Comment

Women from some minorities get too few talks

Heather L. Ford, Cameron Brick, Margarita Azmitia, Karine Blaufuss & Petra Dekens

Researchers from racial and ethnic groups that are under-represented in US geoscience are the least likely to be offered opportunities to speak at the field's biggest meeting.

Biases – structural, implicit and explicit – exclude many people from science, technology, engineering and mathematics (STEM) education and employment, and devalue their contributions[1,2]. Most studies focus on bias against women. Few data sets offer enough generalizability or statistical power to evaluate the representation of minority ethnic and racial groups, or to examine intersectionality[3]. The latter describes the interwoven forms of discrimination that affect a person from multiple marginalized groups (such as racism, sexism, classism or ageism), locate them in systems of oppression and limit their upward mobility – as might be experienced by a young African American woman in science in the United States.

We offer just such a data set here.

Presenting at scientific conferences is key to academic career progression. Scientists don't just communicate results; they also develop relationships with collaborators and mentors, and identify job and funding opportunities. Giving a talk confers recognition and prestige, particularly for students and early-career researchers. Despite historical inequities, women are now presenting more at conferences[4,5] and colloquia[6]. These gains are especially visible at conferences that are organized by women or that specifically support early-career participants.

We found that US scientists from minority racial and ethnic populations already under-represented in science had relatively fewer speaking opportunities at a key scientific conference over a four-year period than their proportion in the sample would predict; the imbalance was most severe for women. This disadvantage for under-represented minority groups held across career stage (see 'Who gets the microphone?').

Our results underscore the pressing need to support minority groups at conferences – as elsewhere in STEM – to advance equity and improve research.

Data set and methods

The American Geophysical Union (AGU) is an international non-profit scientific association with around 60,000 members in 137 countries. Since 2013, the AGU has collected self-reported demographic data from its membership, including gender, race or ethnicity (for US-based academics only), career stage and birth year.

The AGU Fall Meeting is the world's largest Earth- and space-science conference. The attendance each year from 2014 to 2017 was approximately 24,000–28,000 people. Around 22,000 abstracts are submitted for selection as talks or posters each year; few are rejected (<0.05%). Membership is necessary for submitting, although not for attending the meeting.

Abstracts are submitted to topical sessions. Sessions are proposed and organized, and abstracts vetted, by a group of conveners – academics, industry members, government scientists and others. The primary convener must be an AGU member. There are three tracks by which geoscientists get to present at the meeting – two by submission, one by invitation. Authors can submit abstracts to conveners, who decide which will become talks and which posters; or authors can submit abstracts just to give a poster. In addition, session conveners directly invite scientists to speak (strictly, to send in abstracts, which generally results in a talk).

"Giving a talk confers recognition and prestige, particularly for students and early-career researchers."

The database of 87,544 accepted abstracts from the meetings between 2014 and 2017 offers a unique opportunity to probe inequities of opportunity between demographic groups[5]. Presentations are approximately 34% talks (about one-third of which are directly invited) and 66% posters.

Career stage

Of US-based authors, 98% (n = 53,247) provided career information. Researchers had verified themselves as students (undergraduates and graduates) or the AGU had calculated career stage from years since highest degree obtained: early career (0–10 years); mid-career

Some scientists opt to present posters, others are assigned them instead of being asked to talk.

AGU/EPNAC

(10–25 years); and experienced (late career; more than 25 years). Controlling for career stage is crucial because minority racial and ethnic groups are concentrated in the student and early-career stages (see 'Fewer seniors'). This is due to both a leaky pipeline in education and professional advancement[7] and the fact that senior groups more strongly bear the imprint of historical biases.

Race, ethnicity, gender

The AGU recorded self-reported ethnicity and race from US-based authors only (n = 54,446). Of these, 71% (n = 38,768) reported a category (defined as per the US census, see Supplementary information): White (58%), Asian American (7.3%), Hispanic/Latino (3.9%), African American (1.1%), Native American (0.3%) or Pacific Islander (0.2%). The remainder marked 'other' (13%) or 'prefer not to answer' (13%), or didn't respond (2.8%). We did not verify whether Native American respondents were citizens of tribal nations; we acknowledge that self-reported identity is not the same as tribal citizenship. 'Other' could refer to individuals who are multiracial or who do not identify with the categories listed. Before analysis, we decided to exclude authors who were based outside the United States (n = 33,098), who identified as 'other' or who did not report ethnicity or race.

Of our sample of US-based authors who reported their race and ethnicity, more than 99% (n = 38,716) identified as female or male (the third option was 'prefer not to answer'). We appreciate that this binary treatment does not incorporate the full spectrum of gender and sexual identity.

Under-represented groups

Minority ethnic and racial groups make up 31% of the US population[8]. People from these groups are under-represented in the STEM workforce (11%), and specifically in the physical sciences, at 9% (ref. 9). In the AGU abstracts data set, African American, Hispanic/Latino, Native American and Pacific Islander comprise 7.7% of the first-author abstracts in the analysed sample. We combined them into one measure – under-represented minority groups (URMs). We did so to increase the statistical power to detect differences, to limit the risk of multiple comparisons generating false positives and to avoid including potentially identifying information for people from rare groups. We admit that this approach erases meaningful differences in lived experiences between people in these groups, particularly those with the lowest representation. Scientists from each minority group have unique barriers to participation.

We combined the groups White and Asian American into non-URM. We did so because Asian Americans (4.8% of the US population[8]) are well represented in the STEM workforce (20.6%), in physical sciences (17.5%)[9] and in the analysed sample (10.2% of first-author abstracts). We appreciate that this bracketing, too, is suboptimal – it also erases many meaningful differences, pressingly that Asian American researchers do face career barriers, including implicit and explicit biases[10,11] (see Supplementary information).

Results

Our analyses focus on the chances of scientists from minority racial and ethnic groups that are under-represented in Earth and space sciences being given speaking opportunities, compared with other applicants. The key proportions are normalized relative to the population of each group, so that the results indicate representation (see Supplementary information for all inferential statistics).

First authors from under-represented minority groups contributed 7.7% of all the abstracts in the sample (n = 2,981; see 'Fewer abstracts'). The URM applicants were disproportionately students or early-career scientists (79% compared with 59% of non-URM authors; see 'Fewer seniors'). At some career stages, the small number of URM researchers sometimes led to low statistical power to detect differences.

URM authors were invited to give talks less often than were other authors (8% versus 14%, normalized; see 'Too few talks'). Crucially, this was statistically significant in the early-career stage (and overall).

From talk-or-poster submissions, URM authors were assigned talks less frequently than were other scientists (42.9% versus 50.8% normalized in each population; see 'Too few

talks'). Again, this difference was statistically significant in the crucial early-career stage as well as overall. Compared to others, URM authors were more likely to apply to give only a poster (35% versus 24%; see 'Too few talks'). This was significant overall and for each career stage.

Female URM authors had strikingly few opportunities at the AGU Fall Meetings. They had even less chance of being invited to talk (and applied for posters more often) than had URM men (and non-URM women), and were assigned talks less often than were non-URM women (see 'Fewest chances'). This is despite the fact that women (taking all races and ethnicities together) had equal or more opportunities to speak than men had (see 'Equity – why so slow?')[5].

To sum up, scientists from under-represented racial and ethnic minority groups had the smallest chances of being selected and invited to speak, and opted for poster presentations more often than did their peers.

Caveats and confounders

We did not assess abstract quality. An alternative explanation for our results could be that URM scientists submitted abstracts of lower quality. Even if the AGU's selection were perfectly meritocratic, any gap in abstract quality would still, in our view, suggest bias in the STEM pipeline – for example, as a result of discrimination in earlier education[7] and career development. These obstacles result in fewer URM scientists than scientists from other groups holding positions at elite institutions that provide excellent resources and strong collaborators.

Because of small sample sizes, it was not possible to control for career stage when we analysed by gender (see 'Fewest chances').

We did not investigate why URM geoscientists applied to give only a poster more often than did others overall, and at every career stage. There could be several reasons. People might be held back by psychological factors such as lower self-confidence[12]. For example, people from under-represented minority groups often report 'impostor syndrome' – feeling isolated and vulnerable in academia because they perceive themselves as having lower competence than their peers[11]. Or, some URM scientists might value poster presentations – this format could align with different goals, interests or lived experiences, for example by enabling researchers to communicate findings in one-on-one conversations.

Because we left out of our analysis those based outside the United States, those who identified as 'other' and those who did not report ethnicity or race, our results will probably have excluded relevant individuals – people who identify as multiracial, for example. Our main analyses therefore represent a conservative test of speaking opportunities between minority and majority groups.

Notably, combining Asian Americans with under-represented minority groups would have yielded figures that, at face value, looked more representative. We did not do this because the US National Science Foundation (NSF) does not include Asian Americans as an under-represented group in STEM; its policy efforts are focused on the under-represented minorities we track here. In the Supplementary information, we report separate exploratory analyses concerning Asian Americans, and examine career stage further, because of geoscience-specific nuances in the recruitment and representation of people who identify thus[10].

We must also point out that other nations might apply different census definitions to

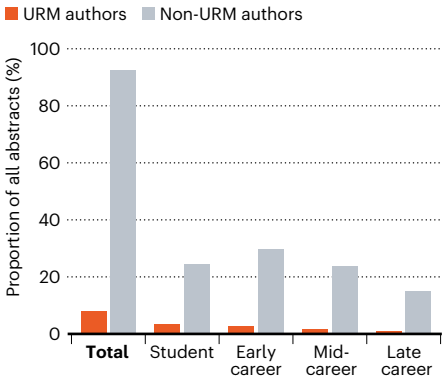
WHO GETS THE MICROPHONE?

Some minority scientists who are already under-represented in science, technology, engineering and mathematics (STEM) and in geoscience are increasingly under-represented at every step on the path to speaking at the American Geophysical Union's Fall Meeting — in terms of abstract submissions, seniority and being offered talks.

SUBMISSIONS

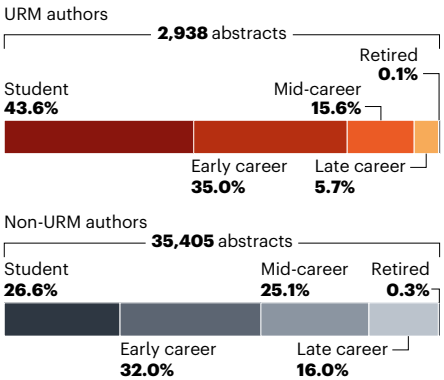
Fewer abstracts

Authors from under-represented minority groups (URMs; see main text for definitions) submitted the smallest proportion of abstracts in total and by career stage.



Fewer seniors

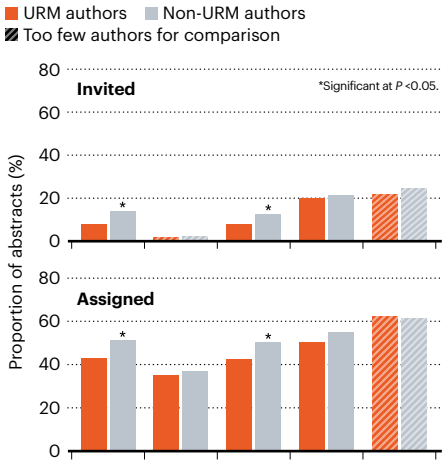
Among URM authors, a bigger proportion of abstracts are submitted by students and early-career scientists than from non-URM authors at these career stages.



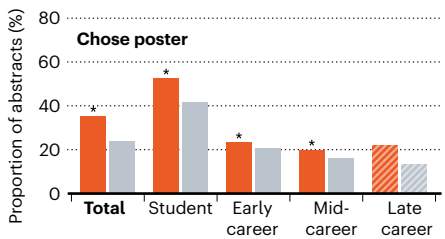
OPPORTUNITIES

Too few talks

URM authors were invited or assigned to speak less often than were other authors, at most career stages.

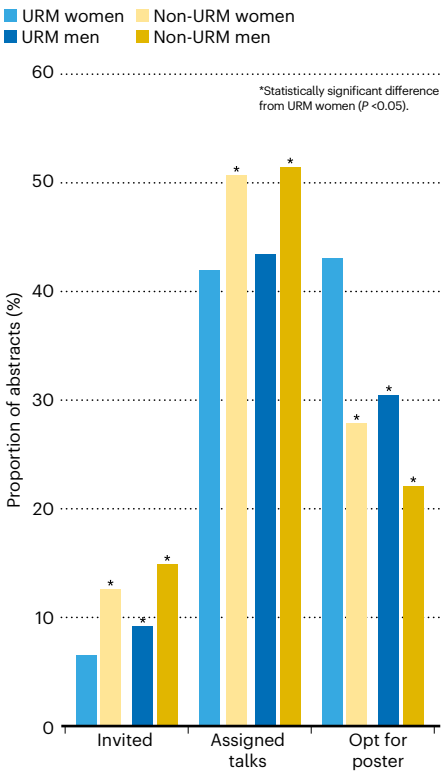


By contrast, a larger proportion of URM authors than others applied for the poster-only option.



FEWEST CHANCES

URM women comprise the group that is least likely to be invited or assigned to speak. But they are over-represented in requesting to present posters.



SOURCE: AM. GEOPHYS. UNION (DATA); H. L. FORD, C. BRICK *ET AL.* (ANALYSIS)

those used here. For example, 'White' in the United States encompasses people who have origins in the Middle East or North Africa.

Next steps

To recap: a woman starting out in her career from a racial or ethnic minority group that is under-represented in US geoscience is less likely to gain a speaking slot at the field's largest conference than are her male peers and her non-Hispanic White peers of both sexes. These findings hold sobering lessons for the AGU and other STEM conferences and activities. We pre-registered our data cleaning and main confirmatory analyses at the Open Science Framework to increase generalizability (see Supplementary information).

One of the AGU's goals for inviting speakers is to "enhance diversity and/or feature early-career scientists". It is particularly concerning that where URM authors are most numerous — in the least-established career stages — they get fewer invitations than their proportion would predict. Such early inequities are likely to affect the retention and promotion of people from under-represented minority groups across geoscience.

There are three clear steps for the AGU to take. First, conference conveners should be blinded to information that is not necessary to rate the quality of submissions. Identifying details such as names and institutions introduce bias[13,14] even in people committed to equity, because many thinking processes, such as stereotype activation, occur outside awareness or control. Double-blind review has decreased bias in allocating time on the Hubble Space Telescope[15].

Second, the AGU should encourage more scholars from under-represented minority groups to participate as conveners. Third, the AGU should provide more travel grants to URM presenters, which could increase the overall population of URM attendees both directly and by shifting norms. We encourage other STEM conferences to make these changes.

Meanwhile, the rest of the community has work to do to (see 'Equity — why so slow?'). Established scholars can support scientists from minority groups by encouraging them to submit talk abstracts and by providing opportunities to practise presenting in local, domestic and international venues. These steps can increase confidence and foster the development of people's identity as scientists.

It is crucial for universities and funding agencies to support organizations that provide openings and mentorship to young scholars from minority groups, such as the Society for Advancement of Chicanos/Hispanics and Native Americans in Science. The NSF aims to broaden participation in STEM through its criteria for grant proposals and through initiatives such as NSF INCLUDES (Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science)[16]. Such programmes can liaise with professional societies.

Racial, ethnic and gender biases harm individuals and undermine the quality of science. Even if all demographic gaps were plugged tomorrow at the level of people graduating with PhDs, and even if these graduates did not have to run the gauntlet of systematic bias that their predecessors faced, it could still take generations to achieve fair representation among senior academics.

We therefore urge more organizations to measure and share the outcomes for scholars from minority groups. With this information and the growing literature on effective interventions, together we can create a more equitable scientific community.

Equity — why so slow?

Laws, policies, training, research and tracking must benefit all.

In the United States, affirmative action is a set of laws, guidelines and policies that aim to increase the representation of historically excluded groups in higher education and professional careers. Overall, White women have been the primary beneficiaries[17], as our results underscore.

A report last year by the US National Science Foundation showed that minority ethnic and racial groups are under-represented in graduate programmes, and that this results in reduced economic and social opportunities[16].

An inclusive environment, visible role models and adequate funding are key to enabling people from under-represented minority groups to participate and succeed in science, technology, engineering and mathematics (STEM)[18]. A growing body of research has highlighted the subtle, indirect and often unintentional actions perpetrated against such researchers by majority groups, and which have an impact on a sense of belonging in STEM spaces[19–21], as well as on career persistence and well-being[22,23].

Small interventions can help, such as asking STEM community members to be mindful of equity, diversity and inclusion. Reminding individuals, particularly men, to consider diversity when selecting potential reviewers can improve gender representation[24].

However, the effects of these reminders on ethnicity bias have not been studied, and reminders might not be effective in the long term in reducing implicit biases in STEM[25]. Implicit-bias training is well-meaning but largely ineffective[26,27]. **H.L.F, C.B. *et al.***

The authors

Heather L. Ford is a lecturer at the School of Geography, Queen Mary University of London, UK. **Cameron Brick** is a research associate in the Department of Psychology, University of Cambridge, UK, and an assistant professor of social psychology in the Department of Psychology, University of Amsterdam, the Netherlands. **Margarita Azmitia** is a professor in the Psychology Department, University of California Santa Cruz, USA. **Karine Blaufuss** is director of business intelligence and data at the American Geophysical Union, Washington DC, USA. **Petra Dekens** is a professor in the Department of Earth & Climate Sciences, San Francisco State University, California, USA.
e-mails: h.ford@qmul.ac.uk; c.brick@uva.nl

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