Open Science, Equal Citations? Investigating gendered participation and citation practices in Communication's Open Science Movement

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Abstract

The field of communication is increasingly adopting Open Science practices and standards, particularly around sharing code and data, pre-registering studies, and conducting replications. Communication scholars have also actively critiqued how open science might create barriers and exacerbate inequalities within the discipline. As the field invests in systems to better support a more diverse body of scholars and researchers, it becomes imperative to better understand how open science adoption might interact with these attempts. In particular, ;ittle is known about who actually participates in Open Science. In this study we look at one common area of inequality, gender, within publication rates and top citations. We design a computationally-assisted data collection workflow that allows us to categorize over 4,000 communication research articles into different gender categories based on first and last author names as well as into a binary Open Science category that captures if an article uses any open materials, pre-registration, or replication practices. We provide empirical evidence for a greater gender inequality among participants in Open Science than quantitative communication in general. This does not appear to extend to citational inequality: Open Science papers do not seem to produce much greater inequality within top citations, although the top citations across the field skew heavily male. We believe a commitment to truly open science requires a commitment to solving participation and citational gender gaps and hope this project will contribute to better, and more equitable, communication research.

Introduction

Spurred by a series of crises within social science, the open science (OS) movement developed as a way to improve the credibility and reliability of social scientific research (Alberts et al., 2015; Dienlin et al., 2021). Some recent reports suggest that, over the past five years, the communication field has increasingly adopted OS practices: which includes, sharing code and

data on public repositories; pre-registering hypotheses and analysis plans; and, working to

conduct both direct and conceptual replications of past research (Markowitz, Song & Taylor,

2021; Lewis, 2019). Other work has criticized how OS might inadvertently reproduce existing

inequalities within the field, and potentially further exacerbate these inequalities under a banner

of openness and transparency (Fox et al., 2021; Bahlai et al., 2019). In this paper, we aim to

investigate adoption patterns of OS and citations by focusing on one important area of diversity:

gender. First, we aim to document whether a greater gender inequality exists among scholars

who participate (i.e. publish) Open Science communication research versus those who publish

communication research more broadly. Second, we compare rates of citation inequality within

Communication and OS communication research, to identify how participation inequalities

might contribute to citational inequality. Citations are associated with value and visibility, as well

as one of the most prominent metrics of prestige (Kwon, 2022). Our research contributes

important empirical evidence for the larger debates around OS adoption within the field of

Communication.

Inequalities among participation and citations within Communication have been widely

documented. Past research has identified disparities in participation, content, and citation with

regards to geographic region (Walter, Cody, & Ball-Rokeach, 2018; Trepte & Loths, 2020) and

gender (Knobloch-Westerwick & Glynn, 2013; Trepte & Loths, 2020; Wang et al., 2021). In

addition, the hashtag and accompanying paper, #CommunicationSoWhite, identified a profound

lack of racial diversity of both the authors and topics that are published within top

Communication journals (Chakravartty et al., 2018). Motivated by this work and discussions at

every level of the field, institutions like the flagship conference for the International

Communication Association (ICA), have adopted new policies and recommendations that

attempt to meet the call to action of improving the equity within the field. These initiatives are important as publication and citation are two of the main ways that knowledge is shared and built upon, as well as metrics used to evaluate careers and potential. The dedicated attention to these two areas highlights the ways that "publication and citation practices produce a hierarchy of visibility and value" (Chakravartty et al., 2018). Here we continue to focus on these areas and specifically look at how open science adoption might have consequences within this wider movement in Communication.

These potential consequences are already a discussion point. In their critique of Open Science practices within Communication research, Fox et al., "fear that many aspects of OS will hamper the diversity and inclusiveness of Communication as a field, both in terms of scholar and scholarship" (2021, p. 774). While the larger cautions of the paper, particularly those around data privacy, are crucial considerations for the field, the greater inequality within OS communication work remains a testable claim. As advocates and practitioners of many Open Science practices ourselves, we take these warnings seriously and advocate for careful and diligent adoption of OS that can reap the maximum benefit of transparency without sacrificing the progress toward a more diverse and inclusive field.

As discussions around improving the scientific integrity of the field continue, we seek to demonstrate the need to take into account both citational equity and OS movements. OS adoption can have a larger impact across the field than merely allowing for more accessible data sets or replication studies. We argue that more clear empirical evidence of its relationship to gender inequality within participation and citation rates will help the field build better OS standards and practices that encourage both more open research and more diversity among participants and references. Specifically, we contribute an empirical assessment of 1) the gendered proportion of

authors participating in the OS movement within the field of Communication (i.e. authors who share data, publish pre-registrations, and participate in replication projects) and 2) the gendered citational practices of papers marked as OS. We compare both of these with rates within the communication field at large with the goal to describe the gender specific landscape within the OS subfield and communication research more generally.

Literature Review

The OS movement emerged from a series of crises, including p-hacking and failures of replication, within psychology and other social science disciplines (Ritchie, 2020). These entrenched and highly questionable research practices, as well as the systems of incentive that reward them, contributed to an increased distrust of science among the public (Alberts et al., 2015; Munafò et al., 2017). To build both better research workflows and to rebuild trust, the OS movement was formally launched through the Center for Open Science and its flagship platform, Open Science Framework (OSF). COS, OSF, and Open Science in general, provide a series of standards for defining open and transparent research as well as institutionalizing incentives for conducting such research (Nosek et al., 2018). These standards described by Nosek (2018) highlight practices like: sharing data and analytic methods (e.g. code), pre-registration of studies and analysis plans, and conducting replications. OS incentives include article badges which journals and editors can use to encourage and reward the adoption of OS practices (Kidwell et al., 2016) as well as required standards set by journals (Nosek et al., 2018). While the structural incentives to change are important aspects of the movement, in this project we focus primarily on researcher-led efforts, or where authors identify the use of OS practices within the text of the article.

The most basic premise behind OS is to make the research processes more clear: "to make explicit the often-implicit decision-tree scientists use to arrive at their conclusions - to allow others to look at the process and make their own judgments about the conclusion rather than having to place full faith in the original scientists' conclusion" (Lewis, 2020, pg. 74). OS encourages more trust in the scientific process by documenting and sharing the many decisions that go into any research project. This open documentation also makes it much more difficult for researchers- who might be externally incentivized to do so- practice some of the more questionable research practices. It allows for a very basic, and relatively easy, audit of a given project.

As a value, openness connotes a commitment to transparency and to the larger scientific community. The former, thus far, drives most of the attention to OS, with the practices and incentives described above directly working towards increased transparency. Yet openness implies a community to be open to; reminiscent of the first of the four Mertonian norms of science, communism (Merton, 1974; see also Ritchie, 2020). This communism, or the collective ownership of science, is re-invigorated by the OS movement and its ideals of free exchange around data, code, and other research materials. The communism of science should also be responsible to the larger public, which, so far, has mostly manifested itself through open access policies (Ritchie, 2020). Most critiques of OS focus on the systematic incentives of OS and how they might be designed to exclude certain methods and knowledge traditions, but it is vital for us to recognize OS's connection to the ideas of science as a public good -- and one that should, thus, reflect the public it serves. The community potentially fostered by OS show promising results as well, with women much more likely to participate in the more collaborative and inter-connected OS than replication studies alone (Murphy et al., 2020). There is potential within the values of

OS to transform the community structures and incentives to better serve both scientists and the public.

The valorization of openness, however, does not necessitate diverse participation or a welcoming culture. In fact, across open knowledge projects that OS is indebted to, if not directly inspired by, like Free/Libre and Open Source Software, openness has been used to anticipate and deflect criticisms around exclusions. By leveraging openness, such projects place the blame on those who do not participate ("it's open"), masking any number of factors that could exclude them; "openness tends toward obfuscation" (Kelty, 2008, p. 143). The very vocabulary of openness, laden with norms around accessibility, transparency, and freedom, can cloud over harmful practices, overwhelming systems, and unwelcoming cultures. Indeed, this is the main worry of Fox et al (2020): those who do not participate within OS -- even if they have good reasons like privacy concerns around sharing data or working with methods that are ill suited to an OS workflow -- are not seen as doing quality communication research. The use of openness forestall its own critiques by placing the blame of its own limitations on those who do not participate. OS should heed warnings of Free/Libre and Open Source Software which continues to struggle with the profound gender gaps hidden by the value of openness (Nafus, 2012).

Scholars have already begun to identify the myriad ways in which an uncritical prioritization of openness within the social sciences can lead to poor ethical decisions, with participants or respondents left unprotected and potentially harmful materials freely accessible; to the further marginalization of qualitative methods that do not easily adapt to OS requirements; and the increased burden, both social and economic, OS requirements place on scholars from the Global South (Fox et al., 2021; Dutta et al., 2021). The trending hashtag #broopenscience, further suggests that the culture surrounding OS is restrictive, unwelcoming, and occasionally

sexist (Whitaker & Guest, 2020; Pownall et al., 2021). These critiques document how OS practices are unevenly available, due to a range of reasons and identify several areas of key concern as OS adoption grows within Communication.

In this paper, we provide empirical evidence for inequalities within OS adoption in the field of Communication. Specifically we ask, **(RQ1)**: what is the gender distribution of authors who are publishing in OS and how does it compare to the gender distribution of authors publishing within the field at large? Based on the critiques and charges of "broopenscience" we registered our hypothesis (**H1)** that OS will have a higher proportion of men authors than non-OS identified papers. Since the critiques are levied at OS at large, and not specific practices, we additionally hypothesize (**H2**) that all domains of OS (open data, pre-registration, and replication) will have similar proportions of women authors. We also present an exploratory analysis of citation inequality in OS, identifying how OS might produce inequalities through different citational standards.

Bridging these literatures on gender inequality within academic knowledge production and the discussions around adopting OS, we contribute a description of the current rate of participation in open communication science research. This provides empirical evidence for the continued discussions about adapting the commits to good, communal science to better fit within the diverse field of Communication. We also present a workflow that leverages computational methods in order to assign meta-categories around author gender and OS practices that can continue to help evaluate the state of field, until a day, soon we hope, where such data is more easily available. Using these tools we are able to provide substantial quantitative insight into the patterns of participation and citation within the field of Communication. We additionally present

some exploratory analysis around top citation practices that identifies how this work can be further applied to understand dynamics within communication and OS.

Methods & Data

Data Collection

We collected empirical journal articles from 23 leading communication journals through Web or Science (WoS), based on a list of journals sourced from Markowitz, Song & Taylor (2021). The selected journals purposely skew quantitative since the OS movement has specifically targeted more quantitative methods. We collect all articles that were published between 2015 and 2021 given that in their study of OS adoption within Communication, Markowitz, Song, and Taylor (2021) identify 2015 as a key year for significantly increased adoption of OS within Communication. We collected the full text of each article using an official university proxy through a Selenium Chrome driver (Vila, Novakova & Todorova, 2017) pipeline using Python version 3.9, which downloads the text of each article into a text file. We excluded journals to which we had no access, or 5 journals, for a total of 17 journals and 4448 empirical papers comprising our final dataset.

For each article, we additionally collected a variety of metadata from WoS including: article name, doi, journal, publication date, authors, and authors, and full citation list. Once we have identified the sample of articles from WoS, we then follow two workflows to (1) identify the author('s) gender and (2) if the article is OS or not. This process is schematically described in *Figure 1*.

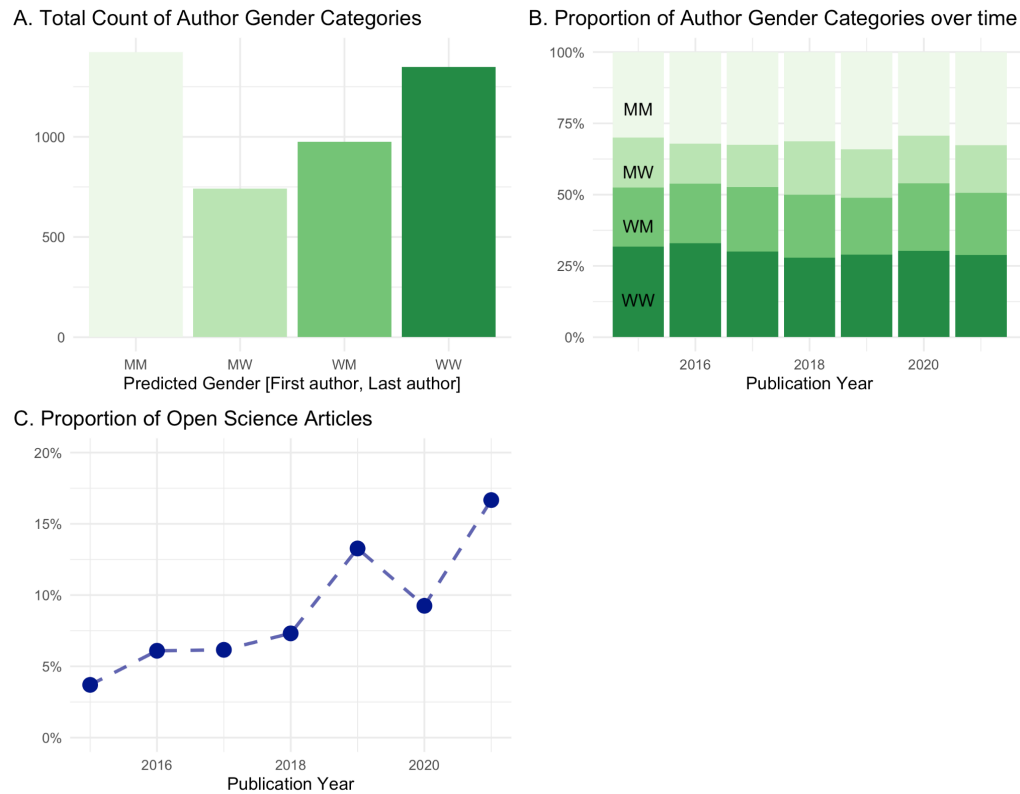**Figure 1. Schematic Representation of Data Collection Workflow**
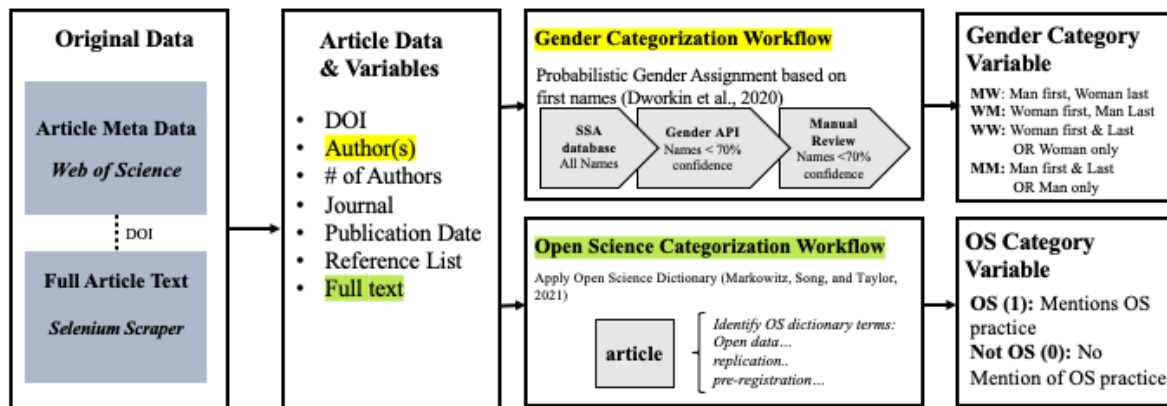
The first workflow produces a gender category variable. To do this, we use a multi-step approach outlined by Dworkin et al (2020) in their study of the gender gap within neuroscience publications. We first separate first from last names, and use the first name to assign a probabilistic gender. It is important to note that because it is a probabilistic assignment, there are almost certainly cases where the author's actual gender misaligns with our assigned gender. This is especially possible since we use only the male/female binary. We don't make our raw data files public to protect from any harms this misgendering might have (along with other privacy issues) and only report in aggregate across our journal levels. In the lack of more robust, self-reported data about gender (and other demographic categories, like race) we hope that our algorithmically derived process can provide enough indication of general trends.

Once we have the names, we first use the Social security administration database to assign authors to men and women categories based on the likelihood of the name to belong to each group. For all names not returned from SSA we use the Gender-API (a paid service) to do the same. We assign genders to any name that returns more than a 0.7 likelihood confidence and manually review all the remaining (400 names, 9% of total) by searching for the author's profile or biography and using the pronouns indicated by the biography. We assign a gender to each first

and last author of each paper, and then assign each article into one of four groups: WW, women first and woman last author or woman sole author; WM, woman first and man last author; MW, man first and woman last author; and, MM, man first and man last author or man sole author.

Our second data workflow produces a binary indicator of whether or not an article included an Open Science practice. We produce this variable by applying the Open Science dictionary created and validated by Markowitiz, Song, and Taylor (2021) to identify discussion of a range of OS activities within the full text of each article. Terms included in the dictionary represent sharing materials (data, code, instruments, etc), pre-registering reports, and running replications. We assign articles as OS (Open Science) if any term from the dictionary is returned and NOS (Not Open Science) if no terms are matched.

These two workflows produce our two variables of interest for each article in our sample: Author gender category and a binary indicator of OS (1= OS, 0=NOS). We additionally include publication year and journal as controls, which were collected from Web of Science. For the exploratory citation analysis, we also disambiguate the full list of cited works included in the Web of Science meta data for each article in our sample.

Figure 2. Trends in Participation Rate & OS adoption over time.

A. Total Count of Author Gender Categories

B. Proportion of Author Gender Categories over time

C. Proportion of Open Science Articles

Results

The gender category participation and OS adoption trends over time are displayed in

Figure 2. Across all our data we find similar proportions of WW (30%) and MM (32%) papers,

with fewer WM (22%) and the least MW (16%) papers, although this is to be expected as WW

and MM additionally capture solo author papers. Notably these percentages stay relatively static

over time (**Figure 2B**). We find that Open Science practices are generally increasing within the

field of Communication, which replicates and extends the findings from Markowitz, Song, and

Taylor (2021) (**Figure 2C**). Only approximately 4% of papers claimed an OS practice in 2015,

but this has increased to 16% in 2021, with a notable increase in 2019.

Our main research question was: do rates of women's participation within OS compare equitably to those in non-OS Communication papers? We investigate this first by comparing the proportions of each author gender category within OS and NOS groups of articles (**Figure 3**). We find that overall OS participation rates significantly diverge from the expected NOS rates (X^2= 13.55, p=0.004). This is mainly driven by a significant increase of MM papers (Two-proportions Z-Test, X^2= 4.32, p=0.04) and a significant decrease of WW papers (Two-proportions Z-Test, X^2= 7.63, p=0.005). The differences in both the rates of WM and MW papers were not significant (p>0.05).

**Figure 3. Gender Category Participation Rate within OS and NOS**
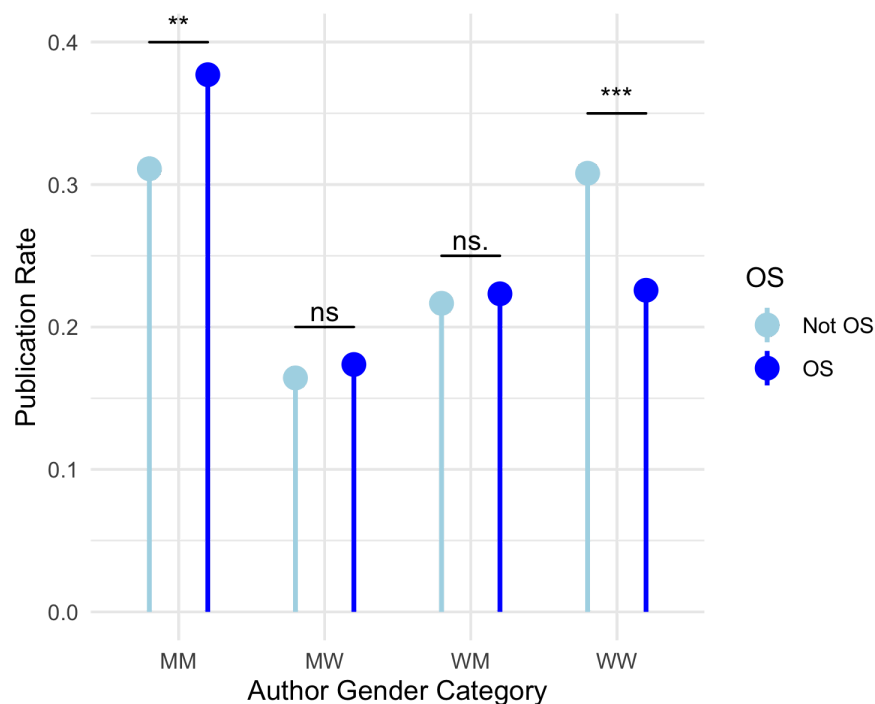
Note: Significance indicators based on Two-Proportions Z-Tests comparing OS and NOS publication rates: p<0.05 (**), p<0.01 (***). Author Gender Category is based on the predicted gender of the first name of the First and Last Author. MM and WW include respective sole authors.

We additionally ran a logistic model specifying GLM with a "binomial" family. Our main predictor of interest included a categorical OS variable (1=OS, 0=Not OS) and controlled for

publication year and journal differences. We examined the relationship for Women Led papers, or those in the WW category which represents papers that had a Women first and last author as well as all the sole woman authored papers. We additionally examined the impact on woman authored papers which included papers from WW, WM, and MW categories. We find that Women led papers are almost 30% less likely to be OS papers (p=0.0008; **Figure 4A**) than men, and women authored (WW, WM, MW) papers are about 25% less likely (**Figure 4B**). We also find small effects at the journal level, with some journals more likely to publish OS work than others, suggesting a diverse roll out of OS practices across the field.

Figure 4. Odds Ratios
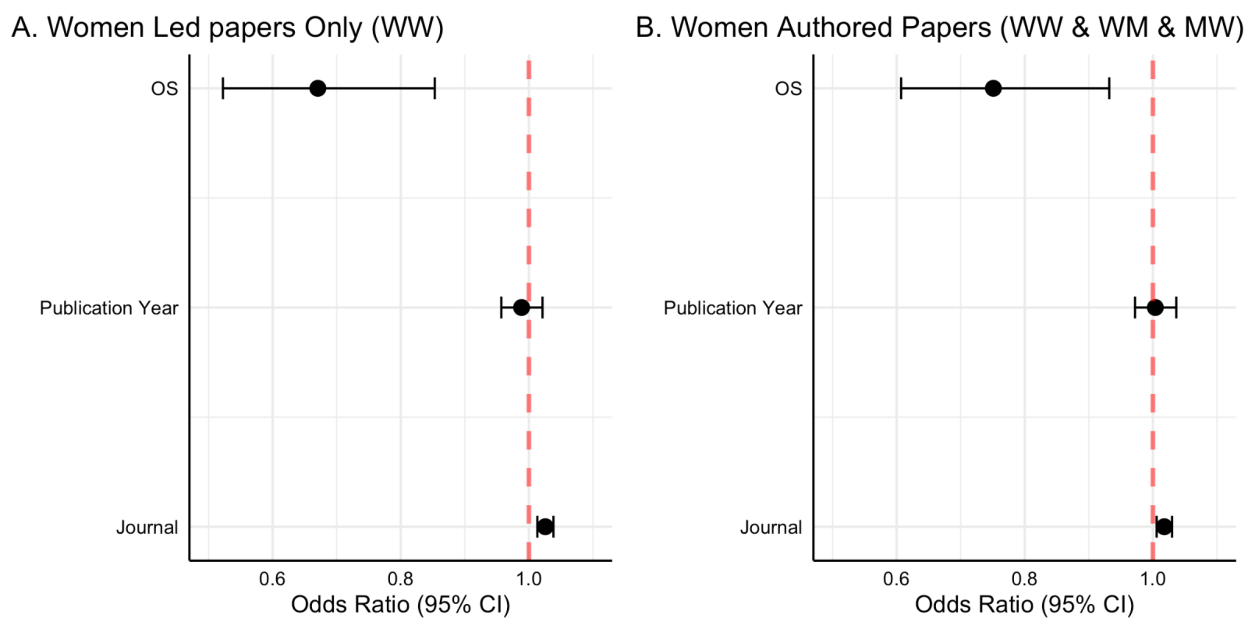
Note. Odds Ratios for our logistic regression models. For model A (Women Led Papers) we created a dummy outcome gender variable where WW =1 and all other categories =0. For model B (Women Authored Papers) we created a dummy outcome variable where WW or MW or WM categories = 1 and MM only=0. Plots include 95% confidence intervals.

Our results indicate a gender inequality within Communication papers that adopt OS practices. This is especially concerning because of the relatively equitable rate of publication within Communication in general, where MM and WW each make up approximately a third of the articles. Women are less likely to participate in OS, especially when it's women-led (WW) work, which could lead to a more evident inequality within the field as OS adoption increases over time. This data should be an alarm for intervention before we see such effects manifest.

Importantly, this data does not reveal the causes of why we see this disparity, only that it exists. We cannot account for journal level differences as well as methodological and topical variations across papers, which would help further disambiguate what features of Communication research might be influencing the observed OS participation inequality. It might be due to methodological inequalities, with women over-represented in areas that are not well suited to OS adoption. It could also be cultural issues of sexism or even harassment within the OS community that make OS practices less accessible to women by actively discouraging their participation. Despite these limitations, our results provide compelling substantiation of Fox et al.'s (2021) fear that OS is creating inequality and exclusions, at least in regards to gender. In all likelihood the reasons for the observed inequality are varied and apply to different researchers in different ways. While we strongly support more investigations into the underlying mechanisms that drive the inequality within OS, we especially urge a greater conversation around how to build a more equitable and diverse OS Community, through adaptations in practices, systems, and culture. As two practitioners of OS ourselves, we argue for concerted efforts around creating a better OS movement, less about enforcing rigid standards and more about a spirit of communalism and rigorous review of our responsibilities to our subjects, participants, and scholarly community.

Exploratory Analysis : Citation Inequality

Accompanying inequities in participation are those within citation lists. Citational inequality has been the focus of academic research and academic activism alike. Past citation analysis studies have identified significant gender disparities in fields as diverse as astronomy (Caplar, Tacchella, & Birrer, 2017), neuroscience (Dworkin et al., 2020), political science (Dion, Sumner, & Mitchell, 2018), and communication (Wang et al., 2021). At least in communication, these gender gaps seem to primarily be driven by men citing articles authored by other men at higher rates than expected (Wang et al., 2021). Academic and other knowledge activists have identified how citations are a valuable metric for assessing a scholar's work and standing within the field, with higher citation counts associated with greater prestige and influence. Yet citations are neither neutral or objective, they are always choices, and ones that can have profound implications on individual careers and the wider system of knowledge production alike (Mazloumian et al., 2011). The citational justice movement has worked to draw attention to the various gaps (namely, gender, racial, and geographic) that occur within citation networks (Kwon, 2022). Accompanied by collectives like the Cite Black Women Collective and Women Also Know Stuff, the citational justice movement spotlights the work of women and non-binary authors in an effort to change citaitonal distrubtions away from the same group of mostly white men. Some scholars have additionally practiced radical commitments to citational equity by not citing any white men (Ahmed, 2017) while others have advocated for citation statements and proposed badges similar to the OS system that reward papers that meet a threshold of gender and racial parity (Zurn, Bassett, & Rust, 2020).

In this analysis we begin to parse the citational differences across our OS and NOS groups of articles. Specifically we ask (**RQ2**): What is the gender distribution of authors cited

within OS and how does it compare with the gender distribution of authors cited in the field at large? Additionally, (**RQ3**): What is the gender distribution of those most frequently cited within OS work? In this question, we hope to move beyond citation counts and look at the most central citations (papers cited by many articles in our sample) in order to propose a measure of influence and to identify who is driving the conversation within the field.

Here we specifically look at RQ3, or top citations within our sample. We gather the list of cited references for each of our articles included in our WoS data collection effort (see **Figure 1**). Our sample includes 322,587 citations with an average of 50.5 cited works per article. The majority of citations occur only once, with an average cite count of 1.5. We examine the top 1% of citations from both OS and the NOS samples (*N*=312 cited works). We assigned the same gender categories to each cited work, following the same protocol established above. We built a bipartite network with one set of nodes as our sample papers and another as the cited works, with ties reflecting a citation (**Figure 5**). Despite the observed inequalities within participation we see less inequality between OS and NOS, across top citations. Although the absolute (non comparative) rate of citation is much more heavily skewed, with MM papers making up the majority of this top 1% of citations. While the overall differences in the proportion of the gender categories within the top citations between OS and NOS are are significant (X^2= 22.9, p<0.0004), they are small and due mostly to changes in the proportion of MW and WM categories. Neither the MM or WW categories show significant increases or decreases when comparing across the two OS groups (P>0.1). Thus, OS does not produce a greatly increased inequality within the top citations, but the top citations within Communication in general are heavily biased towards men led (MM) works and away from woman authored (WW, MW, or WM) works.

Figure 5. Gendered Citation Patterns within NOS and OS among the top 1% citations within sample of comm articles (2015-2021)
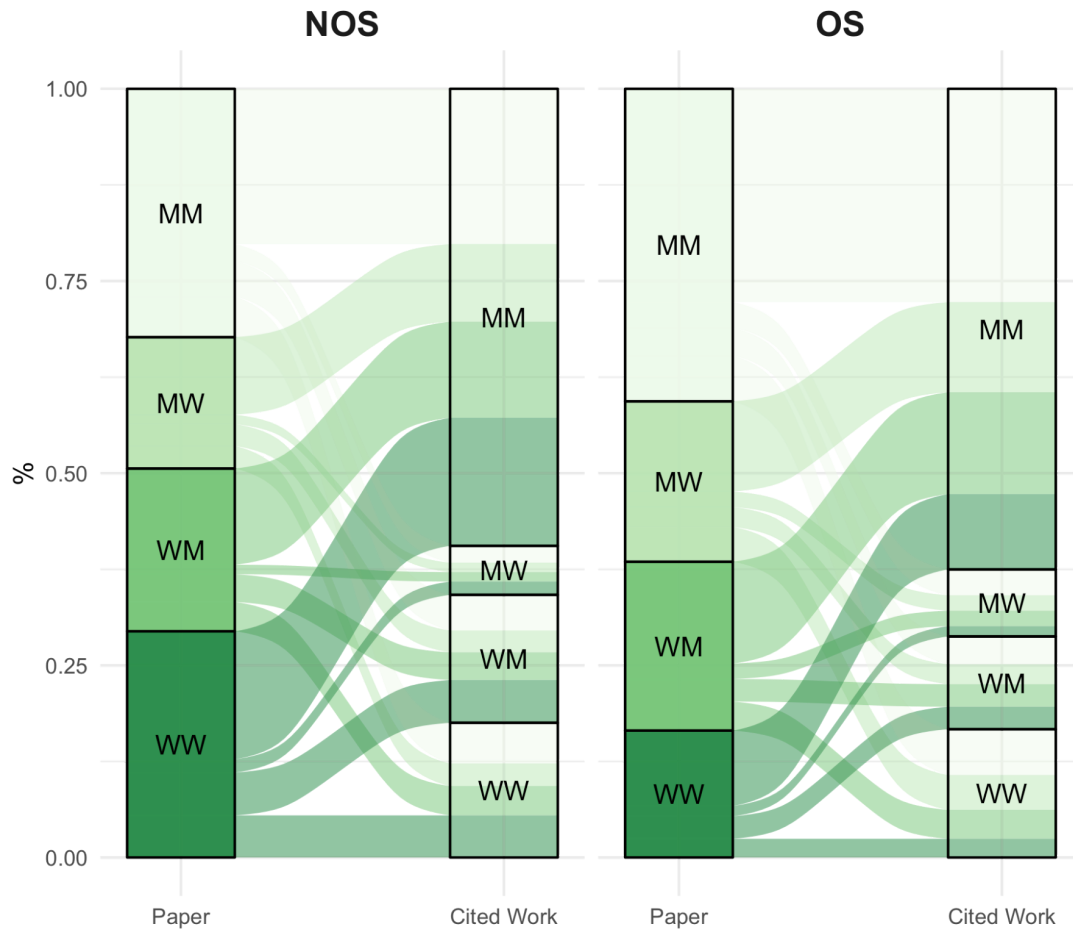
Note: Sankey diagrams display the gender category participation rate among articles in our sample (left column) and within the top 1% of most frequently cited works (right column) within the OS and NOS and groups. The top 1% of citations has n= 312 works.

We are hopeful, based on these early results, that OS, while showing signs of inequality within publication, is not leading to deleterious consequences within citation networks. While the field as a whole has much to improve about our citational practices, we think that the approach to

communism and the value of transparency can extend to greater reflection around citations and contribute to the larger citational justice movement.

Discussion & Conclusion

In this paper we investigate gendered participation and citation patterns within OS adoption in the field of Communication by considering over 4,400 Communication articles published in quantitative journals since 2015. Our results show that OS is associated with a disproportionately larger gender gap relative to what is present within the field. Our descriptive findings provide some of the first evidence of the impact OS adoption might have on the larger field, and especially the ongoing diversity efforts of Communication. Our partipcaiton results, in particular, substantiate the fears of Fox et al. (2021) that Open Science might "close doors" to some researchers. We find that women participate less within OS than they do across quantitative-skewed Communication research as a whole.

However, this pattern does not appear to extend to the top citations. Within the top 1% of papers most cited by our sample of articles, OS and NOS both disproportionately cite men led (MM) works. These findings seem to be driven largely by a widely shared overlap between OS and NOS cited works: of the top 1% of citations, 71% are cited by papers that are in both NOS and OS categories. We suspect that the gender gap we observe within citations is thus not due to a change in citational practices produced by the OS movement (like citing papers that describe a specific OS standard), but are rather due to the gender inequalities that are already prevalent within communication research and that have been described more fully by past research (Chravartty et al., 2018; Wang et al., 2021). More research is called for to better understand the particular relationship between OS and citational inequality. We hope to extend this analysis

beyond our arbitrary 1% threshold to confirm the robustness of our findings and to test whether

inequality within OS citation practices might be more visible at the periphery of the citational

network. Overall, based on these early results, the signs of inequality within publication rates are

not reflected in gender inequality patterns within citation networks. While the field as a whole

has much to improve about our citational practices, we think that the approach to communism

and the value of transparency advocated for by OS could extend and allow for greater reflection

around citations and contribute to the larger citational justice movement.

It is important to consider this work in light of several limitations. We are limited in our

analysis by several factors, including our use of a binary gender category. We also only consider

first and last authors. While there is precedent for this in past studies (Dworkin et al., 2020;

Wang et al., 2021), in future iterations of this project, we plan to use a gender score that includes

every author on a paper. This score would reflect the proportion of women authors of a paper and

would range from 0 (all men authors) to 1 (all women authors). It is also possible that our results

are due to topical considerations, which we are unable to disambiguate beyond the journal level

here. However advances in text analysis techniques could allow us to better model such effects,

and to describe more richly the inequalities we observe.

We hope the workflow established here can be useful for future, more intersectional,

work extending this to other aspects of diversity e.g. racial and geographic diversity. While our

work is limited to quantitatively skewed journals, the field has begun a rich discussion on how to

best adapt the values and practices of OS to fit our methodologically diverse discipline (see

Shaw, Scharkow, & Wang, 2021), and we hope future work will continue this and innovate better

methods and practices for the field in general. Our findings are purely descriptive but emphasize

the need for further research into the consequences of OS adoption on the field's diversity

initiatives. Overall, this paper provides the foundation for continuing to evaluate the tensions within the field, and will hopefully spark interest in continuing to study what OS adoption means for our interdisciplinary field.

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