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The impact of gender on scientific writing: An observational study of grant proposals

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Abstract

Objectives: This study aimed to determine whether there are differences in the language used in grant applications submitted to a Southern Brazil Research Support Foundation (FAPERGS) according to the gender, career stage, and the number of publications of applicants.

Study Design and Setting: This observational study also evaluated the relationship between gender, career stage, curriculum, and writing characteristics. Summaries of all research proposals in the biomedical field of FAPERGS during the years of 2013 and 2014 were evaluated according to six language patterns (Positive emotions, Negative emotions, Analytic thinking, Clout, Authenticity, and Emotional tone) defined by the LIWC software. Applicant's gender, career stage, and the number of publications were also collected.

Results: Three hundred and forty-four (344) grant proposals met the inclusion criteria and were included in the analysis. No statistical differences were observed in the language pattern used by different gender applicants. In the language used by successful and unsuccessful applicants, we only found a small difference for clout (score 54.5 for not funded and 56.5 for funded grants). However, the principal investigators of successful applications had a significantly higher number of papers published (mean number of papers: 104 versus 58.5). Conclusions: Gender bias appears to be a more complex problem than just the type of language used; the way society is organized causes several gender biases that may be reflected throughout the women's career.

Keywords: Gender bias; Observational; Scientific writing; Grant

1. Introduction

Women have been underrepresented in the biomedical field within academia, and this gap widens at each career step, including promotion to full professor [1]. Studies have shown that in academia, men's competencies, productivity, leadership potential, and work quality are consistently evaluated to be superior to women based on gender identification alone [2–5]. There is also evidence that women earn lower salaries and receive fewer research grants [6,7].

Considering that funding is one of the main drivers of scientific activities globally, playing a significant role in defining new scientific projects and that financial aid in

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What is new?

Key findings

- There are no differences in language used by men and women in grant proposals among our sample applicants.
- The number of publications can more substantively affect the results of grant applications than the language patterns used in the application.

What this adds to what was known?

If women do not use different language patterns, gender bias in grant applications seems to be a much deeper problem.

The way society is organized causes several gender biases that may be reflected throughout the women's career.

What is the implication and what should change now?

Funding agencies, universities, and society need to take steps to consider the systemic bias that women experience throughout their careers.

research can also influence the performance of the funded scientist, gender bias in the grant application process can be a fundamental problem [8,9]. The literature indicates that gender inequalities in academia could be related to three main factors [10]. The first factor is individual bias, which can be connected to conscious or unconscious gender bias from reviewers' evaluations of grants. The second one is systemic bias related to how systems – or society in general – are organized. An example in funding agencies is the review criteria, which favor male applicants due to cumulative advantages: if men have more resources and opportunities, they will have more papers published. If they have a higher number of published papers, they will receive more funding what will facilitate the development of further studies and publication of papers, which is a cycle. The third and final factor is lower performance, which can be related to the unconscious use of modest, less compelling language by female applicants, which can also be related to how society represents gender identities [10].

A recent study reported that articles in which the first and last authors were women were less likely to use positive terms to describe research findings than articles in which a man had a leading position. This difference was more remarkable in higher impact journals [11]. On the other hand, another recent study did not identify differences in language choices between men and women applying to a Canadian funding agency [12].

Considering the need for more evidence on gender bias within academia, especially in the context of less developed countries, this study aimed to determine whether there are differences in the language used by female and male applicants' proposals for grant applications submitted to a Southern Brazil Research Support Foundation (FAPERGS). Another objective was to evaluate the relationship between gender, career stage, curriculum, and writing characteristics in accepting these grant applications.

2. Methods

2.1. Trial registration and ethical approval

The Local Ethics Committee (Federal University of Pelotas) approved the study protocol of the present study (protocol # 29343320.0.0000.5318), and the full protocol is available online on the Open Science Framework platform [13]. The consent term was signed by the funding agency president, who gave access to the data. Only one researcher (MCF) had access to original data and codified it before send it to other authors. Only the authors had access to the dataset. This study was reported according to STROBE (The Strengthening the Reporting of Observational Studies in Epidemiology) Statement, a reporting guideline for cross-sectional and case-control studies [14].

2.2. Study design

This study was an observational study partly designed as cross-sectional and partly as case-control, designed to evaluate language patterns between female and male applicants in summaries of research proposals in the biomedical field for a Southern Brazil Research Support Foundation during the years of 2013 and 2014, the most recent years available for research purposes with ethical approval to use from the granting agency. We used a case-control approach to examine language pattern differences between funded and unfunded grant applicants.

2.3. Eligibility criteria

Our inclusion criteria were FAPERGS (Fundação de Amparo à Pesquisa do Rio Grande do Sul, Brazil) grant applications in the biomedical field during 2013 and 2014. Our exclusion criteria were grant applications in fields other than biomedicine. Two team members (M.C.F., D.R.) independently reviewed all successful and unsuccessful grant applications, categorizing them as being included or excluded based on the eligibility criteria. Discrepancies were discussed between the two members to achieve consensus.

2.4. Control group

We matched (1:1 ratio) the included successful applications with a control group of unsuccessful applications. The sample was made by a randomized computer-generated list (www.sealedenvelope.com), and applications were matched by year of funding competition, call for application and content area. This allowed calculation of the pattern of the language of unsuccessful applicants in comparison to funded applicants.

2.5. Data extraction

The data extraction was independently entered by one team member (M.C.F.) and verified by a second individual (D.R.). The name and gender of the nominated principal applicant (NPA), year and modality of grant and title and summary of the application were extracted from each application. All abstracts were translated from Portuguese to English using an automatic translator software (DeepL, Köln, Germany). After the translation, the summaries were entered in the LIWC 2015 (Linguistic Inquiry and Word Count/Pennebaker Conglomerates, Austin, TX), and the software automatically extracted the primary outcome. Before beginning data extraction, a pilot exercise was completed using a separate set of applications.

2.6. Assignment of applicant gender, career stage, and research productivity

The gender of applicants was determined by associating the first names with the probability of the name being held by a man versus a woman, using the Genderize database (https://api.genderize.io/?name=). In cases where researcher gender was not strongly inferred (probability threshold of 90%), we checked how the applicant describes themselves in the applicants' CVs from an online platform widely used in Brazil (Lattes - http://lattes.cnpq.br).

The career stage of the applicants was classified according to the year of the Ph.D. completion. If the Ph.D. was obtained from 0 to 4 years before the grant process, the applicant was classified as early-stage, from 5 to 14 years, the applicant was classified as mid-stage, and for over 15 years, the applicant was classified as established stage. The year of Ph.D. completion was collected on the applicants' online CV on the Lattes platform.

The absolute number of published papers was our measure of the research productivity of the applicants. The number of published papers was collected from the applicants' online CV on the Lattes platform. This online and open access CV platform is available at a National Database, which contains all Brazilian researchers' data. The CV analysis carried out in all regional and national grant application processes in Brazil uses this online platform for researchers' assessment.

2.7. Outcomes

To assess whether men and women diverged in language patterns applied in their research proposal, we used the LIWC software to analyze the summaries and generate language patterns. LIWC is comprised of an extensive dictionary of words and compares inputted written text to its dictionary to generate scores for 92 language variables, including word count, words per sentence, 86 traditional variables, and four summary variables. The variables evaluated in this study were Positive emotions, Negative emotions, Analytic thinking, Clout, Authenticity, and Emotional tone (See Appendix 1 for more details). These six variables are research-based composites that have been converted to 100-point scales, where 0 = very low along the dimension and 100 = very high [15].

The LIWC dictionary is available for English language analyses, and the summaries of the grant proposals were in Portuguese. Therefore, all summaries were submitted to an automatic translation from Portuguese to English before the language pattern evaluation. The software used to translate the abstracts was DeepL (https://www.deepl.com/home), for producing a more natural and fluent output compared to other automatic translators available [16].

2.8. Statistical methods

A descriptive analysis was used to summarize data. Chi-squared test for linear trend was performed to determine the proportion of gender in every career stage. Student's *t*-test was used to determine the number of papers by gender and career stage. T-tests were also used to examine whether gender explains differences in the LIWC variables considered in this study (Positive emotions, Negative emotions, Analytic thinking, Clout, Authenticity, and Emotional tone). *t*-test was also performed to determine whether there were differences in language patterns between successful and unsuccessful proposals. A logistic regression model was performed to estimate the impact of the number of published papers on grant funding and assess a potential confounding bias by gender and career stage. For all the analyses, a $P<0.05$ was considered as statistically significant.

3. Results

Three hundred and forty-four (344) grant proposals met the inclusion criteria and were included in the analysis (172 funded grants and 172 controls – unsuccessful applicants). Table 1 shows the gender distribution of all grants submitted in the biomedical area and the distribution of funded grants. Females were the majority in both the total number of applications and grants funded, with 59.3% of funded applications led by women. Descriptive analysis of the distribution of funded grants according to career stage

Table 1. Total applications and funded applications per gender

Gender	Total applications	Funded applications
p=0.46		
Men	376 (37.67%)	70 (40.7%)
Women	621 (62.23%)	102 (59.3%)
Total	998 (100%)	172 (100%)

Table 2. Proportion of gender per career stage

	Gender				Total	
	Male		Female			
	n	row%	n	row%	n	row%
Career stage					$P = 0.172$	
Early	45	37.2	76	62.8	121	100.0
Middle	59	38.6	94	61.4	153	100.0
Established	34	48.6	36	51.4	70	100.0
Total	138	40.1	206	59.9	344	100.0

Table 3. Mean of the number of papers (confidence interval) published by gender and career stage

Career stage	Gender		*P*-value
	Men	Women	
Early	51.7 (40.4; 62.9)	45.1 (38.6; 51.5)	0.311
Middle	88.4 (69.8; 106.9)	66.6 (56.0; 77.2)	0.045
Established	183.9 (127.9; 240.0)	124.0 (93.1; 154.9)	0.063

of the applicants showed that the majority of funded grants were from applicants in the middle stages of their careers (41.9%), followed by early stages (34.9%) and established stages (23.2%) (data not shown).

The proportion of gender per career stage is presented in Table 2. There were a higher number of women in the early career stage, and that number decreases at every career stage. However, the differences between gender per career stage were not significant.

Table 3 presents results from a T-test with the number of papers published per gender in every career stage. Men have a higher number of publications in all career stages, and this gap is significant for middle career researchers.

Table 4 presents a T-test for the number of papers published, word count of the grant proposal abstract, and the six LIWC variables according to the gender of the applicant. No statistically significant differences were observed for any of the LIWC variables and the application's word count. When evaluating gender differences, men had a higher number of papers published than women ($P = 0.002$).

Table 5 presents the mean number of papers published, word count of the grant proposal abstract, and the score on the six LIWC variables according to the grant application outcome (funded or not). No differences were identified for word count and any of the LIWC variables but clout. However, funded grants had applicants with a higher number of papers published ($P < 0.001$).

Table 6 shows the mean number of papers published and writing pattern characteristics stratified by both grant application outcome and gender of the principal investigator. When stratified by both variables, a gender difference was observed in the number of publications among funded grants, with men having, on average, almost 50 extra published papers in comparison to women (133.5 versus 83.8 published papers).

Estimates from a logistic regression model show that the number of papers influences grant funding, independently of the principal investigator's career stage and gender (Table 7). For every extra published paper, the odds of having a successful outcome increases 1% (odds ratio 1.01, 95% confidence interval 1.01;1.02, $P < 0.001$).

4. Discussion

As far as we know, this is the first study to assess possible differences in language pattern used for grant applications according to the researcher's gender in South America. Overall, no differences were observed in the language pattern used by different gender applicants in summaries of biomedical research grant proposals. These results are in line with a previously published study that evaluated gender differences in language in Canadian NSERC (Natural Sciences and Engineering Research Council) summaries and also found that language between male and female applicants did not differ substantially [12]. The present findings can be explained because when writing becomes more technical, language differences between gender can decrease significantly, as already presented in linguistics studies [17].

Besides no differences in the language used by men and women in the language used by successful and unsuccessful applicants, we only found a small difference for clout – successful applications used a greater number of words that refer to clout. Still, the mean differences in the clout score were very small. However, the principal investigators of successful applications have a significantly higher number of papers published. These results show that the grant proposal's language is not determinant for being awarded. What seems to be more important is the applicant's CV, illustrated here by the number of published papers. This finding may represent systemic bias as men have a higher number of papers published when compared to women [18,19].

It is essential to point out that previous studies have shown that the number of women in academia decreases at each career step. While women are the majority among undergraduate students in various biomedical courses, they are a small minority in leadership positions such as full professorships [1,20]. This suggests that gender bias occurs in the earliest stages of a researcher's career (e.g., during graduation) and remains during the whole career course.

Table 4. Mean of number of papers, word count, and LIWC variables by gender (unequal distribution) with confidence intervals

	Men	Women	*P*-value
Number of papers	99.9 (82.0; 117.9)	68.7 (60.4; 77.0)	0.002
Word Count	320.9 (300.8; 341.0)	341.1 (325.1; 357.1)	0.121
Analytic Thinking	98.0 (97.7; 98.3)	98.0 (97.7; 98.2)	0.767
Clout	55.7 (54.4; 57.0)	55.4 (54.2; 56.6)	0.740
Authenticity	17.3 (15.2; 19.3)	17.5 (15.6; 19.4)	0.877
Emotional Tone	33.4 (30.1; 36.8)	35.9 (33.0; 38.7)	0.280
Positive Emotions	1.55 (1.40; 1.69)	1.56 (1.42; 1.70)	0.885
Negative Emotions	1.34 (1.11; 1.56)	1.22 (1.02; 1.26)	0.107

Table 5. Mean of number of papers published, word counts of the grant proposals, and LIWC variables by grants' outcome (unequal distribution) with confidence intervals

	Grants not funded	Grants funded	*P*-value
Number of papers	58.5 (51.3; 65.6)	104.0 (88.4; 119.6)	<0.001
Word Count	321.6 (303.2; 340.0)	344.4 (327.5; 361.3)	0.073
Analytic Thinking	98.0 (97.7; 98.3)	98.0 (97.8; 98.2)	0.799
Clout	54.5 (53.3; 55.8)	56.5 (55.3; 57.7)	0.025
Authenticity	17.8 (15.6; 19.9)	17.0 (15.2; 18.8)	0.598
Emotional Tone	34.2 (31.1; 37.3)	35.6 (32.5; 38.7)	0.525
Positive Emotions	1.50 (1.35; 1.66)	1.61 (1.47; 1.74)	0.312
Negative Emotions	1.23 (1.04; 1.42)	1.19 (1.04; 1.35)	0.777

Table 6. Career stage of applicants and mean of number of papers, word count, and LIWC variables by grant application outcome and gender (unequal distribution) with confidence intervals.

	Grants not funded[I]			Grants funded		
	Men	Women	*P*-value	Men	Women	*P*-value
Career stage[II]			0.62			0.39
Early	22 (36.1)	39 (63.9)		23 (38.3)	37 (61.7)	
Middle	32 (39.5)	49 (60.5)		27 (37.5)	45 (62.5)	
Established	14 (46.7)	16 (53.3)		20 (50.0)	20 (50.0)	
Number of papers[III]	65.5 (51.9;79;1)	53.9 (46.1;61.7)	0.14	133.5 (102.1;164;8)	83.8 (69.4;98.1)	
Word Count[c]	312.1 (280.2;343.9)	327.8 (305.2;350.4)	0.42	329.5 (304.0; 354.9)	354.7 (332.0;377.3)	0.14
Analytic Thinking[III]	98.1 (97.6;98.5)	97;9 (97.5;98.2)	0.52	98.0 (97.6;98.4)	98.0 (97.7;98.3)	0.75
Clout[III]	54.9 (53.0;56.8)	54.3 (52.6;56.0)	0.66	56.5 (54.7;58.3)	56.5 (54.9;58.2)	0.98
Authenticity[III]	18.2 (15.0;21.3)	17.5 (14.6;20.5)	0.77	16.4 (13.6;19.2)	17.5 (15.0;19.9)	0.57
Emotional Tone[III]	31.4 (26.9;35.9)	36.0 (31.8;40.3)	0.14	35.4 (30.4;40.5)	35.7 (31.8;39.6)	0.93
Positive Emotions[III]	1.46 (1.25;1.67)	1.53 (1.32;1.74)	0.64	1.63 (1.42;1.83)	1.59 (1.41;1.78)	0.79
Negative Emotions[III]	1.44 (1.06;1.82)	1.09 (0.89; 1.28)	0.10	1.24 (0.99;1.49)	1.16 (0.96;1.36)	0.62

[I] Random sample of not funded grants, used as controls in this study.
[II] n(%).
[III] Mean (95% Confidence Interval).

Table 7. Association between the number of papers and grant outcome, adjusted for career stage and gender estimated using Logistic regression

	Odds ratio	95% Confidence interval	*P*-value
Number of papers	1.01	1.01; 1.02	0.002
Career stage	0.68	0.48; 0.96	0.030
Gender	1.23	0.77; 1.96	0.379

Only women who had already been successful through this biased process get to the stage of submitting a grant proposal as a Principal Investigator (PI), so, probably, at these higher career levels, gender bias may not be as apparent.

The findings also demonstrated a trend of gender disparity according to the career stage. A higher proportion of female researchers applying for grants are observed at all career stages than male researchers. However, the pro-

portion of females decreases at the late stages. From our findings, we can observe that in the early career phase, men and women are not far apart in terms of the number of published papers, but this changes substantially during the middle career years. Perhaps that is when women are starting families and taking on more home responsibilities, which may lead to their productivity falling behind in comparison to men. In addition to social pressure, which makes women have greater personal responsibilities compared to men (which is already a way of systemic bias), several other reasons make almost impossible for women have the same number of published papers as men, such as being assigned to more teaching and service responsibilities, receiving harsher peer review and having fewer invitations to write commentaries or articles [19,21,22]. During the established stages of careers, women's number of publications tends to increase slightly. However, the gap is already established and still plentiful.

Our findings demonstrate that applicants' number of publications is far more critical to be successful in a grant application than the language used in the proposal (that do not differ between men and women). It can suggest that the gap between men and women in grant proposals follows a cycle: men have more papers published (which may be due to not having the same domestic responsibilities as women in raising children, for example), a higher number of papers published will, in turn, result in men receiving a higher number of grants. A higher number of grants will lead to men being able to produce more papers and remain in the field, and in the future, be more successful in new grant applications [19].

This study's limitations include the automatic analysis of the language pattern, which can be limited according to the program's sensitivity. Besides that, the sample was composed of applicants' proposals for grant applications submitted to a Southern Brazil Research Support Foundation, which means that one has to be cautious in extrapolating these results to other contexts. Another relevant limitation of the present study is that, since we used an automatic tool to determine the applicant's gender, we considered gender as a binary variable, without considering gender diversity. Another critical point is that we used data from 2013 and 2014 since we only had access to this specific data. Future studies can be done with more recent data to compare findings among the years.

5. Conclusions

We can conclude from this study's findings that there are no differences in the language used by men and women in grant proposals among applicants in Southern Brazil. Therefore, factors such as the number of publications can more substantively affect the results of grant applications as compared to the language patterns used in the application. Gender bias seems to be a much deeper problem than just the type of language used; the way society is organized causes several gender biases that may be reflected throughout the women's career.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jclinepi.2021.01.018.

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