RUNNING HEAD: GENDER AND CITATIONS

Gendered Citation Practices in the Field of Communication

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Abstract

Pervasive gender imbalances exist in the field of communication. In disciplines outside of communication, papers with women as first and last (i.e., senior) authors attract fewer citations than papers with men in those positions. This disparity is partially explained by men's co-authorship networks. The extent to which co-authorship explains the over-citation of men in communication has not yet been quantified. Using data from 14 communication journals from 1995 to 2018, we find that reference lists include more papers with men as first and last author and fewer papers with women as first and last author than would be expected if gender were unrelated to referencing. This imbalance is driven largely by the citation practices of men and is slowly decreasing over time. The structure of men's co-authorship networks partly accounts for the observed over-citation of men by other men. We discuss ways researchers might approach gendered citations in their work.

Keywords: citations; gender; communication; inequality; publication

Gendered citation practices in the field of communication

There is a long and persistent culture of negative bias against women in academia. There are fewer women working in academia than one would expect given relatively comparable numbers of women and men graduate students (Gruber et al., 2020; Monroe & Chiu, 2010), especially in higher academic ranks (Hussar, 2020), and women in academia have lower salaries compared to their men counterparts (Curtis & Thornton, 2014; Hopkins, 1999; Monroe et al., 2008). Women's novel research ideas are discounted more than men's novel contributions (Hofstra et al., 2020), women faculty are less likely than men to be invited to give a colloquium talk at a top 50 college or university (Nittrouer et al., 2018), and men continue to win a higher proportion of awards for their scholarly research than would be expected based on their representation in nomination pools (Lincoln et al., 2012). The introduction of double-blinding in the peer review process, such that author gender cannot be easily inferred, is associated with an increase in the proportion of papers with a woman as a first author (Budden et al., 2008) and experimental work manipulating the gender of research applicants shows that faculty rate men laboratory manager and faculty applicants as more competent and hirable than identical women candidates (Moss-Racusin et al., 2012; Steinpres et al., 1999).

One practice through which inequalities and prejudice emerge is in citation behavior. Citations are a form of symbolic capital that leads to the accumulation of other capital, including reputational capital in the form of prizes or awards (Melnikoff & Valian, 2019) and monetary capital in the form of grant funding (Ginther et al., 2011) and salary (Moore et al., 2001). Despite no clear association between the citation numbers associated with an article and the research quality of an article (Dougherty & Horne, 2019; Nieminen, et al., 2006; West & McIlwaine, 2002), citations are often considered a metric of the quality and the impact of faculty research

(Toutkoushian, 1994) and are an indicator of engagement with the ideas of others (Lutz, 1990). Across disciplines, papers with women as sole authors, first-authors, and last-authors (with last author indicating a senior authorship position in some fields; Buehring et al., 2007) attract fewer citations than papers with men in one of these roles (Dworkin et al., 2020; Larivière et al., 2013). Even in majority-women disciplines, such as sociocultural anthropology, the abundant writing by women has been described as partially erased due to citation practices (Lutz, 1990).

In the field of communication, as in other fields, citations have been suggested as a measure of scholarly productivity (Feeley et al., 2011) and have been offered as ways to rank doctoral programs in communication (Allen et al., 2012; Barnett & Feeley, 2011; Neuendorf et al., 2007), though limitations of using citations as measures of quality are often noted (Levine, 2010). Extensive scholarship indicates that institutional racism and sexism are reproduced in publication and citation practices in communication. Chakravartty et al (2018), for example, evaluated the number of non-white authors among 12 communication journals and discovered that non-white scholars are underrepresented among published first authors, authoring only 746 out of 5,262 (14%) documents published from 1990 to 2016. Moreover, non-white first authors are cited significantly fewer times than their white counterparts (16 to 25, respectively) and articles authored by non-white scholars are cited significantly fewer times, on average, than white authors (1.7 to 2.5, respectively; Chakravartty et al., 2018).

Specific to the under-citation of women in communication, Knobloch-Westerwick and Glynn (2013) examined 1,020 articles published between 1991 and 2005 in *Communication Research* and *Journal of Communication*. Publications with men first authors received more citations than those with women first authors. Further, publications with at least one man author received more citations than publications with only women authors. In examining the citation

practices of authors, they observed that men scholars showed a disproportionate preference for citing men scholars. Women scholars, in contrast, did not show a preference for citing men or women scholars. Providing complementary insights, Mayer et al. (2018) examined *The International Encyclopedia of Communication Theory and Philosophy* (Brun Jensen et al., 2016). Despite the encyclopedia aiming to be a comprehensive collection of communication theory and philosophy, women were named as authors or as co-authors in fewer than 20% of the articles. Further, while 40 articles were dedicated to men communication scholars, women scholars did not have any standalone entry. In a striking example of the under-citation of women, Mayer et al. (2018) examined the first 100 articles of the *Encyclopedia*, encompassing the letters A to F. Only 16 of the 100 articles were first-authored by women. The 100 articles cite references by 1015 individuals (the analyses focused only on single authors or the first named authors in co-authored studies) and women cite other women at more than twice the rate of men (34% vs 13%). This analysis is especially unanticipated given that entries A to F include parts of the literature (e.g., "Feminism", "Feminist Theory") to which women often disproportionately contribute (Hall, 1988; Mathews & Andersen, 2001).

Existing work indicates citation biases in the field of communication with the potential for negative professional implications and career drawbacks for women, racial minorities, and other groups of minorities in contract renewals, tenureship, and peer reviewing of grant and stipend applications. Such citation biases also means that the field of communication overlooks the valuable knowledge produced by certain scholars (Chakravartty et al., 2018; Knobloch-Westerwick & Glynn, 2013). We build upon this work in three ways. First, we increase the breadth of the examination of gender imbalances in citation practices in two journals (Knobloch-Westerwick & Glynn, 2013) and an encyclopedia (Mayer et al., 2018) by examining fourteen

communication journals. We make use of a recently developed approach capable of quantifying the vast amount of data contained in fourteen communication journals (Dworkin et al., 2020) and obtain the predicted gender of the author of each reference by using databases that store the probability of a name being carried by a woman or being carried by a man. We examine the representation of authors of different predicted gender and assess whether citation practices differ by gender. In line with previous work (Knobloch-Westerwick & Glynn, 2013; Mayer et al., 2018), we hypothesize that papers with man first or last authors will receive more citations than those with woman first and last authors, accounting for the papers' relevant characteristics, including year of publication, number of authors, whether the paper was a review article, and the seniority of the paper's first and last authors. Given observations that this imbalance is driven largely by the practices of men, (Dworkin et al., 2020; Knobloch-Westerwick & Glynn, 2013), we hypothesize that the over-citation of men-led papers and the under-citation of women-led papers will occur to a greater extent within papers led by men.

Second, we examine literature between 1995 and 2018 allowing us to quantify gendered citation practices over a relatively long period of time. The systematic undervaluation and prejudice against women's contributions to science and its institutions has been interpreted from the perspective of role congruity theory (Eagly & Karau, 2002; Knobloch-Wersterwick & Glynn, 2013), with implications for potential changes in the undervaluation of women's contributions over time. Role congruity theory, as applied to research, argues that women scientists are judged with prejudice because attributes stereotypically applied to scientists, such as agency and masculinity, are more ascribed to men than women. Because gender-role attitudes have become more egalitarian over time (Bolzendahl & Myers, 2004), Knobloch-Westerwick and Glynn (2013) hypothesized that smaller role incongruity perceptions regarding female scientists would

result in less prejudice and less undervaluation of women's contributions over time. Their data did not support their hypothesis, though they note that due to the slow-evolving nature of academia, changes in gender-role attitudes may not have been captured in their dataset spanning 1991 to 2005. Given that our dataset encompasses papers from 1995 to 2018, we hypothesize a relative increase in the citation of women over time.

Third, we further expand on existing work by considering the extent to which differences in the under-citation of women's research by men may be partially explained by the structure of men's co-authorship networks. Recent work in fields beyond communication show that researchers are more likely to work with researchers of their own gender (Holman & Morandin, 2019). Thus, we hypothesize that co-authorship networks will exhibit homophily, such that researchers of the same gender will tend to work with other researchers of their own gender. The greater tendency for men to work with other men partially explains the over-citation of men in other fields (e.g., neuroscience; Dworkin et al., 2020). This effect of the homophily of men's co-authorship networks on their under-citation of women-led work has been interpreted as resulting from homophily-driven perception biases in the overall gender make-up of a field (Dworkin et al., 2020; Holman & Morandin, 2019; Lee et al., 2019). Men in co-authorship networks with a greater number of men may underestimate the number of woman-led, citable work in the field. The hypothesis that cohesive male co-authorship networks explains the marginalization of women's work in communication has recently been raised (Mayer et al., 2018) but awaits testing.

Method

The code required to replicate the analyses is available at https://github.com/jdwor/gendercitation.

Data Collection and Preparation

On April 4 2020, data were drawn from the Thomson Reuters' Web of Science (WoS) database. We focused on 14 communication journals: *Communication Culture Critique*, *Communication and Critical Cultural Studies*, *Communication Education*, *Communication Monographs*, *Communication Theory*, *Health Communication*, *Human Communication Research*, *Journal of Applied Communication Research*, *Journal of Communication*, *Journal of Computer-Mediated Communication*, *Journal of Health Communication*, *Political Communication*, *Quarterly Journal of Speech*, *Text and Performance Quarterly*. Included journals are those that have been examined in existing work on differences in the representation and citations of scholars from underrepresented demographic backgrounds in the field of communication (Chakravartty et al., 2018) and two additional journals representing work of particular interest to the authors (*Journal of Health Communication* and *Health Communication*).

Information for articles published between 1995 and 2018 available on the WoS database and classified as articles or review articles were downloaded (n=10,052). The data downloaded from WoS included articles' author names, reference lists, publication dates, and a digital object identifier (doi). For articles missing the month of publication, we manually searched journal websites to add the month. Authors' last names were included for all papers. Authors' first names were only regularly included in papers published after 2006. To obtain first names for papers missing these data, we searched for author first names using Crossref's API. We took an additional author name disambiguation step to disambiguate authors for whom different versions of their first name or initials were available across papers. This process allowed us to minimize missing data, to remove self-citations, and to develop a co-authorship network. Detailed information on author name disambiguation may be found in the supplement.

Probabilistic gender assignment of author names. Probabilistic gender assignment was carried out in two steps for all authors with available first names. We first assigned each author to a predicted gender based on their first names using the 'gender' package in R. This method is commonly used in studies examining gender differences in citations and citation practices (e.g., Larivière, 2013). We assigned 'man' ('woman') to an author if their name had a probability of ≥ 0.70 of belonging to someone labeled as 'man' ('woman') according to a given gender assignment source (Dion et al., 2018). We used two such sources: the Social Security Administration (SSA) dataset, which primarily documents United States-based names, and the Gender API (http://gender-api.com/). The Gender API is a paid service that supports approximately 800,000 unique first names across 177 countries. We used the SSA database by default, and we used the Gender API for names not presented in the SSA database or for any name that had a probability between 0.3 and 0.7 of a name being assigned to a man

It is important to clarify interpretations that can be drawn from results using this method. In the SSA dataset, man and woman labels correspond to the sex assigned to children at birth. In the Gender API dataset, man and woman labels correspond to a combination of sex assigned to children at birth and genders detected in social media profiles. In our analysis, then, the term gender does not directly refer to the sex of the author, as assigned at birth or chosen later. The term gender in our analysis also does not directly refer to the gender of the author, as socially assigned or self-chosen. The term 'gender' in our analysis is a function of the probability of assigned gendered names. By woman, we mean an author whose name has a probability ≥0.70 of being given to a child assigned female at birth or belonging to someone identifying as a woman on social media. Similarly, by 'man', we mean an author whose name has a probability ≥0.70 of being given to a child assigned male at birth or belonging to someone identifying as a man on

social media. The author's actual sex or gender is not identified. Relative to a manual assignment (see supplement), the accuracy of the automated gender assessment method is approximately 0.97 (Supplementary Table 1), similar to rates of accuracy observed in work applying this method in other fields (e.g., neuroscience where accuracy was also 0.96; Dworkin et al., 2020).

Removal of Self-Citations. Removing self-citations allowed us to separate external from internal citation behaviors, highlighting external citation behaviors of men and women authors in the communication field. Self-citations do have gendered properties by themselves (King et al., 2017; Dworkin et al., 2020). However, the purpose of this study is to analyze external citation behaviors to identify the majority of gendered citing behaviors in the field of communication. We defined self-citation as when either the first or last author was the first or last author on the citing paper. We chose this considerably restrictive definition because the author gender of this type of self-citation is guided by the author gender of the citing paper (Dworkin et al., 2020).

Data Analysis

Most analyses in this study rely on comparing the observed citation activities of communication journal papers and the rates at which papers would be expected to appear in reference lists if gender were irrelevant. Estimates from the analyses are presented with a 95% confidence interval (CI). When CIs do not contain zero, then there is evidence that the estimate is significantly different from 0. CIs were calculated by bootstrapping citing papers; that is, randomly sampling citing papers with replacement. This method maintained the dependence structure of the clusters of cited articles within citing articles (as opposed to bootstrapping individual instances of citations). The approach taken is based on a recent paper on gendered citation practices in neuroscience (Dworkin et al., 2020).

Hypothesis 1: Man-led papers will be over-cited relative to woman-led papers papers. To quantify citation practices in communication articles, we examined the reference lists of papers published between 2009 and 2018. We decided to specifically consider reference lists from these 10 years to ensure that estimates of over/under-citation were reflective of current behavior, were not a result of aggregating over disparate eras of communication research, contained enough previous citable papers to represent meaningful and stable measures of behavior, and to allow comparison with recent work in fields beyond communication that examined citation practices for these years (e.g., neuroscience; Dworkin et al., 2020). All papers in the dataset were potential *cited* papers but references to *citing* papers refer only to those published since 2009. For each citing paper, we took the subset of its citations that had been published in one of the 14 communication journals since 1995 and determined the predicted gender of the cited first and last authors as described above. We removed self-citations, defined as cited papers for which either the first or last author of the citing paper was the first or last author, from consideration for all analyses. We then calculated the number of cited papers that fell into each of four first author and last author categories: man and man (MM), woman and man (WM), man and woman (MW), and woman and woman (WW). Single-author papers by men and women were included in the MM and WW categories, respectively.

As a first step, we compared the number of citations within each category to the number of citations that would be expected if references were drawn randomly from the pool of papers. To obtain the number of citations that would be expected under this assumption of random draws, we calculated the gender proportions among all papers published prior to the citing paper (i.e., the proportion among the pool of papers that the authors could have cited) and multiplied them by the number of papers cited.

Relevant paper characteristics that may make published papers more or less likely to be cited by later scholarship are not taken into account in the previous measure. To address this issue, we calculated the probability that a given citation would be for a MM, WM, MW, or WW paper conditional on four salient characteristics of the cited paper: 1) the year of publication, 2) the number of authors, 3) whether the paper was a review article, and 4) the seniority of the paper's first and last authors. We defined seniority as the number of papers on which they had been a first or last author in the time span of the study (1995-2018). We then sought to compare the true citation rates to the rates that would be expected if only these non-gender characteristics were relevant.

We obtained the estimated gender probabilities by specifying a generalized additive model (GAM) on the multinomial outcome of paper authorship in the four specified categories of first and last author gender. Papers' membership among these four categories was regressed on publication date, author count, binary review article status, and first-/last-author seniority. The estimated membership obtained for a specific article was given by the model as a set of four probabilities that sum to one and approximately represents the proportion of similar papers (i.e., published around the same time, etc.) that fall within each of the four gender categories. Thus, the model does not predict the number of citations given to individual papers. Instead, it allows us to calculate the rates at which different gender categories would be expected to appear in reference lists if author gender were independent of citation rates, conditional on the other paper characteristics in the model. We fit the GAM using the mgcv package in R (Wood, 2017) using penalized thin-plate regression splines for estimating smooth terms of publication date, author seniority, and team size. Univariate thin-plate splines were used for the smooth terms and no interactions between variables were included in the model.

To test the hypothesis that men-led papers receive more citations than women-led papers, we estimated the expected number of citations given to each author gender category. We calculated this expectation by summing over the GAM-estimated probabilities for all papers contained within the reference lists of citing papers. These totals reflect the expected number of citations given to MM, WM, MW, and WW papers if author gender were conditionally independent of citing a paper, given the paper characteristics included in the model described above. To calculate the observed number of citations given to each group, we summed over the {MM, WM, MW, and WW} dummy variable for all of the papers contained within the reference lists of papers published between 2009 and 2018. These values were compared by calculating the percentage difference from expectation for each author gender group. For example, for WW papers, this percentage change in citation would be defined as:

$$\Delta_{ww} = \frac{obs_{ww} - \exp_{ww}}{\exp_{ww}}, \quad (1)$$

where obs_{ww} is the number of citations given to WW papers between 2009 and 2018, and $\exp_{ww}$ is the expected number of citations given to WW papers between 2009 and 2018.

Hypothesis 2: The over-citation of men-led papers and the under-citation of women-led papers will occur to a greater extent within men-led reference lists. To test the hypothesis that the over-citation of men-led papers and the under-citation of women-led papers will be driven largely by the practices of men, we used similar metrics to those described in Equation 1. Instead of calculating the observed and expected citations by summing over the citations within all reference lists between 2009 and 2018, we performed those summations separately for reference lists in papers with men as first and last author (MM papers) and papers with women as first or last author (W∪W). For example, the over/under-citation of WW papers within the reference lists of MM papers were defined as:

$$\Delta_{WW}^{(MM)} = \frac{obs_{WW}^{(MM)} - \exp_{WW}^{(MM)}}{\exp_{WW}^{(MM)}}, \quad (2)$$

where $obs_{WW}^{(MM)}$ is the total number of citations given to WW papers within MM reference lists, and $\exp_{WW}^{(MM)}$ is the expected number of citations given to WW papers within MM reference lists.

Hypothesis 3: Over-citation of men-led papers will decrease over time. We calculate the change in over-citation of men over time using a measure of the absolute difference between the observed and expected proportion of MM papers cited. This measure of change is given by:

$$\delta_{MM,year} = \frac{obs_{MM,year} - \exp_{MM,yeaar}}{obs_{year}}, \quad (3)$$

where obs_{year} is the total number of citations within a given year, $obs_{MM,year}$ is the number of citations given to MM papers in a specific year and $\exp_{MM,year}$ is the expected number of citations given to MM papers in a specific year. The change in the over-citation of men over time is estimated using a linear regression of $\delta_{MM,year}$ on year.

To estimate the change in over-citation of MM papers separately within MM and W∪W reference lists, we defined group-specific measures of yearly over-citation. For example, over-citation of MM papers within MM reference lists for a specific year would be given by:

$$\delta_{MM,year}^{(MM)} = \frac{obs_{MM,year}^{(MM)} - \exp_{MM,year}^{(MM)}}{obs_{year}^{(MM)}}, \quad (4)$$

where $obs_{year}^{(MM)}$ is the total number of citations within MM reference lists in a specific year, $obs_{MM,year}^{(MM)}$ is the number of citations given to MM papers within MM references lists in a specific year, and $\exp_{MM,year}^{(MM)}$ is the expected number of citations given to MM papers within MM reference lists in a specific year.

Hypothesis 4: Gendered citation practices will be partly explained by the structure of authors' co-authorship networks. To test this hypothesis, we developed a temporal co-authorship network in which nodes were individual authors (only authors appearing as first or last author in at least one paper were included) and binary edges represented the fact that two authors had appeared on at least one paper together before a given date. We estimated the association between authors' local network composition and their citation behavior. Citation behavior occurs at the level of a reference list within a specific paper with both a first and a last author (rather than at the level of a single node or author). We define two measures of local network composition at the paper level. We considered a paper to be the set $\{a_f, a_l, \text{ and } m\}$, where a_f is the first author, a_l is the last author, and m is the month of publication. We then defined a paper's local neighborhood of authors, N_a^p, to be the authors that are connected by shared publication to either a_f or a_l before month m. We also define a paper's local neighborhood of papers, N_p^p, to be the union of all papers authored by anyone within N_a^p before month m.

The two measures of local network composition are man-author over-representation and MM-paper over-representation. We defined man-author over-representation as the difference between the proportion of men within a paper's local author neighborhood, N_a^p, and that of the overall network. For paper p, this measure is given by:

$$MA_{i}(p) = \pi_{M,N_a^p} - \pi_M, \quad (5)$$

where π_M is the proportion of men in the full co-authorship network, and π_{M,N_a^p} is the proportion of men within paper p's local author neighborhood. We defined MM-paper over-representation as the difference between the proportion of MM articles within a paper's local paper neighborhood, N_p^p, and that of the overall network. For paper p, this measure is given by:

$$MMP_{¿}(p) = \pi_{MM, N_p^p} - \pi_{MM}, \quad (6)$$

where π_{MM} is the overall proportion of MM articles within the data, and π_{MM, N_p^p} is the proportion of MM articles within paper p's local paper neighborhood.

To estimate the association between these metrics and the degree of over-citation of men within reference lists, we defined a paper-level measure of the absolute difference between the observed and expected proportion of MM papers. Similar to the previously described $\delta_{MM, year}^{(MM)}$ measure that quantified the over-citation of MM papers within all MM reference lists from a given year, here we defined a measure of over-citation within an individual paper p as:

$$\delta_{MM}^{(p)} = \frac{obs_{MM}^{(p)} - \exp_{MM}^{(p)}}{obs^{(p)}}, \quad (7)$$

where $obs_{MM}^{(p)}$ is the number of MM citations within paper p's reference list, $\exp_{MM}^{(p)}$ is the expected number of MM citation within paper p's reference list based on the GAM-estimated assignment probabilities of each cited paper and $obs^{(p)}$ is the total number of candidate citations within paper p's reference list.

The associations between $\delta_{MM}^{(p)}$, $MMP_{¿}(p)$, $MA_{¿}(p)$, and {MM, WM, MW, and WW} are estimated using weighted quantile regression, with the MM over-citation metric, $\delta_{MM}^{(p)}$, as the outcome. We performed quantile regression because of the bounded and skewed nature of the $\delta_{MM}^{(p)}$ measure. We defined the weights to be equal to the number of candidate citations within a given paper's reference list; this definition gives higher weight to papers for which the outcome is more stable. We also selected the τ value of the quantile regression to be 0.5, resulting in a model fit to the median of the outcomes. CIs were again obtained by the article bootstrap method.

Results

Descriptive Statistics

In all, 8338 articles were included in the final dataset and gender information was available for 7143 (85.67%) articles. The breakdown of articles by the four gender categories is as follows: MM = 2751 (38.51%); WM = 1125 (15.75%); MW = 905 (12.67%); WW = 2362 (33.07%). The proportion of articles of each different category in the sample across time is shown in Supplementary Figure 1 (see Supplementary Figure 2 for journal-specific figures).

Citation imbalance relative to overall authorship proportions

To quantify citation practices in communication articles, we examined the reference lists of papers published between 2009 and 2018 (n=5351; n=4704 with complete author gender information). We compared the number of citations within each category to the number of citations that would be expected if references were drawn randomly from the pool of papers (Figure 1A). Of the citations given between 2009 and 2018, MM papers received 41.90%, compared to 15.20% for WM papers, 16.40% for MW papers, and 26.50% for WW papers. The expected proportions based on the pool of citable papers were 41.80% for MM, 14.30% for WM, 12.40% for MW, and 31.50% for WW. We then defined a measure of over/under-citation as (observed % - expected %)/expected %. This measure represents the percent over/under-citation relative to the expected proportion. By this measure, MM papers were not over or under-cited more or less than expected (0.34%, 95% CI=[-1.86, 2.14]), WM papers were cited 6.31% more than expected (CI=[2.12, 10.58]), MW papers were cited 31.56% more than expected (CI=[26.79, 36.96]), and WW papers were cited 15.79% less than expected (CI=[-18.33,-13.35]).

Citation imbalance after accounting for publication date, author count, review article status, and author seniority

Relevant paper characteristics that may make published papers more or less likely to be cited by later scholarship are not taken into account in the previous measure. We obtained the estimated gender probabilities by specifying a generalized additive model (GAM) on the multinomial outcome of paper authorship in the four specified categories of first and last author gender. Papers' membership among these four categories was regressed on publication date, author count, binary review article status, and first-/last-author seniority. By this measure (Figure 1B), MM papers were cited 2.4% more than expected (95% CI=[0.16, 4.49]), WM papers were cited 7.25% less than expected (CI=[-10.42, -4.04]), MW papers were cited 10.23% more than expected (CI=[6.36, 14.42]), and WW papers were cited 4.73% less than expected (CI=[-7.37,-2.06]).

Author gender and citation behavior

We compared the gender make-up of references within papers that had men as both first and last author to those within papers that had women as either first or last author (Figure 2A). Of the articles published between 2009 and 2018, approximately 34.10% were MM and 65.90% were W∪W. Separating citing articles by author gender, we find that within MM reference lists, other MM papers are cited 13.80% more than expected (CI=[10.03, 18.12]) and MW papers are cited 13.96% more than expected (CI=[5.94, 21.03]). Within MM reference lists, WM papers were cited 13.13% less than expected (CI=[-18.87, -6.65]) and WW papers were cited 20% less than expected (CI=[-24.89, -15.11]). Thus, in MM reference lists, papers with men first authors are over-cited and papers with women first authors are under-cited. Within W∪W papers, papers with women in any first or last author position, MM papers were cited 3.19% less than expected (CI=[-6.32, -0.50]) and MW papers were cited 11.10% more than expected (CI=[6.50, 15.59]).

WM papers were cited 6.03% less than expected (CI=[-9.84, -1.20]), and WW papers were not cited more or less than expected (2.28% ; CI=[-1.29, 6.60]).

After breaking the W∪W group into further subgroups (Figure 2B), we find that mixed gender author groups with man first authors (MW papers) looked remarkably similar to MM author groups in their citation behavior, citing MM papers 9.56% more than expected (CI=[3.90, 15.56]), citing MW papers 15.90% more than expected (CI=[5.32, 26.10]), citing WM papers 9.32% less than expected (CI=[-18.65,-0.67]), and citing WW papers 17.30% less than expected (CI=[-24.30,-10.67]). Thus, in MW reference lists, as in MM reference lists, papers with men first authors are over-cited and papers with women first authors are under-cited.

WM author groups similarly over-cited MW papers by 10.47% (CI=[1.00, 19.63]) and under-cited WM papers by 12.44% (CI=[-19.57,-4.19]) but differed from MM and MW groups by showing no over or under-citation of MM (0.61%, CI=[-4.27, 5.50]) and WW (1.07%, CI=[-5.90, 7.83]) papers. WW author groups were the only group not to under-cite WW papers, instead over-citing them by 12.03% (CI=[6.22, 17.96]). They were also the only author group not to over-cite MM papers, under-citing them by 11.35% (CI=[-15.53, -7.20]) and not to over or under-cite WM papers (-0.34%, CI=[-7.59, 6.02]). Like all other author groups, WW over-cited MW papers, in this case by 9.15 % (CI=[1.59, 16.07]).

Temporal trends of citation imbalance

We examined citation behavior over time (Supplementary Figure 2). We used the yearly absolute difference between the observed and expected proportion of MM citations as a measure of citation imbalance. We found that the gap between observed and expected proportions has been decreasing at a rate of around -0.48 percent points per year (95% CI=[-0.81, -0.12]). Splitting the gender of the citing authors into MM and W∪W papers, we find that the degree of

over-citation of men has been decreasing in both W∪W (-0.48, 95% CI=[-0.93, -0.04]]) and MM (-0.63, 95% CI=[-1.19, -0.01]) papers.

Association between author networks and citation behavior

We aimed to estimate and isolate the association between authors' co-authorship networks and their citation behavior (Figure 3). We used two metrics to quantify gender imbalance within co-authorship networks at the paper level that consider the co-authorship network of the first and last authors of a given paper at the time of the paper's publication. We found that co-authorship networks within MM teams tended to have more men than the field as a whole. The median MM team had approximately 7.60% more men in their co-authorship network than the field's base rate (95% CI=[4.87, 10.47]). WW teams, in contrast, had fewer men than the field as a whole. The median WW team had 5.63% fewer men in their co-authorship networks than the field base rate (95% CI = [-8.65, -2.79]). Mixed gender teams fell in the middle. The median MW team had 1.05% (95% CI=[0.07, 3.89]) more men than the field base rate and the median MW team had no greater or fewer men than the field base rate (0.59% ; 95% CI=[-2.73, 1.54]).

The second measure, MM-paper over-representation, was defined as the difference between (1) the proportion of MM papers within a given paper's neighborhood (the union of papers written by any previous co-authors of a paper's first or last author) and (2) the overall proportion of MM papers within the network at the time of the given paper's publication (see Figure 3B for a visual example of this measure). For this measure, MM papers were overrepresented relative to their overall proportion within the co-authorship networks of MM teams by 6.06% (95% CI=[3.33, 8.69]). In other words, papers with man first and last authors tended to occupy co-authorship networks in which the paper authors' previous collaborators had

written more MM than W∪W papers together. MM papers were underrepresented within networks of WM (-5.6%, 95% CI=[-8.39, -3.70]), MW (-4.34%, 95% CI=[-6.06, -1.58]), and WW (-16.67%, 95% CI=[-20.59, -14.38]) teams.

We determined the degree to which the composition of authors' networks accounted for over-citation of men. We used the absolute difference between the observed proportion of MM citations within a paper's reference list and the expected proportion based on the characteristics of the cited papers. Without accounting for differences in authors' co-authorship networks, we found that the median MM team over-cites MM papers by roughly 5.29% (95% CI=[3.12, 7.07]). The median WW team under-cited MM by 6.67% (95% CI=[-8.97, -3.88]) and there is no under or over-citation of MM papers by the median WM (-0.55%, 95% CI=[-3.65, 2.63]) or MW (2.00%, 95% CI=[-0.89, 4.15]) teams (Figure 4A).

To estimate and account for the role of authors' co-authorship networks, we modeled papers' degree of MM over-citation as a function of author gender category and both man author overrepresentation and MM paper overrepresentation in the citing paper's co-authorship network. Man author overrepresentation in the co-authorship network was not independently associated with median MM paper over-citation (0.01, 95% CI=[-0.08, 0.09]). In other words, the tendency for MM papers to be over-cited in a paper's reference list was not independently associated with the proportion of man co-authors of a paper's first and last authors. MM paper overrepresentation was independently associated with MM over-citation; a one percentage-point increase in the overrepresentation of MM papers in a citing paper's co-authorship network corresponded with a 0.14 (95% CI=[0.04, 0.27]) percentage-point increase in median MM over-citation. In other words, if a citing paper's co-authorship network had an over-representation of MM relative to W∪W papers, then that papers reference list had a greater tendency to overcite

MM papers. After accounting for the degree of overrepresentation of both men and MM papers within authors' co-authorship networks, differences in citation behavior remained across citing authors' gender (Figure 4B). Conditional on authors' networks being gender balanced (that is MA_i and MMP_i=0), the median MM team would still be expected to over-cite MM papers by about 3.13% (95% CI=[0.42, 6.12]), compared to 3.49% (95% CI=[-0.77, 7.17]) for MW, 0.78% (95% CI=[-2.60, 6.12]) for WM, and -3.37% (95% CI=[-6.47, -0.87]) for WW. These results suggest that local homophily in co-authorship network explains part of the over-citation of men by other men.

Additional Analyses. Due to the similarity in the gendered citation practices of MM and MW author categories, we repeated analyses with two categories: MFA indicating papers with man first authors (MM or MW) and WFA indicating papers with woman first authors (WM and WW). MFA papers overcited MM papers by 12.42 % (95% CI=[8.99, 15.45]) and overcited MW papers by 14.65% (95% CI=[8.62, 21.42]). MFA papers under-cited WM papers by 11.75% (95% CI=[-16.71, -6.60]) and under-cited WW papers by 19.13 % (95% CI=[-23.13, -14.93]). WFA papers under-cited MM papers by 6.93% (95% CI=[-9.89,-3.71]), overcited MW papers by 9.65% (95% CI=[3.62, 15.17]), did not over- or under-cite WM papers (5.03% ; 95% CI=[-10.38, 0.15]), and overcited WW papers by 7.99% (95% CI=[3.52, 12.73]). Further results may be found in the supplement.

Discussion

There are persistent gender inequalities in academia, including a pervasive undervaluation of women's research (Budden et al., 2008; Gruber et al., 2020; Hofstra et al., 2020; Monroe & Chiu, 2010). The field of communication is no exception. Women scholars are markedly absent from texts aiming to comprehensively capture the field (Mayer et al., 2008) and

their work is cited less than work by men (Knobloch-Westerwick & Glynn, 2013). Although the citation numbers associated with an article are not a clear indicator of research quality (Dougherty & Horne, 2019; Nieminen et al., 2006; West & McIlwaine, 2002), the extent to which one's work is cited has implications for prizes and awards (Melnikoff & Valian, 2019), grant funding (Ginther et al., 2011), salary (Moore et al., 2001), and promotion and tenure (McKiernan et al., 2019). Citations are also an indicator of an engagement with the ideas of others and, as such, when discussing the partial erasure of women's research from academic fields, citation behavior is often highlighted as a key practice underlying gender inequalities (Lutz, 1990; Rossiter, 1993).

We build on previous work (Knobloch-Westerwick & Glynn, 2013; Mayer et al., 2018) in communication by examining evidence for gender imbalance in citations across fourteen communication journals spanning the years 1995 to 2018. We find that papers with men as first authors are overrepresented and papers with women as first authors are underrepresented in the reference lists of communication journal articles relative to what would be expected if gender were not a factor. The over-citation of men and the under-citation of women remains after accounting for relevant characteristics of papers, including year of publication, number of authors, whether a paper is classified as an article or a review, and the seniority of the paper's first and last authors. The over-citation of men and the under-citation of women is largely driven by the citation practices of men. Papers with men as first and last authors over-cite other MM papers by 13.80% and MW papers by 13.89% and under-cite WM papers by 13.13% and WW papers by 20%. These findings are consistent with results from other fields (Dworkin et al., 2020) and from the field of communication (Knobloch-Westerwick & Glynn, 2013; Mayer et al., 2018) that indicate that men are less likely to cite work by women.

There was some evidence that the over-citation of men was decreasing over time in both MM papers and papers with at least one woman author in the first or last author position. Knobloch-Westerwick and Glynn (2013) observed no evidence for a weakening of the under-citation of women in their examination of 1,020 articles in two communication journals published between 1991 and 2005. Our finding of a weakening of the under-citation of women may reflect the increasing representation of women first and last authors in communication journals emerging after 2005 (Supplementary Figure 1) and increasingly egalitarian gender-role attitudes over time (Bolzendahl & Myers, 2004). Indeed, Knobloch-Westerwick and Glynn (2013) hypothesized that their finding for no evidence of a weakening in the under-citation of women over time may have emerged due to the slow-evolving nature of academia towards gender equality. The decrease in the under-citation of women in communication is a cause for optimism. However, we note that the decrease is slow and small in magnitude. We also note that recent events related to the COVID-19 pandemic are disproportionately affecting women in academia (Myers et al., 2020), beyond already existing disparities, and that these gender disparities will likely impact research in the coming months and years.

The mechanisms underlying the observed gendered citation practices are likely manifold. One potential mechanism we explored was the extent to which differences in the over-citation of work by men may be partially driven by the structure of authors' co-authorship networks. In line with work in fields beyond communication indicating that researchers are more likely to work with researchers of their own gender (Holman & Morandin, 2019), we find that co-authorship networks within MM teams tended to have more men than the field as a whole. The extent of gender homophily in men co-authorship networks partially explained the over-citation of men, in line with previous work in other fields (Dworkin et al., 2020) and hypotheses that cohesive

networks of men authorship and citation is a mechanism underlying the marginalization of women's work in communication (Mayer et al., 2018).

There are a number of implications of the current findings for the field of communication. Continuing with current citation practices risks continuing to marginalize the work of women. In other fields, more attention is paid to ideas when they are discussed by men, even though the ideas had previously been articulated by women (e.g., ethnography; Lutz, 1990) and the novelties introduced by men are more readily taken up by the field (Hofstra et al., 2020). By not actively contending with these problems, we enable marginalization, and miss the opportunity to ensure that the field of communication is representative of all the excellent work contributed by all scholars. A crucial framework that formalizes these issues in communication is the Critical Media Effects (CME) framework. Challenging the current power dynamics of communication research, Ramasubramanian and Banjo (2020) proposed the CME framework, suggesting four interrelated concepts to advance our understanding of critical communication research. One of which is intersectionality. Intersectionality argues that we should consider social inequalities and power dynamics altogether, from different identities of race, gender, class, sexual orientation and others that individuals hold when conducting and evaluating research quality. Citation, as a form of power in academia, should also be evaluated through the lens of intersectionality in order to advance communication research.

Additionally, recognizing the importance of citations as currency, the outgoing President of the International Communication Association, reflecting on the lack of gender diversity in the organization, conferences, and publications, called for members to cite research that has historically been pushed to the margins to shift the field's structural and cultural practices as a step towards achieving diversity, equity, and inclusion (Gardner, 2018). Key in these calls to

address our citation practices is that citations are a practice over which each researcher has control. Addressing the identified gender imbalances in citation will require researchers, particularly men, to engage in more thoughtful citation practices. This conscientious response is made increasingly feasible by open source tools designed to provide insight into the gender composition of manuscript reference (Zhou et al., 2020), reference searches (https://chrome.google.com/webstore/detail/citation-transparency/cepnbdbhabaljgecaddglhhcgajphbcf?hl=en), and gender diversity statement and code notebook (Zurn, Bassett, & Rust, 2020).

Limitations and future outlook

Findings should be interpreted in light of the study's strengths and weaknesses. Our examination of fourteen communication journals provides a breadth to the analysis that expands on previous work on gender citation practice in communication research examining two journals (Knobloch-Westerwick and Glynn, 2013) and an encyclopedia of communication research (Mayer et al., 2018). However, further analysis is needed to document the degree to which the effects might be stronger or weaker in other journals relevant to the field of communication. Second, the method of gender determination was limited to binary man and women assignments. As such, other gender expressions, including transgender and/or nonbinary identifies, are not well-captured. Third, our examination focused on gender. Gender bias is not the only form of prejudice that exists in citation practices in communication. Racial/ethnic minorities are under-cited in communication (Chakravartty et al., 2018) and a consideration of race and ethnicity, class, sexuality, disability, and citizenship, and their intersections with gender (Gutiérrez et al., 2012) is an important future direction.

Conclusion

Citations are an important form of social capital with substantial impact on academic careers. Men are over-cited and women are under-cited in work across disciplines, including communication. Across fourteen communication journals spanning the period between 1995 and 2018, we find that work by men is over-cited and work by women is under-cited, and that these gendered citation practices are driven largely by men. We also find that the over-citation of men is decreasing statistically significantly over time, but very slowly. We additionally provide evidence for the role of cohesive, man co-authorship networks in the over-citation of men. We note that citations are a practice that individuals have control over and encourage researchers, particularly men, to commit to learning about the work of minority scholars and making use of openly-available tools to engage in thoughtful citation practices as one way to minimize gender inequalities in the field of communication.

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Citation Diversity Statement

Recent work in several fields has identified a bias in citation practices such that papers from women and other minorities are under-cited relative to the number of such papers in the field (Chakravartty et al., 2018; Mitchell et al., 2013; Maliniak et al., 2013; Caplar et al., 2017; Dion et al., 2018; Dworkin et al., 2020). Here we sought to proactively consider choosing references that reflect the diversity of the field in thought, form of contribution, gender, and other factors. We obtained predicted gender of the first and last author of each reference by using databases that store the probability of a name being carried by a woman (Dworkin et al., 2020; Zhou et al., 2020). By this measure (and excluding self-citations to the first and last authors of our current paper), our references contain 29.5% woman(first)/woman(last), 18.2% man/woman, 22.7% woman/man, 29.5% man/man, and 0% unknown categorization. This method is limited in that a) names, pronouns, and social media profiles used to construct the databases may not, in every case, be indicative of gender identity and b) it cannot account for intersex, non-binary, or transgender people. We look forward to future work that could help us to better understand how to support equitable practices in science.

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Figure Captions

Figure 1. Construction and visualization of over/under-citation of papers based on author gender. **(A)** Illustration of the random draws model. Gender proportions in reference lists are compared to the overall gender proportion of the existing literature. Right panel shows the over/under-citation of different author gender groups compared to their expected proportions under the random draws model. **(B)** Illustration of the relevant characteristics model. Gender proportions in reference lists are compared to gender proportions of articles that are similar to those that were cited across various domains (the year of publication, the number of authors, whether the paper was a review article, the seniority of the paper's first and last authors). Right panel shows the over/under-citation of different author gender groups compared to their expected proportions under the relevant characteristics model.

Figure 2. Associations between author gender and gendered citation practices. **(A)** Degree of over/under-citation of different author genders within MM (papers with man author in first and last position) reference lists (left) and within W∪W (papers with a woman author in first, last, or both positions) reference lists (right). **(B)** Full breakdown of gendered citation behavior within W∪W reference lists.

Figure 3. Visualization of co-authorship network composition measures. **(A)** Example of region of co-authorship network, where a specific article (edge) and the first and last authors (nodes) are highlighted. **(B)** Examples of the calculation of man author overrepresentation ($MA_{¿}$; top) and MM paper overrepresentation ($MMP_{¿}$; bottom) for the highlighted article. Here, $MA_{¿}$ is the difference between the local proportion of men (purple nodes) and the overall proportion of men. The quantity $MMP_{¿}$ is the difference between the local proportion of MM papers (purple edges) and the overall proportion of MM papers. **(C)** Differences in the local network

composition based on author gender. The panel shows that MM papers tend to have greater overrepresentation of men and man-led papers within their local networks and that WW papers tend to have a lesser overrepresentation of men and man-led papers within their local networks.

Figure 4. Article level over-citation of MM papers before and after accounting for local network composition. **(A)** Over-citation of MM papers by citing author gender. MM and MW papers tend to over-cite MM papers relative to expectation, WM cite MM papers at roughly the expected rate, and WW papers under-cite MM papers relative to expectation. **(B)** Over-citation of MM papers by author gender after accounting for network effects. Local network composition explains some of the group differences, but the general pattern remains.

Figure 1.

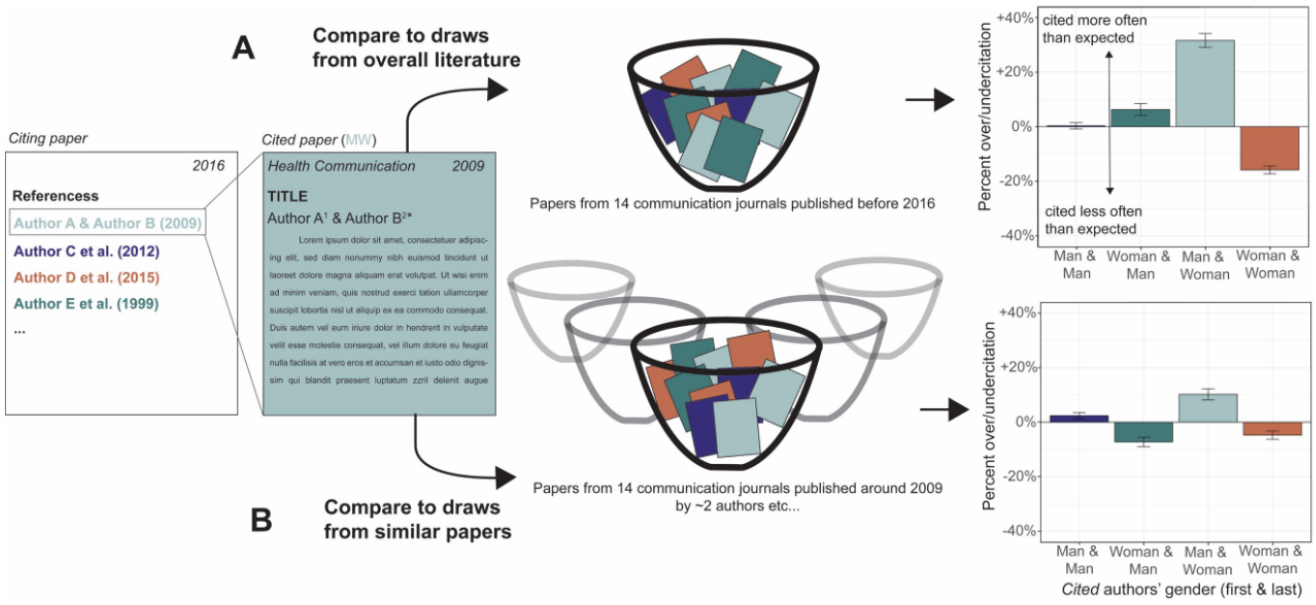
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Figure 2.

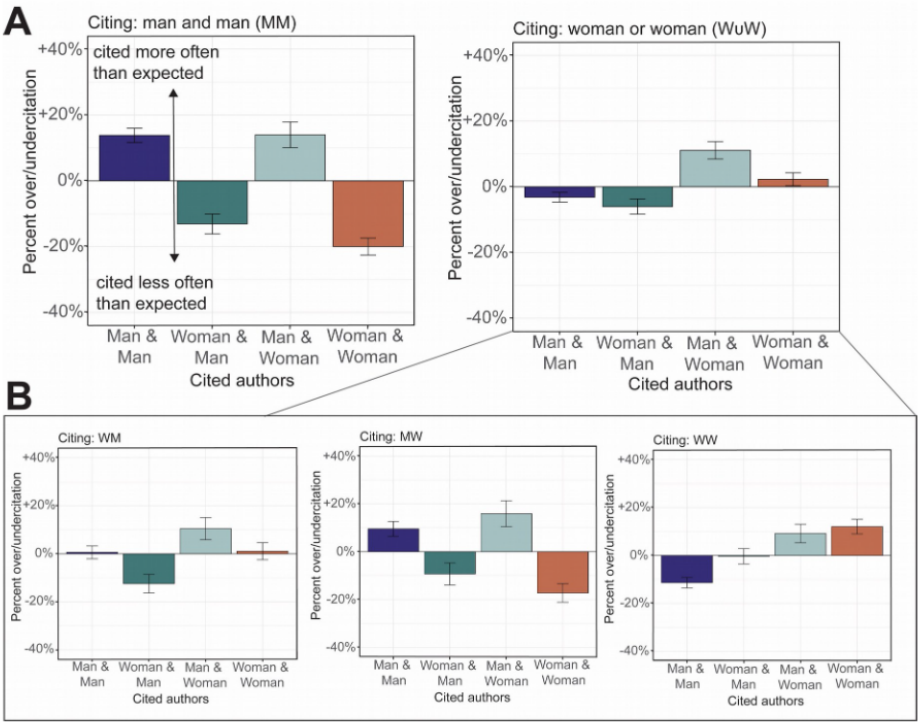

A
Citing: man and man (MM)
cited more often than expected
cited less often than expected
Percent over/undercitation
+40%
+20%
0%
-20%
-40%
Man & Man
Woman & Man
Man & Woman
Woman & Woman
Cited authors
Citing: woman or woman (WuW)
B
Citing: WM
Citing: MW
Citing: WW

Figure 3.

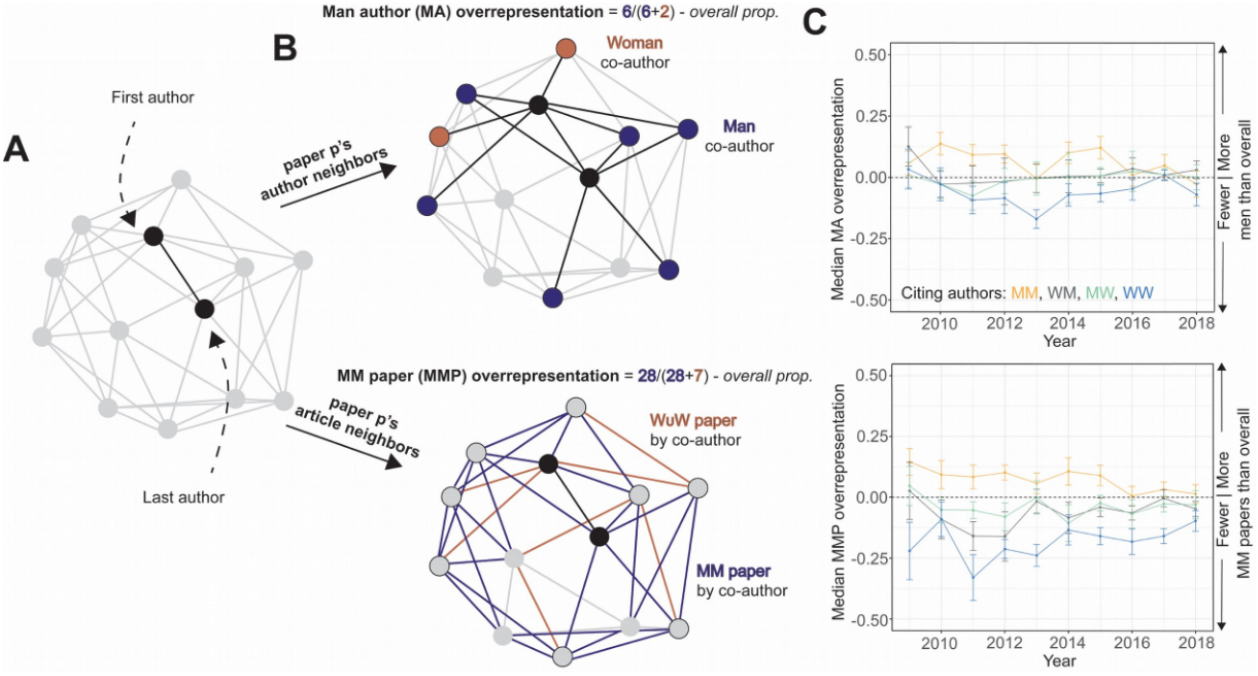
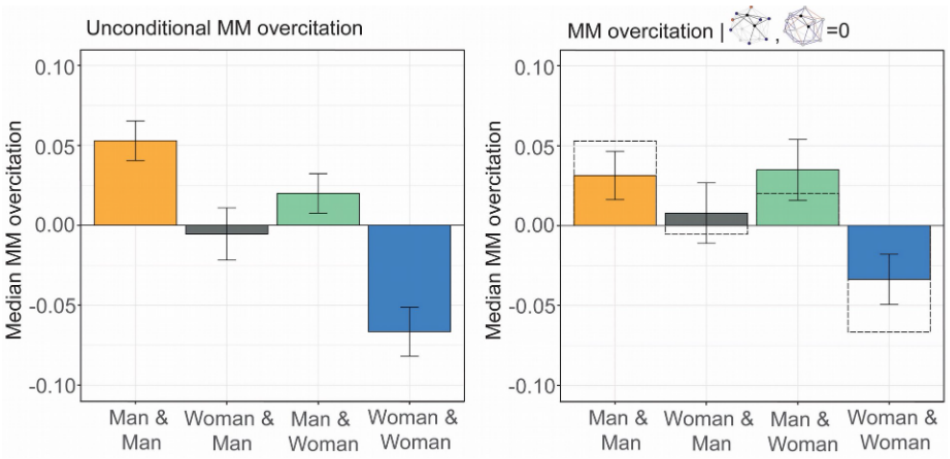

A
First author
Last author
paper p's author neighbors
paper p's article neighbors
B
Man author (MA) overrepresentation = 6/(6+2) - overall prop.
Woman co-author
Man co-author
MM paper (MMP) overrepresentation = 28/(28+7) - overall prop.
WuW paper by co-author
MM paper by co-author
C
Median MA overrepresentation
Citing authors: MM, WM, MW, WW
Fewer | More men than overall
Median MMP overrepresentation
Fewer | More MM papers than overall
Year
0.50
0.25
0.00
-0.25
-0.50
2010
2012
2014
2016
2018

Figure 4.


Unconditional MM overcitation
MM overcitation | , =0
Median MM overcitation
0.10
0.05
0.00
-0.05
-0.10
Man & Man
Woman & Man
Man & Woman
Woman & Woman