Perspective

Gender bias in academia: A lifetime problem that needs solutions

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SUMMARY

Despite increased awareness of the lack of gender equity in academia and a growing number of initiatives to address issues of diversity, change is slow, and inequalities remain. A major source of inequity is gender bias, which has a substantial negative impact on the careers, work-life balance, and mental health of underrepresented groups in science. Here, we argue that gender bias is not a single problem but manifests as a collection of distinct issues that impact researchers' lives. We disentangle these facets and propose concrete solutions that can be adopted by individuals, academic institutions, and society.

INTRODUCTION

The past decades have seen tremendous scientific progress and astonishing technological advances that not long ago seemed like science fiction. Yet, such scientific progress stands in stark contrast to progress in improving the participation of underrepresented groups in academia, particularly in the fields of science,

technology, engineering, and mathematics (STEM). A report from the National Institutes of Health (NIH) published in 2017 highlights the gender disparities encountered in science. Out of 16 NIH directors, only 1 was a woman; in the top 10 research institutes in the US, the percentage of women with tenure among all professors was at most 26% and in some cases even below 20%. Women occupied 37% of the NIH intramural research

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program tenure-track body, but only 21% attained tenured status, with women of color occupying only 5% of tenured positions (Addressing gender inequality in the NIH intramural research program). The numbers show similar trends for PhD programs in the US. According to the Society for Neuroscience, the percentage of women applicants in PhD programs has increased in the recent years from 38% in 2000-2001 to 57% in 2016-2017, with a matriculation rate of 48% for women in 2016-2017. By contrast, women represented only 30% of all faculty for PhD programs.

The statistics are similar in Europe. The European Research Council (ERC; Equality of opportunity in ERC Competitions) reported that only 32% of its panel members and 27% of its grantees in the Horizon 2020 program were women. In the Netherlands, 44% of PhDs were awarded to women in 2018, yet only 22% of the tenured faculty were women. A similar trend is reported in Switzerland, where close to 40% of fixed-term professorships in 2017 were held by women, but for tenured positions, the fraction of women dropped to 25%.

These statistics confirm the gender disparity that exists in higher academic positions, despite an almost equal representation across disciplines at earlier career stages (see Gruber et al., 2020 for a thorough investigation of gender disparities in psychological science). A putative cause of this phenomenon is gender bias, i.e., prejudice based on gender (encompassing the identity and the expression of that gender). Gender bias can be explicit or implicit. Explicit bias is a conscious and intentional evaluation of a particular entity with some degree of favor or disfavor (Eagly and Chaiken, 1998). Implicit bias reflects the automatic judgment of the entity without the awareness of the individual (Greenwald and Banaji, 1995). These types of bias emerge from different sources such as stereotypes, prejudice, and discrimination (Fiske, 1998), which reflect general expectations about members of a given social group. Gender stereotypes are broadly shared and reflect differences between women and men in their perspective and manner of behavior. Importantly, gender stereotypes also impact the way men and women define themselves and are treated by others, which in turn contributes and perpetuates such stereotypes (see Ellemers, 2018 for review). Gender bias impacts all women, with even more impact on women whose gender intersects with other identities that are often discriminated against, including, but not limited to, race and ethnicity (see Women in Academia: Quick Take), socioeconomic status, religion, gender expression, gender identity, sexual orientation, or disabilities (Armstrong and Jovanovic, 2015). Moreover, it has been shown that gender stereotypes influence the enrollment of women in STEM in many countries (Miller et al., 2015; Hanson et al., 2017). As such, properly tackling this issue requires both structural and cultural change. Many of the biases and solutions presented in this article can apply to and be amplified in other minority groups (see the section Not all gender biases are the same: Intersectionality below), but a comprehensive assessment of those issues is beyond the scope of this paper. Indeed, pervasive gender biases do not start at the academic level, but they are deeply rooted in many societies and even appear early in life, impacting young girls' career aspirations and lifetime educational achievements (Makarova et al., 2019). For instance, in many cultures, it is a long-standing stereotype that boys are better at math than girls (Else-Quest et al., 2010), which, in turn, impacts young girls' performance on math tests (Spencer et al., 1999), despite no intrinsic or biological difference (Kersey et al., 2019; Shapiro and Williams, 2012). Parents' and teachers' expectations can also show biases that influence children's attitudes and performance in
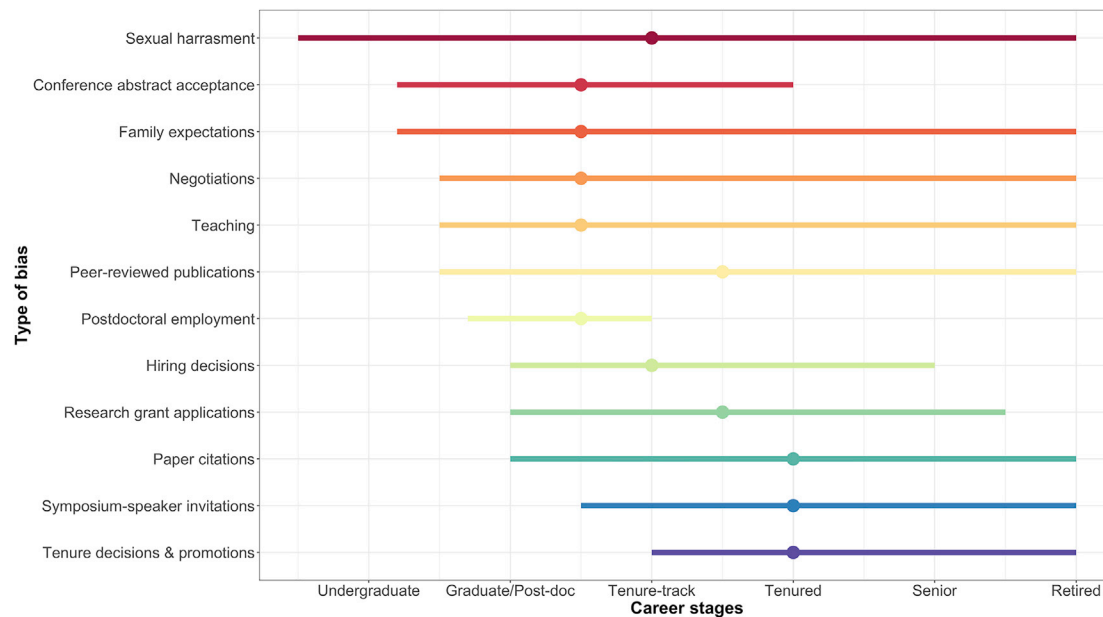
Figure 1. Expression of the accumulation of the different facets of gender bias throughout a woman researcher's career organized according to when they begin to have an impact
Each line represents one aspect of the gender bias and covers the career stages it is prevalent in. The dot represents the estimated peak in time of a given aspect.

math (Gunderson et al., 2012). This gender stereotyping through interactions with parents, educators, peers, and the media has a negative effect on girls' interest and confidence in their performance in STEM subjects, potentially reducing interest in research careers in STEM later in life (Cheryan et al., 2015, 2017).

Here, we will focus on gender bias at the university level, which forms a further bottleneck for gender equity in STEM. The women-to-men ratio progressively decreases with advancing degrees and career stages. Despite remarkable progress made over the last three decades to mitigate gender bias (Eagly, 2018), equity is still far from being reached in academia. Multiple studies have systematically documented bias in every aspect of academia (Fernandes et al., 2020), including journal article and innovation citations (Dworkin et al., 2020b; Hofstra et al., 2020), publication rates (West et al., 2013), patent applications (Jensen et al., 2018), hiring decisions (Nielsen, 2016), research grant applications (Burns et al., 2019), evaluations of conference abstracts (Knobloch-Westerwick et al., 2013), symposia speaker invitations (Schroeder et al., 2013), postdoctoral employment (Sheltzer and Smith, 2014), prestigious science awards (Lunnemann et al., 2019), and tenure decisions (Weisshaar, 2017). These forms of bias are intertwined and evolve and accumulate along the career path (see Figure 1). Their combination can lead to a gradual abandonment of scientific careers by many women, the numbers of which decrease as career stages progress.

Given the prevalent and deep-rooted nature of gender bias in academia, we aim to unravel different forms of bias, evaluate their manifestation over the career span, and provide suggestions toward resolving gender disparity. We explain how pervasive gender bias affects different components, dimensions, and roles of academics and how these barriers to women's advancement differ across each stage of career development. Our goal is to assemble information regarding the different facets of gender bias in a digestible format for the neuroscientific community. We aim to launch a discussion around the multifaceted and deeply rooted issues surrounding gender bias in academia and, in particular, in the field of neuroscience. We discuss problems faced by women in science, which are often taking place behind closed doors, providing information and increased awareness of central issues to academics and institutions seeking a balanced and fair environment. We also recommend both tested and untested concrete solutions to help mitigate the negative consequences of bias along three axes at the individual (i.e., actions we can take as colleagues, friends, or mentors), institutional (i.e., policies and regulations), and societal levels (i.e., legislative action concerning society at large).

Changes in society and culture are often slow and difficult to implement, but without ongoing awareness, gender equality cannot be achieved. Solutions to the problem of gender bias have been difficult to achieve for many reasons, and some may be more tenable in certain circumstances than others. Here, we present exemplary policies from progressive institutions that have been effective in alleviating gender bias mostly in STEM and specifically in neuroscience. We also describe quantitative tracking tools (Table 1) that contribute to identifying and mitigating bias. As several manifestations of bias do not yet have concrete solutions with demonstrated results, we also propose some untested suggestions that may prove useful and which future research could address (Table 2). It is our hope that this article will continue the conversation toward resolving gender bias and bring us closer to tangible results.

Table 1. Tools and resources for addressing gender bias in academia

Resource	Career stage	Description
cleanBib[a]	authorship and peer review, citations	tool to probabilistically assign gender proportions of first/last author pairs in bibliography entries in neuroscience
PEERE	peer review	development of a protocol aiming to openly share peer-review data in Europe
Gender balance syllabus tool[a]	teaching	tool to probabilistically assign gender (and race) of author surnames in course syllabi
EQUIP	early life, teaching	tool for tracking and analyzing patterns in student participation
Gender bias in recommendation letters tool[a]	funding and awards, teaching, hiring and promotions	tool designed to analyze text in recommendation letters for words commonly associated with men or women
Negotiation strategies for women: secrets to success	negotiations	special report on negotiation strategies; also includes practical advice to create equitable work cultures
COACh	hiring and promotions, negotiations	organization dedicated to increasing the number and success of women in STEM careers; hosts career building workshops and distributes training materials
Conference diversity distribution calculator	conferences	tool to compute probabilities of under- and over-representing minority speakers based on their overall representation in the field
BiasWatchNeuro	conferences	tool to track speaker diversity at neuroscience conferences
Respect is part of research	sexual harassment	model for developing peer-led sexual harassment prevention workshops
Bringing in the Bystander	sexual harassment	in-person program teaching individuals to prevent and intervene in case of sexual violence and stalking
Code of conduct templates for conferences and laboratories	sexual harassment, conferences	instructions, frequently asked questions (FAQs), and templates for developing a code of conduct for conferences, events, and/or research laboratories
List of databases of women and minority scientists	authorship and peer review, conferences, intersectionality	List of databases (e.g., Anne's List, 500 Women Scientists, 500 Queer Scientists, People of Color Also Know Stuff, Women in Neuroscience, CompCog.Science, 1000-inspiring-black-scientists-in-america) to find women and underrepresented minority speakers by field

[a]These tools are based on probabilistic algorithms that may not always provide accurate estimates, especially in cases with missing or uninformative data (e.g., initials instead of full surnames or rare surnames). See original publications for limitations.

Gender biases are amplified through career stages

Though gender stereotypes are already strongly shaped in childhood (Makarova et al., 2019), college or university study is a further bottleneck to gender equity. Even in their first year beyond high school, women are 1.5 times more likely than men to leave the STEM higher education pipeline (Ellis et al., 2016). In more advanced university degrees and career stages, the women-to-men ratio progressively decreases, referred to as the "scissors effect." In most countries, the point where the effect begins is at the start of the university years with equal numbers of women and men enrolled. The gap widens (like an open pair of scissors) by the end of the postdoctoral career stage (European commission report 2015, GARCIA Project). In the US, the gender gap continues to grow between the postdoctoral and associate professor years, with women transitioning to principal investigator positions at an ~20% lower rate than men (Lerchenmueller and Sorenson, 2018). Similar data have been reported for other agencies and countries, highlighting the widening gender gap across the career stages (Burns et al., 2019; McAllister et al., 2016; Pohlhaus et al., 2011). Although the percentage of women among undergraduates, graduate students, and postdoctoral researchers has increased in the past few decades, women remain largely underrepresented in STEM faculty positions (Beede et al., 2011; Field of degree: Women-NSF). Possible

Table 2. Summary of the different actions suggested throughout the manuscript to mitigate gender bias by section and level of responsibility

Section	Level	Action	Tested and recommended	Tested and debated	Implemented	Select advocates
Authorship and peer review	individual	educate yourself about these gender issues and proactively consider how to adjust your behavior to ensure equity in your reviews	–	–	–	–
	institution	alternatives to single-blind peer-review system		✔		Schrouff et al., 2019; Tomkins et al., 2017; Rodgers, 2017; Mulligan et al., 2013; Budden et al., 2008; Snodgrass, 2006; Bernard, 2018; double-blind review currently offered by a few major academic journals, such as *eNeuro*, *Current Sociology*, *Social Science & Medicine*, *Behavioral Ecology* (not a comprehensive list); open peer review as currently implemented in *Frontiers* journals
		diversify editorial and referee pools			✔	Schrouff et al., 2019; Squazzoni et al., 2017; Helmer et al., 2017, Murray et al., 2019; implemented by *Progress in Neurobiology*, *eLife*, Nature Publishing Group, Cell Press
		for review and editorial panels, make authors' and reviewers' demographic information publicly accessible			✔	Schrouff et al., 2019; Squazzoni et al., 2017; Murray et al., 2019; Helmer et al., 2017; implemented by Cell Press, *eLife*
Citations	individual	review your citation list for evidence of bias before submission	–	–	–	–
	institutional	increase diversity of review and editorial panels	✔		✔	Murray et al., 2019; Schrouff et al., 2019; Squazzoni et al., 2017; Helmer et al., 2017; implemented by *Progress in Neurobiology*, *Nature Neuroscience*
		journal submission website to automatically notify authors of an unbalanced citation list; editors to require written exception requests for sharply unbalanced citations			✔	Dworkin et al., 2020a, 2020b; Zhou et al., 2020; see Table 1 for more details
		Increase maximum allowable references, or eliminate limits			✔	implemented by *Neuron*, *Frontiers* journals, *Brain*, *Human Brain Mapping*, *PLOS One*
		development of new citation metrics that account for gender bias and self-citation		✔		the m-index (Cameron et al., 2016)

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Table 2. *Continued*

Section	Level	Action	Tested and recommended	Tested and debated	Implemented	Select advocates
Funding and awards	individual	support mentees and colleagues in applying for career transition awards, such as NIH K awards or the Burroughs-Wellcome career award	–	–	–	–
	institutional	funding agencies to set and publish targets for grant applicants, success rates, and amounts awarded	✔		✔	Schrouff et al., 2019; Niederle et al., 2013; Balafoutas and Sutter, 2012; implemented by Max Planck Institute and the Australian National Health and Research Council
		create funding mechanisms awarded exclusively on the merit of the scientific proposal, regardless of the merit of the principal investigator (PI)	✔		✔	Witteman et al., 2019; implemented by Canadian Institutes of Health Research
		alerting review committee to potential gender bias and possibly prefacing grant reviews with bias training	✔		✔	Carnes et al., 2015; Devine et al., 2017; Fine et al., 2014; Smith et al., 2015; Valantine et al., 2014
		make the demographics information of former grantees accessible to the public			✔	Choudhury & Aggarwal, 2020; Charlesworth and Banaji, 2019; implemented by National Science Foundation, National Institutes of Health, the US Department of Agriculture, the European Research Council
Teaching	individual	use tools such as those described in Table 1 to build your syllabi and check it for gender bias; include historical example of successful women scientists	–	–	–	–
	institutional	change the language of prompts in the student evaluations of teaching (SETs) and remind them of their own internal biases before having students fill out evaluations	✔		✔	Stark and Freishtat, 2014; Peterson et al., 2019; Blair et al., 2001
		abandon SETs as primary measure of teaching effectiveness; implement assessments such as classroom observation and examining teaching materials and portfolios			✔	Stark and Freishtat, 2014; University of California, Berkeley Statistics Department

Table 2. *Continued*

Section	Level	Action	Tested and recommended	Tested and debated	Implemented	Select advocates
Hiring, tenure, and promotions	individual	individuals hiring for any position (lab manager, grad student, faculty search committee) should familiarize themselves with best, equitable hiring practices	–	–	–	Bergman et al., 2013
	institutional	mandatory bias training for member of hiring committees	✔		✔	Carnes et al., 2015; Schrouff et al., 2019; Fine et al., 2014; implemented by University of California and University of Wisconsin-Madison
		increase the diversity in search committees and compensate women and other minority groups for this commitment by reducing teaching load or other administrative duties	✔		✔	Schrouff et al., 2019; Bergman and Rustad, 2013; Smith et al., 2004; Zinovyeva and Bagues, 2011
		universities offer financial incentives to departments with diverse representation	✔		✔	Bergman and Rustad, 2013; https://www.nature.com/articles/d41586-019-00919-y
		additional qualification criteria centered on outreach, knowledge dissemination, faculty service, and diversity, equity, and inclusion efforts			✔	Moher et al., 2018
		maintain a list of underrepresented minority mentees that could become targets for job searches and awards (as is done for conference speakers)			✔	Anne's List, 500 Women Scientists, 500 Queer Scientists, People of Color Also Know Stuff, Women in Neuroscience, CompCog.Science 1000-inspiring-black-scientists-in-america
		include mediators from equity committees to participate through the hiring/promotion procedure			✔	Gender Monitoring – Egalité - EPFL
		set concrete targets for number of female applicants based on the number of women working in that field; if targets are not met, require the post to be re-announced			✔	Implemented by University of California, Berkeley Psychology
	societal	when legally possible, academic institutions can set policies on gender equity, set goals for gender ratios in different position categories, and develop recruitment strategies to achieve these goals		✔	✔	Switzerland, Sweden, and Germany

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Table 2. *Continued*

Section	Level	Action	Tested and recommended	Tested and debated	Implemented	Select advocates
Financial negotiations	institutional	institutions publish salary data for all faculty, as well as possible salaries per level	✔			Mazei et al., 2015; required by all public institutions in the US
Conferences	individual	be an active bystander; speak out against harassment and other biased behaviors	–	–	–	–
		when organizing conference, seminar, and symposiums, consult resources such as the directory compiled by Jennifer Glass and Minda Monteagudo, which lists searchable databases of highly qualified women by subfield (Table 1) to ensure equitable balance of speakers	–	–	–	–
		consider turning down speaking opportunities at conferences with an imbalanced speaker lineup	–	–	–	–
	institutional	affirmative attention for council positions, where some positions are required to be filled by women (can be extended to include Black, Indigenous and people of color-only positions, as well)	✔		✔	Tzovara et al., 2021; implemented by OHBM
		conferences can require the inclusion of both men and women speakers or provide a justification for single-gender symposia			✔	implemented by Federation of European Neuroscience Societies (FENS) Forum
		conferences to offer sessions and workshops to raise awareness around bias and the best ways to eliminate it; these sessions should be open to all genders			✔	implemented by OHBM, FENS, SFN, Gordon Research Conferences
		conferences required to have a code of conduct			✔	Parsons, 2015; Marts, 2017; Favaro et al., 2016; implemented at SFN, Cognitive Neuroscience Society (CNS), Social & Affective Neuroscience Society (SANS), Cosyne
		code of conduct includes clear plans of action in the case of harassment			✔	Parsons, 2015; Marts, 2017; Favaro et al., 2016; implemented at SFN
		code of conduct includes the procedure for removing confirmed harassers				Parsons, 2015; Marts, 2017; Favaro et al., 2016;

Table 2. *Continued*

Section	Level	Action	Tested and recommended	Tested and debated	Implemented	Select advocates
Sexual harassment	individual	organizational leaders display an unequivocal anti-harassment stance	–	–	–	–
		be an active bystander; speak out against harassment and other biased behaviors	–	–	–	–
	institutional	sexual harassment to be equated to scientific misconduct, including similar mechanisms for reporting, investigation, and adjudication; this includes barring research found guilty of sexual harassment from applying for new grants			✔	Greider et al., 2019; The NIH is currently implementing this change
		universities to develop programs, distinct from and complementary to legal procedures (e.g., Title IX in the US), which are charged with serving the survivors of sexual harassment, preventing new cases, and training the university-wide community			✔	University of California, Berkeley
		mandatory sexual harassment trainings		✔	✔	Buchanan et al., 2014; Katz and Moore, 2013; Cares et al., 2015; Potter and Moynihan, 2011

Table 2. *Continued*

Section	Level	Action	Tested and recommended	Tested and debated	Implemented	Select advocates
Family planning	individual	consider delays caused by parenthood and childcare responsibilities when evaluating candidates for positions, promotions, grants, and awards	–	–	–	–
	institutional	provide affordable on-site childcare	✔		✔	(Eckerson et al., 2016; Morrissey 2017); ~50% of colleges in the University of California system offer some type of child care
		extend eligibility window for grants and awards based on parental leave			✔	NIH K awards, ERC grants, Emmy Noether Program, and the Research Project for Young Talent, French Young researcher ANR (Agence Nationale de la Recherche) grant
		adopt official extensions of graduate, postdoctoral, and tenure timelines due to childbirth and parenthood			✔	implemented by Norwegian Research Council, European Research Council
		enable "couple hiring" for tenure-track positions			✔	Schiebinger et al., 2008 implemented on a case-by-case basis
		create travel funds for academic parents to attend conferences			✔	(Calisi and a Working Group of Mothers in Science, 2018); Langin 2018; Hope et al., 2019; implemented FENS, OHBM
		conferences should be equipped with nursing rooms and on-site childcare			✔	Cardel et al., 2020; Langin, 2018; Hope et al., 2019; implemented by Society for Neuroscience (SFN)
		provide funds for relocation			✔	included in some offer letters on a case-by-case basis
		provide bridge funds at department and university level to support trainees during gaps in funding, especially during parental leave			✔	Stewart and Valian, 2018; Schiebinger et al., 2008; implemented by University of Washington, University of California San Francisco
	societal	increase the minimum allotted time for parental leave	✔		✔	Jones and Wilcher, 2019; implemented by all countries except for Papua New Guinea and the US; individual universities, like Boston University, have paid parental leave for graduate students and postdoctoral researchers

Each action is classified by its current status (tested/recommended, tested/debated, or implemented) and supported by some examples of highlighted advocates. Note that many solutions for the individual are difficult to quantify and left blank.

factors contributing to the increasing gender gap as careers progress will be reviewed in the following sections, where we will disentangle the various aspects contributing to each factor and propose concrete solutions to close the gender gap.

Gender bias hinders scientific productivity, authorship, and peer review

Women are systematically underrepresented as first and last authors in peer-reviewed publications relative to the proportion of women scientists in the field (Dworkin et al., 2020b; West et al., 2013). The discrepancy is particularly evident for senior author positions, as well as single-authored papers and commissioned editorials, i.e., positions typically reflective of senior roles (Holman et al., 2018; Schrouff et al., 2019; West et al., 2013). Moreover, an overall increase in gender differences in productivity has accompanied the steady increase of women in STEM over the past decades. This difference in productivity between men and women is mostly explained by a higher female than male dropout rate, while the yearly difference in productivity between genders is relatively small (Huang et al., 2020). Furthermore, a study of peer review based on 145 journals in various fields reported that women submit fewer papers than men (Squazzoni et al., 2021). The underrepresentation of women increases with the impact factor of the journal (Bendels et al., 2018). Neuroscience is no exception, as women authors are less likely to submit to high-profile journals, including senior women. In 2016, only ~20% of neuroscience papers sent to *Nature* had a woman as corresponding author (Promoting diversity in neuroscience, 2018). But even when women do submit to such journals, they face gender bias. Indeed, several studies where the identity of the authors was experimentally manipulated demonstrated that conference abstracts, papers, and fellowship applications were rated as having higher merit when they were supposedly written by men. These effects were even stronger in scientific fields viewed as more "masculine" (Knobloch-Westerwick et al., 2013; Krawczyk and Smyk, 2016). Furthermore, a recent study of 9,000 editors and 43,000 reviewers from *Frontiers* journals demonstrated that women are underrepresented as editors and peer reviewers (Helmer et al., 2017). This gender imbalance has also been reported in the editorial board of the top 50 journals in psychology and neuroscience (Palser et al., 2021). Additionally, all editors, regardless of whether they are men or women, display a same-gender preference (homophily), which at the moment favors men, in part because there are more men in the field (Murray et al., 2019).

In addition to publications, a screening of ~2.7 million US patent applications indicated that there was also discrimination in the patent-review process, leading to relatively few approved patent applications registered by women inventors (Jensen et al., 2018). Many of these effects were larger in fields with a generally higher representation of women, such as life sciences, than in technology areas (Hunt et al., 2013; Sugimoto et al., 2015; Whittington and Smith-Doerr, 2008). Though gender bias in authorship has been explicitly acknowledged for years (Women in neuroscience: a numbers game, 2006), it has changed minimally over the last decade (Bendels et al., 2018; Holman et al., 2018; 2018). Although the publication gap is decreasing, it is wrong to assume that there will be a proportional representation anytime soon without further active interventions (Bendels et al., 2018). In some disciplines, such as math, computer science, and surgery, gender parity in publications is unlikely to be reached in this century due to the current slow rates of increased representation of women (Holman et al., 2018). Other fields, such as psychology, have seen relatively greater increases in publications by men authors over time, further widening the gender gap (Ceci et al., 2014). Given that publishing, particularly in high-profile journals, is critical for hiring decisions and career advancement, this inequality in authorship will continue to contribute to the increasing gender disparity across academic ranks (Fairhall and Marder, 2020).

Suggestions for decreasing gender bias at an individual level

Increasing awareness for all scientists, editors, and reviewers regarding gender bias in authorship could help mitigate this issue. All scientists could seek out education in gender bias and proactively consider how to adjust their own behavior to ensure equity in their reviews.

Suggestions for decreasing gender bias at the institutional level

Finding alternatives to single-blind review is needed to increase the transparency of the peer-review process (Barroga, 2020; Lee et al., 2013). One proposed solution to mitigate gender bias in the review process is adoption of double-blind review, hiding the authors' name (Rodgers, 2017). Double-blind review has been introduced in several fields, such as ecology and computational sciences, and has been successful in reducing biases due to geographic location or university reputation (Bernard, 2018; Budden et al., 2008; Mulligan et al., 2013; Snodgrass, 2006; Tomkins et al., 2017). It is also standard usage in the top journals in sociology, political science, and history and was introduced in some neuroscientific journals such as *eNeuro*. However, the efficacy of double-blind review in reducing gender bias is still unclear. An early study found that introducing double-blind peer review significantly increased the number of first-authored papers by women (Budden et al., 2008), whereas later studies found no effect on review gender bias (Cox and Montgomerie, 2019; Tomkins et al., 2017). It is possible that more recent blind reviews were compromised by the use of preprint servers that list authors' full names. Another proposed solution is an open peer review, as currently implemented in *Frontiers* journals, where the names of the authors and the editor and reviewers are made public upon publications. One last alternative would be a hybrid peer-review system combining open discussion between scientists and peers while preserving the anonymity of the latter (Bravo et al., 2019; Lee et al., 2013). Such a system could consist of a pre- or post-publication discussion platform that allows referees, editors, and authors to interact when providing feedback on a paper.

Importantly, academic journals need to pay attention to potential sources of gender bias in order to be able to identify ways to mitigate them. One way to encourage review and editorial panels to improve accountability and transparency is to make demographic information regarding authors and reviewers publicly accessible (Murray et al., 2019). This is already implemented by PEERE, an European protocol designed to be an equitable

way to get more data on the peer-review process (Table 1; Squazzoni et al., 2017). Moreover, an increasing number of publishing groups are publicly releasing statements in support of diversity in authors, citations, and/or referees. As a recent example, Cell Press is encouraging authors to evaluate their citation lists for biases, as well as to ensure diversity in their research participants, authors, and collaborators (Sweet, 2021). It is also the case for *eLife*, which sets a twice-yearly report about actions taken to improve transparency, promote equity, diversity, and inclusion in the publishing process, as well as in their editorial board. Such initiatives are setting a positive example that could be followed by more publishers across all academic fields.

Gender differences in the number of citations

Citation metrics have emerged as a critical index of productivity in the biological and cognitive sciences. Citation counts influence hiring and tenure decisions, grant awards, speaker invitations, and career recognition. As an example, a study in the field of astronomy showed that in 149,000 publications, a paper whose lead author was a woman received 10% fewer citations on average than similar papers with a man as leading author (Caplar et al., 2017). In top neuroscience journals, that number is even greater; papers with women as first and last authors receive 30% fewer citations than expected given the number of such papers in the field (Dworkin et al., 2020b).

Furthermore, recent research reveals that contemporary citation practices skew these metrics in favor of men, undervaluing woman-led research of equivalent quality and potential impact. In particular, men undercite women scientists relative to men scientists, and their rates of self-citation are higher than those of women (Dworkin et al., 2020b; King et al., 2017). Additionally, men are more likely to use promotional language, such as positive words (e.g., "unprecedented" or "excellent") in the title or abstract, which in turn leads to more citations and an inflation of the h-index (Cameron et al., 2016; Kelly and Jennions, 2006; Lerchenmueller et al., 2019; Woolston, 2020). It is also possible that citation bias is exacerbated by the use of social media platforms such as Twitter. A recent randomized controlled trial demonstrates that papers that were tweeted received more citations at the end of 1 year than papers that were not tweeted (Luc et al., 2021). Women academics have disproportionately fewer Twitter followers, "likes," and re-tweets than men academics, controlling for their social media activity levels and professional rank (Zhu et al., 2019).

Suggestions at the individual level

At the individual level, all authors should be more aware of which articles they cite in their work. In particular, articles that already have a high number of citations are seen as "seminal," thus exacerbating biases that may not reflect quality. In the case of multiple possible citations, they should seek to balance the number of citations between genders according to a chosen model of research ethics. In the distributional model, citations would be distributed in a manner that is proportional to the percentages in their field, while in a diversity model, citations would be distributed in a manner that seeks to proactively counteract a history of inequality (Dworkin et al., 2020a, 2020b). Practically, efforts to diversify one's reference list can be supported by algorithmic tools that now exist to predict the gender of the first and last au-

thors of each reference by using databases that store the probability of a name being carried by a woman (Zhou et al., 2020). This tool already exists in neuroscience (Table 1), and we recommend wide implementation across academic fields.

Suggestions at the institutional level

One proposed solution is to increase diversity in review and editorial panels (Murray et al., 2019), as implemented by *Progress in Neurobiology* and *eLife*, among other journals. As a notable example, *Progress in Neurobiology*, has an editorial board with 80% women associate editors. This can help mitigate bias but may not be sufficient, as even women might be biased against other women. One option is to develop alternative citation metrics that account for the influence of self-citation and gender bias. Examples of these metrics are the m-index, which is the h-index adjusted for career age, and the m(Q)-index, which adjusts for career age and excludes self-citations (Cameron et al., 2016).

We also suggest that journal editors incorporate existing quantitative tools that analyze the gender ratio of a reference list by probabilistically inferring the gender of authors in a list of citations (see Table 1). Journals could then require authors to either eliminate any possible bias or provide a detailed justification for their deviation from the expected distribution. We also recommend the implementation of additional algorithmic tools in scientific journal submission websites to identify under-cited articles by women authors in a subfield or notify authors of citation biases in their submissions. Lastly, journal editors could consider increasing limits on the number of citations to accelerate the diversification of reference lists. As an example, *Neuron* modified their guidelines to exclude reference sections from the maximum character limit in research article submissions.

Scientific funding and awards are heavily biased

Funding is crucial to a researcher's scientific progression and career advancement, including gaining tenure and broad professional recognition (Charlesworth and Banaji, 2019; Duch et al., 2012). While the funding landscape is slowly evolving toward gender parity, women still face substantial challenges as they compete for limited resources. Some funding agencies collect data on the distribution of funding across genders. For instance, the percentage of NIH research grants awarded to women has been steadily growing over the past two decades, increasing from 23% in 1998 to 34% in 2019 (NIH Data Book—Data by Gender, 2020), with similar patterns observed for the National Science Foundation (NSF), the United States Department of Agriculture, and the European Research Council (ERC) (Charlesworth and Banaji, 2019; ERC consolidator grants 2019 - statistics, 2019). However, despite this positive trend, progress still needs to be made, as women scientists typically hold fewer grants and receive smaller awards compared to men scientists (NIH Data Book—Data by Gender, 2020).

Interestingly, while women receive more NIH research career grants at an early career stage than men (54%), the percentage of grants awarded to women progressively drops for grants associated with later career stages (research project grants, 34%; research center grants, 26%; NIH Data Book—Data by Gender, 2020. Similar data have been reported for other agencies and countries, highlighting the widening gender gap

across career stages; women are awarded fewer larger grants and are less likely to have them renewed than men (Burns et al., 2019; McAllister et al., 2016). Possible factors contributing to this increasing gender gap might be publication and citation practices, family circumstances, and other barriers resulting from implicit and explicit gender stereotypes (Pohlhaus et al., 2011). Moreover, the percentage of women submitting research grant proposals as a principal investigator (PI) is less than expected relative to their representation in all fields but engineering (Rissler et al., 2020).

The funding gap is also apparent in the amount awarded, with men typically asking for more funds (Waisbren et al., 2008) and obtaining larger grants than women (National Institutes of Health, 2020). A recent study found a median gender disparity in NIH funding of $39,000 per year awarded to first-time principal investigators, while no significant differences by gender were found in the performance measures (i.e., median number of articles published per year, median number of citations per article, and the number of areas of research expertise in published articles prior to their first NIH grant; Oliveira et al., 2019). The differences were even more pronounced for funding acquired by investigators at prominent US universities (median gender difference, $82,000). Although the gender gap is smaller regarding R01 awards (median difference, $16,000), men receive more of them (after controlling for other performance measures; National Institutes of Health, 2020; Pohlhaus et al., 2011). Furthermore, data from the NIH also show that the most dramatic differences in funding amounts were observed for research center grants (average difference, $476,000), again highlighting increasing disparity at later career stages.

Although the proportion of women who receive career awards for their scientific contributions has steadily increased over the past decades, women still receive substantially fewer prizes than men and less money (Ma et al., 2019). Across 13 major STEM disciplines, only 17% of professional award winners were women (Lincoln et al., 2012). This number is lower than expected based on overall representation by women in the STEM fields (38% for junior faculty and 27% for senior faculty), likely indicating review bias with professional efforts and accomplishments of women not receiving the same recognition. Gender disparity is even more dramatic for more prestigious awards. For instance, women represent only 21% of Kavli Prize winners, 14% of recipients for the National Medal of Science, 3% for the Nobel Prize in Chemistry, 3% for the Fields Medal in Mathematics, and 1% for the Nobel Prize in Physics (Charlesworth and Banaji, 2019; RAISE Project, 2018).The year 2020 was a unique year in Nobel Prizes, with two women winning the prize for Chemistry and one woman the prize for Physics. Despite this positive step, gender equity is still lacking, and active efforts need to be continued to ensure that women will keep being represented in prestigious awards in the years to come. Gender bias in distinguished recognition perpetuates the falsehood that only men can aspire to the highest levels of academic achievement, thus sending a harmful message to younger generations of aspiring scientists. Furthermore, disparities in funding and recognition tend to have a subsequent snowball effect. Indeed, grant funding drives scientific productivity, which in turn drives promotions; promotions drive

increases in salaries and stature, and stature drives recognition. Gender bias at each of these collective steps serves to further hamper the advancement of women in their academic careers.

Suggestions at the individual level

The process of applying for certain career transition awards across scientific disciplines, such as NIH K awards or the Burroughs-Wellcome career award, forces both the applicant and the mentor to envision the candidate in the role of a faculty member, something that can have a profound effect on the candidate's internal model of self and the attitude of the mentor.

Suggestions at the institutional level

Solutions could emerge directly from funding agencies in all scientific disciplines if they commit to actively monitoring for gender differences and ensuring gender equity in grant application rates, success rates, and amounts awarded. To ensure fairer funding, we suggest that agencies introduce a gender target for grant applicants, success rates, and amounts awarded. This could consist of a defined percentage of women researchers or amount of funding allocated to them at different career stages. Crucially, funding agencies should hold themselves accountable for attracting more female applicants by changing the procedures used in their competitions to create more equitable outcomes (Niederle, 2017; Niederle and Vesterlund, 2011). Further, it has been shown that having a target representation among women leads to increased numbers of applications by women; this brings stronger candidates to the competition, with little reverse discrimination (i.e., discrimination in favor of women; Niederle et al., 2013). Importantly, in contrast to some affirmative action approaches, this approach preserves the performance and quality of the competition (Balafoutas and Sutter, 2012).

This step could be enhanced by alerting the committee to potential gender bias (that both male and female reviewers are susceptible to) and even prefacing grant reviews with bias training. In addition, women are particularly underrepresented as leaders on large projects and/or international collaborations, and adjusting this imbalance could help establish overall gender equity in research funding. Finally, the Canadian Institutes of Health Research have successfully increased the number of female grant recipients by creating funding mechanisms that dispense awards focusing on the merit of the scientific proposal instead of the merit of the principal investigator (Witteman et al., 2019).

Moreover, monitoring implicit bias by making the demographics information of former grantees accessible to funding committees could help pinpoint the disparities and distribute the resources more equitably (Choudhury and Aggarwal, 2020). To reduce bias in the amount of requested funding, we suggest that submission portals implement artificial intelligence tools to provide researchers with recommendations on amounts of funding given their career stage and type of research. This suggestion follows the findings of Bowles and colleagues, who have shown that women ask for as much as men when ambiguity about bargaining range is reduced (Bowles et al., 2005).

Importantly, department chairs and deans must commit to an equitable distribution of institutional resources across genders. Additionally (but not as an alternative), department chairs could actively encourage, support, and provide the means (e.g., through

release time or workshops) to all faculty members to pursue applications for career awards and large grants such as program projects and center grant funding (see gender equity guidelines for department chairs).

Teaching evaluations reflect biases and gender-role expectations

Gender biases are ubiquitous in the classroom, affecting both the students and their professors (Fan et al., 2019). At the student level, what professors integrate in their course syllabi shapes students' knowledge and perception of academia. Women are under-cited as well as under-assigned in syllabi; 82% of assigned readings in graduate training in international relations across 42 US universities are written by all-men authors (Colgan, 2017), and only 15 of the 200 most frequently assigned works in the section "politics" of the Open Syllabus Project are authored by at least one woman (Sumner, 2018).

At the professor level, large-scale studies have found that women instructors receive lower-than-average scores on their student evaluations in comparison to men and that gender bias can be so substantial that more effective instructors are rated lower than less effective ones (Mengel et al., 2018). These findings have been substantiated in experimental studies, where the gender identity of the instructor in online courses was manipulated, with the instructors receiving lower ratings from both male and female students when they were believed to be women (Khazan et al., 2019; MacNell et al., 2015). Men are perceived by all genders to be more knowledgeable and to have stronger leadership skills than their women counterparts (Boring, 2017), even when there are no actual differences in what students have learned. This bias toward masculine traits during student evaluations of teaching (SETs) can have an important impact on the career of women scientists, as it is commonly used as a measurement of teaching effectiveness for promotion and tenure decisions. Apart from bias in the perception of women as teachers, women also tend to have higher teaching loads compared to men and less time for research (Misra et al., 2011), which can negatively impact their research productivity.

Suggestions at the individual level

We propose the use of existing tools (Reinholz and Shah, 2018; see Table 1) that can help faculty to build their syllabi and bibliographies in a more gender-balanced way (Sumner, 2018). In particular, faculty could provide historical examples of successful women scientists to reinforce female role models, ensure that the resources they give to their students are gender balanced (Table 1), and use more inclusive language (i.e., "folks" instead of "guys"; Bigler and Leaper, 2015).

Suggestions at the institutional level

The necessity to improve fairness and objectivity in teaching evaluations is critical to balance the odds for promotion across genders. A study conducted at the University of California, Berkeley suggested abandoning the SETs as the principal measure of teaching effectiveness and implementing instead other types of assessment, such as observing the teaching and examining teaching materials and portfolios (Stark and Freishtat, 2014). Moreover, improvement in the phrasing of the SETs is also required. Simple changes to the language used (e.g., explicitly

asking students to be aware of their biases) had a positive impact on the assessment of women professors (Peterson et al., 2019). Prefacing SETs with counter-stereotype content could further decrease bias that is evident during the evaluation itself (Blair et al., 2001).

Academic hiring, tenure decisions, and promotions favor men

Evaluation criteria for hiring and promotion commonly used in academia are also susceptible to gender inequality. These biases are common across all hiring stages, encompassing lab manager positions (Moss-Racusin et al., 2012), postdoctoral fellowships (Sheltzer and Smith, 2014), and tenure-track positions (Steinpreis et al., 1999).

Strikingly, despite experimental and observable data in STEM fields reporting favorability toward women in hiring decisions compared to equally qualified men, women remain heavily underrepresented in tenure-track positions (National Research Council, 2009; Williams and Ceci, 2015). This discrepancy has multiple potential sources related to different dimensions of gender bias. Gender biases in recruitment can occur even before applicants are evaluated (Nielsen, 2016). In neuroscience and STEM in general, most departmental or unit leaders are men (Gupta et al., 2005; McCullough, 2019). Consequently, men are more likely than women to define the unit's strategic research foci and/or teaching needs, draft the job profile, and outline the announcement, thereby determining the focus of the search. Defining a profile in a broad or narrow manner directly impacts the number and quality of eligible candidates. Narrow profiles can be used to legitimize the selection of a specific candidate (van den Brink, 2010) and often penalize women, as men's social networks benefit from a higher proportion of scientific leaders (Greguletz et al., 2019; James et al., 2019). The practice of some academic institutions limiting open recruitments presents an added barrier for women. A study in Denmark showed that at the University of Aarhus, ~20% of associate and full professor positions were filled via a closed recruitment procedure (Nielsen, 2015); such procedures are likely to propagate bias, as closed recruitment frequently results in a single applicant (Nielsen, 2015).

The evaluation and selection phase of the hiring process contributes to the persistence of gender imbalance (Rivera, 2017). Since men continue to be overrepresented among tenured/tenure-track faculty, evaluation committees and interview panels tend to have skewed gender composition (Sheltzer and Smith, 2014). Gender bias during hiring is amplified by the role of "elite" male faculty, who employ fewer women in their labs and have a disproportionate effect on training the next generation of faculty; these processes in turn affect hiring at high-ranking research universities (Sheltzer and Smith, 2014). Moreover, studies performed in Italian and Spanish academic institutions across several scientific fields show that when promotion committees are composed exclusively of men, women are less likely to get promoted (De Paola and Scoppa, 2015). Each additional woman on a seven-member promotion committee increased the number of women promoted to full professor by 14% (Zinovyeva and Bagues, 2011). Another important factor in reducing gender

bias in committee decisions is committee member awareness of implicit bias. Indeed, as shown in a recent study in France conducted across scientific disciplines, committee members who believe that women face external barriers in their performance and evaluation are less biased toward selecting men (Régner et al., 2019).

The biases that affect search criteria also influence the evaluation of the applicant's curriculum vitae. When faculty believe the applicant to be a man, they tend to evaluate the curriculum vitae (CV) more favorably and are more likely to hire the applicant (Moss-Racusin et al., 2012; Steinpreis et al., 1999) than when faculty believe the applicant to be a woman. Consequently, only women with extraordinary applications tend to be considered, narrowing the pool of potential women candidates to be interviewed.

Another source of bias during hiring comes from recommendation letters. Their content and quality significantly differ based on the gender of the applicant (Dutt et al., 2016; Madera et al., 2009; Schmader et al., 2007). For example, letters in support of women are typically shorter, raise more doubts, and include fewer "standout" adjectives (e.g., superb or brilliant) and more "endeavor" adjectives (e.g., hardworking or diligent), regardless of the gender of the recommender. Altogether, subtle gender biases throughout the academic hiring process, from job posting to evaluation, increase the risk of creating self-reinforcing cycles of gender inequality (van den Brink et al., 2010; Nielsen, 2015).

Suggestions at the individual level
We recommend that individuals writing job announcements be made aware concerning gender bias issues both explicit and implicit. Individuals evaluating applications should also be trained on topics relevant to gender equity, gender bias, and bias mitigation (Bergman and Rustad, 2013).

Suggestions at the institutional level
Bias awareness workshops could help scientists to improve job advertisements and assess applications more objectively (Carnes et al., 2015; Schrouff et al., 2019). This approach is already in place in some academic institutions (e.g., the University of California system) and could be more widely adopted and made mandatory for all academic members. The University of Wisconsin-Madison has successfully increased diversity by implementing workshops for faculty search committees that raise awareness about unconscious bias and provide evidence-based solutions to counter the problem (Fine et al., 2014). These types of workshops can be broadly implemented across institutions and fields. Finally, numerous studies show that reminding evaluators of their internal biases at the evaluation stage of the hiring process reduces the impact of bias (Carnes et al., 2015; Devine et al., 2017; Smith et al., 2015; Valantine et al., 2014).

Efforts should also be made to increase diversity in search committees. Increasing representation of women is necessary for reducing bias (Schrouff et al., 2019; Smith et al., 2004), despite not being sufficient on its own (see discussion). At the same time, institutions should ensure that women in underrepresented departments are not overloaded with administrative obligations, time-consuming committees, or any other assignment tasks that do not enhance promotion prospects (Babcock et al., 2017). To increase diversity in search committees while not overworking women, we propose that members of search committees be compensated by reducing their teaching or other administrative duties. Importantly, we highlight the strong need for male allies as part of search committees (see discussion).

Some academic institutions have already introduced mediators from equity committees in the hiring/promotion procedure. For example, in Switzerland, such mediators are required to actively provide input in faculty hiring and monitor gender balance (Gender Monitoring_Egalité_EPFL). Although nonacademic advisors cannot judge the quality of scientific work, their input on the fairness of the hiring process can be valuable.

Each institution must commit to policies and action plans that set quantifiable goals for women in different position categories. Ideally, the number of women reaching the interview stages should match the gender ratio of a given academic field. Concrete recruitment strategies to achieve these goals could be developed, for example, by adopting mandatory submission of regular reports on gender ratio with quantifiable measures (Bergman et al., 2013). As an example, if no women candidates apply, the University of California, Berkeley requires the position to be re-announced more broadly. Institutions can be required to be more explicit and transparent about how merit is evaluated. All of the above measures can be enforced with central incentives, such as funding allocations, to motivate departments to implement the necessary steps and hire more women (Bergman et al., 2013). Another solution to help reach a larger and more diverse pool of potential candidates would be the development of a curated and regularly updated list of underrepresented minority mentees that could become targets for job searches and awards (as it is already the case for conference speakers; Table 1).

Importantly, we believe that hiring committees need to recognize forms of scientific contribution to the STEM community not directly tied to scientific productivity. Such contributions include outreach, knowledge dissemination, and faculty service; these are contributions that women make on average significantly more than men, taking time from more traditional forms of research (Guarino and Borden, 2017). The practice of science is evolving, and additional qualification criteria for hiring decisions should be adopted to acknowledge the broader range of roles and responsibilities of contemporary scientists (Moher et al., 2018). In addition to building toward gender equity, recognizing and incentivizing these contributions to our academic communities will benefit all scientists, regardless of gender.

Suggestions at the societal level
When legally possible (as in Sweden, Germany, and Switzerland), any organization, including academic institutions, can set policies on gender equity, set goals for gender ratios in different position categories, and develop recruitment strategies to achieve these goals (Nielsen et al., 2017; Schrouff et al., 2019; Exploring quotas in academia; Des quotas pour promouvoir l'égalité des chances dans la recherche).

Gender bias in negotiation outcomes
Negotiations are important for building a successful career, as they can lead to better starting salaries and start-up packages; salary increases; better work conditions; and increased allocation of personnel, lab space, and other resources. On average, men tend to initiate negotiations more often than women (Babcock et al., 2006; Small et al., 2007). Additionally, when they

do, women still get less out of negotiations, are less likely than men to be successful in receiving the raise they asked for, and may incur a social cost for standing up for themselves (Bowles et al., 2007; Mazei et al., 2015).

Importantly, negotiations might be affected by perceived gender stereotypes, as gender roles influence both parties of the negotiations regardless of their gender (Kray et al., 2001, 2014). In accordance with Role Congruity Theory (Eagly and Karau, 2002), women are often reluctant to negotiate, because initiating negotiations is perceived as stereotypically male behavior. Moreover, expressions of emotions commonly associated with leadership characteristics, such as anger and pride (Brescoll, 2016), are more widely tolerated and even appreciated when they emanate from men compared to women (Brescoll and Uhlmann, 2008). The expression of gender roles is a complex phenomenon though. On the one hand, women may lose social capital (i.e., the work connections that have productive benefits) when voicing their opinions, especially when they go against the group's opinion. On the other hand, it has been reported that women who described themselves as displaying so-called masculine personality traits (i.e., a competitive mindset and willingness to take risks) had a 4.3% greater chance of getting positions and were more likely to take up positions that offered 10% higher wages than those displaying so-called feminine personality traits (i.e., gentle, friendly, and affectionate) (Drydakis et al., 2018). This deep-seated implicit bias, held by all genders, has non-trivial consequences for women's careers in academia.

Suggestions at the institutional level
Transparency is a key element for equity during negotiations. We propose that institutions provide access to everyone's salary and a range of possible salaries per academic level. Gender differences in economic outcomes tend to be smaller when negotiators first receive information about the bargaining range in a negotiation (Mazei et al., 2015). Such an approach could be complemented by providing information to faculty about ranges of research budgets or salaries and construct a rational (rather than *ad hoc*) process for determining how resources are allocated.

Removing stereotypes in both parties of the negotiations can improve women's performance (Kray and Kennedy, 2017). It has been shown that having supportive academic supervisors plays an important role in improving negotiation effectiveness for women (Fiset and Saffie-Robertson, 2020). Also, for mentees eager to develop their negotiation skills, institutions could offer courses on this topic. For instance, several online services, highlighted on Table 1, offer training materials on negotiation strategies, as well as materials targeted for companies wanting to improve their gender representation. These workshops provide techniques for negotiation and conflict resolution.

Gender inequalities are present in conferences
Conferences and meetings are crucial avenues for scientists to communicate new discoveries, form research collaborations, communicate with funding agencies, and attract new members to their labs and programs (Calisi and a Working Group of Mothers in Science, 2018). For instance, invitations to seminars at different institutions increase scientists' visibility and expand their academic networks. However, equally qualified women

scientists are often given fewer opportunities to speak at conferences and seminars than men. For instance, nearly half of the conferences in neuroscience have fewer women speakers than the base rate of women working in the field of the conference (Conference Watch at a glance | biaswatchneuro, (Langin, 2019). Given that conference presentations are an important indicator of the impact and significance of one's research, this form of gender bias has negative implications for women during hiring and promotion. Inviting women speakers and providing them with resources that allow them to attend the conference contributes to their professional development and increases their visibility. This action also contributes to the perception of women researchers as leaders for young scientists in the audience. This visibility is especially important for boosting the confidence of young women researchers. Moreover, women in the conference audience generally remain less visible, as they ask fewer questions than men. This is due to both internal (e.g., being unsure whether their question is appropriate) and structural factors (e.g., when the first question is asked by a man, women are less likely to follow up) (Carter et al., 2018).

Another important point that undermines the experience of women at conferences is unprofessional and inappropriate behavior (Parsons, 2015) (see Sexual harassment is a major obstacle encompassing all career stages). This may cause some scientists to avoid conferences due to feeling unsafe (Richey et al., 2015). Specifically, sexual and gender harassment and micro-aggressions primarily target women and are a common form of reported harassment at conferences (Marts, 2017). Finally, disrespectful and unprofessional questions and feedback during poster sessions and talks may discourage women from presenting their work (Biggs et al., 2018).

Suggestions at the individual level
We recommend that invited participants take proactive actions to promote gender equity. They could ask the organizers what measures are taken to ensure that the symposium and/or conference will not be a man-dominated event and could also decline to speak at conferences with an imbalanced speaker lineup. For instance, attendees can monitor progress in a conference's history of gender balance in speaker selection and see the base rates of women in relevant subfields, as is already possible in neuroscience (Table 1). We believe that scientists of all genders and levels of seniority should take personal responsibility to ensure professional conduct by speaking out against harassment and other biased behaviors.

Suggestions at the institutional level
Conferences can strive to ensure that symposia include gender-balanced speakers and chairs, at least in a ratio that matches the demographics of the field. Conference, seminar, and symposium organizers should have a list of women speakers that they can invite. They can search outside their personal and professional networks by consulting resources such as the directory compiled by Jennifer Glass and Minda Monteagudo, which lists searchable databases of highly qualified women by subfield (Table 1). As a notable example, proposals for symposia at the Federation of European Neuroscience Societies (FENS) Forum are required to include men and women speakers or provide a justification for single-gender symposia.

We also propose that organizers consider existing tools to mitigate their own bias. Gender balance at neuroscience conferences has been publicly monitored through the website BiasWatchNeuro (Table 1). Such measures could be implemented in many academic fields. In the context of conferences, unlike that for citations, diversity must come from the top; the organizations hosting a conference should strive for a committee that is well trained regarding bias. The Organization for Human Brain Mapping (OHBM) has introduced an "affirmative attention" approach by which new council members are elected through a ballot, so that the candidates for at least some open positions may only include women, to ensure that the gender distribution in the council remains equitable, no matter which candidates get elected (Tzovara et al., 2021). Conference organizers can also offer programs that raise awareness of the issue of gender bias. For example, the annual meetings of several major conferences, such as the Society for Neuroscience, OHBM, or FENS, include educational courses, workshops, and informational sessions on gender bias (Seeds of Change within OHBM: Three Years of Work Addressing Inclusivity and Diversity). Another example is the "power hour" institutionalized by the Gordon Research Conferences, which consists of a forum for conversations about diversity, inclusivity, and related topics.

However, in workshops about gender bias, often only highly successful women are represented on panels discussing bias and women's careers in academia. In these instances, we believe that it is important to avoid promoting survivorship bias, which emphasizes positive outcomes without addressing the barriers and challenges that must be overcome to achieve that success more broadly among women scientists. Moreover, men are not usually invited as speakers in these events and are also usually absent from the audience, which renders them less aware of the issues around gender bias and therefore less effective allies. We suggest that the way that the speakers and topics of panels are chosen must be improved to be more inclusive and represent the full spectrum of diversity in the community.

An inclusive code of conduct has been proposed as mandatory for each conference, stating what is and what is not appropriate behavior for conference attendees (Favaro et al., 2016). Conference organizers should have clear plans of action in place in case harassment occurs, including anonymous reporting and removing confirmed harassers from the conference (Marts, 2017; Parsons, 2015). The suggested code of conduct should also include respectful ways to provide constructive scientific feedback (Favaro et al., 2016), a practice that should be implemented across all contexts within academia. Lastly, all attendees should feel concerned about and responsible for maintaining a respectable environment during conferences. Since it can sometimes be hard to intervene as things unfold in real time, we suggest that conference organizers provide a specific contact where members can report unethical or inappropriate incidents.

Sexual harassment is a major obstacle encompassing all career stages

A recent exhaustive report on sexual assault led by the National Academies of Science, Engineering, and Medicine, and funded by the NIH, reported that rates of sexual harassment are as high as 58% for academic faculty and staff and between 20% and 50% for students. The majority of the sexual harassment experienced by women in academia consists of sexist hostility. These unacceptable rates are higher than any other work environment except for the military (National Academies of Sciences, Engineering, and Medicine, 2018). The consequences of harassment are far reaching and require widespread efforts to reduce these high rates if we are to see gender parity in a scientific workplace.

Sexual harassment falls into four main categories: micro-aggression (i.e., comments or actions that express prejudiced attitudes), sexual coercion, unwanted sexual attention, and gender harassment (National Academies of Sciences, Engineering, and Medicine, 2018) for a detailed review). Harassment consists of actions that create a hostile and inequitable environment for members of a specific group. Harassment is not limited to the extreme form of physical assault; it also includes endorsing beliefs that someone's intelligence is inferior to another's or making demeaning jokes that target one gender group.

Unfortunately, all types of sexual harassment are common and lead to negative outcomes for the people who experience them. In addition to the 58% of academic faculty or staff who experienced sexual harassment, 38% of women trainees and 23% of men trainees experienced sexual harassment from faculty (National Academies of Sciences, 2018). More egregious numbers are found in specific fields; a recent study reports that 75% of undergraduate women majoring in physics experienced sexual harassment (Aycock et al., 2019). While peer-to-peer harassment is also prevalent, trainees experience worse professional outcomes when faculty at their university conducted the harassment. These numbers may underestimate the problem, as trainees might not feel comfortable speaking up when their career development, and sometimes even legal status in a country, depends on the person harassing them. In another study of 474 scientists, 30% of women reported feeling unsafe at work, compared to 2% of men (Clancy et al., 2017). The rates were even higher for women of color, where almost 50% of women scientists of color reported feeling unsafe at work (Clancy et al., 2017). These experiences are chronically stressful and have been linked to higher levels of depression, anxiety, and generally impaired psychological well-being (Lim and Cortina, 2005; Parker and Griffin, 2002). People who have experienced sexual harassment report higher rates of absenteeism, tardiness, and use of sick leave (measured on scales where respondents indicated desirability, frequency, likelihood, and ease of engaging in these behaviors) and unfavorable job behaviors (e.g., making excuses to get out of work, neglecting tasks not evaluated on performance appraisal) (Schneider et al., 1997). Finally, and not surprisingly, individuals who experience sexual harassment are more likely to leave their jobs. All of these statistics demonstrate that sexual harassment is both alarmingly common and reduces the scientific productivity and well-being of the people who have been harmed. Yet, when this behavior is reported, the whistle-blowers may be either retaliated against or there may be no repercussions for the perpetrators. Moreover, even the policies that aim to protect victims of harassment have substantial negative consequences, which are more likely to occur to women than men. These include reluctance to have

one-to-one meetings with women or include them in social events or reluctance to hire women for positions that require close contact with them (Atwater et al., 2019).

Suggestions at the individual level

Collegial behavior that does not propagate harassment and micro-aggressions should be the bare minimum expectation in any lab or academic institution. Individuals of all levels should consider their personal responsibility to promote a respectful and professional environment and avoid and denounce unwelcome behavior when witnessed. Besides everyone's own responsibility, it is essential that organizational leaders display an unequivocal anti-harassment message (Buchanan et al., 2014).

Suggestions at the institutional level

Sexual harassment cannot be tolerated and must be severely reprehended by institutions. Although some initiatives for combating harassment exist, there is to date no evidence that current policies have succeeded in reducing harassment (ACD Working Group on Changing the Culture to End Sexual Harassment). To counter this ineffectiveness, the NIH has recently recommended that sexual harassment needs to be equated to scientific misconduct, including similar mechanisms for reporting, investigation, and adjudication. A recent report form the NIH has revealed that since 2018, 75 PIs have been removed from their grants after sexual harassment or discrimination complaints (Update on the ACD Working Group Recommendations on Changing the Culture to End Sexual Harassment).

Researchers found guilty of sexual harassment could be barred from applying for new grants over a period of years deemed appropriate by the various regulatory entities similar to the penalty for scientific misconduct. Examples of such entities in the US would be the Department of Health and Human Services (HHS), their Office of Research Integrity (ORI), and the NIH. Importantly, the committees involved in investigating and adjudicating harassment should be independent of the institution leaders (Greider et al., 2019).

One solution often proposed to combat sexual harassment is anti-harassment training. This consists of requiring students and staff to participate in workshops detailing sexual harassment policies and what constitutes unwelcome behavior. This approach has been widely suggested and is currently implemented in several institutions despite its debatable effectiveness in reducing harassment. Indeed, it has been shown that some approaches could have the opposite effect, with men being less likely to judge a situation as harassment after receiving training, leading to gender stereotype reinforcement (Roehling and Huang, 2018). Moreover, empirical studies have shown that training employees to recognize what constitutes harassment can be followed by decreases in women managers (Dobbin and Kalev, 2019). By contrast, training managers to recognize signs of harassment and intervene results in increases in women managers (Dobbin and Kalev, 2019). This seeming discrepancy may be due to gender differences in perception of harassment so that women are more likely to believe victims of harassment. Departments need to carefully design their sexual harassment training, as studies have reported that the designs of such training are essential and need to be adapted to the targeted populations (Dobbin and Kalev, 2019). Interventions that place

trainees as allies, such as bystander intervention training, showed positive effects on sexual harassment prevention in academia and military sectors (Buchanan et al., 2014; Cares et al., 2015; Katz and Moore, 2013; Potter and Moynihan, 2011). For instance, Potter et al. (2019) are developing videogames to educate college students bystander intervention skills in situations of sexual harassment and stalking.

One example of a novel yet untested approach is the "Respect is Part of Research" initiative by graduate students in the University of California, Berkeley Physics Department. During these trainings, participants discuss case studies in small groups together with a facilitator, addressing what is wrong about the behavior of the actors in the example, separating intent from impact, and methods to resolve the situation. Providing trainees with the tools to handle difficult situations and creating a supportive community has the potential to significantly shift the culture toward more respectful behavior in academia. However, its effectiveness for combating harassment in the long-term still remains to be tested.

Another factor that can assist in reducing harassment is adopting clear anti-harassment policies in codes of conduct (Why and How to Develop an Event Code of Conduct), both at conferences and in individual labs. Enforcing a code of conduct is a challenging task, and future efforts should focus on drafting clear policies for different scenarios.

Suggestions at the societal level

To lower the rates of sexual harassment, all members of the scientific community, and the community at large, need to make widespread changes. Learning to recognize sexual harassment should be an ongoing goal for any nation, starting with education in schools. We recommend that all organizations develop programs charged with reducing the prevalence of sexual violence, sexual harassment, and stalking through prevention, advocacy, training, and healing (for example, see the Path to Care center from University of California, Berkeley). This approach is distinct from and complementary to the purpose of official university legal procedures (e.g., Title IX in the US); while such officers legally arbitrate gender discrimination disputes, the university program we envision would be dedicated to serving the survivors of sexual harassment, preventing new cases, and training the university-wide community.

Encompassing all sectors: Family planning in academia

Gender inequity exists in the division of household labor. Women typically shoulder most of the burden in childcare and maintenance of the household, even among dual-career partners (Chopra and Zambelli, 2017). Women have increasingly joined the paid labor force, increasing their total work time, but men have not increased the amount of time they spend in unpaid household work. The coronavirus disease 2019 (COVID-19) pandemic is the most recent evidence of the impact of gender inequality in the labor market (Alon et al., 2020). During the lockdown, women scientists submitted fewer manuscripts and started fewer research projects than men (Viglione, 2020), consistent with an additional and disproportionate burden of childcare. While the majority of studies consider households composed of one man and one woman, further work is needed to evaluate the relations between gender and labor in single-parent homes or same-gender parent homes.

Although academia has its perks for the single-parent, same-gender-parent, and different-gender-parent families, such as flexible hours and additional time to tenure, other working conditions can become barriers for family planning. Career stages where funding and mobility are critical, such as transitions between graduate school, postgraduate training, and tenure positions, often correspond to a time when researchers may wish to start a family (see Figure 1). However, pregnancy, childbirth, nursing, parental leave, and early childcare take a considerable amount of time, physical and mental resources, and money that constitute a competitive disadvantage in a scientific career. Indeed, parental leave negatively impacts metrics of productivity of early career scientists who are parents (Chapman et al., 2019), yet with a stronger effect for women (Morgan et al., 2021), which in turn impacts the possibility to obtain grant funding (i.e., several calls are limited to a certain amount of years post-degree according to funding agency policies).

Women with children are reluctant to attend conferences due to the lack of childcare support (Calisi and a Working Group of Mothers in Science, 2018). Conferences in distant locations add another layer of complexity, as transoceanic flights often mean a longer stay away from home. Adequate facilities, such as lactation rooms or support for a traveling caretaker to assist in the care of their infant as the scientist attends the meeting are rarely provided. This limited mobility reduces parents' opportunities for international collaborations and funding, which are common criteria used for promotion and evaluations.

Importantly, women face even stronger discrimination when they are part of nontraditional family formations; single mothers experience stronger work-family strain than partnered ones (Baxter and Alexander, 2008). Studies of single-mother doctoral students have shown that they fear being judged in their departments and that they often feel excluded by university life and academic schedules (AmiriRad, 2016). Although LGBTQ+ (Lesbian, Gay, Bisexual, Transgender, Queer, Plus other gender identities and sexual orientations) parents face similar challenges as cisgender and heterosexual parents (King et al., 2013), LGBTQ+ individuals might have fewer health or retirement benefits and face unequal treatment in academia (Cech and Waidzunas, 2021; Thompson and Parry, 2017). Future studies should address the particular challenges and biases faced by single-parent and LGBTQ+ families and their potential impact on academic achievements.

Apart from the academic aspect, most societies are not built to assist families where both parents pursue a demanding career path. For instance, public schools in some countries like Germany often stop in the early afternoon, and it can be hard to find public preschool or after-school childcare. Moreover, working mothers often feel stigmatized, as they risk being looked down upon by citizens of more "traditional" societies for their choices to work instead of staying at home with their children.

Suggestions at the individual level
Parents should not have to choose between having a family and an academic career. Evaluation of academic progress should take into consideration delays caused by parenthood and childcare responsibilities. Individuals should also assess their own possible tendencies to judge or exclude academics with young children and become prepared to support initiatives that would

encourage their participation in gatherings, conferences, and other professional activities.

Suggestions at the institutional level
Institutions need to adopt official extensions of graduate, postdoctoral, and tenure timelines due to childbirth and parenthood. To address the financial difficulties for academic families, we suggest a number of measures. First, job security can be improved by creating longer-term contracts where possible and providing bridge funds at the department or university level to support trainees during gaps in funding (Stewart and Valian, 2018). Both universities and funding institutions should put measures in place to prevent a gap in funding during parental leave (Powell 2019). Special provisions for parenthood can be made in calls for proposals and funding mechanisms. A few funding organizations include childbirth in their policies as a valid reason to extend the eligibility window (from 1 year for NIH K awards to 18 months for ERC grants or a 2-year extension to post-PhD limits per child for the Emmy Noether Program of the German Research Foundation) or subtract time for parental leave ("Research Project for Young Talent" proposed by the Research Council of Norway, 2–7 years post-PhD). Finally, efforts should be made to reduce the difficulty in returning to work after maternity leave, such as providing lactation rooms.

Solutions can be found to support couples in which both partners are in academia (Schiebinger et al., 2008). By enabling couple hiring for tenure-track positions, institutions can help women pursue their academic career. Critically, universities should ensure access to affordable, on-site childcare, as this both improves outcomes for children enrolled in such programs and increases women's participation in the workforce (Morrissey, 2017; Eckerson et al., 2016).

Specific funding should be allocated for parents to travel for conferences and sabbaticals. Conferences, universities, and funding agencies can reserve a part of their budget to create travel funds for parents. Compared to a decade ago, more conferences are offering nursing rooms (Cardel et al., 2020; Hope et al., 2019; Langin, 2018) and other types of on-site childcare, which should be accessible to all parents (Cardel et al., 2020; Langin, 2018). However, unfamiliar caregivers are not always a viable option, and parents will likely feel most comfortable knowing their child is cared for by a primary caregiver. To address these issues, some conferences, such as FENS or OHBM, are offering childcare grants, which can either cover travel expense for a trusted caregiver (spouse, partner, or nanny) to accompany the parent and child, or pay for expenses involved in leaving the child at home (Calisi and a Working Group of Mothers in Science, 2018; Langin, 2018; Tzovara et al., 2021).

Suggestions at the societal level
These issues require a broad reshaping of society, which still relies on parental roles or family patterns that are increasingly obsolete. Law in all countries needs to enforce official extension of timelines to accommodate pregnancy, childbirth, and parenthood, as increases in parental leave result in fewer women leaving the workforce (Jones and Wilcher, 2019). For instance, the total paid period of parental leave in Norway is between 46 and 59 weeks, with maternal and paternal quotas of 15 weeks each and a joint period of 16 weeks. The downside of providing parental leave to both parents is that previous research has

shown that giving the same extensions to both parents puts mothers at a disadvantage, as fathers are more likely to increase their productivity during this period (Antecol et al., 2016). It is therefore important for parents to have an equal split of child-caring duties and profit from allocated time to bond with their child.

Not all gender biases are the same: Intersectionality

Discussions surrounding plans to combat gender bias in academia are incomplete without attention to the unique struggles of women who hold additional identities are subject to discrimination. Barriers faced by all women in academia are compounded for those who are members of additional underrepresented groups (e.g., based on, but not limited to, race, ethnicity, first-generation status, religion, socioeconomic status, gender expression, gender identity, sexual orientation, and disability) that interact with and increase gender bias (Armstrong and Jovanovic, 2015). For instance, the gender wage gap has been shown to be wider for transgender women (Schilt and Wiswall, 2008) and black women (Guillory, 2001). Women of color faculty are the least likely to receive tenure of all demographic groups despite comparable productivity (Armstrong and Jovanovic, 2017). As such, successful interventions must consider these supra-additive effects and take an intersectional approach.

Suggestions at the institutional level

Across all career stages and aspects of academia, institutions could develop interventions and programs that take into account the specific needs of overlapping identities. For instance, Flores (2011) proposed that financial awards or targeted mentoring programs could help underrepresented women to overcome practical and psychological burdens associated with intersecting identities. Policies to increase the Latino community in STEM propose mentoring and educational programs in different languages for women whose native language is not English (Flores, 2011). A first step in developing such programming can be interviews and focus groups with underrepresented minority women in order to receive feedback on structural inequalities that can be addressed at the institutional level. Intersectional approaches can include targeted networking events, mentorship pipelines, and funding initiatives, as well as rigorous data collection to assess efficacy of these approaches. As with any intervention, special care needs to be taken to not overburden the individuals experiencing discrimination with additional tasks and administrative overload.

Discussion

In this article, we review empirical evidence demonstrating pervasive gender bias throughout all stages and venues of academic life. Studies have shown that women are less likely to be hired or to receive tenure than men, despite equal performance. They receive less grant funding and fewer prestigious awards. The rates of accepted publications, presentations, and patents are lower for women, and women are less likely to be first or last author on publications or submit to high impact journals. Studies are documenting a prevailing notion that the work of men has higher merit than that of women, a perception that is reflected in the discrepant number of citations of men versus women authors in research papers or assigned classroom readings. Positions on review panels with the power to hire, promote, approve funding, or decide policy are still largely offered to men,

whose own biases (unconscious or otherwise) may impede the advancement of women academics. Women's salaries are lower than men's, and women take on the greater burden of childcare, restricting their opportunities to conduct research or attend conferences. Finally, women continue to experience sexual harassment and hostility at an alarming rate, not only in their work environment but also at conferences and other academic venues.

Apart from the ethical issues this evidence raises, a large proportion of the highly trained and talented individuals who are essential for advancing research and educational practice are not progressing in their academic careers, largely due to the rectifiable issue of gender bias. Here, we gather, explore, and suggest actions at the individual, institutional, and societal levels aimed to mitigate the effects of gender bias. Implementing some of the proposed recommendations will not be trivial, as new regulations and controls might themselves require monitoring for bias. We cannot predict the outcomes of the proposed suggestions. However, openly and explicitly acknowledging gender bias (that all genders are susceptible to) is an essential starting point to restore the unbalanced academic environment. In considering such complexities, institutions should engage the advice and guidance of social science experts and the affected groups to ensure optimal solutions.

Diversity is essential to delivering excellence in science, as it increases cognitive diversity, which in turn leads to novel solutions (Page, 2008) and innovations (Hofstra et al., 2020), as well as increased problem-solving (Hong and Page, 2004) and scientific discovery (Nielsen et al., 2018). Besides the invaluable contribution to science, it will also help reduce stereotypes (Miller et al., 2015). To ensure successful changes, mindsets must change, and our proposed solutions provide a step in that direction. However, many challenges first need to be understood and overcome. Thus, a few important aspects of gender bias must be addressed.

The fight for gender equity needs diverse role models and strong allies

First, we need to amplify the voices of underrepresented scientists and mentors as role models in order to encourage diversity. One of the main reasons for leaving science is a lack of mentoring, which affects more women than men trainees, as women are less likely to be mentored (Preston, 2004). In line with this reported gender bias in mentoring in academia, experimental evidence showed that women and men science faculty were less likely to offer mentoring to a trainee when their application materials were assigned a female rather than a male name (Moss-Racusin et al., 2012). In order to overcome this bias against women trainees, mentors have to make an intentional effort to offer mentoring to women trainees to ensure that mentoring is provided equally to women and men trainees. This study also found that female applicants were rated as less competent than the male applicants with an identical application. Awareness of implicit bias is an important first step to overcome these barriers and enable mentors to improve equal support of women mentees. For instance, they could actively encourage them to submit to higher impact factor journals, apply for funding opportunities and large grants, nominate them to awards, invite them to speak in conferences and seminars, and meet potential collaborators. All scientists should consider gender equity when building a

team of principal investigators for collaborative work, particularly on larger or more prestigious projects. Having encouraging mentors and role models with whom students and scientists can identify will positively shift their perception of themselves (Morgenroth et al., 2015) and mitigate imposter syndrome (Abdelaal, 2020). This type of support can make the academic career path more inclusive and accessible, irrespective of race, ethnicity, sex, sexual orientation, or gender.

Second, everyone needs to be on board, irrespective of gender or career stage. This is particularly critical, as men still hold most positions of power in STEM and can use their positions to change the system from within. This can be challenging, as there are several persistent misbeliefs about preventing progress (Johnson and Smith, 2018). One might argue that giving more opportunities to women necessarily comes with a loss of privileges for men. However, the situation in some STEM domains is not a zero-sum game. Many countries suffer from an overall STEM worker shortage; thus, adding women to the workforce would improve overall industry performance. In addition, gender equity comes with many benefits; organizations with more female leaders offer employees more generous policies (Ingram and Simons, 1995), producing better business results (Berdahl, 2007). Some men might feel that gender equity "is not their fight." The answer to this concern is two-fold. First, gender equity is a moral imperative, and the voices and actions of all are needed. Second, gender equity *is* a man's fight. Gendered roles impact not only women but also men; many still believe that "child caregiving/domestic work is not a male job" and that "a man needs to be the family breadwinner," beliefs that can have a strong impact on mental health (King et al., 2020). This position reflects a "fixed mindset" about gender roles, which leads men to rationalize the status quo, i.e., engage in system justification about gender inequality (Kray et al., 2017). A more fundamental antidote in combating gender bias is to promote growth mindsets (e.g., "things can change, there is no reason why men and women can't occupy the same social roles"; Dweck, 2016).

Notably, the concern and interest around the topic of women's underrepresentation in STEM has not been matched by a similar concern about men's underrepresentation in healthcare, early education, and domestic roles (Block et al., 2019; Croft et al., 2015; Meeussen et al., 2020). However, gender experts are now pointing at men and men's representation as a key component to advance women's place in society (Block et al., 2019; Croft et al., 2021). Gender equity will benefit men by freeing them from societal biases. In turn, a change in the aspirations and careers of men will likely benefit overall gender equality; men who take on nontraditional roles can enable women and girls to envision themselves in less traditional, complementary roles (Block et al., 2018; Croft et al., 2014). When more men turn to roles in health care, education, and domestic work, there will be more STEM roles that can be occupied by women. To quote one of our reviewers, "As long as there is stagnation in men's roles, there will be an upper limit on the amount of change that can be achieved for women's roles as well."

Importantly, as soon as the fight for gender equity becomes a universal cause, the overload of academic work weighing on women should be alleviated. The approach of several institutes

or funding agencies for improving equity is to task women with taking part in administrative obligations during hiring processes, panels in conferences, etc. However, being fewer in number, the same women find themselves having to manage substantial extra work. Besides these administrative burdens, they are also often asked to participate in initiatives aimed at promoting diversity. This work additionally affects women disproportionately and even more so women of color (Nair, 2014). It may seem natural that individuals facing discrimination would have the strongest interest and possibly knowledge on how to resolve it. However, leaving the work that promotes diversity to those directly affected by the lack of diversity/inclusivity can contribute to further injustices. This work thus needs to be shared with advocates from the non-minority category.

When implementing some of the proposed solutions, it is important to consider complexities that might emerge from "positive discrimination," where the "best" candidate might be overlooked in favor of a candidate who meets another requirement (e.g., ethnicity, first-generation status, religion, socioeconomic status, gender expression, gender identity, sexual orientation, and disability; STEM Women, 2019). Not dismantling structural conditions of inequality means that existing disadvantages triumph. Institutions should carefully consider these complexities and include affected minorities in policy development to ensure optimal solutions.

Challenges and major open questions in addressing gender bias

Improving gender equity in science represents challenges at several levels. First of all, despite an abundance of research, there is a lack of systematic and validated metrics to assess gender bias and evaluate the efficacy of various initiatives in improving gender equity. Without standardized data collection and metrics to objectively measure gender bias, it is often impossible to draw solid conclusions on the degree of its presence and/or origin. However, for appropriate measures to be deployed, the source of bias needs to be properly established so that proposed actions can differentially target the real cause. One reason for this is that despite its far-fetched consequences, evaluating the existence of bias can be very subtle and challenging. Measuring presence and then reductions in implicit bias in a controlled setting does not necessarily translate to changes in real-life situations (Forscher et al., 2019). It is crucial that advocacy goals do not bias the presentation of scientific evidence for and against different interventions and policy changes (Eagly, 2016, 2018). Moreover, there is a lack of systematic gathering and reporting of gender data from various organizations such as universities, conferences, funding agencies, or award and hiring committees. Moving forward, we encourage institutions to gather and report data about gender representation in their membership and collaborate with social scientists who can provide valuable expertise. Importantly, we encourage all scientific bodies to increase transparency about the successes and failures of interventions that they have used in the past to address bias.

Notably, for many of the issues raised in this article, no straightforward solutions exist. Despite an increasing number of actions taken to mitigate gender bias in the workplace over the past decades, a thorough assessment and evaluation of their impact on diversity are often lacking, as their short- and

long-term impacts are hard to quantify in the real world (Paluck and Green, 2009; Paluck et al., 2021). Long-term impacts are vital to quantify, especially as some evidence suggests that gender bias persists even after gender representation becomes balanced, paradoxically perpetuated by members who believe that gender bias has been overcome (Begeny et al., 2020). Not all of the potential solutions presented here are destined to work, but several of them are certainly worth consideration (see Table 2 for an overview of tested versus proposed actions).

For instance, diversity training is oftentimes recommended as one potential tool to mitigate gender bias. The admirable goal is to raise awareness on implicit and explicit biases that every human being carries. Although it is an intuitive way to tackle bias, the efficiency of diversity training is currently debated. Some studies, especially in the corporate sector, have reported modest to no effect of trainings with potential adverse effects for certain minority groups (Dobbin and Kalev, 2013; Dobbin et al., 2011; Kalev et al., 2006), while other studies have shown encouraging results in both corporate sectors (Anand and Winters, 2008) and academia (Carnes et al., 2015). Multiple factors influence the effectiveness of diversity training (Roberson et al., 2013). Among them, the design of the training itself (e.g., format, length, and, most importantly, the way men are depicted [as allies and not oppressors]) and the way to assign training (i.e., voluntarily or in person) may positively influence the outcome of these initiatives (Bezrukova et al., 2016; Kalev and Dobbin, 2020). Genuine motivation, support, and commitment from superiors; social accountability; and transparency play important roles (Chang et al., 2019; Dobbin and Kalev, 2020). Lastly, as diversity training is not effective to change behavior in isolation (Kalev et al., 2006), other actions and concrete changes at the institutional and societal levels are needed (Dobbin and Kalev, 2020; Paluck et al., 2021).

Combining several actions is required for successful outcomes. For instance, increasing the representation of women across scientific bodies (i.e., hiring committees, review panels, in mentorship) and career stages can be helpful in reducing bias, but on its own, it is not enough. Extensive research in hundreds of thousands of participants and across multiple countries has shown that increasing the enrollment of women students in higher education can reduce gender stereotypes. However, increasing the employment of women as researchers reduces explicit, but not implicit, stereotypes (Miller et al., 2015). The perseverance of explicit gender stereotypes is stronger in disciplines that are male dominated, but implicit stereotypes remain, even in disciplines where women are well represented (Smyth and Nosek, 2015). Gender stereotypes are also prevalent in women, who can be biased against women. It is important to highlight that increasing the representation of women is a necessary, but not sufficient, condition for addressing gender bias.

A second major challenge in improving gender equity is that not all scientific fields have the same gender imbalances across career stages. Several fields like psychology typically achieve a more balanced gender ratio than other men-dominated fields such as engineering. Future attempts should implement initiatives that cater to the needs of each subfield and also test the generalizability of initiatives across fields.

Last, one major open question is that of governance. To date, there is a lack of governance models for monitoring gender bias and deciding whether a given solution is sufficient or well implemented. Importantly, the decision about whether a solution is successful often relies on arbitrary metrics and does not take into account the experiences of women who are targets of bias. We invite scholars to develop better governance models and oversight committees for monitoring gender bias in an inclusive and objective way.

Conclusions

Gender bias is a complex assortment of problems, encompassing all career stages. Concrete actions are required to address each of the facets of gender bias and need to be initiated by every academic entity, from individuals to departments to conferences and professional organizations. These actions, in combination with strong role models and a diverse pool of allies, will make it possible to shift the culture and bring positive change. The time for action is now.

WEB RESOURCES

ACD Working Group on Changing the Culture to End Sexual Harassment, https://acd.od.nih.gov/working-groups/sexual-harassment.html
BiasWatchNeuro, https://biaswatchneuro.com/
cleanBib, https://github.com/dalejn/cleanBib
Conference Watch at a glance | biaswatchneuro, https://biaswatchneuro.com/conference-watch-visual/

Des quotas pour promouvoir l'égalité des chances dans la recherche, http://www.snf.ch/fr/pointrecherche/newsroom/Pages/news-210205-des-quotas-pour-promouvoir-egalite-des-chances-dans-la-recherche.aspx?fbclid=IwAR2XGRQ4LB1Gl3kL0iXzA-lMuP2Qe5jQQC0-nv-MIF6qsJrqAWEHSopfW0c

Equality of opportunity in ERC Competitions, https://erc.europa.eu/sites/default/files/document/file/Equality_of_opportunity_in_European_Research_Council_Competitions_Barbara_ROMANOWICZ.pdf

EQUIP, https://www.equip.ninja/

ERC consolidator grants 2019 - statistics, 2019, https://erc.europa.eu/sites/default/files/document/file/erc-2019-cog-statistics.pdf

Exploring quotas in academia, https://www.embo.org/documents/science_policy/exploring_quotas.pdf

Field of degree: Women-NSF, https://www.nsf.gov/statistics/2017/nsf17310/digest/fod-women/

GARCIA Project, http://garciaproject.eu/

Gender balance syllabus tool, https://jlsumner.shinyapps.io/syllabustool/

Gender equity guidelines for department chairs, https://www.aaup.org/issues/women-higher-education/gender-equity-guidelines-department-chairs

Gender Monitoring_Egalité_EPFL, https://www.epfl.ch/about/equality/fr/egalite-epfl/gendermonitoring/

INCLUSION: directory compiled by Jennifer Glass and Minda Monteagudo, http://www.jenniferglass.com/Jennifer_Glass/Inclusion.html

NIH Data Book—Data by Gender, 2020, https://report.nih.gov/nihdatabook/category/16

Path to Care center, https://care.berkeley.edu/

PEERE, http://www.peere.org/

RAISE Project, http://www.raiseproject.org/

Research Project for Young Talent, https://www.forskningsradet.no/en/call-for-proposals/2020/forskerprosjekt-for-unge-talenter/

Respect is Part of Research, http://www.respectispartofresearch.com/

Seeds of Change within OHBM: Three Years of Work Addressing Inclusivity and Diversity, https://www.ohbmbrainmappingblog.com/blog/seeds-of-change-within-ohbm-three-years-of-work-addressing-inclusivity-and-diversity

STEM Women, 2019, https://www.stemwomen.co.uk/blog/2019/09/positive-action-vs-positive-discrimination-what-can-your-company-do-to-lawfully-encourage-more-female-applicants

Update on the ACD Working Group Recommendations on Changing the Culture to End Sexual Harassment, https://acd.od.nih.gov/documents/presentations/06102021_Lauer.pdf

Why and How to Develop an Event Code of Conduct, https://www.asaecenter.org/resources/articles/an_plus/2019/october/why-and-how-to-develop-an-event-code-of-conduct

Women in Academia: Quick Take, https://www.catalyst.org/research/women-in-academia/

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