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# Is there a Matilda effect in academic patenting?

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## Introduction

Despite the important progress that has been made in the last decades, gender disparities in science are still an issue in most spheres of academia. There is a decreasing representation of women in each step of the academic career path (Shen, 2013), and women obtain less research funding (Ley & Hamilton, 2008), publish less (Larivière, Ni, Gingras, Cronin & Sugimoto, 2013; West, Jacquet, King, Correll & Bergstrom, 2013), patent less (Ding, Murray, & Stuart, 2006), and are less central in collaboration networks (Ghiasi, Larivière & Sugimoto, 2015) than men. In research teams, women tend to perform less important tasks than their male collaborators, and thus appear less often in key author positions (i.e., first and last) (Macaluso, Larivière, Sugimoto & Sugimoto, 2016).

One explanation put forward in the literature is the lack of recognition of women's achievements or potential, which Rossiter (1993) called "the Matilda effect". The literature contains substantial empirical evidence of the Matilda effect, such as the Lincoln, Pincus, Koster and Leboy (2012) study showing that women are less likely than men to win research awards. In a randomized experiment, Moss-Racusin, Dovidio, Brescoll, Graham, and Handelsman (2012) asked STEM faculty to rank the same application for a laboratory manager position, and found that male applicants were perceived as more competent and more hirable, and deserving of higher salaries than female applicants. Ceci & Williams (2011) however argue that discrimination against women in science is a problem of the past, and that today's gender disparities are mainly caused by factors relating to choices, preferences, and expectations. In 2015, the same authors published a study in which they found that women were twice as likely as men to be hired for assistant professor positions biology, engineering, economics, and psychology (Williams & Ceci, 2015). There thus seems to be some disagreement as to the existence, or at least the extent, of discrimination against women in science.

Patenting is a sector in which gender differences remain particularly striking (Ding et al., 2006). Women are patenting much less than men, not only in academia, but in industry and government as well (Sugimoto, Ni, West & Larivière, 2015). Previous studies identified factors such as women's lack of ties with the industry (Meng, 2016), their reserves about the commercialization of science (Murray & Graham, 2007), and their attitudes towards risk and competition (Stephan & El-Ganainy, 2007) as potential causes for the gender gap in patenting. Few studies have focused on the gender differences in the attribution of inventorship in academic research teams. Using survey data, Haeussler and Sauermann (2015) found that gender had no significant effect on inventorship. However, in an analysis of 680 patent-paper pairs (PPP) formed by patents and papers reporting the same discovery, Lissoni, Montobio and Zirulia (2013) found that women were more likely than men to be excluded from the patents. The present study takes this investigation a step further by analyzing a large dataset 6,838 PPPs to determine the relationship between gender and inventorship when controlling for the authors' position in the byline, their reported contribution, and the discipline.

## Data and Methods

Using a method similar to that used by Magerman, van Looy and Debackere (2015), we formed PPPs using articles in the Web of Science (WoS) published between 1991 and 2015 and USPTO patents applied for between 1986 and 2013. The authors and inventors were matched using their last names and first initials, and pairs were formed when at least one author on the paper was listed as an inventor on the patent, and when the similarity score of the two documents is equal to or greater than 0.30. The similarity score formula is $\frac{x(y+z)}{2yz}$, where $x$ is the number of common terms in the patent and the paper, and $y$ and $z$ are the total number of terms in the title and abstract of the patent and the paper, respectively. Additionally, the paper must have been published within one year prior to five years after the filing of the patent. In cases where multiple papers were matched to the same patent or vice versa, we kept the PPP for which the highest number of authors were also listed as inventors. If multiple matches remained, the PPP with the highest similarity score was kept. Additionally, we removed all cases where one or more inventor of the patent was not listed as an author on the paper to ensure as much as possible that all individuals who contributed to the patent are listed on the paper.

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PPPs were then divided into three disciplines: biomedical research, natural sciences and engineering. A paper is assigned to the discipline it cites the most; the disciplines of references are in turn based on the journal in which cited articles are published. We then identified authors' gender using a list of first names and gender developed by Bérubé, Ghiasi and Larivière (in preparation). Since WoS records did not include the full first names of authors before 2008, we retrieved the missing first names by looking up the articles online. Table 1 presents the resulting dataset.

**Table 1. Number of PPPs by discipline and number of authorships by gender and discipline.**

| | | Number of authorships | | | |
|---|---|---|---|---|---|
| **Discipline** | **Number of PPPs** | **Female** | **Male** | **Unknown** | **Total** |
| Biomedical research | 3,578 | 5,025 | 13,297 | 3,795 | 22,117 |
| Natural Sciences | 2,074 | 1,007 | 5,659 | 1,861 | 8,527 |
| Engineering | 1,186 | 425 | 2,479 | 863 | 3,767 |
| Total | 6,838 | 6,457 | 21,435 | 6,519 | 34,411 |

To account for the reported contribution of the authors in our analysis, we searched the full text of the article for all PPPs in biomedical research to retrieve the authors' contributions, when available. We were thus able to identify the contributions of the 1,142 authors of 142 articles, which we divided into six categories: conception, analysis, provision of material, experiment, writing, and supervision.

### Result

We used logistic regression models to determine the relationship between gender, position on the byline, and discipline and inventorship (Table 2, model 1). The second model in Table 2 includes the contribution (the discipline variable is excluded from the second model as contribution data was only collected for biomedical papers).

**Table 2. Binomial logistic regression models predicting inventorship.**

| Category | Variable | Model 1 | | Model 2 | |
|---|---|---|---|---|---|
| | | **B** | **SE** | **B** | **SE** |
| | Constant | -1.975* | 0.034 | -3.410* | 0.209 |
| Gender | Male | 0.437* | 0.046 | 0.456* | 0.209 |
| Position on the byline | First author | 2.322* | 0.049 | 1.921* | 0.310 |
| | Second author | 0.996* | 0.062 | 1.229* | 0.313 |
| | Third author | 0.204* | 0.063 | 0.610 | 0.361 |
| | Third to last author | 0.064 | 0.050 | -0.451 | 0.452 |
| | Second to last author | 0.715* | 0.046 | 1.192* | 0.298 |
| | Last author | 2.362* | 0.051 | 3.698* | 0.371 |
| Discipline | Engineering | 1.306* | 0.033 | | |
| | Natural sciences | 0.852* | 0.043 | | |
| Contribution | Conception | | | 1.142* | 0.198 |
| | Material | | | 1.099* | 0.247 |
| | Analysis | | | 0.593* | 0.201 |
| | Experiment | | | -0.068 | 0.209 |
| | Writing | | | 0.326 | 0.212 |
| | Supervision | | | -0.039 | 0.472 |

* $P < 0.05$.

The models indicate that inventorship is mostly related to the authors' position on the byline (models 1 and 2), and to their reported contribution to the research (model 2). Model 1 also shows that authors are most often named inventors in engineering, and least often in biomedical research. Model 2 shows that tasks relating to the conception of the experiment, the provision of materials, and the analysis are the only tasks that are positively and significantly associated with inventorship. Finally, and most importantly, we see that in both models, gender is a significant predictor of inventorship.

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The gender differences in the probability of being listed as an inventor are visualized in Figures 1 and 2. We see in Figure 1 that independently from their position on the byline, women are less likely than men to be inventors. Women occupying the third, third to last, and second to last positions in engineering are exceptions, as they appear to have a slight advantage over their male colleagues.

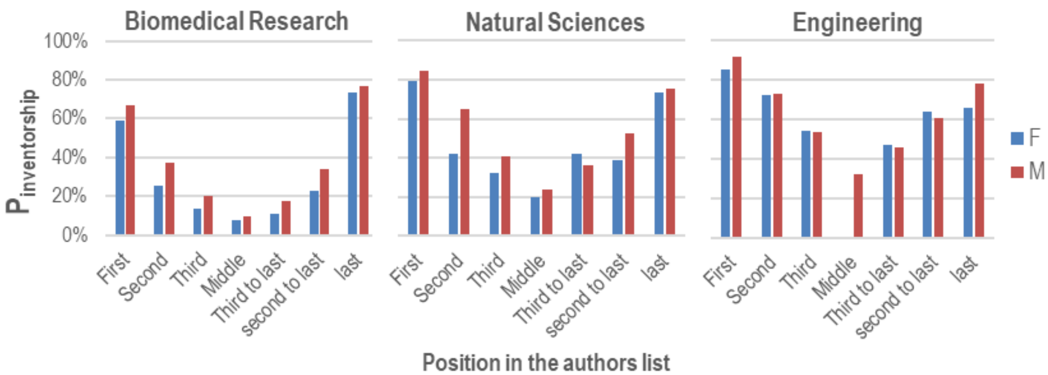


**Figure 1. Proportion of authors named inventors as a function of the position on the authors list, gender, and the discipline.**

For the subset of PPPs for which authors' contributions were available, Figure 2 shows that independently of their position on the byline, women are less likely than men to inventors when we consider only authors who did not contribute to either the conception of the experiment, the provision of materials, or the data analysis (the three significant predictors of inventorship identified in Table 2).

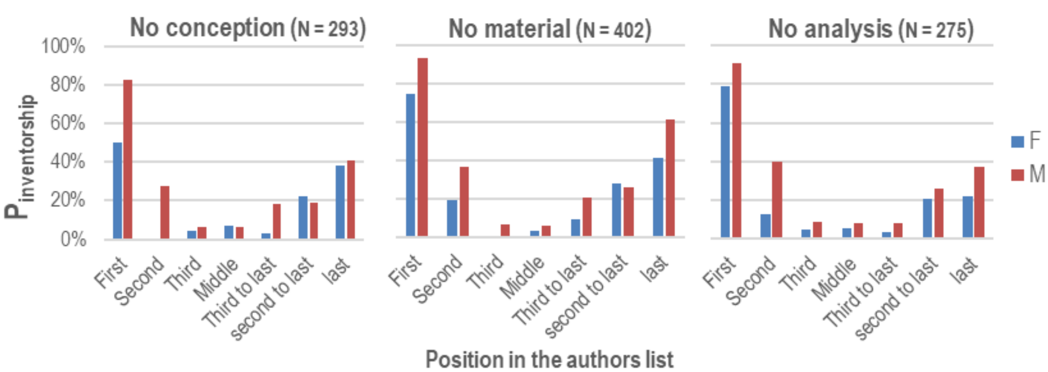


**Figure 2. Proportion of authors named inventors as a function of the position on the authors list, gender, and the type of contribution.**

Overall, our results seem to indicate that the differences in the proportion of female and male inventors are not solely explained by differences in the nature and extent of their contributions, and that other factors – potentially a Matilda effect – are at play.

**Discussion and conclusion**

Our results shed light on disciplinary differences in the division of labor, and more specifically on the division of inventive labor. The medical field appears to be more hierarchical, with the last author and, to a lesser extent, the first authors, monopolizing the intellectual work (and thus inventorship). At the other end of the spectrum, the intellectual work in Engineering appears to be shared more evenly among the members of the research team, as evidenced by higher and more evenly distributed rates of inventorship. Gender, however, appears more like a constant in our results: women being less likely than men to be listed as inventors on the patents.

A recent paper by Macaluso, Larivière, Sugimoto and Sugimoto (2016) provided compelling evidence that in collaborative research, women are more often performing less important tasks, while the more conceptual work is more often done by their male collaborators. This may partly explain why in absolute terms, women are patenting less than men. However, our results suggest that even when women *do* occupy key positions in the byline, and *do* perform conceptual work, they are less likely than their male colleagues to be rewarded for their work with inventorship. While progress has been made towards reducing gender inequalities in academia, and despite some claims that gender discrimination is no more an issue in contemporary science, our results suggest that the Mathilda effect is still affecting women in science today, at least when it comes to patenting, and that there is still a long way to go before we can really make gender disparities a problem of the past.

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