Pride and prejudice: Why science is sexist

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It is a truth universally acknowledged, that a man in possession of a white coat and a bad haircut is more likely than any woman to be a scientist.

'Science remains institutionally sexist'. This is the claim with which *Nature* addressed the matter of women in science, in an issue dedicated to the subject in 2013.[1] The sexism referred to is evident in the lower representation of women in the scientific workforce – an imbalance made dramatically clear by the low number of female Nobel Laureates (fewer than 2% of the Chemistry and Physics Laureates to date), or Fellows of the Royal Society of New Zealand (9%), or their overseas equivalents. More pragmatically, women have lower success rates for research grants[2] and have lower citation rates[3]. There is therefore no question whether science is sexist: it is however of considerable importance to understand why this is the case – assuming, of course, that we would like to understand how to fix the current situation.

A belief in innate differences between the abilities of women and men is the only explanation that justifies the maintenance of the status quo. For this reason, it is something that every woman who participates in science will be confronted with at some point. Larry Summers, the then President of Harvard, gave an infamous version of this argument in 2005 when he argued that it was the increased variability of the male population on a number of measures – in which he conflated the measurement of height, weight, and 'scientific ability' – that explained their dominance 'at the top end'[4].

Such an argument echoes older studies that demonstrated differences in the performance of men and women – or girls and boys – on tests of mathematical skill. However, the subsequent demonstration that the effect of culture is more significant than that of sex[5], in combination with the observation that these differences have been narrowing over time, leaves little doubt that such differences are primarily due to social influences.[6,7]

Not all sex differences are necessarily false. In tests of ability with the mental rotation of three-dimensional objects, boys may have a persistent edge over girls[8]. However, the observation that socioeconomic factors affect performance on such tests leaves room to doubt any interpretation of the data along lines of 'natural' or biological differences in ability[9]. But quite beyond the existence of subtle sex differences, the idea that the very specific skill sets that these tests measure should directly translate into improved scientific ability – whatever that is supposed to be – is risible.

The literature that most convincingly provides an explanation for the gender imbalance evident in science is based on an understanding of human psychology, stereotypes, and biases. It is supported by numerous studies, which provide similar evidence of gender bias in society in general: but recent work has convincingly demonstrated these effects at work in the scientific community more specifically.

Drivers of sexism

I will discuss four major drivers of sexism in science, which seem most pertinent: actual sexism, unconscious bias, stereotype threat, and impostor syndrome. It is of some use to distinguish between these individual effects, although as we shall see, there are many ways in which they interact in a concerted fashion.

Sexism

Actual sexism – conscious, directed prejudice based on an individual's sex – is probably not the major issue for women in science. But then again, I would say that. As a woman in science, I am affected by the incongruous denial of personal advantage[10]

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demonstrated in studies of gender discrimination. In short, as with sexual harassment, women may be reluctant to admit to having been the victim of gender discrimination, despite being willing to admit that it exists.

The evidence that it exists is not lacking. For example, a recent study of the experiences of both men and women at scientific field sites clearly demonstrated the existence of sexual harassment, primarily of scientific trainees; in the case of the women respondents, the harasser was generally senior to them within the research team[11].

Unconscious bias

It is not with any intent to dismiss the significance of sexual harassment that I say that it is instead the evidence of unconscious bias that I find most disturbing. In a study led by Moss-Racusin designed to test the hypothesis of gender bias amongst science faculty members[12], male applicants were preferred over female applicants for a job as laboratory manager, despite the only difference in the application materials being the gender of the applicant. On competence, hireability, and the willingness of the faculty member to mentor the applicant, the men fared significantly better than the women. This advantage added up to an additional 12% in the salary offered, a rather credible demonstration of the origin of the gender pay gap.

Perhaps most significantly, the bias in the evaluations was not affected by the gender of the faculty member – in other words, and the reason that this should disturb us all: men and women are equally biased.

How can this be? Why would a woman act in a way that perpetuates the system of bias that is prejudicial to her own career? One answer is because the bias is unconscious. The acceptance that we are all subject to unconscious biases is, in my opinion, a necessary first step in making sense of the situation of women in science.

A key reason for the impact made by the Moss-Racusin study of gender bias, was not that the demonstrated bias was new: it was entirely consistent with previous studies of gender bias and gender schemas. However, it was the first study to explicitly demonstrate this bias amongst practicing physical scientists – though a previous study had demonstrated very similar levels of bias amongst psychological scientists[13]. As the authors state, the applicability of those previous studies could be challenged on the basis that 'science faculty members may not exhibit this bias because they have been rigorously trained to be objective'; but this is demonstrably not the case.

The role that objectivity plays in reinforcing unconscious bias – or the application of it – may not be immediately clear. A demonstration which I find particularly striking was achieved in a 2005 study of gender bias in the evaluation of the curriculum vitae (CV) of an applicant for the job of police chief.[14] The CVs evaluated demonstrate either a higher level of educational achievement, or a more significant period of practical experience, and are supplied to the participants with male and female names respectively, in random order. Several important points are clearly made in this study. The first is that the demonstrated gender bias is justified, after the fact, by the use of 'constructed criteria': the male candidate is always preferred, and the selection of the male candidate will be justified on the basis of either the greater experience or education, depending on which CV is supplied. The second major point is one of the important beacons of light in such studies: if the participants are asked beforehand to state the criteria upon which they will base their decision, the demonstrated gender bias disappears. This has obvious implications for the processes around CV evaluation that are so prevalent in science: whether for hiring, grant evaluation, or promotion.

The third major point of this study is, however, the one most clearly applicable to science. The participants are requested to evaluate their own level of objectivity, and the results are correlated with the level of bias in their CV evaluation. Those who rate themselves as highly objective are highly biased; those who rate themselves as not highly objective provide evaluations of the CVs which are almost completely unbiased.

Pride has a few different meanings, but the definition given by the Merriam-Webster: 'inordinate self-esteem', seems to fit the self-perception of objectivity. It is no great step of logic to connect this effect with the comment in the Moss-Racusin study, on the possibility of greater objectivity of scientists, and realise that here, we have a clue about what science-specific feedback loops may drive the persistent exclusion of women from science. The pride inherent in self-perceived objectivity is a predictor of persistent prejudice.

Is objectivity central to scientific identity? Certainly, it plays a role, and I am not the first to observe a correlation between scientific disciplines, which place perhaps the highest value upon objectivity – mathematics, computer science, and physics – and their gender-typing, resulting in the low representation of women typical in those disciplines.

The use of citations is a key component of metrics designed to measure the impact of a scientific work – and, when aggregated, the impact of an individual scientist's body of work. Despite significant differences between typical levels of citation in different fields, they are used as a way of comparing the value of the work performed by different scientists – most typically, in the situation of a job or grant application. They therefore have a marked influence on the careers of individual scientists.

In a recent study, science communication, a field within which there is a wide range of topics of different gender types, was chosen to study the evaluation of gender-typed topics[15]. Topics related to computers or politics were assessed as male-typed, while matters to do with children or parenting were evaluated as female-typed. Gender-neutral topics were, for example, to do with health or the media. Abstracts on all these topics were supplied to participants with either male or female author names; the study participants were then asked to evaluate the quality of the abstract. For the gender-neutral topics, no gender bias was apparent. For the female-typed topic, a female author name produced a slightly favourable evaluation of quality. But the real effect is seen for topics that are male-typed; male authors are evaluated much more favourably, with the bias amounting to a factor of five over what was seen for the female-typed topics.[16] A final point made in this study is that these evaluations of quality are mirrored in the willingness of the study participant to collaborate with the author of the abstract: these small evaluations have a significant impact on careers over time.

As in the case of the Moss-Racusin study, men and women provided equally biased evaluations. The effect of gender-typing on judgements of women's behaviour has also been well demonstrated. This disadvantages women, e.g. competent women are viewed as 'overaggressive' and 'not nice' and traditionally subservient ones as 'incompetent'[17].

Stereotype bias

The third major issue, perhaps even harder to combat than either the direct sexism or unconscious biases outlined above, is the insidious effect of gender stereotype on our self-evaluations. This is stereotype threat – the effect that our own prejudices and beliefs have on our own performance.

Science itself is strongly gender-typed – meaning that it is perceived, in the culture of which we are a part, to be a domain of male activity and excellence.[18] Such gender typing can be easily understood when one looks down the list of Physics Nobel Prize winners – especially in Physics or Chemistry, but only as a matter of degree. The duty of being a role model to aspiring women in science falls heavily upon a few sets of shoulders: Marie Curie, Lise Meitner, Rosalind Franklin. The fact that the stories of these few women are so heavily recycled in turn leads to the idea that to be a woman in science is to be special; it is to be better than the rest of one's gender. Not that these ideas are clearly formed or articulated – they do not need to be in order to have an impact on young women. And in the meantime, while women are penalised for taking the part of other women,[19] men may obtain sponsorship from senior scientists without being seen to be special cases, where women do not have such a privilege.[20]

Women who are conscious of the stereotype that women have lower mathematical ability than men will perform worse on a mathematics test than if they are told that there are no gender differences, a precondition which lowers stereotype threat.[21] These effects have since even been demonstrated to exist in national assessment data in the US, outside of an artificial laboratory setting.[22] Even the studies of mental rotation, which have previously been held up as persistent evidence of sex/gender differences, have been shown to be seriously affected by stereotype threat.[23] A broad conclusion to be made about the evidence regarding stereotype threat is that the narrative of choice surrounding the decision of women, as a cohort, to leave science – the narrative of the so-called 'leaky pipeline', which sees many women leave science after postgraduate training but before achieving an independent career – is itself a fallacy.

Imposter syndrome

This fallacy of choice is pervasive, and reinforces the kind of self-questioning doubt that could cause anyone to leave science – the dark side of scientific success, and my fourth issue for women in science: imposter syndrome.

Do I belong here? is a question that any of us might ask in a challenging environment in which it is made clear that success is not guaranteed. There has been recent attention given to the high rates of mental health issues amongst PhD students[24] – a matter which should concern anyone involved in our academic institutions. Competition is present in any career, in some degree: but academic science is particularly vicious both in terms of the duration over which career advancement is highly competitive, and by the frequency with which our work is subjected to peer review.[25] Imposter syndrome is not itself gender specific – I am in no doubt about that. But it is also clear that those who do not fit the gender schema, or gender typing of their area of specialisation, will have additional causes for self-doubt. Being the subject of one's own unconscious biases – or always in a condition of stereotype threat – can do little other than reinforce the self-doubt that already exists.

Ways forward

So what can be done? I have already touched on a few suggestions made in the relevant journal articles – but it seems like it could be useful to pull these together in some form. Just as the problems I have outlined above are liable to reinforce each other, so should the solutions to the issues facing women in science be considered as a whole.

There are three different aspects of the lack of women in science that we might wish to consider. The first issue is the recruitment of girls into science, in which attitudes towards science are of paramount importance. The second is the retention of women in science: to combat the 'leaky pipeline'. The third issue is the promotion of women into the most senior positions in science. Each of these issues deserves serious consideration and the development of practical solutions.

The lack of role models for women in science – which is to say, the historical discrimination against women which has left us with such a skewed historical record – is a real issue. Serious efforts are being made to combat the prevalent stereotypes and encourage girls to see themselves as welcome in science: the EU Commission has 'Science: It's a girl thing!'[26]; in the US, there is a White House led initiative,[27] in New Zealand, the National Advisory Council on the Employment of Women recognises the issues,[28] but on the whole, there are few direct initiatives that one can see making a measurable impact. One reason for caution may be that these efforts have been known to misfire: the original 'Science, it's a girl thing' initiative was widely panned for its video campaign which used images of young girls in heels, lipstick, laboratory coats, and safety glasses. The criticism was broadly valid, but at its extremes had issues of its own: we should be careful not to suggest that femininity itself – lipstick and heels! – conflict with a scientific identity. The recent hostile reaction to a mathematician who took on a science television hosting role in the UK, after numerous calls for such a female role model, laid bare the catch 22 that faces women who attempt to step into these roles.[29] Moreover, while we still have so few women in senior positions in science, it is not clear that requiring gender parity from our public role models does women who need to find the time to perform these roles any favours; this concern is reinforced by evidence which suggests that exposure to anti-stereotypical role models does as much good as female role models.[30] What matters is breaking the stereotype enough to dismantle the gender schema of science, and if our male colleagues are brave enough, this is something they can help with.

In the case of the information available on gender biases present in citations and evaluations of quality, the sane response which I have seen suggested is for a woman to publish using only her initials, to avoid making her gender evident to reviewers and readers. But surely, if we need more role models in science, we need to encourage women to be visible – but should we expect them to do so to the possible detriment of their own careers? This is a question with no easy answer – but it shows clearly the way that the examples given previously interact with each other: this is not a question that male scientists are ever required to consider, as they prepare a paper for publication.

Training in overcoming unconscious bias for panels and decision makers is a straightforward and cheap step to address the retention and promotion of women in science. Such programmes have already been implemented in numerous contexts:

notably, in the funding processes of the European Research Council.[31] This seems to be a necessary precondition for any approach to be successful, given that the root causes of both stereotype threat and (women-specific aspects of) imposter syndrome tightly depend on the gender schemas that dictate our societal unconscious bias. Linked to any requirement for unconscious bias training must be the collection of data on the gender of awardees or appointees, and aggregated success rates that show no evidence of gender bias should be a prerequisite for continued public funding of any institution. Practical outcomes to be expected from unconscious bias training should include a requirement for the criteria upon which any evaluation will be based to be clearly stated from the outset. None of this amounts to gender-based positive discrimination – but is there perhaps a case for that, too?

So far, I have avoided any mention of the issue that inevitably comes up in discussions about women in science: the matter of children, and the disproportionate cost to women's careers of having a family. This too is well documented: the cost to a woman's career averages 4% of earnings per child, while men, in contrast, benefit from the status that accrues to them from being the 'head' of a family, at 6% of earnings per child.[32] In another study, mothers were offered $11,000 less in salary than women without children, and $13,000 less than fathers.[33] But unless one believes that women must necessarily take on a disproportionate share of the work of raising a family, discussion of the choice to have a family is a red herring in explaining why science is sexist. The impact of having a family on a woman's career is because of structural barriers in the workplace and societal expectations that rely on unconscious biases for their survival, in the absence of direct sexism. And it gets worse: discussing the difficulties that women face in science after choosing to have a family can lead to a reinforcement of those biases. If science is harder for women who have a family, say the skeptics, then expecting gender equality in science is unreasonable. Perhaps then we should be aiming only for 25% women? 30%?

To this I say no. It is harder – currently – for women who have children to stay in science. But the children are only the proximate cause; the ultimate cause remains gender bias. This remains the key issue that we need to address.

The need for mentoring for women is a measure that is often suggested to try to keep women in science, combatting the steady outflow from the leaky pipeline. It is an interesting example, because the need for women-targeted mentoring programmes stems not from an inherent gender-difference – women are in no more innate need of mentoring than men – but because they have lower rates of access to good mentors. In my opinion, this needs to be made explicit, to combat the idea that women need women as mentors, to deal with women-specific matters. While this can at times be true, it is not generally the case, and the presumption that it is a woman's job to act as mentor to the younger women in her field is yet another inequality that needs to be challenged. This inequity is only more evident when we look to the issue of sponsorship: defined as the active promotion of a person into a position of responsibility, it sounds a lot like special treatment when one thinks about asking that this be done for more young women to promote them into a position of power. Yet, it has been argued in the business community that sponsorship is one of the key ways in which women's careers are harmed by gendered behavioural differences.[34]

The data I have discussed so far – those which are robust, and demonstrated across different contexts – indicate that the root of the problem for women in science, the origin of the multitude of barriers for women, is our own stereotypes and bias: our own minds. Surely, then, discussing these issues – raising awareness – is the best way forward?

I think the answer to this is both yes and no. On the one hand, I am certain that raising awareness of our unconscious biases is the single biggest thing that we can do as individuals to fix the problems that remain for women in science. A solution addressing the root causes of gender bias would have the advantage of being extensive: the issues faced by ethnic groups historically excluded from science (in New Zealand, Māori and Pasifika) have much in common with the issues faced by women. There is certainly cause to argue for acknowledgement of unconscious bias as a first step. However, the evidence also shows that unconscious biases are persistent: most of the studies that demonstrate them have been carried out on undergraduate students.

Reflect on that, for just a minute, before you suggest that the situation of women in science is improving in our generation, and that we should be patient.

Another question that is germane to the issue of women in science, is why there are such differences in gender representation between disciplines. In a sense, we know the answer when we ask the question: biological sciences are more female typed – because we think they are – while physics and engineering are male typed. But can we dig down a little deeper?

A suggested explanation could be based on the relationship between demonstrated bias and the self-perceived objectivity mentioned earlier. Do physics, mathematics, and engineering all value objectivity to a greater extent than the social sciences or biology, which deal with messier – or one might say more complex – objects?

Additional insight is provided by a study that demonstrated the way that gender bias was affected by environmental changes – in particular, the gender ratio of the pool of CVs being evaluated for a job.[35] If the number of female candidates falls below 25%, the gender bias found in the evaluation of those CVs increases. Being seen as special is not an advantage.

This self-perpetuation of skewed demographics defines the uneven playing field upon which we base a scientific career. Yes, the goal posts are the same height, and the length of the field the same – but the field itself is uneven, though it only exists in our minds. This needs to change, and it is very hard to conceive of a way in which awareness of unconscious bias – on its own – will achieve meaningful change. There is certainly no free market of ideas between the genders, if one accepts the evidence of gender differences in citations.

A final reason for intervention in science – which is to say, in the public funding systems which control through incentives the promotion of women in science – is provided by the recognition of the number of broader careers impacted by such biases, but where intervention is much harder. In science, funding mechanisms can be centrally tuned to drive a desired behaviour, and we can hope to do this on a sufficiently large scale that distortionary effects on individuals can be avoided. However, the same biases lead to well-documented demographic challenges for the private sector – in engineering and technology, in particular – and it is unclear whether these biases can be as effectively addressed in those environments. Surely, we must start with our universities.

There is no justification for continued inaction. The principles of science deserve to be followed without pride or prejudice.

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