


## ARE GIRLS DISCRIMINATED AGAINST IN THE SCIENCES? LESSONS FROM THE ENS COMPETITIVE ENTRANCE EXAMS

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### Summary

Stereotypes and social norms push girls towards studying the humanities rather than the sciences. The aim of this IPP Note is to examine the extent to which professors are liable to reinforce this self-selection by discriminating against girls who try to enter male-dominated disciplines. Using the competitive entrance exams for the *École normale supérieure* de Paris as a “natural experiment”, we show that in reality, the reverse phenomenon is at work. Discrimination occurs in favour of girls in the traditionally male-dominated disciplines (mathematics and philosophy, for example), and in favour of boys in the subjects considered the most “feminine” (biology and literature), slightly reducing gender segregation between the disciplines. The tendency of examiners to discriminate on the basis of a candidate's gender is identified by the differences between the results of anonymous written tests (which neutralise gender discrimination) and oral tests (where the candidate's sex is known to the examiners). This discrimination goes against gender stereotypes, which is likely to be explained by the fact that examiners try – consciously or not – to help the minority gender in their discipline. The results suggest that girls can follow study paths traditionally reserved for boys, without fear of being discriminated against. ■

- Girls are under-represented in the hard sciences and the reasons for that are still not well known.
- This study uses the ENS competitive entrance exams, comparing results from anonymous written and oral tests in order to assess the extent to which discrimination against girls helps to explain their under-representation in the science disciplines.
- The study shows that girls are advantaged in the oral part of the admissions competition in the most male-dominated subjects (maths, physics and philosophy). The reverse phenomenon is seen in the disciplines less dominated by boys, where it is boys who are advantaged.
- These results reveal that young women are not necessarily discriminated against when they try to take up study in traditionally male-dominated areas.

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In France, as in most developed countries, gender inequality in education has essentially disappeared, even been reversed to the advantage of girls. On average, girls gain better results than boys in national school assessments, study longer and obtain more higher education qualifications. In the labour market, women have become the majority in prestigious professions traditionally dominated by men, such as law and medicine. One important difference remains, however: girls are massively under-represented in the hard sciences.

### Persistent and problematic under-representation of girls in the hard sciences

Only 15 per cent of university mathematics researchers in France are women (see Figure 1). In the United States, they constitute only 25 per cent in the scientific professions, engineering, computing and mathematics (National Science Foundation, 2006). The fact that men remain the broad majority in these occupations constitutes **one of the most persistent distinctions between male and female employment**.

This distinction is problematic because it is one of the principle causes of gender inequality in the labour market. The gender segregation between scientific and arts study streams is one of the most important explanations for the gender wage gap. The problem is accentuated in France by the importance placed on excellence in mathematics and by the elitist system of the *classes préparatoires* at the *Grands écoles*. The virtual absence of young women in the *classes préparatoires* for maths, physics and engineering sciences, where they represent around 15 per cent of the workforce, looks like a strong potential determinant of the salary gap between men and women, and in particular of the glass ceiling in France: the under-representation of women in leadership positions is in part a result of their marginal presence in the paths that lead to such posts.

Through understanding better the under-representation of women in the hard sciences, we hope to find potential means by which to improve their future situation in the labour market.

### Little-known causes

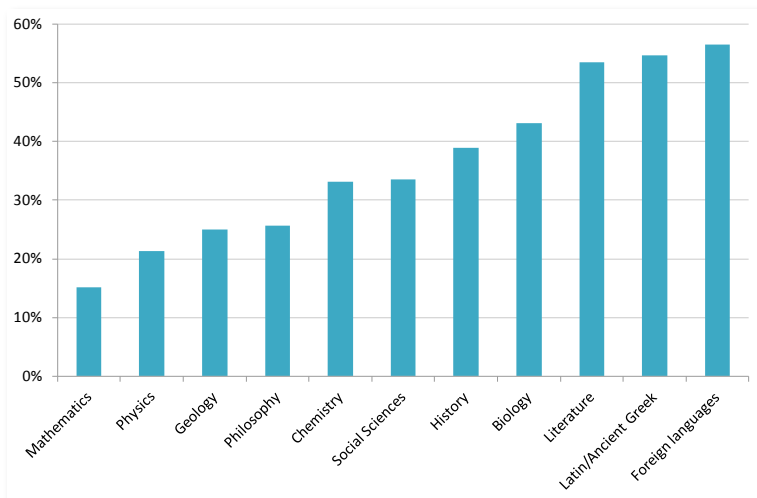
In 2005, at a now-notorious public conference, economist Lawrence Summers advanced **three possible reasons for the under-representation of girls and women in the sciences**: i) discrimination against them in recruiting and promotion processes; ii) greater reluctance among them to sacrifice family life for a scientific career at a high level, and iii) greater « innate » male ability in mathematics such that even if they are not better on average, more of them are very talented and eligible to become very high-ranking scientists. Summers preferred the latter explanation, which caused a scandal in the American academic world and cost him his post as president of Harvard University.

While large-scale assessments such as the PISA inquiry show that boys tend to obtain slightly better results than girls in mathematics, whereas girls do much better than boys in reading tests, research shows that these differences are cultural in origin, not innate, as Summers argued: the differences vary too much from one country and region to another, and they reduce too quickly over time to reflect changes of a « biological » nature. Moreover, these differences in results can only explain a tiny portion of the differences observed in choice of career orientation: on the same level, **girls are twice as less likely than boys to choose the most scientific streams**.

In the same way, the hypothesis that claims that girls accord greater importance to family life can explain only marginally their school choices, since these are generally made before the age of 25. To explain the differentiation of study choices in relation to gender, university research clearly insists on differences of preference (or taste) between girls and boys, differences that are strongly determined by social norms and gender stereotypes.

To stereotypes that lead girls to prefer arts subjects rather than the sciences, can be added potential direct discrimination against those who would like to challenge the social norms. Nevertheless, **the existence of such discrimination is up for debate**. Until recently, there were no field studies directly proving that discrimination explains the absence of girls and women in the sciences.

Figure 1: Proportion of girls among senior lecturers and professors in the different university disciplines of the ENS entrance exams



Source: Ministère de l'Éducation nationale, de l'enseignement supérieur et de la recherche.

Note: The subjects are ordered from the most to the least male-dominated. The index of « male domination » corresponds to the proportion of women among senior lecturers and professors in French universities in 2007.

## An original methodology : Using the *Normal'Sup* entrance exams

The research on which this IPP Note is based contributes to the debate about possible causes of under-representation of girls and women in the sciences through studying the role played by the examiners of the competitive entrance exams for the *École normale supérieure (ENS)* of Paris. More precisely, it measures whether examiners discriminate more against female candidates in the most scientific subjects, and more generally in subjects that are traditionally male-dominated in academia.

### Why the ENS ?

While at first glance, the context of this study – the *ENS* entry competition – might seem too particular to allow us to draw conclusions that can be generalised, in reality, it is central when we are looking at the place of women in science. Indeed, the *ENS* recruits the researchers of tomorrow, both male and female. **This institution is thus likely to play an important role in the process that leads girls to disappear from science courses.**

The *ENS* entrance exams are designed to measure as accurately as possible the academic skills of candidates at the end of their years in the *classes préparatoires*. The study shows that even in this context, examiners can be biased, which challenges the general idea that a totally neutral and meritocratic evaluation is possible.

### The method : comparing written and oral exam results

We use a specific aspect of the competition to identify the tendency of examiners to discriminate for or against candidates on the grounds of gender: **the written examinations are anonymous** (which neutralises gender discrimination) while **the oral exams are not**<sup>1</sup>. By comparing the relative performance of girls and boys in written and oral tests in each subject evaluated, we can investigate (i) the existence of discrimination in each subject and (ii) how that discrimination varies from one subject to another.

The first exercise consists of examining whether the shift from written to oral advantages girls or boys in the different tests. It only allows us to isolate the « pure » effect of discrimination if we assume that there are no systematic differences in skills between girls and boys in this change from the written to the oral.

If, for example, girls are more at ease in the orals than boys, then this approach could lead us to interpret as gender discrimination the gaps that, in reality, arise from differences linked to test modalities.

To resolve this problem, we examine how the relative advantage (or handicap) of girls to boys varies from one oral test to another, these gaps being purged of the differences between boys' and girls' results in the written tests. That done, **we no longer measure absolute discrimination in each subject, but rather a relative discrimination from one subject to another**. The advantage of this approach is that it allows us to abstract the difference in marks that simply reflect an unequal aptitude between girls and boys in oral exams compared with written ones, and vice versa: as soon as the competence gap between the written and the oral is constant from one subject to another for girls and boys, it is possible to identify the relative variation of examiners' discrimination against girls among subjects seen as « very masculine » and other subjects.

Box: The Paris *École normale supérieure* and its competitive entrance scheme.

The *ENS* (or *Normal'Sup*) is one of the *Grands Écoles*, a grouping of higher learning establishments that recruits students through a competitive entrance system at the end of two or three years of *classes préparatoires*: the *ENS* is the only multidisciplinary *Grands école* and it focuses student learning on higher education and research (around 80 per cent of the students follow their *ENS* studies with a thesis. Being multidisciplinary, the *ENS* recruits its students from five main streams in the preparatory classes : Mathematics and Physics (MP), Physics and Chemistry (PC), Biology, Chemistry, Physics and Earth Sciences (BCPST), Social Sciences (BL) and Humanities (AL). The entrance competition is hence divided into five distinct sub-competitions, which are all organised in the same way. At the end of a series of written tests, around one-third of the candidates is considered eligible for admission and authorised to sit a second series of tests, this time oral. Only one-third of those admitted to the oral exams makes it through to final admission (see Table 1). The *ENS* admission competition is thus considered very selective: only ten per cent of preparatory class students become candidates and among those candidates, just ten percent are finally admitted.

1. Male and female writing present differences that may be detectable by some examiners. However, in the context of our approach, such a phenomenon must lead to an under-estimation rather than an over-estimation of discrimination in the orals, to the extent that similar discrimination could also appear in the written tests.

Table 1: The *ENS* competitive entrance exams

Track	All together	MP	PC	BCPST	BL	AL
Number of eligible candidates (2004-09)	3026	745	491	420	334	1036
Average per annum	504	124	82	70	56	173
Number of admitted per annum	184	42	21	21	25	75
% of candidates admitted among eligible	37%	34%	26%	30%	45%	44%
% of girls among eligible candidates	40%	9%	17%	56%	53%	64%
% of girls among admitted	40%	12%	13%	44%	47%	59%

Source:  
Data from the *ENS* entry competition for the period 2004-2009

Note:  
The table presents descriptive statistics from the *ENS* entrance exam system and each of its sub-competitions – Maths and Physics (MP), Physics and Chemistry (PC), Biology, Chemistry, Physics and Earth Sciences (BCPST), Social Sciences (BL) and Humanities (AL).

## Results of the study

**Our results show that what discrimination works against stereotypes:** the more a subject is considered «masculine » (resp. « feminine »), the more the difference between the marks gained in the oral and written exams turns in girls' (resp. boys') favour. For example, in maths and physics, the move from written to oral allows girls to exceed about 10 per cent of the total candidates (Figure 1). That is, in the oral as compared to the written tests, girls make up 10 out of 100 candidates. Interestingly, the effects are symmetrical: boys are advantaged to the same extent in the oral exams for subjects seen as feminine, such as foreign languages and literature.

Figure 2 presents the detailed results for the least feminised of the ENS exams (MP: Maths-Physics) and for the most feminised (AL: Humanities). The subjects are ordered from the most to the least male-dominated according to the proportion of women among professors and senior lecturers in the different disciplines (Figure 1).

**The results are striking.** In those two exam competitions, we see that the more a subject is reputedly « masculine », the greater the difference in marks for both oral and written exams shifts in favour of girls. This phenomenon is also observed in the three other ENS entry competitions. It should be noted that the scientific subjects are not all more male-dominated than the humanities subjects. Biology and to a lesser extent chemistry, are more feminised than, for example, philosophy. Our results for the BCPST, BL and AL exams reflect these differences and confirm the overall phenomenon: candidates appear to be advantaged in the orals for philosophy, but penalised in biology.

The precise assessments show that a 10 per cent reduction in the number of women among professors and assistant professors in a discipline is associated with **an increase in girls' success in the oral exams by an average of 3 per cent in candidate rankings in that discipline.** To put it another way, [...] compared with written tests, oral tests enable girls to win 10 per cent more candidatures in the most masculine subjects (maths) than in the most feminine one (languages).

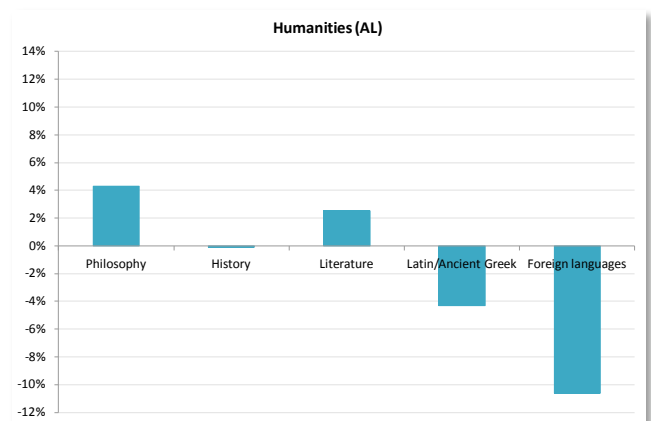
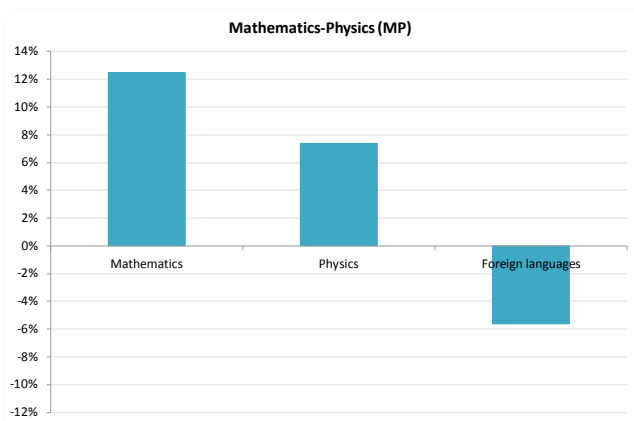
These results rest on a rigorous methodology and they should not reflect initial differences between the candidates, such as their social origins or their academic level. We verified that such is the case: the results are practically identical among candidates who gained similar marks in the baccalaureate, who came from the same *classe préparatoire*, who did not repeat their second year of *classe préparatoire*, and whose parents belong to the same socio-professional category.

### Do male (female) examiners favour girls (boys)?

Quite logically, the juries for the most male-dominated subjects are most often composed of men rather than women. The bonus in the orals for candidates in the most masculine subjects might, therefore, reflect the fact that it is men who assess them. By using the variations in jury composition from one year to another, it is possible to identify separately the discrimination arising from the more or less masculine character of the different subjects, and those arising from a possible link between the genders of a candidate and an assessor.

The results show that **it is the degree of feminisation of disciplines and not the gender of assessors that explains the differences** in girls' ranking between written and oral exams in one subject or another.

Figure2: Variation in girls' ranking between oral and written tests in each obligatory test for the Maths-Physics (MP) and Humanities (AL) entrance exams



Source: Data from the ENS entrance exams for the period 2004-2009

Note: In Mathematics-Physics, the move from written to oral allows girls to exceed 12 per cent of candidates in maths and 7 per cent in physics. On the other hand, they lose place in the languages rankings.

### Are ENS candidates a population apart?

This study is based on the very selective competitive entrance exams for the *École normale supérieure*. The candidates are all excellent students who have been very well prepared. Thus, they are obviously not representative of the whole population. Nevertheless, the choices of these students seem to be influenced by gender stereotypes as much as those of broader populations.

To illustrate this, **we examined candidates' specialisation choices**, which consist of choosing either to do a supplementary exam in a discipline of their choice, or to assign a greater coefficient to one of the obligatory oral exams. Analysis reveals that girls disproportionately choose more female-dominated specialisations (see Figure 3 for the PC, BCPST and AL streams). These differences might be explained by the fact that girls are better in those disciplines and that they choose them for that reason. But this is not the case: when we consider candidates who had similar marks in the mandatory written and oral components of the exams, the differences largely remain.

In Physics-Chemistry, for example, while gaining similar grades in the obligatory written and oral tests, girls are still twice less likely to choose a supplementary oral in physics rather than chemistry. These differences are very high and indicate that **candidates do not maximise their chances of admission to the ENS**: girls should more often choose the more masculine options, while boys should do the opposite.

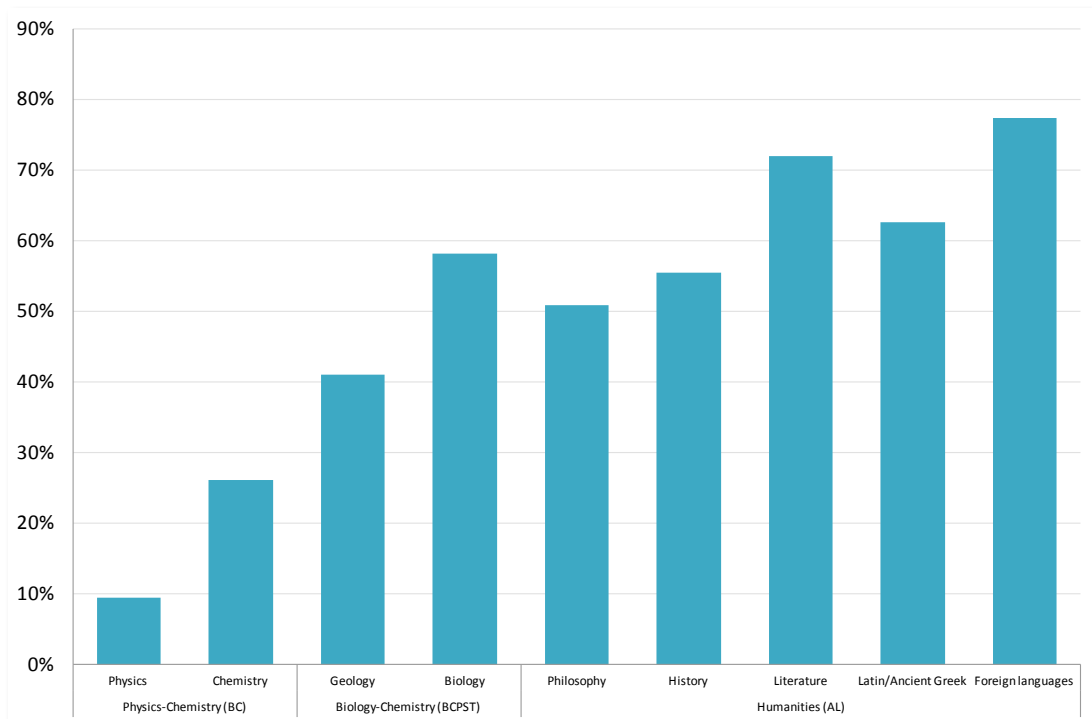
The study of speciality choices shows that ENS applicants, although highly selected, do not escape gender stereotypes. **In that sense, the ENS candidates do not constitute a population apart.** Moreover, the fact that girls only rarely choose to sit a supplementary oral test in the most male-dominated subjects indicates that they are not very self-confident in these areas. This implies that the bonuses they gain in the orals in those subjects are not due to the differences in self-confidence that are particularly obvious in the orals, but rather to differential treatment by examiners.

### Does the discrimination reflect a preference for the minority gender in the discipline?

Even if it is difficult to make a definitive conclusion, we believe that our results reflect **a preference among examiners for the gender that is in the minority in their discipline.** That may be in order to counter-act the negative role of stereotypes of which they are conscious, or for other personal reasons (such as, because they prefer a more mixed working environment).

Furthermore, we have shown that different examiners in an entrance competition do not co-ordinate their actions: hence, discrimination in the oral exams does not reflect an affirmative action policy on the part of ENS because they want to limit gender segregation in their competitive entry system.

Figure 3: The possible proportion of women in each specialization in the competition for Physics-Chemistry, Biology-Geology and Humanities



Source: Data from the ENS entry competition for the period 2004-2009

Note: The choice of specialisation consists of either sitting a supplementary oral test in the discipline of choice or increasing the value of a coefficient in one of the required oral tests.

Note: In each competition, the subjects are ranked from the most male-dominated to the least male-dominated. With the exception of ancient languages (Latin, Greek), the proportion of girls is systematically higher in the most feminine specialisations.

## Conclusion

The main conclusion of this study, based on the « natural experience » of the ENS competitive entrance exams, is that discrimination does not systematically reinforce gender stereotypes. Consequently, we probably need to find other possible reasons to explain and to address the lack of women in the hard sciences.

While this result is shown in a particular context – that of competitive exams for entry into a *Grande école* – it seems to have broader applicability. Indeed, **the conclusions of this study confirm those of other research carried out in very different contexts**, which suggest that girls are not necessarily discriminated against at school. Recent research by Camille Terrier reveals similar findings, of bias in teachers' marks in favour of girls in mathematics, seen among the pupils the last year of junior high school in the Créteil académie (see IPP Note no. 14, published in tandem with this one).

Finally, if girls hesitate to choose the most male-dominated streams, **it is partly because they have internalised the stereotyped idea that those disciplines are not for them**. They may thus imagine that they will not be welcome or will be discriminated against in those areas, possibly like the female candidates in the ENS entrance exams who choose the most « feminine » options. This study shows that it is not the case: ENS candidates would gain more by choosing more « masculine » options. More generally, young women should not hesitate to choose the streams that they like the best, even if these are still largely dominated by men: in general, they are not discriminated against when they do.

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## References

This Note is based on research work led by Thomas Breda and Son Thierry Ly, which can be accessed on the authors' web page:

<http://www.parisschoolofeconomics.com/breda-thomas/wp.html>

For further reading, the site contains references to numerous works on the theme of gender discrimination in the sciences.

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