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FEMALE LANGUAGE IN POPULAR SCIENCE

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Abstract: *Fewer women than men are involved in STEM (Science, Technology, Engineering, and Mathematics) fields and one of the reasons might be a lack of exposure to familiar linguistic structures in reading materials designed to spark interest and to recruit new scientists. Popular science, as a multifaceted genre, creates an accessible kind of exposure to the scientific world that can potentially lead to a career in that field. Considering this potential of the genre and keeping in mind that most popular science is written by men, the present study examined fifteen articles (five written by men, five by women, and five co-written by authors of both genders) for the presence of female language. Female language was differentiated from gendered language (which is tied to female stereotypes) and identified based on the frequency of certain linguistic markers found in texts produced by women. The results demonstrate that women and teams of authors that include women write differently than men do, thus confirming previous investigations into differences in linguistic production between men and women. The study suggests that exposing young women considering a career in science to popular science written by females might be beneficial in cementing their aspirations, as language has a strong connection to self-perceived gender identity.*

Keywords: *female language, popular science, gender identity, STEM, women in science*

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1. Introduction

The fact that fewer women are involved in STEM (Science, Technology, Engineering, and Mathematics) and certain branches of social science such as economics, for example, has been well documented (Son & Bell, 2022; Wu, 2018), and by the middle of the 21st century several solid indicators of the problem were identified, with attempts made to address the underlying issues (MacKenzie et al., 2022). Scientific communication, in general, is broadly criticized for its inaccessibility to non-dominant social groups—i.e. male native speakers of English have a clear advantage (Ammon, 2012; Son & Bell, 2022). For linguists addressing the participation of women in science, the focus on gendered and biased language was the default analytical mode when contributing to the discussion. Many studies that uncovered the damaging effects of gendered language (e.g. Getchell & Beitelspacher, 2020; Hammer, 1997) were instrumental in helping remove some of the barriers for women to join research fields historically dominated by men. At the same time, the majority of these studies examined overt linguistic structures that represented the female in a stereotypically-unfit way. Wu (2018), for instance, notes that in economics fora women are routinely associated with such lexemes as "pregnant" and "breast"—highlighting physical attributes and functions.

The present study takes a different approach by looking at more covert linguistic structures that do not necessarily denote the female, yet are statistically associated with writing produced by females. A number of researchers have noted differences in male/female language produced in conversation (Plug et al., 2021 provide an excellent summary of existing research); however, fewer studies consider writing, while analyses of writing in a particular genre are especially lacking. One of the closest studies to analysing popular scientific communication is Sleath & Rubin (2002), who considered contextual variables in a medical setting, reporting findings from conversations between medical professionals and patients.

I hypothesise that a lack of linguistic representation in popular science publications targeting the general audience might be a contributing factor to a relatively weak women's involvement in STEM research fields. In other words, if young women considering careers in STEM do not come across linguistic constructs that they themselves produce, they may be less likely to find the subject matter and its associated career field engaging. The present study draws clear distinctions between gendered and female language and argues that while gendered language contributes to the alienation of women from STEM research fields, female language may be the means of attracting female and female-identifying researchers.

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To address the potentially problematic assumption of a dichotomy of female/male language, it might be beneficial to consider studies of linguistic activities associated with gender non-conforming individuals, trans individuals, and lesbian and gay persons, who in their attempts to move away from stereotypical perceptions of gender draw heavily on linguistic expression to achieve those means (e.g. Langer 2011). Such individuals, in pointing out the lack of gender-neutral expressions, inevitably uncover differences between female and male linguistic identities. "We…have a need to verbalize in order to formulate our identity to ourselves and for another to comprehend us as individuals" (Langer, 2011, p. 304). Such studies also offer additional evidence for the idea that "gender roles are culturally and socially determined" (Rey, 2013, p. 138). Specifically, they show a significant role language plays "in the construction of gender roles" (Rey, 2013, p. 138). What also becomes apparent is that the "norm" associated with the female/male language is clearly identifiable whether those involved in its production acknowledge it or not.

Several studies that intersect language use/production with psychology and self-identity present a clear connection between language and self-perception (Canagarajah, 2012; Corkhil, 1999; Langer, 2011). Canagarajah (2012), analysing ethnicities, argues that multiple linguistic identities can co-exist within one individual and that they emerge in "situated uses." Langer (2011) reports that certain gender groups may experience alienation and feelings of illegitimacy or non-belonging when participating in discourses that lack the language the group needs to recognize and describe itself. Corkhill (1999, p. 1042) advocates for studying "'authentic'" female language as a means of expression for "experience" and "self-identification" for women.

While the harmfulness of gendered language in public discourse has been well researched, the benefits of female language remain to be examined. Systematic investigations of female language to date tend to show that awareness of linguistic gender differences has a positive effect on dispelling stereotypes about female means of expression and presents a tool for combating gendered language.

To that effect, the present study is devoted to one aspect of scientific discourse—popular science articles published and available online in such outlets as *The Smithsonian, Wired, Discover, The Scientist,* and *The Scientific American*. The goal is to determine whether or not there is a significant lack of female language in these articles and how female language is distributed among articles written by women, men, and co-written by authors of both genders.

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1.1. Gendered versus Female Language

It is important to distinguish early on between gendered language and female language. In reviewing literature on the subject of gender linguistics in public discourse, I came across a notion that female language is no different from the stereotypical language associated with women. In this study, however, I wish to draw a clear line between what is the *expected* linguistic output for a female in the English language and what is the *natural language* that females and female-identifying individuals produce. The former, I will consider gendered language; while the latter I will regard as female language. It is the gendered—expected and stereotypical—language that can be harmful when produced by either gender, and it is the non-conformity to the gendered language that is at times detrimental to women. Gendered language can play a role in constructing a gender identity that conforms to stereotypical standards. Sohn (2022) introduces an example of a government using linguistic resources to shape women's identities. Research shows that "deviations from expectations of speaking style are more harmful for women than for men" (Roberts & Utych, 2020, p. 42). Natural female language, however, carries no stigma and is not tied to the stereotypically female domains of the home, family, caregiving, etc. As Roberts and Utych (2020) demonstrate through statistical investigation, "words are indeed often perceived as either masculine or feminine" without an added positive or negative connotation based on biological gender. The same researchers argue in favour of the "gendered personality," which, they suggest, "is often more predictive of attitudes and behaviours [including linguistic production] than one's biological sex or gender" (Roberts & Utych, 2020, p. 42). Female language manifests, I argue, through vocabulary and grammatical structures that are statistically more likely to occur in female and female-identifying individuals.

The importance of statistically-supported frequencies is underscored by Mulac et al.'s (2001, pp. 124-125) idea that differences in linguistic features between males and females "should be viewed as…gender-indicative tendencies" and not as "'speech markers'" which are associated with "group membership" and point to one group or another by mere presence. Gender-indicative tendencies, they suggest, "are used by both genders. It is the extent to which they are used" which allows differentiation. For instance, both males and females use hedging devices; however, several studies show evidence that hedges are found more often in texts produced by females (Holmes, 2005; Pfiester, 2009; Reid et al., 2003). Thus a hedge does not characterise male or female language, yet its frequency contributes to such identification. It is

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also significant to keep in mind that interlocutors tend to accommodate each other through shifts in style, tone, vocabulary, etc. In this regard, it is possible for a female to produce a male-language output or for a male to use female language when addressing a certain audience (e.g. Pfiester, 2009; Thompson et al., 2001). Thompson et al. (2001) observed that it was the gender of the addressee and not the gender of the writer that influenced production in their study of email messages.

It might be useful for writers of popular science not to simply acknowledge the reader as someone not versed in a particular subject (as many current writing manuals suggest), but to take a subtler approach to readership identities. It is, of course, impossible to anticipate all aspects of reader identity, yet such a general category as gender could be helpful to consider since it is one of the more powerful social identities and one that correlates with linguistic production. To use terminology from social identity theory (Burke, 1969; Burke & Stets, 2009; Stets & Cast, 2007), popular science written with the idea of targeting female readers, through the use of female language, can become a resource in identity verification for those women who intend to join the scientific community. Resources can be "objects, goods" that are "symbolic or material" that offer a benefit in terms of power in society or offer some type of enhancement to an interaction (Stets & Cast, 2007, pp. 518-519). Certainly, written popular science fits this category.

1.2. Female Language and Written Popular Science

In general, written popular science is an interactive genre, and when it comes to the analysis of female language, multiple studies (e.g. Hannah & Murachver, 2007; Holmes, 2005; Mulac et al., 2001; Pfiester, 2009; Rey, 2013; Roberts & Utych, 2020; Stubbe, 2013; Thompson et al., 2001) suggest various manifestations of interactivity as features of female language. Because of this overlap, it is important to determine a list of features signalling female language and to exclude those features that might be categorized as "female" yet are attributes of written popular science as a genre.

The interactivity of popular science is well established (e.g. Calsamiglia, 2003; Gülich, 2003; Luzón, 2013; Moirand, 2003; Myers, 1990, 2003, 2010; Pilkington, 2016). Within the general notion of interactivity, there are two terminological categories—interactional metadiscourse (Fu & Hyland, 2014; Hyland, 2005a, 2005b, 2010; Hyland & Jiang, 2016) and dialogicity (Aull & Lancaster, 2014; Calsamiglia & Ferrero, 2003; Lancaster, 2016a, b;). Both aim to describe and label ways in which written popular science establishes a relationship

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between the author and the reader. As a result of these studies, a clear list of linguistic markers that contribute to interactivity is available. Fu and Hyland (2014) supply a comprehensive summary of interactivity features, which could be found in other studies as well. These include: hedges, boosters, attitude and engagement markers (reader-inclusive pronouns, questions, asides, self-mentions).

Hedges and questions are linguistic markers that correspond to both popular scientific writing and female language. Other overlapping features fall under the category of attitude markers and have been labelled in female language as "references to emotion" (Thompson et al., 2001), "intensive adverbials" (Mulac et al., 2001), "uncertainty verbs" (Mulac et al., 2001).

While attitude markers and questions are important intentional features of popular scientific writing, hedging deserves special attention since it is a bridge feature between professional and popular scientific writing and performs multiple communicative functions from indicating uncertainty (e.g. Hyland, 1998) to stance taking (Aull & Lancaster, 2014; Lancaster, 2016) to signalling fictionality (Limnios, 2022). When it comes to hedging as a feature of female language, most of the studies consider hedging, but not every study that sets out to analyse the frequency of hedging reports significant differences between production in males and females. For instance, Hancock and Rubin (2015) and Waara & Shaw (2006) observed no differences. When significant preference for hedging is found in the language produced by females, it is most often associated with tentativeness and uncertainty (Holmes, 2005; Pfiester, 2009; Reid et al., 2003).

Since the present study focuses exclusively on the genre of written popular science, it will exclude hedges, questions, and attitude markers from the features of female languages because of their prominence in the genre of writing under investigation. As such, the list of female features under consideration includes *dependent clauses, sentence initial adverbials, oppositions and negations*.

2. Method and Data Collection

In order to determine what grammatical structures and/or vocabulary are quantitatively more likely to occur in texts produced by females, I turned to studies in psycholinguistics and sociolinguistics that describe male and female language output in quantitative terms. It was important to distinguish actual quantified data from culturally perceived norms. For example, Thompson et al. (2001) report the following cultural expectations for female language: intensive adverbials, subordinating conjunctions, compliments, modals, hedges, questions, self-

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derogatory comments, lack of opinion, and focus on emotions. At the same time, Mulac et al. (2001) and Thompson et al. (2001) concluded that, in general, the statistical distribution matches the culturally perceived norms. Nevertheless, this study will disregard those features of female language for which no quantitative data exists. Plug et al. (2021) conducted a comprehensive literature review of studies concerning quantitatively observed female/male linguistic markers. Their study and several others (e.g. Mulac et al., 2001; Pennebaker, 2011; Rey, 2013; Roberts and Utych, 2020; Thompson et al., 2001) provide the basis for the features of female language examined in the present study. Taking into consideration the overlaps between interactional/dialogic markers inherent to written popular science (outlined in section 1.2), the features of female language examined were limited to *dependent clauses not associated with hedging*, that is, dependent clauses with markers other than "if"; *sentence initial adverbials, oppositions* (including subordinate conjunctions), and *negations*.

The articles for analysis were selected from non-subscription options from *Scientific American*, *Smithsonian Magazine*, *The Scientist, Discover*, and *Wired*. From each popular science outlet, I selected articles published in 2022 and 2023 to represent the texts that today's young women interested in STEM are likely to encounter. Five articles written by female authors and five articles by male authors were examined alongside five articles written by teams of two or more authors representing both genders. The magazines listed above were chosen for their name recognition and popularity among lay readers and for the accessibility of the material (non-subscription options). The main selection criterion for the articles was the gender of the authors; secondly, I looked to cover a wide variety of STEM subjects. In total, I worked with a corpus of 28416 words (15 articles). To identify female and male authors I used the names provided by the magazines. To make sure that the names and gender matched correctly, I conducted a google search for each author to determine the pronouns used by each person. Only binary gender norms were considered, and no non-binary authors were identified through the search.

Once the articles were selected, they were manually coded for the presence of female language markers. To do so, I used the FIND feature of a word-processing software. To identify dependent clauses, I isolated the following markers: *after, although, as, as if, because, before, even if, even though, if, in order to, since, though, unless, until, whatever, when, whenever, whether, and while* (based on Hancock & Rubin, 2015) and examined the sentences where they occur to make sure each instance corresponded to a dependent clause. To record instances of oppositions, I searched for *but* and *yet* (based on Mulach et al., 2001). Finally, I analysed each

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of the articles for the presence of the following negation markers: *not, didn't doesn't couldn't, wouldn't* (based on Hancock & Rubin, 2015). Since no previous study of frequency of female language markers supplied a list of sentence-initial adverbials likely to occur, I marked every adverb placed at the beginning of sentences. For example, the following sentence from Scoles (2023), starts with an adverb: "**Eventually** that system started to build the biological equivalent of 747s (and then actual 747s)." This and similar sentences throughout the corpus were coded as containing sentence-initial adverbials.

For each article a percentage of female language markers was calculated out of the total number of words. This method, in addition to providing percentages of female language markers for each article, also allowed me to calculate averages for each author group along with total percentages of female language features in each group. The numerical findings are displayed in Tables 1-3. in the following section.

3. Results

Having analysed the three groups of articles, I identified a pattern where features of female language are more frequent in texts written by female authors and in co-authored articles while articles written by male authors exhibit a comparative lack of female language. The details of the findings are presented in Tables 1, 2, and 3 below. The appendix provides bibliographical information for the articles marked 1-5 in each group.

Author Type	Article 1	Article 2	Article 3	Article 4	Article 5
Female	0.7%	2.3%	1.8%	1.6%	2%
Male	0.2%	0.8%	1.5%	0.8%	1.2%
Co-authored	2%	1.3%	0.3%	0.8%	2%

Table 1. Frequency of Female Language Markers across Individual Articles

Author Type	Total % of Female Language	Average % of Female Language	Number of words Analysed
Female	8.4	1.68	15647
Male	4.57	0.7	5422
Co-authored	6.43	1.2	7347

Table 2. Summative Frequencies of Female Language Markers

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A nearly 4% difference between total features of female language in articles written by women and articles written by men supports previous studies' conclusions that a difference in linguistic production does exist and is significant enough to be quantifiable (e.g. Thompson et al., 2001; Rey, 2013; Roberts & Utych, 2020; Mulac et al., 2001; Pfiester, 2009; Hannah & Murachver, 2007; Holmes, 2005; Stubbe, 2013). Some of the previous studies (e.g. Hazenberg, 2016) also considered linguistic production of queer or transgender individuals; however, none of the previous researchers looked at frequencies of female language markers in texts created by mixed groups. While the present study supplies a very small sample, it may still be indicative of a trend. It is worth noting that those studies that reported no significant difference (e.g. Waara & Shaw, 2006, Hancock & Rubin, 2015) considered hedges as one of the analytical categories. The present study, as noted above, did not take hedges into account. Overall, I report differences across the features analysed. For details, see Table 3.

Author Type	Dependent clauses	Oppositions	Negations	Sentence-initial adverbials
Female	84	82	58	6
Male	26	18	10	3
Co-authored	49	14	35	9

Table 3. Number of Individual Markers of Female Language

When it comes to frequency of individual markers of female language, dependent clauses appear to be the most indicative feature, while sentence-initial adverbials are the least frequent. The dependent clause is the most frequent marker in both female-written and male-written articles. In articles written by women, however, oppositions are a very close second most frequent element, while the difference in the number of occurrences of dependent clauses and oppositions in male authored texts is even greater. The comparison with the co-authored articles renders similar results where the dependent clause is still the most frequent feature of female language and the sentence initial adverbial is the least observed one. However, the second most frequent category in co-authored articles is that of negations.

3.1. Female Language in Presented Discourse of Scientists

Distribution of the female language markers within the sections of the articles (Introduction, main body—including explanatory segments, conclusion) does not have a

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notable pattern; however, when considering female language features in presented discourse of experts interviewed for the articles, there appears a discernible difference.

In popular science, presented discourse can be seen as simply quoting or paraphrasing scientists. It is a common way for popular science authors to achieve credibility and to include expert knowledge. "There is more to the idea of presented discourse, however. First of all, it doesn't deal with speech only. A writer or speaker can easily present the thoughts of others. Second of all, more recently, linguists have started talking about the presentation of writing alongside presentation of speech and thought" (Pilkington, 2019, p. 24). The examined articles contain all three types of presented discourse of experts. Essentially, presented discourse can be a place where the voices of the author and of the expert merge, and it could be hard for an ordinary reader to distinguish between them. Presented discourse is an important feature of written popular science and has been established as a carrier of multiple vital aspects of content from explanation to fictionality and dramatization (e.g. Pilkington, 2019). Pilkington (2018, pp. 46-47) shows that presented discourse can be used to enhance introductions of discoveries and to make dense scientific information more accessible and relatable. She also argues that presented discourse is a textual space where important relationships between the experts and the readers are forged (Pilkington, 2018, pp. 174-175).

As Livnat (2012, p. 59) points out, "In scientific writing, the act of handling other speaker's utterances is less free than in other genres." This holds true for popular science as a subset of scientific writing. Livnat (2012, p. 59) continues to say that each author who includes presented discourse is bound to include his or her own interpretation of what an expert says, thinks, or writes. Taking these assertions into account, it is important to see if the presented discourse carries female language features and to what degree. In other words, are the authors themselves responsible for the female language markers or do they "outsource" this feature to the scientists whose words they include in the articles?

The majority of female language markers occur in narrated portions of the articles with presented discourse carrying a small number of such features. The number of female language features found in presented discourse of the articles written by women (42) is significantly greater than in male-authored and co-authored texts (14 and 15 respectively). At the same time, when percentages and not numbers are analysed, the initial pattern is preserved. See table 4. Articles written by women and co-authored articles employ a similar percentage of female language features, while male authors demonstrate different frequency counts.

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Type of Author	Percentage of Female Language in Presented Discourse
Female	16.8
Male	24.5
Co-Authored	13.5

Table 4. Percentage of Female Language Features in Presented Discourse out of Total Number of Female Language Features in Each Group of Articles

This raises the question: do male authors tend to include presented discourse of women more so than men? The answer is no: male authors include presented discourse of men more frequently than presented discourse of women. Male authors who included presented voices of women did not demonstrate features of female language in those passages. Out of the five male-written articles only two (articles 3 and 5—see the Appendix for bibliographical information) exhibited presented discourse that contained female language. It is worth considering that while the gender of a quoted or paraphrased scientist is notable, it is ultimately the article author's choice to decide what presented discourse to introduce to the reader and how to do it, and the decision to include presented discourse with or without female language features is likely a choice based on content, rather than a conscious decision based on the type of language.

Overall, the frequency data reveal a clear pattern where female and co-authored articles demonstrate similarities, while male written articles stand out in the comparison.

4. Discussion

Plug et al. (2021, p. 59) in their summary of gender language studies come to a conclusion that the findings on the differences of male and female features are inconclusive due to "the diversity of the studies' theoretical perspectives, purposes, and contextual settings." At the same time, the studies in this area of gender linguistics continue to be published, which obviously demonstrates a continued interest among researchers and points to the existence of evidence. In their remarks about inconclusiveness of the findings, Plug et al. (2021) never mention lack of evidence. One of the problematic variables that they identify is "contextual settings." It is, perhaps, true that identifying iron-clad parameters for female and male language that would apply to any linguistic situation is a huge challenge; what is more achievable, however, is identifying female language in a specific context—as this study does.

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Having identified the general features of the context (or genre, in this case), it is possible to determine what female language would look like in this particular environment. For instance, including hedges, intensifiers/boosters, questions, and references to emotion would have falsely increased frequency counts for female language features in popular science. The above-mentioned categories do signal female language in other contexts, but in popular scientific writing they are genre conventions, and both female and male authors are bound to use them. Thus, the very limitations of the present study—confining it to one genre and working with a small corpus—prove to be valuable constraints that help avoid generalization of the findings.

It appears that popular science has not been a context of frequent analysis when it comes to female language features. According to Plug et al. (2021, p. 58) "[A] substantial amount" of research on gender and linguistic production has been undertaken in "the medical domain;" however, written popular science was not reported as an analytical contextual setting. On the other hand, many discussions on the role of women in science have taken (and continue to take) place, and popular science is a universally recognized recruitment and visibility outlet.

Popular science as a genre and related literary genres of lab lit and science fiction, however, continue to be dominated by men (Marchant, 2011). The same is true for professional scientific writing (Son & Bell, 2022) and some educational materials (Chapman, 2022, Murray et al., 2022). And as the data presented here demonstrates, men tend to write in a way that is different from women when both genders compose within the genre. It is thus possible to suppose that women initially interested in science might feel discouraged or less engaged since they are not seeing themselves represented linguistically. Previous studies of gender disparity in science (e.g. Murray et al., 2022; Son & Bell, 2022; Ross et al., 2022), considered non-linguistic representation such as images and authorship credit. At the same time, linguistic identity is an important factor in engagement with the scientific community. Studies by Corkhill (1999), Langer (2011), and Rey (2013) show that linguistic identity is connected to self-perception, satisfaction, and well-being.

Lack of exposure to female language in popular scientific texts is a subtle but potentially crucial detractor in women's engagement with science. Current efforts to increase the visibility of women in science and to attract new potential scientists focus on visual representation and exposure to female role models already successfully functioning in the field. The potential of language, it seems, has not been explored to its full potential although there are efforts like that of Sarah Chapman (2022) that do rely on language. Chapman's (2022, p. 173) messaging

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protocol "IMPACT instead of LABEL" advocates for the use of one type of language as opposed to the other. Her protocol though does not take into account linguistic gender identity. Prieto-Rodriguez et al. (2022) does focus on identity but centres on a STEM identity for girls, which does not necessarily incorporate language. However, as this study demonstrates, gender language identity is a powerful component that is currently underutilized in STEM recruitment efforts for females.

It is the recommendation of this study to increase access to popular science written by women (including co-authored pieces where at least one member of the writing team is female) for those females who are considering scientific careers. Female language can become one more facet of the complex mosaic of efforts currently employed to equalize women's place in the scientific community.

The pattern that this study identified, where articles written by a group of authors that includes at least one female resemble articles written by women, is indicative of a number of social factors. First of all, it is possible that in a group-authorship setting women are more likely to be producing the texts. If this is the case, then female language features can serve as evidence of a disparity—men collect data, women are left to write it up. Ross et al. (2022), however, identify a different disparity where women are denied attribution altogether. Their study employed qualitative strategies (interviews) and statistical analysis of published articles and compared them to records team members kept during research projects. Ross et al. (2022) did not consider any linguistic features, yet the analysis of female language markers in a given article or a corpus can provide one more point for potentially missing authorship credit. An article with all male authors that is high in female language markers might raise a red flag. On the other hand, the fact that female language features in co-written articles are more prominent points to a significant role women play in creating consumable products of research. As a classic study by Latour & Woolgar (1986) suggests, texts (especially articles) can be seen as final outcomes of research in the scientific community.

5. Conclusion

The study examined 15 popular scientific articles available online without subscription fees from the followings journals: *Scientific American*, *Smithsonian Magazine*, *The Scientist*, *Discover*, and *Wired*. Five of the articles were written by female authors, five by male authors, and five were co-written by teams where both genders were represented. In total, 28416 words were examined for features of female language. To determine what linguistic features qualify

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as "female," a range of previous studies was consulted, and only those features that were quantifiable and quantified by other researchers were considered. After compiling a list of female linguistic markers, I considered the writing conventions of the genre popular science. Upon consideration, it became clear that certain features of female language prominent in previous studies would not function as gender markers in popular scientific writing as they constitute genre conventions that any author is bound to employ with sufficient frequencies. Thus hedges, boosters, questions, and appeals to emotion were excluded even though other studies identified them as quantifiable indicators of female language. The markers of female language that this study analysed were: dependent clauses with indicators other than "if" (to avoid hedges) sentence initial adverbials, negations, and oppositions.

As a result of the analysis, it became evident that there are differences between articles written by women and those written by men. The number of female language markers was higher (8.4%) in articles written by women compared to articles with male authors (4.57%). At the same time, articles co-written by males and females exhibited similarities to texts produced by women, with female language markers accounting for 6.43%. This similarity was preserved when female language in presented discourse was considered. It appears that men included presented discourse of experts with more markers of female language, however.

Overall, the study contributes to an existing body of research that confirms quantifiable differences between female and male language. While previous investigations focused on spoken conversations and medical communication, the present analysis adds popular scientific writing to the contextual fields examined. The identifiable differences between male and female writing in the genre of popular science may potentially influence the recruitment of women into the field. Up to this point, recruitment efforts do not show a robust focus on language; however, this study demonstrates that a focus on language might prove productive.

Appendix - Bibliographical Information for the Analysed Articles Coded 1-5 in Each Group

Female Authored Articles:

1. Dance, A. (2022). Could getting rid of old cells help people live disease-free for longer? *Smithsonian Magazine*, December. https://www.smithsonianmag.com/innovation/could-getting-rid-of-old-cells-help-people-live-disease-free-for-longer-180981361/
2. Doudna, J. (2023). By studying corn, Barbara McClintock unlocked the secrets of life. *Smithsonian Magazine*, March. https://www.smithsonianmag.com/smithsonian-institution/by-studying-corn-barbara-mcclintock-unlocked-secrets-life-180981555/

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3. Scoles, S. (2023). Scientists are abandoning conventional thinking to search for extraterrestrial creatures that bear little resemblance to Earthlings. *Scientific American*, February. https://www.scientificamerican.com/article/the-search-for-extraterrestrial-life-as-we-dont-know-it/
4. Thompson, A. (2023). How to engineer buildings that withstand earthquakes. Scientific American, February 22. https://www.scientificamerican.com/article/how-to-engineer-buildings-that-withstand-earthquakes/
5. Tucker, A. (2022). Sniffing out the science of smelling. *Smithsonian Magazine*, October. https://www.smithsonianmag.com/science-nature/scientific-mysteries-smelling-180980756/

Male Authored Articles:

1. Byrne, B. (2022). Here's what the black hole in the center of the milky way looks like. *Smithsonian Magazine*, May. https://www.smithsonianmag.com/science-nature/heres-what-the-black-hole-in-the-center-of-the-milky-way-looks-like-180980078/
2. Falk, D. (2023). What does the universe sound like? *Smithsonian Magazine*, March. https://www.smithsonianmag.com/science-nature/what-does-the-universe-sound-like-180981715/
3. Handwerk, B. (2023). This man underwent brain surgery 3,500 years ago. *Smithsonian Magazine*, February. https://www.smithsonianmag.com/science-nature/in-roughly-1500-bce-this-middle-eastern-man-underwent-brain-surgery-180981679/
4. Mann, A. (2023). Has anyone created a black hole on Earth? *Scientific American*, February 14. https://www.scientificamerican.com/article/has-anyone-created-a-black-hole-on-earth/
5. O'Callaghan, J. (2023). Scientists made a new kind of ice that might exist on distant moons. *Scientific American*, February 7. https://www.scientificamerican.com/article/scientists-made-a-new-kind-of-ice-that-might-exist-on-distant-moons/

Co-authored Articles:

1. Burgess, M., Schot, E., & Geiger, G. (2023). This algorithm could ruin your life. *Wired*, March 6. https://www.wired.co.uk/article/welfare-algorithms-discrimination
2. Drakeford, C. M., & DelViscio, J. (2023). This particle accelerator makes a substance that has not existed in 13 Billion years. *Scientific American*, February. https://www.scientificamerican.com/video/this-particle-accelerator-makes-a-substance-that-has-not-existed-in-13-billion-years/
3. Phelps, S., Donaldson, Z., & Manoli, D. (2023). Monogamous prairie voles reveal the neurobiology of love. *Scientific American*, February. https://www.scientificamerican.com/article/monogamous-prairie-voles-reveal-the-neurobiology-of-love/
4. Piszczek, M., & McAlpine, K. (2023). The psychological benefits of commuting. *Discover*, March 9. https://www.discovermagazine.com/mind/the-psychological-benefits-of-commuting
5. Wu, C., Cheresh, D., & Weis, S. (2023). Stopping the cancer cells that thrive on chemotherapy. *The Scientist*, January 17. https://www.the-scientist.com/news-opinion/opinion-stopping-the-cancer-cells-that-thrive-on-chemotherapy-70897

2023 Author(s). This is an open access article licensed under the Creative Commons Attribution 4.0 International Public License (http://creativecommons.org/licenses/by/4.0/).

References

Ammon, U. (2012). Linguistic inequality and its effects on participation in scientific discourse and on global knowledge accumulation: With a closer look at the problems of the second-rank language communities. *Applied Linguistics Review 3*(2), 333–355. https://doi.org/10.1515/applirev-2012-0016 (accessed 10 April 2023).

Aull, L., & Lancaster, Z. (2014). Linguistic markers of stance in early and advanced academic writing: A corpus-based comparison. *Written Communication 31*(2), 151–183.

Burke, K. (1969). *A rhetoric of motives.* University of California Press.

Burke, P. J., & Stets, J. E. (2009). *Identity Theory*. Oxford Academic.

Calsamiglia, H. (2003). Popularization discourse. *Discourse Studies 5*(2), 139–146.

Calsamiglia, H., & Ferrero, C. L. (2003). Role and position of scientific voices: Reported speech in the media. *Discourse Studies 5*(2), 147–173.

Canagarajah, A. S. (2012). Migrant ethnic identities, mobile language resources: Identification practices of Sri Lankan Tamil youth. *Applied Linguistics Review 3*(2), 251–272. https://doi.org/10.1515/applirev-2012-0012

Chapman, K. (2022). Chemistry textbooks still portray men as scientists while women perform domestic duties. *Chemistry world*. Royal Society of Chemistry. 6 January. https://www.chemistryworld.com/news/chemistry-textbooks-still-portray-men-as-scientists-while-women-perform-domestic-duties/4014991.article (accessed 21 April 2023)

Chapman, S. (2022). The Power of partnerships to promote engagement of young people in STEM: International and local perspectives. *Gender, Science, and Technology 14*(2), 169–175. http://genderandset.open.ac.uk

Corkhill, A. (1999). Female language theory in the age of Goethe: Three case studies. *The Modern Language Review 94*(4), 1041–1053. https://doi.org/10.2307/3737236

Fu, X., & Hyland, K. (2014). Interaction in two journalistic genres: A study of interactional metadiscourse. *English Text Construction 7*(1), 122–144.

Getchell, K., & Beitelspacher, L. S. (2020). Better marketing for female marketers: Gendered language in the Forbes CMO list. *Business Horizons 63*(5), 607–617.

Gülich, E. (2003). Conversational techniques used in transferring knowledge between medical experts and non-experts. *Discourse Studies 5*(2), 235–263.

Hammer, H. (1997). Symbolic exclusion in statistical literature: The impact of gendered language. *The American Statistician 51*(1), 13–19. https://doi.org/10.2307/2684685 (accessed 21 March 2023)

Hancock, A., & Rubin, B. (2015). Influence of communication partner's gender on language. *Journal of Language and Social Psychology 34*(1), 46–64. https://doi.org/10.1177%2F0261927X14533197

Hannah, A., & Murachver, T. (2007). Gender preferential responses to speech. *Journal of Language and Social Psychology 26*(3), 274–290. https://doi.org/10.1177%2F0261927X06303457 (accessed 19 April 2023)

Hazenberg, E. (2016). Walking the straight and narrow. *Gender and Language 10(2)*, 270-294. https://doi.org/10.1558/genl.v10i2.19812

2023 Author(s). This is an open access article licensed under the Creative Commons Attribution 4.0 International Public License (http://creativecommons.org/licenses/by/4.0/).

Holmes, J. (2005). Leadership talk: How do leaders 'do mentoring', and is gender relevant? *Journal of Pragmatics 37*(11), 1779–1800. https://doi.org/10.1016/j.pragma.2005.02.013

Hyland, K. (1998). *Hedging in scientific research articles*. John Benjamins.

Hyland, K. (2005a). *Metadiscourse: Exploring interaction in writing.* Continuum.

Hyland, K. (2005b). Representing readers in writing: Student and expert practices. *Linguistics and Education 16*, 363–377.

Hyland, K. (2010). Constructing proximity: Relating to readers in popular and professional science. *Journal of English for Academic Purposes 9*, 116–127.

Hyland, K., & Jiang, F. (2016). Change of attitude? A diachronic study of stance. *Written Communication 33*(3), 251–274.

Lancaster, Z. (2016). Expressing stance in Undergraduate Writing: Discipline-specific and General Qualities," *Journal of English for Academic Purposes 23*, 16–30.

Langer, S. J. (2011). Gender (dis)agreement: A dialogue on the clinical implications of gendered language. *Journal of Gay & Lesbian Mental Health 15(3),* 300–307.

Latour, B., & Woolgar, S. (1986). *Laboratory life: The construction of scientific facts*. Princeton University Press.

Limnios, O. (2022). Fictionality markers in professional scientific articles: A new approach to hedging. *English for Specific Purposes Today 10*(2), 245–262.

Luzón, M. J. (2013). Public communication of science in blogs: Recontextualizing scientific discourse for a diversified audience. *Written Communication 30*(4), 428-457.

Marchant, J. (2011). Why are so few popular science books written by women? The Guardian, 4 October https://www.theguardian.com/science/blog/2011/oct/04/popular-science-books-women (accessed 12 April 2011)

Moirand, S. (2003). Communicative and cognitive dimensions of discourse on science in the French mass media. *Discourse Studies 5*(2), 175–206.

Mulac, A., Bradac, J. J., & Gibbons, P. (2001). Empirical support for the gender-as-culture hypothesis: An intercultural analysis of male/female language differences. *Human Communication Research 27*(1), 121–152. https://doi.org/10.1111/j.1468-2958.2001.tb00778.x

Murray, C. et al., (2022). Representations of women and men in popular chemistry textbooks in the United Kingdom and Republic of Ireland. *Chemistry Education Research and Practice 23*, 373–384. https://doi.org/10.1039/D1RP00187F (accessed 21 April 2023)

Myers, G. (1990). *Writing Biology: Texts in the Social Construction of Scientific Knowledge.* The University of Wisconsin Press.

Myers, G. (2003). Discourse studies of scientific popularisation: questioning the boundaries. *Discourse Studies 5*(2), 265–279.

Myers, G. (2010). *Discourse of blogs and wikis*. Continuum International Publishing.

Pennebaker, J. (2011). *The secret life of pronouns: What our words say about us*. Bloomsbury Press.

Pfiester, R. A. (2009). Stereotype threat in mixed-sex dyadic communication (Doctoral dissertation, University of Texas at Austin).

2023 Author(s). This is an open access article licensed under the Creative Commons Attribution 4.0 International Public License (http://creativecommons.org/licenses/by/4.0/).

Pilkington, O. (2016). Popular science as a means of emotional engagement with the scientific community." *International Journal of Science Culture and Sport 4*(1), 118–125. http://dx.doi.org/10.14486/IntJSCS466

Pilkington, O. (2018). *Presented discourse in popular science: Professional voices in books for lay audiences.* Brill.

Pilkington, O. (2019). *The language of popular science: Analyzing the communication of advanced ideas to lay readers*. McFarland.

Plug, I. et al., (2020). Do women and men use language differently in spoken face-to-face interaction? A scoping review. *Review of Communication Research 9,* 43–79. https://doi.org/10.12840/ISSN.2255-4165.026 (accessed 10 April 2023)

Prieto-Rodriguez, E. et al., (2022). Investigating the impact of an outreach intervention on girls' STEM identity formation. *Gender, Science and Technology 14*(2), 183–206.

Reid, S., Keerie N., & Palomares, N. (2003). Language, gender salience, and social influence. *Journal of Language and Social Psychology 22*(2), 210–233. https://doi.org/10.1177%2F0261927X03022002004 (accessed 19 April 2023)

Rey, J. (2013). Changing gender roles in popular culture. In Douglas Biber and Susan Conrad (eds.), *Variation in English*, 138–157. Routledge.

Roberts, D. C., & Utych, S. M. (2020). Linking gender, language, and partisanship: Developing a database of masculine and feminine words. *Political Research Quarterly 73*(1), 40–50. hDttOpsI://1d0o.i.1o1rg7/71/01.10167579/10269519192897149887438 83

Ross, M. et al., (2022). Women are credited less in science than men. *Nature 608*, 135–145. https://doi.org/10.1038/s41586-022-04966-w

Sleath, B. & R.H. Rubin. 2002. Gender, ethnicity, and physician–patient communication about depression and anxiety in primary care. *Patient Education and Counseling 48*(3), 243–252. https://doi.org/10.1016/S0738-3991(02)00177-5

Sohn, B. G. (2022). Designing new Korean mothers, daughters-in-law, and wives: An analysis of Korean textbooks for newly arrived marriage migrants in South Korea. *Applied Linguistics Review 0*(0). https://doi.org/10.1515/applirev-2022-2016 (accessed 18 April 2023)

Son, J. Y., & Bell, M. L. (2022). Scientific authorship by gender: Trends before and during a global pandemic. *Humanities and Social Sciences Communication 9*(348), https://doi.org/10.1057/s41599-022-01365-4 (accessed 18 April 2023).

Stets, J., & Cast, A. (2007). Resources and identity verification from an identity theory perspective. *Sociological Perspectives 50*(4), 517–543. https://doi.org/10.1525/sop.2007.50.4.517

Stubbe, M. 2013. Active listening in conversation: gender and the use of verbal feedback. In S. Yamazaki and R. Sigley (eds.), *Linguistic insights - Studies in language and communication: Approaching language variation through corpora*, 365-416. Peter Lang.

Thomson, R., Murachver, T., & Green, J. (2001). Where is the gender in gendered language? *Psychological Science 12*(2), 171–175.

2023 Author(s). This is an open access article licensed under the Creative Commons Attribution 4.0 International Public License (http://creativecommons.org/licenses/by/4.0/).

Waara, E., & Shaw, P. (2006). Male and female witnesses' speech in Swedish criminal trials. *HERMES-Journal of Language and Communication in Business 36*, 129–156. https://doi.org/10.7146/hjlcb.v19i36.25842

Wu, A. H. (2018). Gendered language on the economics job market rumors forum. *Gender Issues in Economics 108*, 175–179. https://doi.org/10.1257/pandp.20181101

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