record is still too modest to matter. The data, however, do not support this explanation. The effect hypothesized in H2c is not greater, nor are the effects hypothesized in H2a and H2b diminished, among academically "older" authors (those with above-median post-PhD experience at publication). More plausibly, the failure of the prediction may be due to the correlation between the authors' total citation count and academic specialization. Because narrow specialization helps academics obtain citations (Leahey 2007) but favors creation of incremental rather than highly novel contributions, highly cited authors may excel in normal science but struggle to convince peers of the quality of their highly novel work. Alternatively, H2c may lack support because the gradually earned expert status reflected in authors' citation counts—as opposed to status immediately bestowed by prestigious academic degrees or associations—is not effective in counteracting traditional gender status beliefs. In experiments by Thomas-Hunt and Phillips (2004), expert women were paradoxically perceived by others as less expert and had less influence than nonexpert women.

Another limitation of this study is that the uncertainty-related causal mechanisms in its argument were not observed. The study examined hypotheses implied by these mechanisms and the relationship between novelty and uncertainty, but it did not capture the role of uncertainty in generating or counteracting gender bias. Future work may test this role by examining other contexts where audiences face uncertainty about quality, such as the general blurring of quality standards in times of paradigmatic shifts, or by comparing fields of knowledge with different degrees of certainty in the definition of quality standards. Under high uncertainty in such contexts, the argument of this study would predict a pattern similar to the one described in this study—a female penalty (relative to low-uncertainty conditions) when authors lack high status on other salient characteristics and no gender difference among high-status authors.

The sociology of creativity is still forming; compared to psychology and management studies, the contribution of contemporary sociology to creativity research has been modest (Godart, Seong, and Phillips 2020). This is particularly regrettable because sociologists' premier expertise in social inequality uniquely equips them to explore the role of creative work in generating social and economic disparities. As innovation economies develop, supposedly merit-based inequality between creative professional elites and the working classes feeds frustration and political polarization (Sandel 2020). Understanding the interplay between creative work and social inequality is therefore a pressing task. By adding to the nascent sociological research on access to creative work (Koppman 2016) and gender inequality in such work (Mauskapf et al. 2018), this project aims to encourage sociologists to have a stronger voice in the search for remedies to today's social divisions.

## Notes

1. Studies of gender bias do not always distinguish between novelty, creativity, and innovation/innovativeness when referring to generation of new ideas. According to Amabile (1988, 1996), the terms "creativity" and "innovation"

apply to useful ideas, while "novelty" is neutral about usefulness or other aspects of ideas' value. To convey this neutrality, "novelty" will be used throughout this article. The other two terms are only used to preserve the usage in cited sources.

2. The measure of novelty was chosen over an alternative, custom-designed measure that was tested with the same procedure and did not pass the threshold of acceptability.
3. The awards are described at https://www.ieee.org/membership/fellows/index.html and https://www.itsoc.org/honors/claude-e-shannon-award.
4. The file clus_nway.ado can be obtained at http://faculty.tuck.dartmouth.edu/adam-kleinbaum/software.

## About the Author

**Denis Trapido** is an assistant professor of management and organization at the University of Washington Bothell. His published research has examined evolution of professional communities, obstacles to network formation and ways of overcoming them, and rewards of creative work. His current research interests include understanding origins of inequality in rewards of creativity and explaining the tendency of creativity in fields to peak and irreversibly decline.

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