Article
Segregation, Stereotypes, and STEM

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Abstract: Scientific, technical, engineering, and mathematical (STEM) occupations are strongholds of gender segregation in the contemporary United States. While many Americans regard this segregation as natural and inevitable, closer examination reveals a great deal of variability in the gendering of STEM fields across time, space, and demographic groups. This article assesses how different theoretical accounts accord with the available evidence on the gender composition of scientific and technical fields. We find most support for accounts that allow for a dynamic interplay between individual-level traits and the broader sociocultural environments in which they develop. The existing evidence suggests, in particular, that Western cultural stereotypes about the nature of STEM work and STEM workers and about the intrinsic qualities of men and women can be powerful drivers of individual aptitudes, aspirations, and affinities. We offer an illustrative catalog of stereotypes that support women's STEM-avoidance and men's STEM-affinity, and we conclude with some thoughts on policy implications.

Keywords: gender; STEM; segregation; stereotypes; culture; work; occupations; science; inequality

For more than three decades, American educators, policy makers, activists, and business leaders have engaged in research and policy initiatives to increase the presence of women and other underrepresented groups in scientific, technical, engineering, and mathematical (STEM) occupations and fields of study. These efforts have been motivated by interests in broadening opportunities in lucrative, high-status occupations and in ameliorating acute STEM labor shortages that are believed to threaten national prosperity, private profits and the public welfare.

Despite wide-ranging research and policy efforts, STEM occupations remain strongholds of gender segregation in the contemporary United States. Women made up nearly half of the US labor market in 2015, but only 28% of all scientific and technical workers. Within STEM, gender segregation is also very strong, with women comprising 48% of life scientists and 60% of social scientists, but only 28% of physical scientists and 15% of engineers (NSF 2018, Appendices 3–12).[1] While some fields have integrated over time, others have become more segregated. Women's share of US bachelor's degrees in computer science, for instance, declined from 28% to 18% between 2000 and 2015 (NSF 2018, Appendices 2–21).

While many Americans understand men's dominance of scientific and technical work as natural and universal, the gender typing of STEM fields varies a great deal across space, time, and socio-demographic groups. Recent comparative studies have shown that scientific degree recipients are disproportionately *female* in Iran, Saudi Arabia, Romania, and Georgia, for example, and that the gender gap in children's STEM aspirations is larger in more affluent societies (Charles 2011a, 2017;

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[1]   Even within engineering women and men tend to do different work: about 10% of mechanical and electrical engineers are women, compared to 20% of civil engineers (ibid.).

Stoet and Geary 2018; see also Women in Engineering in Predominately Muslim Countries n.d.). Within the United States, the gender composition of STEM fields has varied over time as well—including in computer programming and quantitative social science, which have transitioned from female- to male-labeled since their founding (Luker 2008; Abbate 2012; Ensmenger 2015). STEM gender gaps also vary in size across groups defined by race, class, and immigration status (Xie and Shauman 2003; Ma 2009; Nores 2010). In 2015, for instance, 22% of Black engineers, but only about 14% of White, Asian, Hispanic and Latino engineers were women in the US (Wong and Charles 2018).

This strong contextual variability suggests an important role of sociocultural factors in the gender segregation of scientific and technical work. Contributors to this volume explore these factors through in-depth analyses of the STEM-relevant experiences and outcomes of US-based workers and students.

The current article assesses how different theoretical accounts of segregation accord with available evidence on the gender composition of STEM fields. We find most support for accounts that allow for a dynamic interplay between individual-level traits and the broader sociocultural environments in which they develop. The evidence suggests, in particular, that Western cultural stereotypes about the nature of STEM work and STEM workers, and about the intrinsic qualities and relative social status of men and women, can be powerful drivers of gendered aspirations and affinities. Our discussion of the existing theoretical and empirical literature is followed by an illustrative catalog of stereotypes that have been found to support women's STEM-avoidance and men's STEM-affinity. We conclude with some thoughts on policy implications.

1. Why are STEM Fields so Segregated?

Sociologists commonly distinguish between micro- and macro-level explanations for gender inequality. The former consider characteristics of persons (e.g., individual workers and employers) and the latter focus on characteristics of larger units (e.g., organizations, national societies). Below, we consider how each framework accords with the available evidence on gender segregation of STEM fields, and how micro- and macro-level processes may interact to produce highly resilient forms of gender inequality.[2]

1.1. Micro-Level Explanations

The explanations of gender segregation that are most popularly resonant invoke the personal traits of workers and employers. These are often dubbed "supply-side" and "demand-side" accounts, respectively, in reference to the sellers and buyers of labor depicted in classical microeconomic theory.

Supply-side explanations focus on differences between men and women in aptitudes, preferences, or workplace productivity (Becker 1985; Mincer and Polachek 1974). The segregation of STEM fields might, for example, be attributed to women's stronger orientation toward interpersonal relations and care, or to men's greater investment in the requisite human capital or greater capacity for analytical thinking. Biologically-based supply-side accounts emphasize sex hormones and brain structures as drivers of gendered behaviors and divisions of labor (Baron-Cohen 2003; Ceci and Williams 2011). Socialization accounts emphasize the sorting of people into binary sex categories at birth and the rewards (sanctions) that accrue for gender-conforming (-nonconforming) behaviors. Because gendered traits are eventually internalized, adult women are expected to prefer roles that draw upon feminine traits, and adult men are expected to prefer roles that draw upon masculine traits (Parsons and Bales 1955; Marini and Brinton 1984).

Explanations emphasizing gendered workers resonate widely and align well with the ubiquitous "Mars and Venus" mythology that depicts men and women as innately "opposite" sexes (Gray 2012). High-profile supply-side accounts of gender inequality in STEM include a 2005 speech by Harvard president Lawrence Summers, and a 2017 memo by former Google engineer James Damore,

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[2]   For a more general review of the literature on occupational gender segregation, see Wong and Charles (2018).

both attributing women's underrepresentation to fundamental gender differences in abilities and preferences. These accounts generate fierce resistance among advocates for equality because they seem to blame women for their lesser status in these fields and suggest that the current gendering of occupations is inevitable.

Most social scientists view supply-side explanations as inadequate—among other things, because the gender typing of occupational roles varies strongly across time and space, and over the individual life course (Jacobs 1989; Tolley 2003; Penner 2008; Grier 2005; Charles 2011a, 2017) and because measurable differences between men and women are too small to account for the extreme patterns of segregation observed in many occupations and workplaces. Even when men and women differ on average on some aptitude or personality trait, between-gender differences are typically much smaller than within-gender differences, and the size of observed gender gaps frequently vary by context or disappear when men and women have the same status (Epstein 1988; Ridgeway and Smith-Lovin 1999; Eagly 1995; Hyde 2005; Stoet and Geary 2018). An exhaustive analysis of the science of sex differences accordingly concludes with the following observation:

> Personality traits and predispositions are not identical in individuals, but they are also not well captured by the binary system of gender . . . We aren't blank slates, but we also aren't pink and blue notepads (Jordan-Young 2010, p. 290).

Even gendered divisions of family labor, a central focus of neoclassical micro-economists (Mincer and Polachek 1974), appear to have little power to explain differences in career trajectories between women STEM and non-STEM professionals (Glass et al. 2013). In this volume, for instance, Sassler et al. (2017) find that differential STEM persistence of men and women degree holders in computer science and engineering are unrelated to family factors, and Shauman (2017) shows that gender disparities in early career outcomes of STEM doctorates cannot be attributed to actual parenthood/marriage patterns, as is commonly presumed. Overall, it appears that differences between men and women in the typically invoked individual-level characteristics have limited explanatory power for understanding gender-differentiated STEM career paths.

Among the standard "supply side" variables, occupational aspirations and expectations typically show the most robust effects on career trajectories: aspirations are strong predictors of occupational outcomes, and gender is a strong predictor of occupational and educational aspirations, holding constant a host of other factors, including employment continuity and expectations for marriage and children (Okamoto and England 1999; Xie and Shauman 2003). The causes of gendered occupational aspirations are less well documented. Further on, we identify one important causal factor: the cognitive biases that can result from stereotypes about hard-wired gender difference (i.e., "gender-essentialist" belief systems).

Demand-side explanations switch the focus from attributes of men and women workers, to actions and attributes of employers and clients (and, at the macro level, characteristics of firms and policy regimes). The simplest demand-side explanation for labor market inequality is that employers with "tastes for discrimination" are willing to pay a wage premium to hire members of preferred groups (Becker 1957).[3] Although economic theory holds that discrimination puts employers at a competitive disadvantage, some economists have attributed its persistence to employers' imperfect information about the relative productivity of potential workers. According to "statistical discrimination" theory, employers may seek to maximize profits by discriminating against groups whose members they believe are less productive on average (Phelps 1980). For example, if an employer believes that the average woman has a weaker capacity for analytical reasoning than the average man (and if analytical

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[3]   Employer discrimination also figures prominently in queuing theory, which holds that modern labor markets are built around two queues: a labor queue in which employers rank the desirability of employees, and a job queue in which workers rank the attractiveness of jobs (Reskin and Roos 1990). Because women are systematically ranked below men in the labor queue, they are overrepresented in the least attractive jobs.

reasoning were difficult to measure directly), it might seem rational to discriminate against all women in hiring for jobs that place a premium on analytical reasoning.

An important point here is that employers' personal beliefs about average gender differences need not be true to produce extreme gender segregation. Because many employers are exposed to the same taken-for granted cultural stereotypes about men's and women's average capacities, statistical discrimination can be a powerful mechanism for translating cultural beliefs about gender difference into gendered individual preferences and outcomes (Bielby and Baron 1986). We discuss this sort of macro-micro interplay further on.

Gender discrimination is difficult to measure—in part because it is illegal in the United States and few people will admit to it. Some of the most compelling evidence of discrimination in STEM hiring has been gathered through experiments and audit studies. One double-blind audit study demonstrated, for example, that STEM faculty members were less likely to hire female than male candidates for a lab manager position, because women were perceived to be less competent (Moss-Racusin et al. 2012; see also Goldin and Rouse 2000). Other research has shown that faculty are more likely to respond to email requests for graduate mentoring from persons with male, white-sounding names (Milkman et al. 2015) and that scientific papers are judged to be of higher quality when attributed to a male author (Knobloch-Westerwick et al. 2013). In this volume, Blair-Loy et al. (2017) provide new evidence of unequal treatment in the STEM hiring process in the form of videotaped job talks that show more interruptions of women than men candidates for faculty engineering positions.

Importantly, supply- and demand-side processes can reinforce one another by generating self-fulfilling prophesies. For example, knowledge (or even rumors) of discrimination in male-dominated science and engineering fields may influence occupational aspirations, leading some girls and women to forego STEM training and thereby reducing their future competitiveness in these fields. STEM avoidance by a few girls can have multiplier effects because adolescents respond strongly to standards set by same-gendered peers (Legewie and DiPrete 2014). Discriminatory treatment is also reinforced by behavioral responses to unbalanced gender ratios. In her classic ethnography, Kanter (1977) showed how the intense visibility and performance pressures experienced by numerical minorities ("tokens") in work organizations give rise to stereotype-confirming behavior and interactions that reproduce existing inequalities (1977). For example, token women may react to discriminatory treatment and gender stereotyping by enacting some organizationally sanctioned version of femininity to which they can reasonably conform. The result is often constrained opportunities and feedback loops of disadvantage and personal dissatisfaction (Turco 2010; Ridgeway 2011; Banchefsky and Park 2018; Garr-Schulz and Gardner 2018).

The interactional processes that disadvantage women in male-dominated STEM workplaces are often compounded by other forms of minority status, including nonwhite or immigrant identities, and non-hegemonic forms of gender or sexuality (Fenstermaker and West 2002; Williams et al. 2014; Alfrey and Twine 2017; Cech and Pham 2017; Ma and Liu 2017; Sassler et al. 2017). In US academic physics, for example, the cultural image of the white male scientist intensifies pressure on women of color, who frequently face skepticism about their competence and belonging (Ong 2005).

1.2. Macro-Level Explanations

Gender segregation of STEM is generated within social environments that vary widely. In the following, we consider how individual aptitudes and preferences are conditioned by broader structural and cultural forces.

A first set of macro-level accounts focus on societies or countries as the unit of analysis. One influential structural theory suggests a generically egalitarian effect of socioeconomic modernization—either because discrimination is too costly to sustain in competitive market economies (Treiman 1970; Jackson 1998; see also Cole and Cole 1973 on meritocracy in science), or because countries absorb liberal universalistic cultural values from the affluent West as they modernize and develop tighter links to global institutions and world culture (Ramirez et al. 1997; Berkovitch 1999;

Meyer 2010). Consistent with these evolutionary accounts, gender equality has increased around the world on many important dimensions—in particular with respect to formal legal rights and participation in labor markets and educational institutions. In other respects, however, inequality has proven to be highly resilient in the industrial West. Today some of the most gender-segregated STEM workforces are found in highly affluent, reputably gender-progressive societies (Charles 2011b, 2017; Stoet and Geary 2018).

The "postindustrial" restructuring of economies has had similarly uneven effects on gender stratification, supporting rising rates of female employment while also contributing to the consolidation of pink-collar "occupational ghettos" (Charles and Grusky).[4] These shifting labor market dynamics have been reinforced by the postwar expansion of higher education—in particular, the proliferation of two-year and vocational institutions and the expansion of programs such as human development, home economics, and teacher education, which were explicitly designed to appeal to what were understood to be women's natural interests (Bradley and Charles 2004). In short, women have often been incorporated *as women* into expanding labor markets and educational institutions. And since the middle of the twentieth century, "women's work" has not included most STEM occupations.

Gendered employment patterns are also heavily shaped by national policies and traditions. Social arrangements—for example, relating to hours, working conditions, family leaves, childcare, worker protection, and taxation—regulate individual behavior and reproduce normative models of work and family (Buchmann and Charles 1995; Gornick and Meyers 2003; Thébaud 2015; Ecklund and Lincoln 2016). Social democratic policy regimes, which offer greater support to working parents, tend to promote more egalitarian family structures and higher rates of women's full-time employment (Charles and Cech 2010; Pedulla and Thébaud 2015; Hegewisch and Gornick 2011), but they are at best weakly related to gender segregation in STEM—as evidenced in the highly segregated scientific and technical labor forces found in policy-progressive Scandinavian countries (Charles and Bradley 2006; Charles 2011a).

A second set of macro-level accounts focus on characteristics of workplaces and work organizations. For instance, much has been written about the role of organizational bureaucratization in reducing the operational salience of masculine, white, and heteronormative biases. Some studies show that technology firms that emphasize formal rules and procedures—as opposed to informal peer-group control—are characterized by less discrimination and more opportunities for recruitment and advancement of women scientists (McIlwee and Robinson 1992; Baron et al. 2007). Other analyses suggest that formal bureaucracy obscures discrimination in "gendered organizations" by advancing structures that presume male workers but discourses that leave the gender of the ideal worker unspecified (Acker 1990).[5] In one Swedish information and communication technology firm, for example, requirements for travel and long hours away from home were found to restrict women's ability to acquire advanced technological expertise and resulted in their concentration in administrative roles (Holth et al. 2017). But while workplace expectations for high temporal and spatial availability tend to elicit gendered responses (Blair-Loy 2003; Zippel 2017), they appear to affect advancement and retention in similar ways across different sorts of professional occupations (Glass et al. 2013). They do little, therefore, to explain the extreme gender segregation of STEM fields in particular.

Given the limited explanatory power of other accounts, it is not surprising that a growing body of research centers on the uniquely gendered cultural elements of STEM disciplines and work environments in Western societies and organizations. Gender is a dominant cultural frame that

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[4] Many expanding industries (e.g., in childcare, health, elementary teaching) produce services that are symbolically or functionally linked to women's domestic work, and high labor demand has led some employers to reorganize these jobs to appeal to married women—for example, through part-time scheduling (Oppenheimer 1973; Goldin 1990; Charles and Grusky 2004).

[5] Other organizational characteristics that have been linked to occupational gender segregation include firm size, personnel policies and practices, skill requirements, opportunities for team work, unionization rates, women's presence in management, and workplace traditions (Bielby and Baron 1986; Baron et al. 1991; Reskin and McBrier 2000; Smith-Doerr 2004).

organizes everyday social relations, shapes individual identities, and inscribes gender inequality in social and economic institutions (Ridgeway 2011). In contemporary Western societies, persons are widely presumed to occupy one of two distinct gender categories, and many work tasks are presumed to be intrinsically masculine or feminine (Bem 1993; Faulkner 2000; Nosek et al. 2002; Des Jardins 2010). Many people believe, therefore, that occupations like engineering and preschool teaching are highly segregated *because* they require aptitudes and bodies that map neatly onto the "Mars and Venus" gender dichotomy. As such, occupations themselves become implicitly categorized by gender, just as people do. In the case of STEM, this categorization is often reinforced by the distinctively masculine cultural beliefs, norms, and practices that pervade STEM educational and work environments.

Of course, an occupation's gender composition depends upon diverse factors, including the economic and social conditions operative at the time of its expansion (e.g., labor shortages, technological developments, barriers to entry) and the functional and symbolic proximity of its task profile to work historically done by men or women. But, once segregated, occupational gender labels become imprinted in the popular imagination and are absorbed at an early age. "Draw-A-Scientist" studies show, for example, that young American children have taken for granted the masculinity of STEM workers for at least five decades (Miller et al. 2018). These gender labels are naturalized as people identify aspects of the work process (e.g., physical, analytical, or emotional demands) that support cultural stories about the occupation's intrinsic masculinity, often remembering evidence that is consistent with their preexisting beliefs and discounting evidence that undermines them (Bourdieu 1975; Milkman 1987; Fiske 1998; Tolley 2003; Charles and Grusky 2004). Greater exposure to women scientists and proximity to same-gender role-models appear to weaken these stereotype effects, however (Miller et al. 2018; Jacobs et al. 2017; Misra et al. 2017).

Evidence is growing that cultural beliefs associated with STEM occupations can bias cognition and affect individual decision-making, thereby reproducing occupational segregation. We believe that this interplay between macro and micro-level processes offers a particularly fruitful explanation for the resilience of gender segregation in STEM in advanced industrial societies.

1.3. Micro-Macro Interactions: Cultural Stereotypes into Aspirations

The cultural gender stereotypes that we associate with people and jobs reproduce occupational segregation by affecting both labor demand and labor supply. On the demand side, the most obvious intermediary mechanisms are discrimination against workers and applicants whose gender does not "fit," or align with, the gender of the job, gendered recruitment practices, and biased assessments of individuals' relative qualifications (Becker 1957; Phelps 1980; Bielby and Baron 1986; Foschi 1996; Heilman 2001). On the supply side, stereotyping reinforces segregation by leading people to make gender-conforming choices that affirm their masculinity or femininity, and avoid social sanctions and discriminatory work environments (West and Zimmerman 1987; Ridgeway 2011; Cech 2013; Blair-Loy et al. 2017; Weisgram and Diekman 2017).

Research also shows that gender stereotypes affect supply-side processes by biasing people's understandings of their own aptitudes and affinities. That is, people may choose gender-conforming occupations because they believe, perhaps erroneously, that they will be more skilled at this work or enjoy it more (Correll 2004; Charles 2017). These biased self-understandings are powerful because they can shape occupational aspirations, and behaviors even in the absence of direct structural constraints, discrimination, or individual-level socialization.

For instance, recent research documents how cultural gender beliefs affect people's confidence in their abilities to carry out the technical tasks and assume the identities associated with gender-atypical occupational roles (Thébaud 2010; Cech et al. 2011; Stets et al. 2017; Hill et al. 2017; Sanabria and Penner 2017; Wynn and Correll 2017). An important experimental study by Correll showed that women's exposure to (false) information about men's generally superior performance at a specific task led them to rate their own task performance lower and to express less interest than men in careers that

purportedly draw upon related skills (2004). No gender gaps in self-assessments or aspirations were found when participants were exposed to the belief that men and women were equally proficient at the task.

Besides biasing self-assessments of ability, cultural gender stereotypes can also bias individuals' beliefs about their own affinities, so that they will more often expect to enjoy work that involves gender-conforming tasks. Cech (2013) finds that college students are more likely to later choose female-dominated occupations if they describe themselves in culturally feminine terms, such as emotional, unsystematic, and people-oriented. Comparative research suggests that this gender-typing of career aspirations is especially pronounced in affluent, "postmaterialist" societies (Charles and Bradley 2009; Charles 2017). In these contexts, concerns about existential security are less salient in career choices and cultural narratives emphasize "following your passions" and "doing what you love" (Inglehart and Welzel 2005; Tokumitsu 2015). Since many persons, especially adolescents, do not know in advance what they will love doing, postmaterialist career aspirations may be built more often upon stereotypes about what people like them (often same-gendered people) love. Girls, for example, may expect to enjoy work that they think will be more communal and interactive, and following these passions will probably not lead them toward the solitary science career depicted in Western popular culture. The implication is that widespread cultural beliefs about how men and women are different and what they enjoy doing contribute to career choices that reproduce the gender order but are experienced as the expression of personal likes and dislikes.

This emotional buy-in contributes to the reproduction and legitimization of gender segregation in advanced industrial societies and helps account for the surprising cross-national differences in the gender composition of STEM occupations. Whereas ideologies of male primacy—and vertical inequalities—tend to weaken in affluent Western democracies, beliefs in categorical gender difference are easily reconciled with the liberal individualistic ideals that permeate these cultures (Charles and Grusky 2004; Cotter et al. 2011; Levanon and Grusky 2016; Knight and Brinton 2017; Chatillon et al. 2018). Under these "postmaterialist" gender regimes, horizontal forms of gender segregation, such as professional women's underrepresentation in STEM fields, retain legitimacy because they are easily understood as the outcome of free choices by equal but innately different men and women.

Culture can also affect performance in a stereotype-consistent manner. Experiments on "stereotype threat" show that people do worse on tests when they fear confirming a negative stereotype about their gender (or racial) group. In one study, a significant gender gap in test performance was observed when subjects were told that men generally do better, but not when they were told that men and women do equally well on the test (Spencer et al. 1999). Beliefs in essential gender differences in aptitudes have especially strong effects in fields such as STEM, where practitioners often attribute success to innate talent (Leslie et al. 2015). This is another way in which stereotypes can be self-fulfilling.

The preceding analysis has identified diverse ways in which cultural stereotypes contribute to the gender-typing of STEM—among other things, by influencing how men and women perceive themselves, how they are treated by others, and how societies and work environments are structured. The cognitive schemas and life experiences that result from taken-for-granted cultural beliefs about men, women, and STEM produce aspirations and outcomes that are far more gender-differentiated than any underlying distribution of individual-level traits. They therefore have far more power to explain the extreme gender segregation of STEM fields observed in the contemporary United States.

In the following section, we unpack the underlying content of cultural beliefs about the gendered nature of persons and jobs that are revealed in this volume and elsewhere. By assembling these stereotypes in one place, we hope to demonstrate their prevalence, range, and potential to shape individual cognition, aspirations, and behaviors. We also aim to articulate why the culture of many STEM disciplines and occupations remain bastions of masculinity in the contemporary United States.

2. Stereotypes about Men, Women, and STEM Workers, Work, and Workplaces

Before discussing stereotypes that are specifically relevant to the segregation of STEM fields, we provide some general background on the descriptive and prescriptive content of gender stereotypes.

2.1. Descriptive and Prescriptive Gender Stereotypes

For decades, social psychologists have documented the content of cultural stereotypes about men and women (see Rudman and Glick 2008 for a summary). In the US context, men are believed to be more agentic and competent than women, whereas women are believed to be more communal than men. That is, men are not only privileged on competence-related traits like intelligence, skill, and capability, but they are also believed to be more able to get things done by being more assertive, goal-oriented, ambitious, independent, competitive, and self-interested. By contrast, women are presumed to be primarily oriented toward others—by being more warm, kind, nurturing, friendly, and polite.

One might imagine that these descriptive stereotypes would be outdated, given women's progress toward equality in the workforce and in education over the last half-century. And indeed, a recent study suggests that that the belief that women are in general less intelligent or skilled than men has waned in more recent cohorts (Eagly 2018). At the same time, though, research shows that especially high levels of intelligence or ability—characteristics like "brilliance," or "genius"—remain masculine-coded (Furnham et al. 2006; Stephens-Davidowitz 2014), and stereotypes still privilege men's ability in male-typed tasks like mathematics (Ridgeway 2011). Furthermore, there has not been any discernible change in the belief that women are less agentic than men, and stereotypes about women's greater communality are even more strongly held today than they were in earlier cohorts (Eagly 2018).

Importantly, these commonly held beliefs do not merely describe men and women (i.e., they presumably are this way), but they also set prescriptive expectations for behavior (i.e., men and women ought to be this way) (Prentice and Carranza 2002). For instance, being assertive and ambitious is intensely prescribed for men (i.e., cultural beliefs dictate that men really ought to possess this trait in order to be liked and respected by others), whereas being warm and kind is intensely prescribed for women (i.e., cultural beliefs dictate that women really ought to possess this trait in order to be liked and respected by others). This prescriptive dimension of gender stereotypes is critical for understanding persistent inequality, since it sets the foundation for several micro-interactional processes that ultimately motivate both men and women to behave in stereotype-consistent ways (Heilman 2001; Rudman and Glick 2008). It is noteworthy, however, that normative pressures to conform tend to be particularly strong for men because society places greater value on the traits and abilities associated with men and masculinity than on those associated with women and femininity (see e.g., Ridgeway 2011). For instance, Rudman et al. (2012) demonstrate that the traits that men are supposed to possess are high in status (e.g., competitive), whereas the traits that women are supposed to possess are more neutral in status (e.g., friendly). In contrast, the traits that men are not supposed to possess are low in status (e.g., emotional) and the traits that women are not supposed to possess are high in status (e.g., aggressive). As such, it is not surprising that normative expectations and perceptions—especially when enforced by same-gender peers—are particularly relevant for understanding men's behavior, given that gender conformity translates into a status advantage for men but not for women (Kimmel 2008; Pascoe 2007).

2.2. Stereotype Content and Inequality in STEM

Both the descriptive and prescriptive content of stereotypes about men and women have direct implications for inequality in STEM. To begin, contemporary stereotypes about STEM workers, work, and workplaces simultaneously privilege masculine-coded traits like high levels of intelligence and agency while devaluing the communal traits that women supposedly possess. Many STEM fields,

especially the more male-dominated ones like physics and computer science, share a culture in which high levels of raw talent and brilliance are viewed as essential to success. Recent studies suggest that differences across fields in the strength of this "brilliance narrative"—both among academics and within the broader culture—map directly onto the distribution of men and women across fields (Meyer et al. 2015; Leslie et al. 2015).

Beyond prizing high levels of raw intelligence, many science and engineering disciplines idealize workers who embody such stereotypically masculine traits as assertiveness, competitiveness, dominance, and strong identification with work (Bailyn 2003; Cooper 2000; Williams et al. 2006). Furthermore, a "geek" stereotype is today associated with many STEM fields and workers (Cheryan et al. 2009; Varma 2007; Ensmenger 2015). The "geek" cultural image is of a person who is exclusively interested in and focused on scientific or technological endeavors (e.g., someone who stays up all night coding). When the "geek" image is not valued, other forms of masculinity and masculine identity may be present. For instance, some technology workplaces have been found to valorize "brogrammers"—who are supposedly more sociable and outgoing than "geeks," but only in the way that a stereotypically party-focused fraternity brother would be (Alfrey and Twine 2017; Wynn and Correll 2014). Both the "geek" and frat-like "brogrammer" cultural images exemplify the agentic qualities that women supposedly lack, and they devalue the communal traits that women supposedly possess: such individuals are thought to lack "social skills," to be disconnected emotionally, and/or to be less caring toward others.

In our view, the broader implication of these numerous linkages between masculine traits and abilities and many STEM disciplines, workers, and workplaces is that men are not only perceived as a better "fit" for these social spaces from a descriptive point of view, but they are also likely to experience greater social pressure and rewards for pursuing them. That is, by pursuing one of these fields, a man can align his presumed abilities and interests with a high-status career, while also living up to prescriptive expectations for how he ought to behave. As such, his occupational choice is likely to increase his chances of being liked and respected as a man. The calculation is less clear for a woman. While she may be respected for pursuing a high status career, her choice may not necessarily be perceived as a good fit for her interests or abilities, and it may not win her greater admiration or respect as a woman. Instead, she may risk discrimination, dislike, or ostracism for being "too" aggressive, ambitious, etc. (see e.g., Heilman 2001 on backlash effects). As such, men are more likely to experience strong incentives to pursue STEM fields and to retain commitment to them, whereas this not always the case for women, notwithstanding the material advantages of STEM careers.

This argument is supported by recent research on the linkage between masculine traits and abilities, STEM, and men's and women's decision-making. Gendered beliefs about the relationship between high levels of innate intelligence and qualification for particular pursuits have been shown to affect career aspirations from an early age. One recent study found that, by age six, girls are less likely than boys to believe that members of their gender are "really, really smart," and that they begin to avoid activities believed to be for children who are "really, really smart" (Bian et al. 2017). In this volume, Hill et al. (2017) similarly find that middle schoolers who believe that raw intelligence is a fixed trait from birth are more likely to endorse the idea that boys are better than girls at science and less likely to believe that they themselves could be a scientist. Sanabria and Penner (2017) also show that boys are more likely than girls to persist in STEM majors after failing an introductory calculus, perhaps because stereotypes about gender differences in mathematics ability make boys less likely to attribute poor test performance to a lack of intrinsic ability.

Presumptions of greater male scientific and technical competence also reinforce gender segregation through their effects on workplace interactions. Experimental studies show, for example, that women's expectations of discrimination and gender bias reduces their anticipated sense of belonging and their interest in STEM careers (Moss-Racusin et al. 2018). Cech and Pham (2017) deepen our knowledge about this relative devaluation of feminine traits in STEM workplaces by illustrating the ways that lesbian, gay, bisexual and transgender (LGBT) workers—whose gender performance often deviates

from normative expectations—experience disadvantage in STEM workplaces. It is this very disconnect between the cultural traits linked to women and the cultural traits linked to normative STEM workers and STEM workplaces that catalyzes inequality.

Men's stronger interest in and greater likelihood of persistence in STEM fields is also driven by gender-differentiated self-perceptions of fit and ability (Cheryan et al. 2009; Wynn and Correll 2017) and the application of double standards for competence (Blair-Loy et al.; Foschi 1996). Both of these mechanisms arise from the mismatch between expectations for STEM workers and expectations for women's behavior. Such stereotyping processes are especially insidious because they matter even when an individual personally disagrees with them (Ridgeway and Correll 2004). That is, merely knowing that most other people hold certain beliefs about gender and STEM is enough to bias attitudes and behaviors. This is one reason why the content of stereotypes often remains relatively stable even in the face of changing occupational preferences and choices.

Finally, it is not just stereotypes about STEM workers and STEM workplace cultures that create a gender mismatch. As much of the research in this volume shows, stereotypes about the content of STEM work itself can deter women. For instance, many young people endorse the stereotype that science careers are not compatible with having a family. Weisgram and Diekman (2017) show that this belief, whether true or not, powerfully reduces many young women's interest in pursuing a science career. Similarly, Kyte and Riegle-Crumb (2017) find that holding the cultural belief that science is socially relevant—e.g., that science can help people or solve everyday problems—positively predicts young women's, but not young men's, intentions to major in a STEM field.

Sociocultural processes like these offer a fruitful alternative to the standard individual human-capital and family-status explanations for gender differences in STEM entry and persistence. The stereotypes identified here and elsewhere in the volume are important not only because they encourage social stigma and discriminatory treatment by others, but also because they cause people to under- or over-estimate their own qualifications and their own potential affinity for gender-nonconforming work. As a result, men and women (boys and girls) are likely to aspire to different occupations, pursue different educational and occupational pathways, and experience their work interactions and environments in gendered ways. In liberal egalitarian societies, many forms of gender inequality are reproduced and legitimated through the conversion of cultural stereotypes into gender-conforming preferences—and then into seemingly free choices by different-but-equal men and women (Charles 2011b).

We turn next to consider the practical implications of this research: What, if anything, might be done to diversify STEM occupations?

3. Policy Implications

Experimental and audit studies provide strong evidence that women's underrepresentation in scientific and technical fields is at least partly attributable to cultural gender stereotypes and discrimination, which can be converted subsequently into gender-specific aspirations and choices. Even if the composition of STEM occupations reflects gender-differentiated career aspirations, this segregation may be problematic for at least three reasons. First, history shows that "separate but equal" principles generally produce unequal outcomes. This is evident, among other things, in the lower pay in women's than men's occupations (Levanon et al. 2009). Second, gender segregation has cultural feedback effects, reinforcing stereotypes and limiting perceived educational, family, and career options of subsequent generations. And third, women (and racial/ethnic minorities) represent an untapped labor pool globally in fields such as engineering and computer science, where shortages threaten to undermine national development or competitiveness. These concerns have motivated myriad initiatives by governments, non-governmental organizations, and industry leaders around the world to broaden and diversify opportunities in scientific and technical occupations and fields of study.

The research presented in this volume suggests that gender integration will not come easy and will partly depend on increasing girls' and women's interest in STEM. This will in turn depend upon the erosion of two kinds of cultural stereotypes: those that depict women as intrinsically ill-suited for STEM work, and those that depict STEM work as uncreative, solitary, and masculine. While cultural change of this sort can only occur gradually, some efforts toward counter-stereotype programing are evident in the growing popularity of toys like GoldieBlox engineering kits and women Lego scientists, which provide parents of young girls with alternatives to toy store pink-aisle marketing. Also challenging male math nerd stereotypes are efforts to rebrand STEM as compatible with conventional femininity. These include books like *Kiss my Math* and *Hot X: Algebra Exposed* by actress Danica McKellar, and even an updated Barbie doll in 2010. While her 1992 Teen Talk sister recited canned phrases like "Math class is tough," and "Let's go shopping," Computer Engineer Barbie presents computing as both feminine and fun—a "geek chic" that essentially replaces one set of stereotypes with another.

A more aggressive strategy for reducing the salience of gender stereotypes would be to create more opportunities for girls and boys to learn directly about gender-nonconforming fields and about their own abilities to enjoy and excel in them. Expanded high school graduation requirements, including in mathematics, computer science, and engineering could help reduce reliance on stereotypes and increase girls' confidence in their mathematical and technical ability. Although such policies would seem to be at odds with American ideals of individual choice and self-expression, research suggests that they might also weaken penetration of gender stereotypes and reduce peer pressure in course taking. Comparative studies show that the gender gap in STEM aspirations and outcomes tends to be smaller in countries and schools where curricular choice is reduced or delayed and where high school science and mathematics curricula are stronger (Federman 2007; Charles and Bradley 2009; Cheryan et al. 2009; Legewie and DiPrete 2014; Scheeren et al. 2018). This may be because reluctance to transgress gender norms declines with age (Gerson 1985; Jacobs 1989), or because exposing students to a broader array of fields provides them with better information about what they like and what they are good at.

In India, for example, a strong national mathematics curriculum makes girls more confident in their ability to learn computer skills, even if they are less likely to have computers at home, than their American counterparts (Varma and Kapur 2015). In Malaysia and India, where women earn about 45% of information and communication technology (ICT) degrees, computing is viewed as a woman-friendly profession that offers a safe and pleasant indoor working environment. This presents a sharp contrast with the male hacker image in the United States, where women earn only 23 percent of ICT degrees (Margolis and Fisher 2002; Lagesen 2008; Varma and Kapur 2015; UNESCO 2018).

But mandated early exposure will backfire without careful attention to the culture and organization of STEM classrooms and workspaces. Encouraging a sense of belonging for underrepresented groups requires work, study, and family environments that include diverse role models, supportive peer networks (including summer and afterschool clubs like Women in Engineering), and freedom from gender stereotypes and discrimination. Even the physical environment can matter. One experiment by Cheryan et al. (2009) showed that exposure to stereotype-consistent computer science classrooms (e.g., with Star Trek posters and video games visible) decreased girls', but not boys', interest in a computer science major, and that gender differences in interest were smaller when subjects were exposed to classrooms that did not conform to current stereotypes (e.g., with nature posters and phone books visible). College website descriptions may also attract more women by including information on the social relevance and collaborative nature of engineering (Da Costa and Stromquist 2018).

Some elite universities have recently implemented organizational changes aimed at undermining stereotypes about computer science work and diversifying the "boy hacker" culture. Changes have included revamping introductory computer science courses to offer a more inclusive and socially relevant curriculum, and increasing mentorship and peer support of underrepresented groups. Increases in women's share of computer science graduates have been impressive, going from 10% to 40% in five years at Harvey Mudd College, for example (Cheryan et al. 2009).

Once women have entered a STEM job, organizations and governments will need to develop policies and practices that keep them there. Policies relating to work hours, flexible scheduling, family and sick leave, and childcare are important, but research shows that it is not enough to *have* these policies. Workplaces must have cultures that support their *use*—by both women and men. True or not, many STEM workers report stigma associated with using family accommodation policies (Cech and Blair-Loy 2014).

A key finding from the historical, experimental, and interview-based research reported in this volume and elsewhere, is that individual occupational preferences are social products. Aspirations for STEM work are shaped by the (real or perceived) culture of STEM fields and by deeply rooted beliefs about the intrinsic natures of men and women. American girls who aim to "study what they love" might be just as passionate about computer science and engineering as they are about teaching and nursing if they had more chances to find out whether they love these STEM fields (e.g., through required courses, after school clubs, or summer programs for underrepresented groups), and their passion might grow if they could more easily imagine themselves fitting into these professional cultures. Counter-stereotype programming, and more exposure to women scientists might help them make that leap of imagination.

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