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Women in science: from images to data

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Abstract

In recent decades research in the social sciences, including in the history of science, has shown that women scientists continue to be depicted as exceptions to the rule that a normal scientist is a man. The underlying message is that being an outstanding scientist is incompatible with being an ordinary woman. From women scientists' reported experiences, we learn that family responsibilities as well as sexism in their working environment are two major hindrances to their careers. This experience is now backed by statistical analysis, so that what used to be regarded as an individual problem for each woman of science can now be identified as a multi-layered social phenomenon, to be analysed and remedied as such. Over the last five years, international scientific unions have come together to address these issues, first through the Gender Gap in Science Project, and recently through the setting up of a Standing Committee for Gender Equality in Science (SCGES) whose task is to foster measures to reduce the barriers that women scientists have to surmount in their working lives.

Keywords

science

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1. A Measure of the Gender Gap in Science

In 2017, I joined the Executive Committee of the Gender Gap in Science Project. This was an international project led by the International Union of Pure and Applied Chemistry (IUPAC) and by the International Mathematical Union (IMU), and supported by the International Science Council (ISC), within which I represented the international Union of History and Philosophy of Science and Technology (IUHPST) [1]. My enthusiasm for the project stemmed from several motivations. First, there is a significant and unaddressed gender gap in the discipline to which I belong, and which I represent in the Gender Gap in Science Project. Secondly, historical studies on women and gender in science shed interesting light on why the gender gap in science persists and how historical and scientific discourse and practice may contribute to perpetuating it. Last but not least, the Gender Gap in Science Project is an important "first", in that it was set up and conducted by women and men of science rather than by science policy makers, in other words, by actors rather than observers.

A survey of scientists, covering all regions and development levels, and several disciplines, was carried out as part of the project. It shows that women's experiences in science are consistently less positive than men's, in both educational and employment settings [2, p. 19]. For example, more than 25% of women scientists who answered the survey reported having encountered sexual harassment during their studies or at work (compared to less than 4% of men). Moreover, women are 3.3 times more likely to report slower rate of promotion after having children than men [2, pp. 35, 48-52]. These quantitative data are crucial, because they shed a different light on women's individual experiences in the scientific profession: these experiences are no longer the personal problem of each of them, to be surmounted without "unnecessary fuss", but a feature of the profession itself, that needs to be dealt with by the scientific communities at various levels.

These and other figures in the results of the survey confirm the fact that the gender gap in science will not simply be reduced as the result of a spontaneous evolution. Progress towards equality in every part of our societies does not just happen "naturally." In order to devise and implement strategies to actively promote gender equality in science, we need to better understand the processes that have resulted in the present situation, and that contribute to the perpetuation of the gap. In what follows, I share some reflections based on social studies of science, mainly but not exclusively historical. I discussed some of these ideas with participants in the final conference on the Gender Gap in Science Project [2], from whom I received very valuable feedback. Discussions during this conference also brought out the need to create permanent links between concerned scientists in order to work towards gender equality in science. I will conclude this article by setting out how we have undertaken to do that.

2. Picturing Scientists: Children's Drawings and Nobel Prizes

Since the 1950s, specialists in science education have conducted experiments with students in Anglophone countries, asking them to "draw a scientist". Unlike in Romance languages, in English this sentence does not point to a gender, as the indefinite article "a" is neuter. Nevertheless, an overwhelming majority of both boys and girls represent the scientist as male. The figure of the male chemist in his laboratory seems to have long predominated in their drawings [4, 5]. Although the proportion of women among scientists has increased since the experiment was first conducted, a study published in 2018 reported that a majority of children continued to depict a scientist as male; moreover, the older the children are, the more likely they are to draw male scientists [6]. The title of a *Washington Post* article that discussed this study tersely summed up the situation: "Only 3 in 10 children asked to draw a scientist drew a woman. But that's more than ever." [7]

As the authors of the 2018 article remark, "women remain under-represented in several science fields, and information about such imbalances is filtered through multiple sources such as mass media and social interactions". Children are simply representing the world they see. Indeed, according to UNESCO statistics published the following year, about 30% of scientists around the world (excluding Canada and the USA, for which the data appear to have been unavailable) are women, with significant variations according to countries [8]. But

presence and visibility are not the same thing. Today, the scientists who appear in the media, those who are awarded prizes, and those who give expert advice are still overwhelmingly male. Again, this remains true even though one sees many more women as award recipients than a few decades ago.

Let us take the case of chemistry, the discipline that children in these experiments often take to represent science. Since the Nobel Prizes were created in 1901, the prize in chemistry has been awarded to 178 men, and to seven women. They are, in chronological order: Marie Curie (1911), Irène Joliot-Curie (1935), Dorothy Crowfoot Hodgkin (1964), Ada E. Yonath (2009), Frances H. Arnold (2018), Emmanuelle Charpentier (2020) and Jennifer A. Doudna (2020). If one looks back only to the last decade, 23 laureates are men and three are women. As in children's drawings, there is no denying that the proportion of women is increasing here too. There is no denying either that the gap remains wide.

Chemistry, of course, is not an exception. Since 1901, four women and 211 men have been awarded the prize in physics; twelve women and 110 men have been awarded the prize in physiology and medicine. The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel, founded in 1969, has been awarded to two women, and to 84 men [9]. In mathematics, the Fields Medal, first awarded in 1936, has been awarded to 59 men and only one woman. The gender imbalance is overwhelming across disciplines, whether in the social sciences or in mathematics and natural sciences. This discrepancy between visibility and reality is both a consequence of the history of women's participation in science, and a hindrance to the reduction of the gender gap in science. The visibility of women scientists, perhaps even more than facts and figures about them, is crucial to representations of science and of scientists among the public. In what follows, I would like to reflect on these representations in science in a historical perspective.

3. Saying the Names of Women Scientists

Continuing to focus on chemistry, let us look back further than the twentieth century, at the received narrative of the history of this discipline, exemplified by the Wikipedia article on the subject. It is a long genealogy of men of science, most of them European. The illustrations in the article include 23 portraits of chemists; among them one finds the photograph of one woman, Marie Curie (who is doomed to represent "the woman scientist"), and a "Portrait of Monsieur de Lavoisier and his Wife" (1788) [10]. The wife in question, Marie-Anne Paulze Lavoisier (1758-1836), has only recently begun to be studied as a chemist in her own right [11]. The Wikipedia article devotes a paragraph to her: we are told that she made a contribution, not directly to chemistry, but instead to her husband's refutation of the then prevailing theory of phlogiston, according to which combustible bodies contained an element (phlogiston) that was released during combustion. The other twenty-one portraits in the Wikipedia article represent men; one collective photograph of the participants of the first Solvay conference (1911) shows Marie Curie and 23 men. The only representative of Antiquity depicted is Democritus (c. 460 – c. 370 BCE), the atomist philosopher. And yet, one of the earliest figures in the alchemical tradition of expert practice was a woman, referred to

in English as Mary the Jewess, who lived in Alexandria, probably in the 1st century CE. She is credited with the invention of the alembic and of a device mentioned in most Western cookbooks: the eponymous *bain-marie*, though for her it functioned as a source of gentle heating for alchemical processes rather than as a culinary technique [12]. These are three splendid archetypes: Marie Curie is the exception that confirms the rule; Marie-Anne Paulze Lavoisier is somebody's wife; Mary the Jewess has been immortalised in the most feminine of domestic spaces, the kitchen.

The preceding paragraph should not be read as a criticism of Wikipedia. As academics well know, Wikipedia reflects received knowledge, and is what its users make it: since 2012 it has a working group dedicated to “ensuring quality and coverage of biographies of women scientists,” the WikiProject Women Scientists [13]. All this goes toward showing that it is not only the “facts”, but also the representations that prevail, that need to be worked on in order to understand the gender gap in science as in societies past and present. Such investigations are essential in attempts to reduce this gap. And one thing they have already shown is that the “Three Marys” mentioned above are not the only women in the history of chemistry, and that there are so many of them that it would be impossible to list them here —but one needs to look for them, in many cases elsewhere than in the very masculine memory of science. It is this memory, rather than history, that is engraved in the list of Nobel Prize winners and of members of academies of science. Granting visibility to women past and present is therefore a major goal to attain [14].

Both academic historians and popular authors have written book-length biographical accounts of women scientists. This is indeed a means of granting them visibility, and of celebrating them —to take up the motto put forward by UNESCO in its yearly International Day of Women and Girls in Science (“Celebrating women in science”, 11 February). Here again one of the earliest biographies one comes across is that of Marie Curie by her daughter Eve Curie, published four years after her mother's death [15]. Reading a couple of sentences from it suffices to realise that this was no attempt at a “historically objective” account of Marie Curie's life and work, but rather a heroic one: “She was a woman, she belonged to an oppressed nation, she was poor, she was beautiful. A powerful vocation prompted her to leave her homeland, Poland, to come and study in Paris [...]” But, in science as elsewhere in our societies, the experiences of women matter, rather than their looks or their patriotic feelings, Their successes and achievements —not just the difficulties or discrimination they suffer— are worth highlighting. The celebration mode, however, has its limits and risks when it focuses on one or a few individuals. As Patricia Fara remarked in her review of biographies of women scientists, many biographies use the heroic mode as a selling point, and by doing so perpetuate the myth that “it is impossible for someone to be both a normal woman and a first-class scientist.” [16]

4. The Gaze on Women Scientists

Although women scientists write their autobiographies less often than men scientists [17], these autobiographies may provide a necessary counterbalance to heroic narratives. Yvonne Choquet-Bruhat, the first woman elected as a full member of the French Academy of Sciences

in 1979, is best known for providing the earliest mathematical proof of the existence of solutions to Einstein's equations. Her autobiography, written at the request of her children, describes her work, the travels that it entailed, and her private life. She recounts that during the year she spent at the Institute for Advanced Study, Princeton, in 1951-1952, she discussed her work with Einstein himself. Before that, she evokes her "everyday life" at the Institute for Advanced Study with her husband Léonce Fourès, also a mathematician, and their one-year old daughter Michelle:

"...We hired a 15 year old girl to come after her school hours and look after Michelle. Michelle and the baby-sitter were very happy with this. When the baby-sitter was away, Léonce sometimes replaced me. Fortunately, one can do mathematics anywhere, so that the presence of our daughter did not hinder my work. I had, by the way, noticed when taking tea in the common room that some colleagues were sitting there, absorbed in playing that game of Chinese origin called go. Once, as I was leaving the common room to take over when the baby-sitter had to go home, one of them told me: 'Obviously, a woman can't be a mathematician, she has to look after her children.' I retorted: 'She can't stay late to play go.'" [18, p. 99]

Yvonne Choquet-Bruhat's concerns about childcare arrangements will seem familiar to many readers of the present article, who like her combine a scientific career and family life. Alas, so will the comment made by her male colleague (to Choquet-Bruhat, it goes without saying that the colleagues she mentions were men; in the original French text the gender of the speakers is specified by a pronoun). Together, they encapsulate the everyday experience of women scientists. The anecdote she recounts is now backed by the conclusion of the worldwide survey conducted in 2018, that is, more than sixty years after her stay at the Institute for Advanced Studies. It should be emphasised, however, that this experience is not specific to the scientific profession: both the responsibility for childcare falling to mothers and sexist comments that question the legitimacy of women's status as professionals are common everywhere in our societies. As an institution, science is not immune to phenomena that pervade the societies in which it is established.

Today, 27% of scientists in France are women, and more than fifty out of the 286 members of the French Académie des Sciences are now women [19]. However, the cliché that being a woman and being a good scientist are incompatible proclaimed by Yvonne Choquet-Bruhat's go-playing colleague remains vivid all around the world. Thus in 2014, when the Fields Medal was awarded to a woman for the first time, some comments on the social media targeted the laureate, Maryam Mirzakhani (1977-2017), for her allegedly masculine looks. This is nothing more than the continuation of a long and disheartening tradition. Women who have come down in history as great mathematicians, such as Émilie du Châtelet (1706-1749), Sofia Kovalevskaya (1850-1891) and Emmy Noether (1882-1935), have been subjected to similar comments — coming from women as well as men — that denied the compatibility between being female and being a mathematician of some standing [20].

5. The Discourse of Science on Women

But the legitimacy of women in scientific professions has been put in question by more than unpleasant comments from male colleagues. Historians of science usually date the establishment of science as a modern institution to the nineteenth century, with the setting up of universities and the definition of academic disciplines taught there [21]. At the time, it went without saying that a scientist was a male scientist. Since then, male scientists have not only been at best slow to admit women among their ranks; they have also used science to argue that women must (for their own good) be kept out of science. I will mention a single example: Edward H. Clarke (1820-1877), who was a Professor of Materia Medica at the Harvard Medical School from 1855 to 1872, by no means a marginal figure. In 1872, in the context of increasing pressure in favour of higher education for women, he published a book entitled *Sex in Education, or A Fair Chance for the Girls*, which was successful enough to undergo seventeen editions in twenty years. Contrary to what its title suggests to twenty-first century readers, the book's main argument is that the intellectual demands placed on boys at university are too hard for girls, in whom they trigger "physiological disasters," leading to "nervous collapse and sterility." Clarke describes seven medical cases in support of his argument. The description of these cases might make one smile today, if it were not for the fate of his patients, some of whom ended up being consigned by him to an asylum [22]. The point I want to make here is that the discourse produced by Clarke, on whom the institutions of his day bestowed weighty scientific authority, barred girls and women not only from studying and practicing science, but more broadly from the intellectual training provided in higher education that had been devised for young men.

Today one would swiftly characterize Clarke's analysis of his cases and treatment of his patients as an example of harmful exercise of power by a prejudiced medical authority. Still, a study conducted less than ten years ago on anatomy textbooks used at university concluded that these textbooks were not gender-neutral, and that while the students who use them "recognise the importance of gender issues and do not wish to associate with sexism, most are unaware of the possible negative aspects of sexism within anatomy" [23]. Sexism pervading scientific discourse and practice is not a thing of the past. Over the last three decades, an abundant literature has shown how it continues to affect medical treatment of women, and therefore their health [24]. It also reduces their ability to share the social space equally with men in all quarters.

6. Women Scientists, Across Disciplines, Around the World

In sum, scientific progress does not of and by itself purge out gender biases either from the behaviour of scientists or from the knowledge that they produce and teach. Instead, there is a continued need to address these biases as social phenomena present in science as elsewhere in our societies. And despite the historical continuities in ideas and behaviours that have hindered the access of girls and women to science, it is here that one can find some ground for optimism. Acknowledging that science, like all human activity, is produced in social contexts that contribute to shaping it opens possibilities for bringing to light the mechanisms that underlie the gender gap that pervades scientific studies and professions and thereby for remedying it. Women scientists, who a century ago were few enough to be singled out as heroic "exceptions that prove the rule" of women's incapacity in that field, are now too many

for their presence in science to be accounted for individually in the heroic mode: one is dealing with figures and statistics. As well as “say their names,” we now can now “count their numbers.” This is what the worldwide survey undertaken as part of the Gender Gap in Science Project has done.

This project was carried out jointly by a number of international scientific unions, joined by a few other international organisations. For the first time, scientists themselves have taken the matter into their hands in a cross-disciplinary way. The results of this survey give a clear measure of the gender gap. These results vary from discipline to discipline, but the overall situation is the same for all of them. This being said, the quantitative approach, valuable as it is, does not replace the sharing of individual experiences, and does not make qualitative approaches to the gender gap in science obsolete. This sharing remains as necessary as ever, first and foremost to account for the diversity of ways in which the gender gap manifests itself in various parts of the world. Thus, at the closing conference of the project [25], one of the speakers, Shobhana Narasimhan, recounted that, at the Career Development Workshop for Women in Science that took place in Trieste in 2013, one of the participants said to her:

“This is the first conference of any kind that I have attended... this is the first conference my husband allowed me to attend. He allowed me to attend this one because I told him that only women would be there.” [26, slide 13]

To most of those coming from Europe and the Americas who heard Shobhana Narasimhan’s report, the fact that a scientist might need permission from her husband to attend a conference was new, even though we were all aware, in principle, of the diversity of situations of women scientists around the world; this kind of situation is not, obviously, specific to a particular discipline. Exchanges of this nature highlight the crucial need to develop worldwide and cross-disciplinary networks of support for women scientists, among other things in order to exchange experience and adjust best practices to local conditions.

The awareness of this diversity was one of the motivations for the scientific unions who took part in the Gender Gap in Science Project in the decision to set up a permanent structure in order to continue to work together at an international level and across disciplines to monitor the gender gap in the profession and to foster measures in favour of gender equality. This structure, the Standing Committee for Gender Equality in Science (SCGES), started working with its nine founding partners in September 2020. As of January 2021, it has 15 partners, six international unions having joined in, and more of them are expected to join [27].

One especially noteworthy feature is that three of the partners, the International Union of History and Philosophy of Science and Technology (IUHPST), the International Geographical Union (IGU) and the International Union of Psychological Science (IUPsyS) represent disciplines that lie at the intersection of the natural and the social sciences. This reflects the fact that the natural and the social sciences form one single institution. Thus SCGES aims at bringing together all the disciplines represented among the members of the International Science Council (ISC). This will be beneficial in two ways: firstly, because the social

sciences have developed research on gender in science (and more generally at large in our societies), on which the present contribution relies, and secondly because the gender gap exists in all academic disciplines. All the sciences, be they natural, mathematical or social, stand to gain by coordinating their efforts to work towards gender equality.

The first action of SCGES, undertaken at the request of one of its partners, has been to issue a statement “Standing for gender equality in times of Covid-19” on the consequences of the coronavirus pandemic on women scientists’ working conditions and career prospects. This statement aims to specify the actions that can be taken by scientific institutions, funding agencies, recruitment committees, journals, associations and conference organisers. Individuals and institutions engaged in science can and should join forces in supporting women colleagues whose research careers are jeopardized by gender-specific pressures caused by the pandemic [28]. The various forms of support recommended in this statement can and should be perpetuated beyond the present crisis.

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