Why do so few women take on scientific careers?

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There were around 8 billion human beings in 2022, 50% of them women. Although there are as many women as men, the former continue to be underrepresented in science.

The list of Nobel Prize laureates is a case in point: out of 956 winners,

only 60 (6%) are women. Could the differences between men and women justify such a disparity?

Natural differences?

The first difference between the sexes can be observed at the level of chromosomes. Human beings are endowed with 23 pairs of chromosomes, the last pair differing according to sex: two X chromosomes for women, and one X and one Y chromosome for men. This difference accounts for the difference in genitalia, which are distinguishable from birth in over 99% of cases.

Gender, a social norm that defines how we should behave according to our sex, comes on top of these biological differences. Throughout history, gender expectations over how we ought to speak, sit, walk and dance have varied not only across time, but space: in 17th-century France, wealthy men wore shoes with heels, reflecting their high social status. Nowadays in Europe, with the notable exception of the Scots, few men wear skirts. In Asia, however, skirts are widely worn by men. Such variations show that when it comes to expressing gender identity, a person's sex counts less than their social and cultural context.

Gender is also defined by stereotypes on skills, which as we shall see largely explain why women are so little present in science.

We know that, from the earliest age, boys' and girls' environments differ according to these stereotypes. And yet, by the time they enter first grade in France, girls outperform boys in French and are on a part with them in math. Once in academia, however, only 22% of mathematicians are women.

What has happened in the meantime? Phenomena that affect not only the women on the receiving end, but also teachers, recruiters and

parents—namely, stereotypes and gender bias.

The power of stereotypes

Stereotypes are character traits that are arbitrarily attributed to specific groups of people. Although they have no scientific basis, they nevertheless influence the way people behave.

Girls, for example, quickly take to the idea that they are not cut out for math. Such gendered stereotypes are hardly new. During the Renaissance, a dark period for equality between men and women, women were excluded from the cultural, economic and political spheres. Then, during the Enlightenment in France, feminine names that existed for intellectual and artistic professions (author, painter, poet, doctor, etc.) were suppressed by the Académie Française, legitimizing the absence of women in these professions.

Research in the 21st century has continued to starkly expose such preconditioning. In 2009, researchers at the University of Aix-Marseille sought to test the mathematical skills of 12-year-old children of both sexes, divided into two groups. In the first group, the children were told they were taking a geometry test. In the other, they were told they were taking a drawing test. The boys ended up outperforming the girls in the "geometry test" group, while girls not only beat them in the "drawing test", but outscored the boys from the first group. Although the test was the same, the girls performed less well when told they were taking a geometry test. So, it is the mention of geometry that is an obstacle, not differences in ability, since in the "drawing test" instruction, they are better than the boys.

This is the stereotype effect: we observe a drop in performance in situations where individuals fear confirming a negative stereotype attributed to the group to which they belong. This is known as stereotype

threat. While the stereotype itself has no biological basis (at the cerebral level, the brains of two men have just as many differences as those of a man and a woman), it induces behavior in those who are its target that conforms to it: women will be less self-confident, and feel less legitimate in disciplines from which stereotypes exclude them, such as math, and science in general.

Stereotypes will also induce biases in those who teach, judge, evaluate and recruit. One study has shown that, for the same CV sent for a position of a laboratory manager in a university, a male candidate (boy's first name) will be judged more competent than a female candidate (girl's first name), and will be offered a higher salary. This is what we call gender bias: we treat people differently, not because of their skills or qualities, but because of their gender.

The exclusion of women from scientific careers and its mechanisms

Gender inequality, which is evident at the outset of scientific studies, is amplified throughout a career. Although their numbers are on the increase, women are still in the minority among teaching and research staff in all disciplines (40% in 2021 in France), but more pronounced in the sciences (at the same date, 34% of female lecturers and 19% of female professors in science and technology). This erosion is described and analyzed in the documentary *Picture a Scientist*.

Because women are endowed with the same abilities as men, could it be that they have less of an appetite for the sciences?

It is significant to note the wide variations from one country to another in the proportion of women in scientific courses. Paradoxically, the more egalitarian the country, the more women are excluded. Indeed,

women who manage to study in countries where they have to fight to gain access have already made a transgressive choice, so their disciplinary orientation is freer. We can see that these variations are explained by context and, as mentioned above, not by natural gender differences. In countries where women's access to education is not in question, stereotypes play a role in the choice of disciplines. It also has an overall impact on test results, according to the mechanism known as stereotype threat described above.

As a result, the percentage of women in France's top scientific schools is very low, particularly at ENS-PSL (École normale supérieure), as described in the study: "Girls + Sciences = an Unsolvable Equation?". We were particularly struck to find how commonplace gendered appreciation was in teachers' school reports. Specific teacher training is therefore desirable to limit these biases.

This phenomenon is not limited to studies. The behavior of promotion juries at the Centre for National Scientific Research (CNRS) has been analyzed by Isabelle Régner: it is not the implicit bias that is responsible for inequality in terms of women's promotion, but its non-recognition by the jury.

Why act and how?

We need to work toward greater individual and social equity, which will in turn lead to greater efficiency. In academic research, but also in industry and education, several studies have shown that mixed groups (gender, social origin…) perform better.

We need to capitalize on this observation on a global scale. Given the scientific challenges we face, we must not lose 50% of our brainpower.

We therefore need to inform and convince people of the deleterious

effects of gender bias, which is more widespread than is generally believed. With Association Implicit Test, the strength of this bias can be measured in the difficulty, via slowness, of associating the words "man" with "literature," or "woman" with "science."

A perverse effect should also be mentioned: while representation on university bodies is parity, which is desirable, there are also burn-out effects on women's careers. Indeed, since the pool of female professors remains unequal, particularly in the higher positions (full professor, called "A rank" in France), women find themselves individually over-solicited for collective tasks that are not particularly rewarding in terms of their careers. The result is ultimately, and paradoxically, contrary to the objective of equity.

Instead, we should be looking at the foundations—that is to say, the conditions of access to university and research careers. Incentive measures could be envisaged to encourage laboratories to recruit young women by helping them at the start of their careers: welcome funding in addition to that already in place, award of a thesis grant within two years of taking up the position… Measures also justified by inequalities in terms of biological clocks. And above all, in order to objectify these issues of gender bias, we need to collect gendered data on careers and working conditions: Nancy Hopkins in the documentary *Picture a Scientist* shows that, at the Massachusetts Institute of Technology (MIT), laboratory space allocated to female professors was significantly smaller than that allocated to male professors. And, as Jane Willenbring says in the same documentary, it is important to make scientific universities a welcoming place for women.

In short, even if changes are moving in the right direction, they are still very slow. Should we carry on at the current pace, a recent study by the French Ministry of Higher Education and Research estimates that gender equality within the field of higher education and research won't happen

before 2068, despite being enshrined in law. Action is thus urgently needed.

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