Is there a gender gap in social media metrics?

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Abstract
The gender gap in science has been the focus of many analyses which have, for the most part, documented lower research productivity and citation impact for papers authored by female researchers. Given the rise of scholarly use of social media to disseminate scientific production and the healthy proportion of women on these sites, further investigation of potential gender disparities in social media metrics are warranted. Comparing event counts from Twitter, blogs, and news with citations, this study examines whether publications with male and female authors differ regarding their visibility on the social web and whether gender disparities can be observed in terms of social media metrics. Findings demonstrate increased gender parity using social media metrics than when considering scientific impact as measured by citations. It is acknowledged that this could be the results of the different impact communities, as the scientific community constituting the citing audience is more male-dominated than the social media environment. The implications for the use of social media metrics as measures of scientific quality are discussed.

Conference Topic
Altmetrics

Introduction
Early Internet use was heavily male-dominated—to the point of being considered a "boy toy" (Morahan-Martin, 1998; Weiser, 2000)—and promises of gender equity in computer-mediated communication were left unrealized (Herring & Stoerger, 2013). However, recent transformations in both the function and functionalities of the Internet have led to increased participation of women, particularly in the use of social networking sites (Kimborough et al., 2013). As of September 2014, slightly more women are using social networking sites than men (Duggan, Ellison, Lampe, Lenhart & Madden, 2015). However, although men and women now both employ social media, the ways in which they use them remain gendered (Correa, Hinsley, de Zuniga, 2010; Koenig, 2015; Muscanell & Guadagno, 2012; Piazza Technologies, 2015).

Twitter—an online social networking service for microblogging—is one of the top websites in the world (Alexa.com). However, despite equality in other social media sites, there appears to be a growing gender disparity in Twitter, with men using the platform at higher rates than women (24 vs 21%) (Duggan et al., 2015). Moreover, the gender gap in Twitter usage has been increasing in the last two years (Duggan & Brenner 2013; Duggan et al., 2015). Gender bias is also reflected by journalism's practices on Twitter, where reporters' tweets severely underrepresent women in quotes (Artwick, 2013). This speaks to women's

underrepresentation as authorial voices—that is, voices that can speak as experts and authority on matters of merit. Given the rise of scholarly use of Twitter (Costas, Zahedi & Wouters, 2014; Haustein, Costas & Larivière, 2015; Holmberg, Bowman, Haustein & Peters, 2014; Pscheida et al., 2013; Rowlands et al., 2011), further investigation of potential gender disparities in scholarly communication and measures of impact from this site are warranted.

Microblogging is not the only web space with demonstrated gender disparities. Given the underrepresentation of women in science (Larivière, Ni, Gingras, Cronin & Sugimoto, 2013; West, Jacquet, King, Correll & Bergstrom, 2013), many studies have sought to examine whether the web might provide a democratizing space for female academics. These studies have shown that men tend to have greater web presence than women (van der Weijden & Calero Medina, 2014) and blog at a greater rate (Puschmann & Mahrt, 2012; Shema, Bar-Ilan & Thelwall, 2012). Bar-Ilan and van der Weijden (2014) recently investigated whether gender specific differences could be found when considering Mendeley (a social bookmarking service) readership counts. Using the gender of one of the co-authors of astrophysics papers—a field where *hyperauthorship* is commonplace (Cronin, 2001), thus making it difficult to distinguish papers attributed to female researchers from male researchers—they showed that the share of papers, to which at least one male contributed were found more often on the platform that those to which at least one women contributed. On the other hand, women attract more profile view in Academia.edu (an academic social networking site) in certain disciplines (Thelwall & Kousha, 2014). Many of these social media sites are associated with less formal ways of discussing and sharing research results with a wider audience (Shema, Bar-Ilan & Thelwall, 2012; 2014). The degree to which this engagement is gender-neutral begs further investigation.

This study builds on these analyses and seeks to examine whether publications with male and female authors differ regarding their visibility on the social web, and whether gender disparities can be observed in terms of social media metrics. Comparing event counts from Twitter, blogs and news with citations, this study aims to answer the following research questions:

- Does the gender gap in scholarly communication observed for publications and citations extend to social media?
- Does the visibility of male and female authored papers differ among Twitter, blogs, and mainstream news media?
- Does the gender gap in social media visibility of scholarly journal articles differ by scientific discipline?

There has been a growing call for researchers to demonstrate social impact (e.g., Force 11, 2011; REF, 2014). Social media metrics have been promoted as a source of such impact measures (Priem, 2014). However, the degree to which gender inequalities exist on such platforms must be investigated prior to wide-scale adoption and use of social media metrics.

Methods

Data were drawn from Thomson Reuters' Web of Science (WoS), which includes the Science Citation Index Expanded, the Social Science Citation Index and the Arts and Humanities Citation Index. These databases index annually documents published in over 12,000 journals across all scholarly disciplines. To determine differences between scientific disciplines, the

NSF field classification of journals (National Science Foundation, 2006) was used instead of WoS categories in order to avoid possible double counting of papers by classifying, as the NSF classification assigns each journal to only one specialty.

Only papers published in 2012 were considered, as this year provides the best compromise between the length of the citation window—citations to papers take time to accumulate—and the recent uptake of social media activity (Thelwall, Haustein, Larivière & Sugimoto, 2014). Citations to 2012 papers were counted until the end of 2013, which allows for a citation window of at least one complete year for all papers. Selecting 2012 publications also has the advantage of guaranteeing complete coverage of social media data for the whole year, as Altmetric.com started data collection mid-2011 (Costas, Zahedi & Wouters, 2014).

Altmetric.com was chosen as the data source for social media and mainstream media counts, as it is the most comprehensive source of social media data associated with scientific papers (Robinson-García, Torres-Salinas, Zahedi & Costas, 2014). News items, tweets and scientific blogs entries were selected for the analysis. Mainstream media and news sources captured by Altmetric.com include online mentions of scientific papers in more than 1,000 mainstream media and news outlets such as the Washington Post, Süddeutsche or CNN[1], giving insight on the visibility of a paper among the general public. The audience of Twitter and scientific blogs covered by Altmetric.com may reflect the overlap between the scientific community and the general public as both are widely used outside of academia but also by scholars. These metrics were selected because they represent three different types of social media events and levels of engagement from users, ranging from the one end of the spectrum with an engagement limited to 140 characters on Twitter, to the redaction of whole blog entries or newspaper articles, at the other end. Altmetric.com data includes counts collected up to August 2014. Given the quick uptake of social media-based indicators (excluding Mendeley) reported by Thelwall et al. (2014), we consider that the social media activity window of more than a full year considered in this study is long enough to cover the vast majority of social media activity around papers published in 2012.

The link between WoS papers and the Altmetric.com list of indicators was made using the Digital Object Identifier (DOI). Hence, papers that did not have DOIs were excluded from the analysis. As one might expect, the proportion of papers with DOIs is not distributed evenly across scientific disciplines. While, for most fields, the proportion of journals with publications with a DOI is very high (e.g., above than 70%), a substantial share of journals (30%), particularly in the Social Sciences and Humanities, do not use DOIs (Haustein, Costas & Larivière, 2015). Hence, for papers published in the latter group of journals, results from Altmetric.com are more likely to underestimate their actual online visibility, which represents a limitation of this study (as well as the great majority of social media metrics analyses). Arts and Humanities papers were thus excluded of the analysis because of the low number of papers and of citations. The gender of authors was attributed using the authors' given names, following the method developed in Larivière et al. (2013). The method allowed to assign a gender to the first author of 67.7% (N=696,186) of all 2012 papers that had a DOI (N=1,028,382). The analysis is, thus, based on this dataset of papers, and the gender of the first author is used to categorize the paper as female or male.

The prevalence of social media metrics is measured through intensity, which indicates the mean number of events for papers that show at least one of the particular events (non-zero

[1] http://www.altmetric.com/sources-news.php

counts) and coverage, percentage of papers with at least one event. While coverage reflects the probability of a document to be cited or mentioned on the particular platform, the intensity indicate rate aims to measure the frequency or popularity with which documents are (re)used once they are on the platform and remains independent of the coverage and zero values (Haustein, Costas & Larivière, 2015).

The scientific impact of male and female researchers is compared using the average of relative citations (ARC). The ARC provides a field-normalization and thus allows the comparison of citation impact between the different specialities that have otherwise different citation practices. More specifically, the number of citations received by a given paper is divided by the average number of citations received by articles in the same NSF research specialty published in the same year. An ARC greater than 1 indicates that an article is cited above the world average for the same field, and an ARC below 1 means that it is cited below the world average.

Results

Figure 1 compares the ARC of papers first authored by women and men, respectively, in order to assess whether a gender gap can be found in the dataset of papers used. Figure 1 confirms the widespread gender disparities observed in science (Larivière et al., 2013) in terms of scientific impact. More specifically, in each discipline, papers first authored by male researchers have higher citation impact, with the only exception of Engineering and Technology where papers first authored by female researchers have a slight advantage (ARC value of 1.18 for women and 1.17 for men). Biomedical Research (0.95 for women and 1.11 for men), Professional Fields (1.11 for women and 1.26 for men), Mathematics (1.03 for women and 1.19 for men) and Psychology (0.97 for women and 1.12 for men) show the greatest gender differences regarding citation impact.

Figure 1. Average of relative citations of papers first authored by female and male researchers, by discipline and ordered by gender gap, 2012

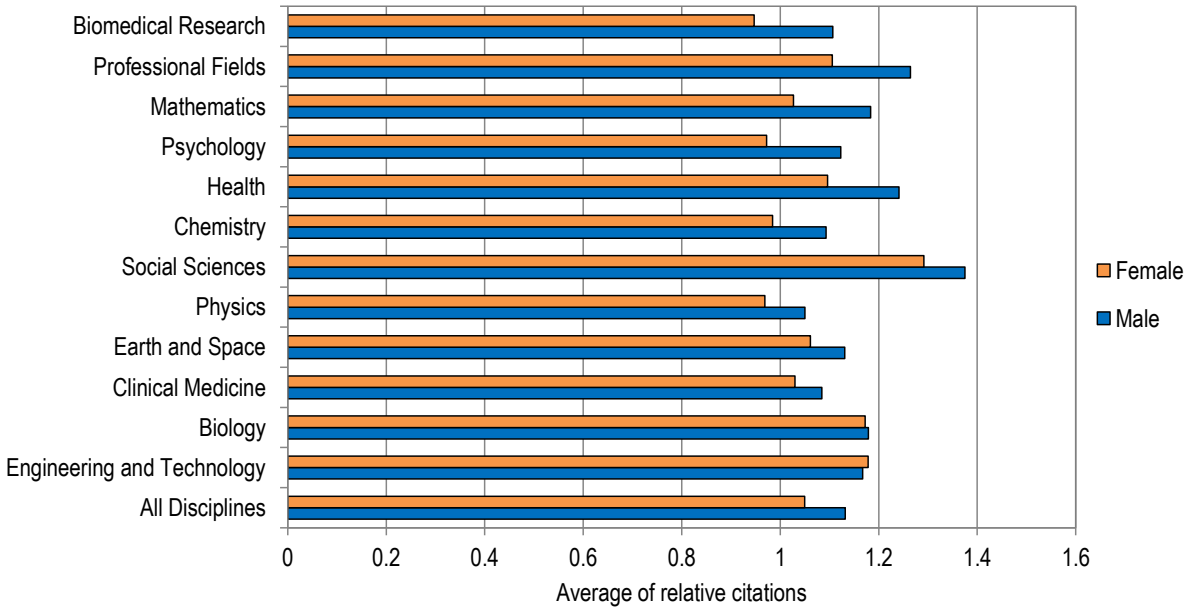

Figure 2 compares papers first authored by female and male researchers, in terms of intensity of news items (i.e., the mean number of events for all documents with at least one event) and coverage by news items (i.e., the percentage of papers with at least one event). All disciplines

taken together, the intensity and the coverage of news items is gender-balanced, with an intensity difference of less than 0.07 event and a coverage difference of less than 1%. Physics (mean number of 1.04 for women and 1.34 for men) and Biomedical Research (1.63 for women, 1.87 for men) are the disciplines showing the strongest gender gap in terms of intensity of news items, in favour of papers first authored by men, corroborating the gender gap found in terms of citation impact (Figure 1). Coverage by news items of papers published in Biomedical Research (1.20% for women, 1.49% for men), Earth and Space (1.17% for women, 1.42% for men), Chemistry (0.59% for women, 0.84% for men) and Psychology (1.26% for women, 1.50% for men) also confirm the gender gap found in terms of citation impact. However, papers first authored by female researchers in Health (1.32 for women, 1.26 for men), Clinical Medicine (1.39 for women, 1.33 for men) and Professional Fields (1.47 for women, 1.17 for men) have higher mean numbers of news items than that of male researchers while in Biology (0.73% for women, 0.62% for men), Engineering and Technology (0.60% for women, 0.55% for men) and Clinical Medicine (0.67% for women, 0.52% for men) they have a greater coverage.

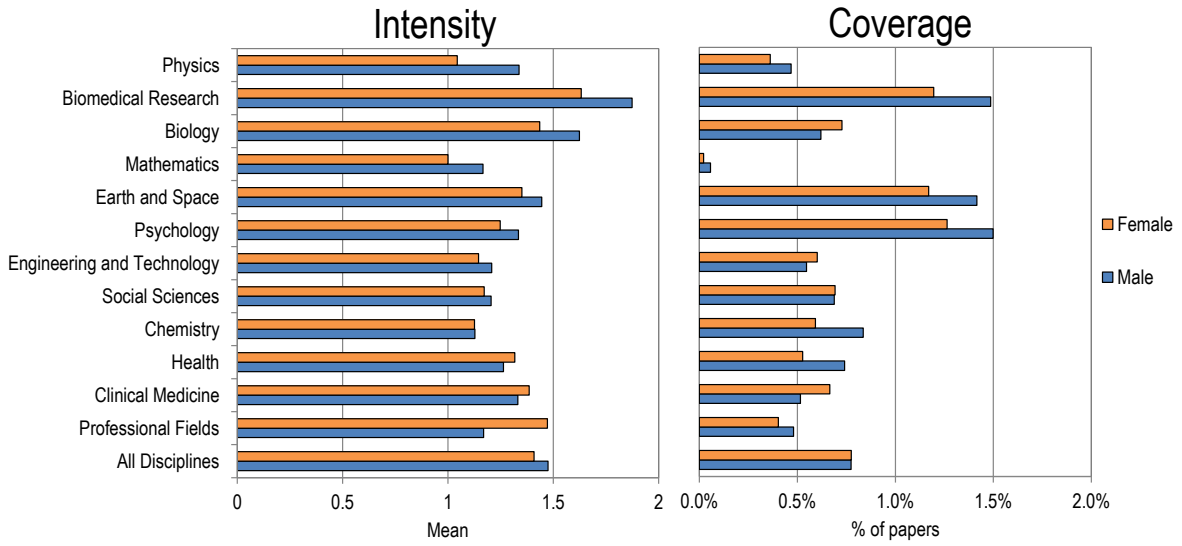

Figure 2. Intensity and coverage of news items of papers first authored by female and male researchers, by discipline, 2012

Figure 3 provides the average numbers of tweets for all papers with at least one tweet (intensity for non-zero event items) and the percentage of papers with at least one tweet (coverage) by gender. It clearly shows that Twitter is the most popular platform among the three social media and mainstream media metrics analysed here, with an intensity of almost 3 tweets for papers tweeted at least once and coverage of almost 20% of papers (all genders and disciplines taken together). Gender analysis shows that, for all disciplines, papers first authored by female researchers are more intensely tweeted (2.98 tweets for women, 2.94 for men) and have a higher probability of being tweeted than papers first authored by male researchers (21% for women and 18% for men). Consistent with what has been found in terms of citations (Figure 1) and news items (Figure 2), Psychology and Biomedical Research show the highest gap in favour of men in terms of mean numbers of tweets.

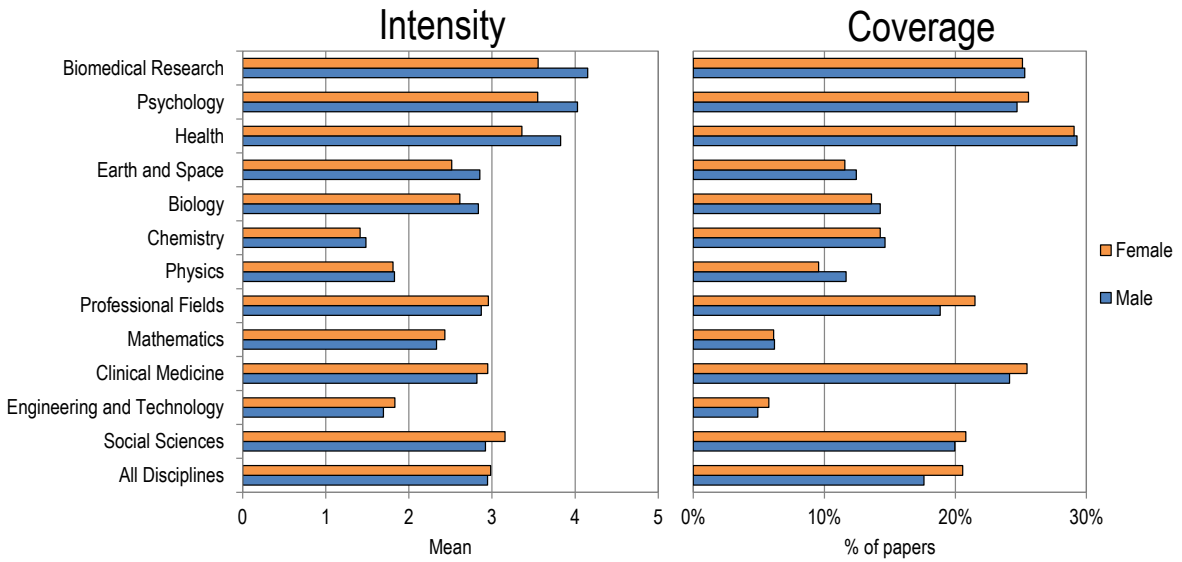

Figure 3. Intensity and coverage of tweets of papers first authored by female and male researchers, by discipline, 2012

Figure 4 presents intensity and coverage by blog entries of papers first authored by women and men. All disciplines taken together, papers first authored by male researchers show a slightly higher intensity in terms of mean number of blog entries (1.33 for women, 1.40 for men) and higher coverage (1.68% for women, 1.78% for men). As previously shown, Psychology and Biomedical Research present important gender gaps, both in terms of intensity and coverage of blog entries. With respect to intensity, the average of blog entries of papers first authored by female and male researchers are equivalent in Health, Physics and Chemistry and papers authored by women have a slight advantage in Engineering and Technology. Papers authored by female researchers have stronger blog coverage in Clinical Medicine (1.30 % for women, 1.23% for men), Professionals Fields (1.08% for women, 1.02% for men) and Engineering and Technology (0.95% for women, 0.89% for men). However, the extreme gender gap in blog authors—both Puschmann and Mahrt (2012) and Shema, Bar-Ilan and Thelwall (2012) showed that about three quarters of bloggers where male—seems to transfer to the authors cited in blogs as confirmed by the coverage of papers authored by male researchers.

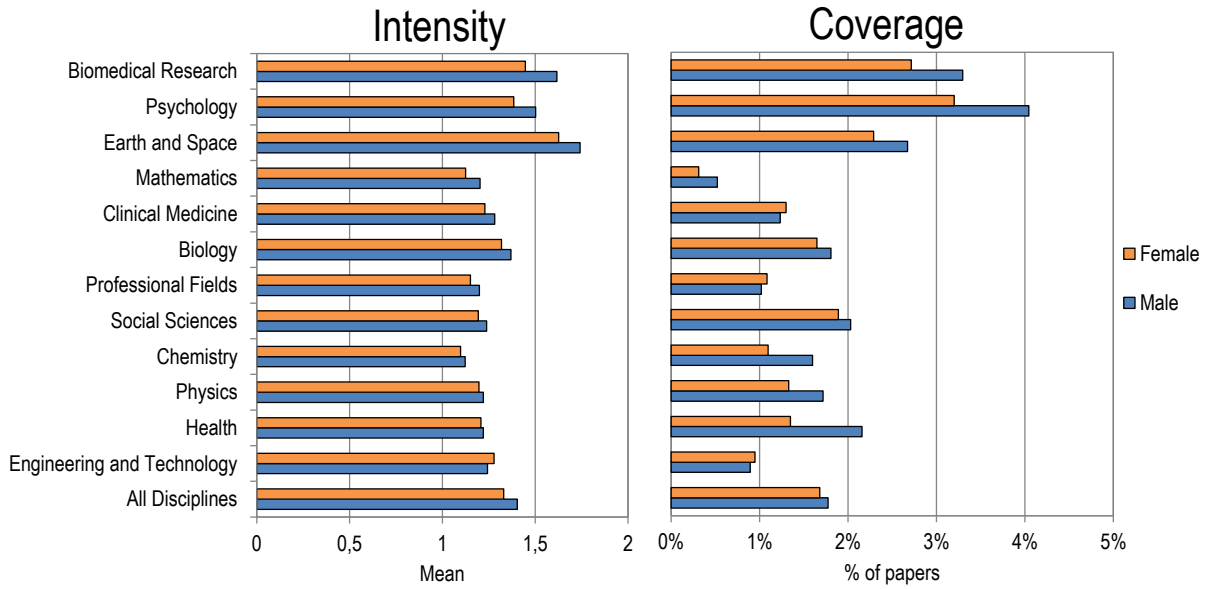

Figure 4. Intensity and coverage of blog entries of papers first authored by female and male researchers, by discipline, 2012

Discussion and conclusion

Our findings demonstrate a more gender-balanced portrait when considering social media and mainstream media metrics (Figures 2 to 4), than when considering scientific impact as measured by citations (Figure 1). This could be explained by the fact that the impact communities contributing to these metrics are different: the scientific community which constitute the citing audience is more male-dominated than the social media environment (Kimbrough et al., 2013).

However, there is uniformity in the results neither by discipline nor platform. Coverage varied significantly by discipline, as did the mean impact score by gender. Furthermore, gender differences were found when examining microblogging, blogging, and news coverage. This suggests more information is needed before conclusive evidence on gender equality or inequality in social media metrics can be determined.

It could be argued that the diversity of the social media audience gives a broader audience an ability to respond to scholarly communication and therefore these measures of impact are a more honest metric of the absolute value of the work. However, lacking adequate validation of the meaning of social media metrics (Wouters & Costas, 2012), it is perhaps pre-emptive to make such a claim, as many tweets are actually made by bots (Haustein et al., in press). Further research on the nature of highly tweeted research will thus be necessary to assess the underlying mechanisms underneath the observed trends.

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