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Challenging Explanations for the lack of Senior Women in Science: Reflections from Successful Women Scientists at an Elite British University

Alison Chapple and Sue Ziebland

University of Oxford, UK

ABSTRACT
Despite many initiatives to improve diversity, women working in science in the UK are still under-represented at senior levels. There are few studies drawing on the accounts of successful women scientists about gender discrimination and workplace stereotyping. We interviewed 39 women scientists working at an elite British university. A qualitative thematic analysis drew on three controversial 'explanations' for gender inequality in science, which are variously challenged by our data. The women we talked to were all ambitious and successful and (unsurprisingly, given this success) did not suggest that they have personally experienced serious discrimination in their careers. Some conceded that perhaps *other* women may not reach senior positions in science because of social expectations, low confidence or a lack of support. A few had experienced, or heard of, negative consequences of stereotyping, implicit bias or a 'boys' network', whereby men met outside work for activities such as pub visits or football, which were the main reasons given to explain why some women do not progress to senior positions. Encouragingly some described how gender stereotypes are being resisted; these women scientists are themselves role models for junior colleagues.

KEYWORDS
women in science; stereotyping; discrimination; narrative interviews; implicit bias; unconscious bias

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INTRODUCTION

The Aim of this Study

Much of the research on stereotypes in science, and on how people explain gender inequality, has been conducted in the laboratory, classroom or lecture theatre, looking at implicit automatic associations (e.g. Valian, 1999), by conducting large-scale questionnaire surveys (e.g. Cech & Blair-Loy, 2010; Losh, 2010; Miller, Eagly & Linn, 2015; Smith, Brown, Thoman & Deemer, 2015), or through content analysis of journals, newspapers, novels, films, television programmes or photographs on websites (e.g. Christidou & Kouvatas, 2011; Haynes, 2016). With notable exceptions (e.g. De Welde & Laursen, 2011), very few studies have paid attention to how women scientists talk about their perceptions of gender discrimination and stereotyping in the workplace. In this article we add to the literature with some of the results of a narrative interview study on the experiences and perceptions of women scientists based at a British university that was highly rated in the *Times Higher Education World University Rankings 2015-2016*. The article presents our findings on women scientists' perceptions of why they are under-represented at senior levels in science. Our findings are analysed in the light of comments made by Laurence Summers (2005) at a conference 12 years ago (see below).

Background to the Study

In spite of many initiatives to improve diversity, women working in science in the UK and in the USA are still under-represented at senior levels (House of Commons Science and Technology Committee, 2014; Reuben, Sapienza & Zingales, 2014). According to the Women in Science and Engineering (WISE) Campaign's latest analysis of UK labour-market statistics, in 2016 women made up 21% of the workforce in core science, technology, engineering and maths (STEM) occupations, but only 14% of science, engineering and technology (SET) managers were women (www.wisecampaign.org.uk). Also, among full-time professors working in SET subject areas in the UK, 81.5% are men). In some areas, women are still very poorly represented at all levels – for example, in the engineering professionals occupational category, women represent only 8% of this group (Equality Challenge Unit, 2015). In medicine, in the UK, women are also under-represented in academic medicine (Penny, Jeffries, Grant & Davies, 2014); although 54% of medical students are women, only 29% of clinical academics and 18% of professors in academic medicine are women (Medical Schools Council, 2016).

There have been many attempts to explain why women are under-represented in numerous scientific fields, particularly at senior levels. Wilson, Broughan and Hillier (2017), for example, investigated 21 women's perceptions of the barriers to progression of female STEM academics at one UK university. The authors of the current study also asked women to talk about their experience of the functioning of existing policies to support a healthy work/life balance. Some of the women we interviewed said that they had been given inconsistent advice about progression

and stressed the importance of encouragement by a line manager. They suggested that there was a long-term career penalty for career breaks or reducing hours for a period. Women senior managers described the planning and development of strategies to manage periods of absence or part-time work as critical to their success.

Twelve years ago, Laurence Summers (2005), an American economist and then President of Harvard University, gave a speech at a conference where he suggested three hypotheses for why there are fewer women than men in senior positions in science. Firstly, he said that women may not want high-powered jobs, which they will have to think about 80 hours a week; secondly, he suggested that women may have different innate 'aptitudes' and 'attributes'; and thirdly, he said that discrimination and stereotyping may be partly to blame. He said that in his view these hypotheses probably rank in the order he mentioned them, and he concluded that he would have served his purpose if he had 'provoked thought on this question' and the marshalling of evidence to contradict his ideas.

Summers not only 'provoked thought' but much criticism. Losh (2005), for example, was highly critical of Summers' suggestion that the most important reason for the dearth of women in science is women's reluctance to work long hours. She pointed out that thousands of women in the USA now appear willing to put in 80-hour weeks in medical residencies and internships and to become partners in law firms. Losh (2005) and others (e.g. Wallon, 2005) also suggested that academics should strive to move past inaccurate clichés and long-held prejudices about innate gender differences. Others decried the lack of evidence produced by Summers for his controversial comments, arguing that he oversimplified a very complex issue; Ceci and Williams (2007), for example, suggest that there may be cultural and biological bases for a dearth of women in mathematics, science and technology, and point out that, 'Often, all sides in the debate draw on the very same evidence but interpret it differently' (p. 213).

The current study adds an analysis of narrative interviews to this debate. We interviewed ambitious and successful scientists whose thoughts and experiences contribute a unique perspective to understandings of gender inequality at work.

How Stereotypes May Affect Careers in Science

Science is still frequently portrayed as a 'masculine' subject demanding hard work, long hours, technical skills, mathematical ability, physical strength and emotional detachment (Barnard, Powell, Bagihole & Dainty, 2010; Rhoton, 2011; Miller, Eagly & Linn, 2015). Girls may encounter negative stereotypes about women in science when they are at school, so may be deterred from choosing science as a career (Miller et al., 2015). At university, women may find that there are few role models of successful academic women in science, or they may encounter gender group stereotypes that may undermine their ambitions to continue with scientific subjects or may hinder progression to senior levels (Beasley & Fischer, 2012; Edmunds et al., 2016). After graduation, women still encounter stereotyping; in 2015, for example, British Nobel laureate Sir Tim Hunt, when speaking at a conference in Seoul, described women in the laboratory as a distraction. He said:

> Let me tell you about my trouble with girls. Three things happen when they are in the lab. You fall in love with them, they fall in love with you, and when you criticise them, they cry.

A storm of criticism ensued, with responses ranging from outrage to humour, including a twitter hashtag #distractinglysexy which accompanied images of women dressed in protective lab coats, boots and goggles. Sir Tim later apologised and explained that his comments had been made in jest (Whipple, 2015).

Steele, Spencer and Aronson (2002, p. 389) refer to the negative impact of stereotyping as 'stereotype threat', which they define as follows:

> When a negative stereotype about a group that one is part of becomes personally relevant, usually as an interpretation of one's behavior or an experience one is having, stereotype threat is the resulting sense that one can be judged or treated in terms of the stereotype or that one might do something that would inadvertently confirm it.

Stereotype threat can lead to lack of confidence, anxiety, underachievement and poor decision-making (Inzlicht, Tullett, Legault & Kang, 2011; Miller et al. 2015; Smith, Brown, Thoman & Deemer, 2015). A survey of undergraduate students in the USA found that, when stereotype threat increased – as it did particularly for women working in male-dominated physics classes – women were less likely to identify with science (Smith et al., 2015). Increased threat affected women's degree selection, degree completion and future intentions to engage in research.

Reuben et al. (2014) designed an experiment to show how stereotypes may impair women's careers in science. When employers had no information other than a candidate's physical appearance, women were only half as likely to be hired as men because they were (erroneously) perceived to be less competent at arithmetic. However, recent research suggests that attempts to combat formerly widespread sexism in hiring may have succeeded in the USA (Williams & Ceci, 2015).

Peters, Ryan, Haslam and Fernandes (2012) found that women who perceive that they do not fit in with the dominant occupational identity in male-dominated professions, such as surgery, are more likely to leave that profession. Initial gender equality in ambition and confidence in these male-dominated professions is steadily eroded and women report *less confidence* that they will succeed over the first few years, indicating that women may be adjusting their expectations in line with their perceptions, developing a personal cost-benefit analysis regarding work. The Opportunity Now project (Nawrockyi, Swiszczowski, Saunders, & Colquhoun-Alberts, 2014) underlines that women in the key 28–40 years age group are just as ambitious as their male colleagues but are also aware of (or suspect) more barriers in access and opportunity than are apparent to the men. The project report's authors propose that solutions to rectify gender inequality in the workplace need to educate men (who still hold the majority of senior positions) and line managers to

recognise and address the organisational culture barriers that are evident to many women yet are less visible to those who are not affected by them.

METHOD

Having obtained university ethics committee approval, we invited women scientists who were leaders and senior researchers in their field to take part in face-to-face narrative interviews about their careers. We also interviewed a few early-career women scientists working at the same institution.

The Sample

We wanted to interview women scientists from a range of departments and disciplines so obtained suggestions from members of our advisory group. Information about the study was sent to 51 women. Twelve either did not reply or said that they were too busy to take part in the research. The 39 women who agreed to be interviewed were aged 28–64 years. Most of the women were working at professor level. Three women were still doing a DPhil, but two of these had already qualified as clinicians and all had won prestigious, nationally recognised doctoral fellowship awards. The women worked in 20 different departments, from various disciplines including academic medicine (physiology, anatomy and genetics, pathology, haematology, hepatology, cardiology, rheumatology, immunology, epidemiology, ophthalmology, vaccinology, public health and primary care), experimental psychology, biochemistry, molecular biophysics, computer science and plant science. Most of the women had between one and three children. The nine who did not (yet) have children were aged 28–40 years. Twenty-nine of the participants described themselves as white British, others as Chinese, British/Asian, Italian, British/Ugandan, American, British/New Zealand, Dutch and Spanish.

The Interviews

Most women chose to be interviewed in their own office. Two were interviewed at home. Interviews usually took about an hour, and all were audio recorded and fully transcribed. Having read the information sheet and signed consent forms, the women were initially asked to talk about how they became interested in science, their early influences and decisions, and to describe their careers in as much detail as they wished. We asked further questions about key moments such as becoming a graduate student, applying for an academic job, non-traditional career pathways, obtaining fellowship funding, role models, mentoring, changing the culture in science (including discrimination and stereotypes), and work/life balance, including family and caring responsibilities. This produced a rich dataset. For this article, we focus on perceptions and experiences of discrimination, implicit bias and stereotype threat in the context of this sample of women, who are highly competent and career oriented. Pseudonyms are used throughout.

Analysis

Our qualitative interpretative approach (Tuohy, Cooney, Dowling, Murphy & Sixsmith, 2013) combined thematic analysis with constant comparison (Glaser & Strauss, 1967). NUD*IST QSR N6 (a qualitative data-indexing package) facilitated the analysis (QSR International Pty, 2002). We took a modified grounded theory approach to data collection and analysis because our study was informed by

relevant literature (Smith & Biley, 1997). However, we did not start out with preconceived hypotheses and were alert to emerging themes.

Analysis continued in several phases, an iterative process. After having conducted about half the interviews, we developed an initial coding frame, which was modified as the project continued. We decided to use 24 high-level codes, some of which were then subdivided into other codes. There were 49 codes in total, which were used to sort data from the interviews into useful categories, from which we generated the QSR N6 data reports. Before writing this article we carefully read the relevant data reports, discussed them and used the literature (mainly that mentioned in the introduction but also several articles that focused on public images of scientists past and present) to develop interpretation. The relevant N6 data reports included the following:

- Gender discrimination – the situation in the past
- Gender discrimination – the recent situation
- Gender stereotyping
- Getting promoted
- Athena SWAN and other initiatives to promote gender equality in the workplace.

FINDINGS

The women interviewed in the study were all highly successful and rarely suggested that their careers had been hampered at all by gender discrimination. Younger women, in particular, said that they had not been aware of gender stereotyping or other forms of discrimination during their current employment. For example, Ella, a postdoc, thought that she had had the same opportunities as men in her field and had been equally expected to work hard. Joyce, a professor, felt that she had made her own choices about work.

> I don't really feel as if I have been discriminated against as a woman. I feel, in situations where I have been pushed hard, the men have been pushed hard. I don't feel I have been [overlooked] for anything because I am a woman. (Ella)

> I don't think I have ever felt discriminated against. … If there is something I haven't gone for it is because I decided I didn't want to, not because I thought I couldn't do it or that I would be discriminated against. (Joyce)

Some of the more senior women, who had been aware of gender stereotyping in the past, said that things had improved, although they regretted that there are still few women in the most senior positions in academic science. One of the consequences is that senior women are asked to serve on committees that are 'short of women'.

> I've certainly been in sets of circumstances where I've been the only woman [on a committee]. But I think I wasn't; I wasn't being discriminated against. In fact, I think I was being positively included because they were short of women.

Why Are There So Few Women At Senior Levels?

We noted earlier that Laurence Summers (2005) suggested three main reasons why women might have difficulties in progressing in their careers in academic science. In the next section we consider women's accounts in the light of these reasons.

Women May Not Want High-Powered Jobs

Only one of the women we talked to said that she would have preferred to stay as a postdoc rather than become a principal investigator. All of the others were deeply engaged with their work and highly successful and ambitious. Some conceded that other women (and men) might make different choices; Joyce said that women may feel that they have the choice to 'stop going up the ladder' while men think that it is harder to take this option:

> It's a shame that there aren't more women [in senior positions]. And we can talk about it until the cows come home. (…) We may never get an answer, except for the fact that I think that women feel they have a choice that they can stop going up the ladder if they want to, and I don't think men feel that. I think the pressure is that they have to keep on going, and I think that what that means is, there's a lot of mediocre men in high positions who probably would, if it had been acceptable to go off and do something else or decide not to just keep pushing through, would have made that decision. But society doesn't allow it.

Joyce's comment draws attention to the potential negative consequences if 'mediocre' men are promoted beyond their abilities, and perhaps also beyond their preference, due to perceived pressure to perform as a primary earner and breadwinner. A younger woman also suggested that gender inequality at senior levels may be partly due to (other) women's different priorities as well as off-putting images of what may 'lie ahead'. She said:

> I don't feel disadvantaged because of being a woman, but if I look at the demographics of the group, there are a lot of women; there may possibly be more women than men if you look at the whole group. But if you look at the senior ranks, there are hardly any women. So there is some discrepancy.
>
> Interviewer: Have you thought about why that might be so?
>
> It could be a number of things. I think perhaps women make different decisions. Maybe some very able women who would have gone to the senior ranks decide actually that's not for them. They don't want what lies ahead, and perhaps have different priorities. That's certainly a possibility, that it sort of puts people off.

Innate Aptitudes and Different Traits

Summers' (2005) second explanation was that men and women may have different aptitudes or attributes. Hannah's account suggests that women's career progression may be hampered by 'intrinsic' traits:

> I think as women we tend to be much more self-critical than our male colleagues, and it means that we don't apply for things [e.g. grants] as much. Now, I don't think it's easy to change that because I think it's a very intrinsic thing about different traits of the two genders.

Others also suggested that women may lack or display less confidence, which could affect their progression. However, women may have *learned* that if they display confidence they will be regarded as 'competent but cold', the 'ice maiden' or 'the dragon lady' (see Fine, 2010, p. 58).

As indicated in the introduction to this study, there has been much debate about the role of biology in gender differences. Some neuroscientists (Fine et al. 2013; Rippon, 2016) believe that the latest scientific research shows that there is no basis for the theory that male and female brains are different. They argue that we are all part of a spectrum, so dividing us into binary categories gives misleading results. They also point out that there is an emerging awareness of brain plasticity, suggesting that stereotype threat can itself change brain circuitry. Having looked at much evidence, Fine (2010, p. 184) argues that characteristics such as mathematical eminence are not 'fixed' or 'hard wired' or 'intrinsic', but instead are 'responsive to cultural factors that affect the extent to which mathematic talent is identified and nurtured or passed over, stifled or supressed in males and females'. Fine (2010, p. 174) also argues that 'There's urgent need for editors, journalists, and schools to develop far more sceptical attitudes towards claims made about sex differences in the brain.'

Implicit Bias, Stereotyping and the 'Boys' Network'

In line with Summers' (2005) third explanation for the lack of women in senior positions – that discrimination and stereotyping may be partly to blame – some women we talked to suggested that implicit bias, stereotyping, and the 'boys' network' might have affected women's careers. Florence, a professor, said that unconscious bias may affect recruitment. She explained that 'senior men have a number of male protégés that they put forward for every single job'. She said that 'men only think of men', and that they perhaps forget that there may be suitable women who could do the work equally well. When another respondent, Amelia, was asked if she thought there was still gender stereotyping she said:

> Yes. We had unconscious bias training from the university. … This unconscious bias training was to make us aware of that and to help everybody pull themselves up if they are biased in any way, and also to try to see it happening in other people and to try to intervene if they can.

Those who are successful in a system are rarely aware of the barriers faced by those lower down the rungs (Nawrockyi et al., 2014) and tend to assume (self-

protectively) that they have achieved their position on merit. Alicia said that she had become aware of negative stereotyping in the last few years when she discussed with a male colleague the lack of women professors in science at the university:

> I was talking to a very senior colleague once about why there were too few female professors in [this university] and he just sort of said to me, 'Well, that's because professors are appointed on merit.' And I said, 'Oh. Are you aware of all the research, the CVs where they put Jack and Jill's name – or whoever it is – on, and then they get scored very differently based on gender?' It was then that I could see the look of horror coming across his face as almost to say, 'Oh my God. She's one of those. Oh no.' And it was almost like I'd suddenly grown a tail. I thought, 'Whoops!' [laughs] So, I mean, you see [gender stereotyping] everywhere.

Polly, a psychologist, had recently changed jobs. She was sure that there is a pervasive stereotype that men are better than women at quantitative work. Polly described what happened at a conference when she was working at another university, recalling the event as 'extremely damaging' and demoralising:

> There was something that happened at a recent conference. I do work that involves computational modelling, and there are very few women who do this kind of work. I was giving a talk and I presented this work, and a female colleague of mine who also does modelling work was sitting in the audience and she told me afterwards that, at the point in my talk when I put up the slides with the models, her male colleague sitting next to her turned to her and said, 'Who did Polly's modelling for her?' … Assuming that my male colleague collaborator had done it for me, that I can't write the code to do it myself. And that is extremely damaging because I did do it myself. It's totally demoralising because then you think, because there are fewer women in the field, and any paper is going to have multiple co-authors, it's inevitable that I will have male co-authors on my papers, and your worry is that the public perception [will be] that, 'Oh, it's the men on the paper who are devoting the brute brain power to the project.'

Polly pointed out further negative consequences of these assumptions. She said that if women are seen as incapable of doing computational work, they might be at a disadvantage when applying for funding, and she emphasised that this perception needs to be tackled:

> That's something that I worry about because, as the field is moving in this more quantitative direction, that is going to be a risk factor for heightened gender discrimination and we have to make sure that that doesn't happen.

Another respondent also said that when she goes to conferences, other people assume that her male colleagues are leading the work. She was aware that this needs to be challenged but did not want to be perceived as ungracious or self-promoting. Encouragingly, she had enlisted the men in her team to correct these

assumptions, and she had also increased their awareness of gender bias about leadership. She said:

> If I go with a male medical colleague to a meeting or conference, the default tends to be that people think he's leading the work, and we've had conversations about this. … You don't want to sound surly, and it probably actually backfires if you try to assert yourself and say, 'Actually, I've been doing this.' So the way I've approached it is that I tell my male clinical colleagues, who I work with very closely … 'You're going to be the ones being seen to be leading this, so it's going to be you that has to correct that and say actually, you know, this is [my female colleague's] work.' And that's actually worked really well. So, for me, a lot of this culture bias in a way is about trying to educate.

Olivia is a physicist. When she started her university studies, she was one of very few women in her field. When asked if she had ever experienced gender stereotyping she said:

> Yes, I have experienced that, because I'm at the technical end of our field, so I can play with electronics and hardware, design hardware and computer programming and so on. [Men] tend to think that you won't be able to do it. But then when you arrive with your toolkit, they maybe take you a bit more seriously. But you're always under test at the beginning. My attitude now [is that I've] reached the age where I actually think it's their problem, not mine. It's taken me years to get to that place, but it's very, very nice to be there. I really don't care anymore. I mean I know what I can do. … I don't mind being judged anymore because I've got further than I ever thought I would get.

Some respondents recalled inappropriate comments made by male colleagues that they believed were due to gender stereotyping. Anne, however, didn't think there was malice involved:

> I think it's fair to say that there have been instances where perhaps more senior, older members of the department might phrase things inappropriately, or say things in a way where you think actually they're trying to be nice but actually it comes across in a bit of a condescending way and you think, 'Well, would you have said that to my male colleague?' Probably not. But I don't think it's meant with any malice; I think it's just their age, and their own experience.

Another respondent suggested that stereotyping might result from intentions to be 'family-friendly' that then position the parent as less available and, by implication, less serious about work.

> It's difficult because part of me thinks that sometimes people are trying to be positive, so for example saying things like, 'You can't make an eight o'clock meeting because you've got children,' or something like that – actually they're

> trying to be helpful, but just the way that it's said and the tone with which it's said is actually quite negative sometimes.

This quote highlights why holding all meetings during core hours is important, so that people with caring commitments, who might not be able to attend early morning or late afternoon meetings, are not seen as less committed to their work.

Of the women interviewed for this study, nearly all of the senior women had at least one child, yet Bethany, a professor, pointed out that, at a senior level, science is still sometimes seen as a subject that is suitable only for people who are committed to their work to the exclusion of other life interests:

> For me, the funny thing is the number of people who are surprised when I talk about children. The assumption is that you as a woman, as a successful senior woman, don't have a family, don't have kids, aren't doing the juggling. In terms of stereotyping, that's the strangest thing for me – how you automatically get stereotyped as not being someone with a family. I'm partly guilty of that myself. There is still an assumption that if you've got a successful career, you haven't had a family.

Other respondents mentioned negative attitudes that they had heard about in relation to women who had children. For example, Susan recalled:

> There was one case where a more senior postdoc in another group came to me in floods of tears one day and said that she had had a really horrendous meeting with her male group head where she had basically been told, 'You aren't really serious about your career in science because you've got children and you would never have had these children if you had really wanted to progress and to focus and to move on with your career.' And I just couldn't believe that she had been told that by somebody. It was really horrendous.

This incident happened about ten years ago, yet respondents suggested that there is still anxiety about when to have children and whether it will affect their careers, including how they are perceived by colleagues. One younger woman said that recently she felt like a 'naughty school girl' when she went to see her boss to explain that she was pregnant with her first child. As far as she was aware, her boss had not given her any reason to feel this way but nonetheless she had felt anxious. Very few of the mothers we talked to had taken more than a few months' maternity leave. Encouragingly, many of the younger couples shared childcare so that both could continue their careers. Shared parental leave – common in Scandinavian countries and introduced in the UK in 2015 – may help shift attitudes about gender and childcare. Kirsten was aware that she and her husband are challenging stereotypes:

> I think there is still the stereotype that, when you have children, it's the woman who stays at home and will take care of the kids. But I think hopefully also this is changing, and I think my husband is maybe an example that it's not only the woman who is staying at home, looking after the kids.

Some respondents talked about other factors that might have a negative impact on women's careers. Luciana, who had grown up in Spain and studied in the USA, talked about what she saw as a 'boys' network' in Britain. Unlike the 'old boys' network', which links men who attended the same private schools, the network that Luciana perceives is connected to activities such as football and the pub, which may feel less inviting to women. This only became visible to her when she joined the senior staff:

> I noticed more the discrimination, or the difference of being a woman, when I became more senior. And I think there I started to feel the existence of boys' networks, and the fact that women can be isolated because they are not part of this football team that plays every week or you don't have the time to go to the pub. And in lots of occasions I thought that decisions and discussions were being had outside the workplace that would have an impact in work, and I think that has become really evident. It wasn't evident when I wasn't part of those decision-making groups, but when you become one of [them] you realise how much informal discussion there is that actually informs decisions, and you are outside that.

Another respondent also said that she believes that major decisions about issues such as finance are made outside the board room by men who belong to what she called the 'old boys' club'.

It is encouraging to note that, when asked about problems due to stereotyping, very few respondents mentioned women's physical appearance being a factor. Heather said that a typical image of someone working in a lab is someone who wears drab clothes, a lab coat and no make-up. Only Florence, who has been a professor for many years, mentioned how appearance might affect whether or not someone is taken seriously at work. She said:

> I think it's more attitudes around the boardroom. If you are the only woman, or [there are] one or two women in 16 men … I remember, at one stage, people used to say, 'Why don't you ever tie your hair back? Because they'll take you seriously,' And I said, 'No, I'm never going to do that.' But I did put my glasses on because it did make a difference.
> Interviewer: Does it?
> Actually, it still does.

DISCUSSION

Previous studies have tended to concentrate on the 'leaky pipeline' in academic science, which sees women become increasingly rare at each step up the promotions ladder, whereas our study contributes the perspectives of women who have remained, successfully, in their careers. The women we interviewed rarely suggested that their own careers had been hampered by gender discrimination. Research in the USA also found that successful women scientists often denied disadvantage due to gender discrimination (Rhoton, 2011). Senior women in

science may sometimes explain gender inequality by invoking other women's lack of motivation or lack of training (Cech & Blair-Loy, 2010). Smith et al.

(2015) suggest that people may not be willing to admit to, or even have insight into, personal experiences of prejudice and stereotyping. Several studies have indicated that people who do not experience barriers are less aware of their existence – for example, in the Opportunity Now survey (Nawrockyi et al., 2014) men did not see barriers and inequities that were apparent to women. Women may perceive gender stereotypes as valid (De Lemus et al., 2013) or may have 'false consciousness', the holding of false beliefs that sustain one's own disadvantage. According to Jost (1995, p. 404), 'people may accept unsatisfactory outcomes if they can be made to believe (even falsely) that the procedure used to determine them is fair or legitimate.' Also, as Cech and Blair-Loy (2010, p. 376) suggest, 'Women may deny discrimination because of their need to see themselves as competent, integrated, well-liked, and *deserving* professionals.' They may not want to be seen as grumblers and people who have received special treatment. Thus some of the women we interviewed may have been hampered by discrimination at some stage of their career but may not have been aware of it or may have chosen to minimise its importance.

Many of Rhoton's (2011) respondents said that they preferred working with men, tending to distance themselves from female colleagues, whom they described as too emotional, lacking objectivity and reluctant to take criticism. Rhoton (2011, p. 711) concludes that 'Women scientists' distancing practices not only support and reproduce gendered structures and cultures that contribute to gendered barriers for women in STEM disciplines, but they also have implications for efforts to dismantle these barriers.' She goes on to say that successful women may demonstrate solidarity with the occupational culture and focus on individual-level factors, shifting responsibility for failure to individual women.

A few of the women we talked to recalled incidents suggesting male colleagues assumed that senior appointments are awarded purely on merit, that women (but not men) who have children are less serious about their work and that women are less capable at mathematics and computation. Leach and Livingstone (2015) point out that we must not underestimate psychological resistance to gender stereotyping and disadvantage, though the women we interviewed had also worked with colleagues to overcome unhelpful stereotypes, challenge bias and support junior colleagues: Olivia was determined not to let stereotype threat affect her and said that she was no longer afraid of being judged; Polly said that she felt quite demoralised by assumptions that she had not done her own mathematical modelling and urged others to fight this type of gender stereotyping; and Florence did not follow advice to change her hairstyle, though she was aware that when she wore glasses she was more likely to be taken seriously. Florence also said that she keeps a list of successful women so that if someone needs a name for an award or a job she can suggest women's names. Anne, meanwhile, framed some types of stereotyping as unintentional and forgivable when enacted by older men, while

other women argued that education and training in unconscious bias is vital to tackle all stereotyping, even when it is not intended to be unkind.

As we said in the introduction, research has found that stereotyping can have a negative effect on women's careers, their choice of subject at university and their intentions to stay in the field. Sexist attitudes are not limited to science and are increasingly challenged by academics. Recently Kurian and Munshi (2015), who run the Public Understanding of Science Blog, drew our attention to a review written for the journal *PLOS ONE*, where a reviewer suggested that the two women co-authors should 'find one or two male biologists to work with' to make sure they didn't drift 'too far away from empirical evidence into ideologically-biased assumptions'. The editors of PLOS ONE apologised for the review.

Many universities, aware of the danger of losing talent when women do not stay in academic science, have developed gender equality initiatives, including diversity training for staff (Phipps, 2008; Fox, Sonnert & Nikiforova, 2011). Several university departments have also obtained silver or bronze Athena SWAN awards (and a very few have achieved gold), indicating that they have moved some way to transforming gender equality in their institutions (see http://www.ecu.ac.uk/equality-charters/athena-swan/). Important changes include introducing measures to help those who wish to work part-time, such as having meetings during core hours instead of late in the evenings; training in unconscious bias; and mentoring schemes. Some universities also encourage women to take courses in leadership, such as Aurora, a women-only leadership development programme (see https://www.lfhe.ac.uk/en/programmes-events/programmes/women-only/aurora/)

However, more needs to be done if equality in the workplace is to be ensured (Grubbs & Grubbs, 2016). Inzlicht et al. (2011) recommend reducing stereotypical content in the media, improving women's exposure to positive role models and making sure that images of women scientists are visible in work environments. Miller et al. (2015) suggest that multiple, reinforcing examples of successful women scientists are needed to change stereotypes, pointing out that, if people only see a few examples of successful women scientists, these women may be dismissed as atypical and assumptions may be made about their (lack of) home life. Group leaders have a particularly important role to play in improving the representation of women in 'masculine' occupations (see Peters et al., 2012).

Men are also often willing to be enlisted to challenge negative stereotyping. One of the women we interviewed said that the men in her team stepped up to correct false assumptions about who led the work. DuBow and Ashcraft (2016), who interviewed 47 corporate employees, found various factors that motivate men to participate in gender equality initiatives but that several obstacles, such as apathy, fear of making themselves vulnerable in a workplace setting and lack of time, still discourage men from participating in workplace advocacy.

Phipps (2008) points out that there needs to be a major transformation of education and public and private life if the state and corporate world's responsibility

to deal with gender inequality in science is to be recognised. She argues that, instead of changing women to fit science, engineering, construction and technology, activities should focus on reshaping these fields to be more welcoming to women from all social backgrounds as well as to the many men who do not fit the 'masculine' ideal of those working in these fields.

Our qualitative study conducted at one elite British university included women from minority ethnic groups and nearly all were parents, but as a small study it was unable to explore key issues of intersectionality. While we do not claim that these highly successful women are typical of women scientists, their experiences illuminate how gender discrimination in the context of their work is currently perceived and challenged. The women we interviewed would be unlikely to claim that they had been seriously adversely affected by gender discrimination, yet their experiences are enlightening and lend some empirical weight to critiques of Summers' hierarchy of explanations for gender inequality in science.

CONCLUSION

While discussing the low numbers of senior women in science, the women we interviewed mentioned all three of the reasons that Summers (2005) proposed to explain women's lack of progression to senior positions. They thought that unconscious bias, stereotyping and the 'boys' network' were the main reasons that women do not progress, thus contradicting Summers, who suggested that choice and innate differences between men and women were the most important reasons. Although these women did not think that negative stereotyping had seriously affected their own careers, they were aware that it may have affected those of others. They were certainly aware of a continued gender imbalance at senior levels and the consequences of this for role models, sponsorship and committee representation; indeed, many were working to overcome these barriers within their institution and disciplines and for individual colleagues.

There is also evidence of a shift in expectations about gender and child-rearing, particularly among the younger women we interviewed. Scientists may not want to lose their career when they have children – and with more equality of income there is less likelihood that career and family decisions will be made in the context of having a 'primary earner' in the family. Women scientists in a relationship often earn as much as their partner, and it is in the interests of neither for their careers to suffer due to unequal caring responsibilities.

The findings also provide encouraging evidence of a vanguard of successful academic women scientists who are role models for younger colleagues of both genders and are working in a context that is increasingly supporting gender equality in the workplace.

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