American Psychologist

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Online First Publication, May 13, 2019. http://dx.doi.org/10.1037/amp0000480

American Psychological Association

American Psychologist

0003-066X/19/$12.00

http://dx.doi.org/10.1037/amp0000480

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Women are notably underrepresented in the academic sciences. Psychology is a pertinent case study of gender inequality in science, because women make up over three quarters of undergraduate and graduate students but only a third of all full professors. Here, publication records from 125 high-impact, peer-reviewed psychology journals are analyzed to describe nuanced patterns about how men and women contribute to research psychology. To determine gender, we classified over 750,000 authors on 200,000 unique publications by comparing the 1st name of each author to openly available census data. The data replicate previous reports of publication and citation gender gaps in psychology and significantly extend these results by showing that these gaps are persistent across subdiscipline and time but are mediated by various contextual factors. For example, although the size of the publication and citation gaps are not explained by the university affiliation of the authors' and frequency of coauthorship, the gaps are larger in high-impact journals and at the last-author position. These patterns have remained largely unchanged since at least 2003. These results provide a detailed look at the variety of factors contributing to the differences in how men and women publish in research psychology and provide free and openly available tools for assessing publication and citation differences across time, journals, and other academic disciplines.

Keywords: gender differences, diversity, publication rates, citations

Supplemental materials: http://dx.doi.org/10.1037/amp0000480.supp

There is a pervasive underrepresentation of women in the academic sciences, especially in senior research positions (Handelsman et al., 2005; National Science Foundation, 2017; Nelson, & Brammer, 2011). In an effort to document and describe nuanced patterns in the representation of men and women in research science, researchers have increasingly focused on analyzing large-scale, freely available publication and citation records (e.g., Dehdarirad, Villarroya, & Barrios, 2015; Duch et al., 2012; Eagly & Miller, 2016; Larivière, Ni, Gingras, Cronin, & Sugimoto, 2013). These records are valuable sources of data because of their low cost and because publication quantity and quality is one of the most—if not *the* most—important factor in grant, hiring, tenure, and promotion decisions. Publication records are also rich sources of data, containing information on when and in which journal each article was published, how many citations it has accumulated to date, the number of coauthors, each author's h-index, affiliation, authorship position, and so forth. Indeed, publication analyses across academic disciplines, including biology (Long, 1992; Symonds, Gemmell, Braisher, Gorringe, & Elgar, 2006), radiology (Piper, Scheel, Lee, & Forman, 2016), medicine (Jagsi et al., 2006), political science (Maliniak, Powers, & Walter, 2013), and social sciences (West, Jacquet, King, Correll, & Bergstrom, 2013), have shown a strikingly consistent publication and citation gender gap in scientific output, impact, and collaboration: Female authors are published less, are cited less, and have more coauthors compared to male authors (for reviews, see Dehdarirad et al., 2015; Larivière et al., 2013).

But, in contrast to the broad agreement that female authors are published and cited less than are male authors, the question of *why* these patterns are observed across academic sciences remains hotly debated. Some have argued that publication gaps are the byproduct of fewer women's choosing to pursue careers at high-caliber research institutions (Ceci, Ginther, Kahn, & Williams, 2014; Ginther & Kahn, 2006; Hunter & Leahey, 2010; Sears, 2003). Duch et al. (2012), for example, found that academic fields with larger requirements for financial and personnel support had

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Open Science Framework link: https://osf.io/3ajzq/.

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larger observed publication gaps; given that fewer women than men work at elite research universities (Ceci & Williams, 2011), the publication gap may, therefore, begin at the level of hiring, rather than at publication (but see Maliniak et al., 2013). Alternatively, some have suggested that although women may publish less, their work is more impactful and more highly cited, trading off a temporary publication gap for a long-term equality of impact (Ceci et al., 2014; Long, 1992; Symonds et al., 2006). A third common explanation for the publication gap is that female authors choose to divide work and publish with many more coauthors than do male authors, thereby diluting their contributions (Araújo, Araújo, Moreira, Herrmann, & Andrade Jr., 2017; Brooks & Della Sala, 2009; Larivière et al., 2013; Maliniak et al., 2013).

As a field, psychology offers a unique lens into mechanisms behind the underrepresentation of women in senior academic or research positions. For one, unlike with other science, technology, engineering, and mathematics (STEM) fields, women enroll in psychology programs at a high rate (Duch et al., 2012): In 2014, for example, over 70% of granted psychology doctorates in U.S. institutions went to women, with women also representing the majority of granted doctorates in every major subfield of psychology (National Science Foundation, 2016). Hence, any disparities in psychology at senior academic levels cannot be attributed to poor initial recruitment into the field. Second, any proposed biological or cultural differences, such as women's preferences for helping people rather than dealing with abstract "things" (e.g., Su, Rounds, & Armstrong, 2009) should, if anything, increase the probability of women's joining psychology. Finally, psychological research tends to require fewer monetary resources for research than do other STEM fields (Duch et al., 2012), reducing the potential impact that any well-documented discrepancies in grants or institutional support (e.g., Oliveira, Ma, Woodruff, & Uzzi, 2019) might have over publication and citation gaps.

Despite the advantages that psychology should hold over other STEM fields, previous work has found evidence of publication and citation gaps for women in research psychology. Eagly and Miller (2016) analyzed a subset of the massive data set previously collected by Larivière et al. (2013) and demonstrated that female authors are less published and less cited across all of psychology. Duch et al. (2012), using a sample of about 27,000 publications, also showed a publication gap for female authors in psychology, though they noted this difference may be accounted for by differences in support between institutions. On the other hand, two studies focusing on specific journals—*Cortex* and *Nature Neuroscience*—have reported no gender gaps in their respective publications (Brooks & Della Sala, 2009; "Women in Neuroscience," 2006).

The aim of the present analysis was to extend this previous work on the publication gap in psychology by analyzing publication records for men and women in over 200,000 unique publications from 125 highest impact, peer-reviewed psychology journals, spanning major subdisciplines and impact factors, from 2003 to the present. The analyses reported here focus on both quantifying and understanding *why* any observed publication and citation gaps may exist through three questions: (a) Is there evidence of a publication and citation gap for the 125 available journals between 2003 and 2018? (b) Do these gaps persist across contextual factors such as authorship position, subdiscipline, individual journals, number of coauthors, and author university affiliation? and (c) Have these patterns changed between 2003 and 2018?

Method and Materials

To analyze publication patterns in psychology, we used two freely accessible tools: the R RISMed package (Kovalchik, 2017), which allowed us to scrape and index the open PubMED database given a search query (e.g., journal name), and the OpenGenderTracking Project database (Ros, Hyland, & Matias, 2013), which has previously been used to examine gender biases in journalism (Matias & Evans, 2012). This free database contains a list of over 90,000 first names, along with the probability of each name's being male or female based on the U.S. and United Kingdom census data. The database was supplemented by adding an additional 200 names that most frequently occurred in the sample but were lacking from the database by consulting online baby name directories. The entire sample of names—as well as all of the tools used to download the data—are available for free online at https://osf.io/3ajzq/ and http://odic.psych.ubc.ca/PublicationGenderTracking.html.

Before downloading the data, we selected the relevant journals by focusing on three criteria: (a) The journal had to be in the top 200 highest impact psychology journals in 2016 (the last available year for impact factors in the Journal Citation Records database), (b) the journal had to be indexed by PubMED, and (c) the total number of indexed publications from 2003 to 2018 had to exceed 100 publications. For journals that PubMED did not fully index prior to 2003, the individual records that were indexed only because of compliance with NIH Public Access Policy were removed. Following these criteria left us with a set of 125 journals from which publication data were downloaded. It is important to note that because PubMED did not record the full first name data for each author for publications before 2003, the analyses focused entirely on the range of 2003—2018. Therefore, the available data comprise all publication records from these 125 journals for the range of time from 2003 to 2018 during which PubMED was fully indexing these journals; any records prior to 2003 or prior to the year at which indexing began were removed from the data.

The data were collected and cleaned in five steps. First, on February 8, 2018, the eligible PubMED records were downloaded and saved into R objects by identifying, for each journal, the unique PubMED search term and downloading the entire set of available publications between 2003 and 2018. Second, each publication was split object into its constituent authors, creating a large spreadsheet where each row represented a single author on a single publication matched with the PubMED numeric identifier, article title, journal title, author position, total number of authors, year of publication, number of citations, author university affiliation, and country of publication. Information such as abstracts, grants, keywords, and so forth was left out but can be easily extracted from the downloaded data. Third, the records were cleaned by eliminating all publications without listed authors (e.g., editorial notices, errata), stripping all accents in first and last names (e.g., turning an *è* into an *e*), removing dashes in names (e.g., turning *Jean-Luc* to *JeanLuc*), and eliminating first names that were listed as only initials. Fourth, the census data were loaded from the OpenGenderTracker (OGT) project by merging the U.S. and United Kingdom data sheets into one and removing duplicates by prioritizing the larger U.S. data set. This data set uses census data to assign a probability to a first name as male or female; although the vast majority of names have a probability of over 99% of being male−female given the census data, unisex names such as Pat or Jamie are much lower in their probability. A relatively conservative criterion of 80% was set as large enough to classify a name as male or female; all names that have a listed probability of less than 80% male or female were classified as unisex. Names that were not present in the OGT were classified as unknown. Finally, the classified author spreadsheets were combined into one large file, allowing us to examine data across all 125 publications. All of these acquisition and processing steps were done through custom-made scripts in R, using RStudio, and can be downloaded at the links cited earlier. The provided scripts can be freely used to continue updating the data year by year or modified for use in other fields whose publication records are saved on PubMED.

The final data set had, in total, records on 869,974 total authors, of which 303,794 had unique full names (i.e., the combined first, middle, and last name), with a median of five authors per article. Of these, 27,554 (3.16%) were classified as unisex, and 78,194 (8.99%) as unknown, because they did not occur in the names database; although unisex and unknown names were eliminated for all analyses reported here, a full analysis of these names is presented in the online supplemental materials. This left us with a final sample of 764,226 total authors (87.8% of the total sample) that were reliably categorized as male or female, of which 258,148 had unique full names, publishing across 199,700 unique publications.

Results

Do Female Authors Publish Less?

Consistent with previous work (e.g., Duch et al., 2012; Eagly & Miller, 2016), the first analysis investigated whether there is evidence for a general publication gap for female authors in psychology by examining the total percentage of male versus female authors across all publications, authors, and authorship positions. Then, the publication gap was investigated with two additional analyses: (a) by regressing publication counts on unique authors and their characteristics (including gender and university affiliation) while controlling for the inherent skew of publication data and (b) by examining publication counts across distinct authorship positions (e.g., single-author publications, first authors).

Replicating findings in previous work (Duch et al., 2012; Eagly & Miller, 2016), the results show that—even though women make up over 70% of master's and doctoral students in psychology (National Science Foundation, 2016), only 44.17% (95% confidence interval [CI] [44.06, 44.28]) of all authors between 2003 and 2018 are classified as female, whereas 55.83% (95% CI [55.72, 55.94]) are classified as male. Women also publish less often: Whereas an average unique male author has 3.56 (95% CI [3.52, 3.60]) publications in the 15-year period for the top 125 highest impact journals we investigated, an average female author has 2.44 (95% CI [2.42, 2.46]). Together, these patterns broadly replicate results of previous work showing a publication gap in psychology.

Next, the publication counts of each unique author in the database were examined, combining the person's first, middle, and last names to get his or her unique author identification. Because publication counts naturally show a strong right skew (i.e., most authors publish a few times, but a few publish many times), the data was fit to a negative binomial regression model (Maliniak et al., 2013) with the publication counts over unique authors as the dependent variable and the gender of each unique author as the independent variable. This analysis returned a significant effect of gender ($z = 88.85$, $p < .001$), with the incident rate ratio (IRR) showing a 1.46 (95% CI [1.44, 1.47]) advantage for male compared to female authors. In other words, for every publication that a unique female author has, a unique male author can expect about 46% more (i.e., for each one a unique female author has, a male author can expect roughly two).[1]

[1] One potential explanation for this data is that—as a group—male authors have higher seniority in the field and have been publishing over a much longer period of time. To account for this, we performed a separate negative binomial regression over publication counts, inputting the year of authors' first recorded publication for in the database as a proxy for their seniority. This analysis showed a significant effect of first year of publication (IRR = .88; $z = -293.98$; $p < .001$), unsurprisingly suggesting that authors who published earlier also had more publications overall; it still returned a significant effect of gender (IRR = 1.22; $z = 50.13$; $p < .001$), even when controlling for this factor.

There was one small silver lining in the data: The publication gap is less pronounced for first-author positions (i.e., first authors on multiauthor publications), where 50.43% (95% CI [50.18, 50.67]) of the authors are female and 49.57% (95% CI [49.33, 49.82]) are male (for similar patterns in fields outside of psychology, see Piper et al., 2016; West et al., 2013). Given that the majority of subfields within psychology place lead investigators—most often graduate and postdoctoral students—as first authors,[2] this suggests that the gender gap is already bridged in graduate school. At the same time, however, the publication gap is wider for single-author publications, where women represent only 29.70% (95% CI [28.97, 30.43]) of all authors whereas men represent 70.30% (95% CI [69.57, 71.03]). The gender gap is also strongly pronounced for last authors (i.e., last authors on multiauthor publications)—the position typically reserved for principal investigators—where 36.09% (95% CI [35.86, 36.32]) of authors are female and 63.91% (95% CI [63.68, 64.14]) are male (see also Larivière et al., 2013; West et al., 2013). These patterns are further confirmed with publication counts over unique authors, where negative binomial regressions reveal an advantage for unique male over female authors at every authorship position, including for first authors (IRR = 1.19; 95% CI [1.18, 1.20]; $z = 29.62$; $p < .001$), single authors (IRR = 1.20; 95% CI [1.16, 1.25]; $z = 10.02$; $p < .001$), and last authors (IRR = 1.45; 95% CI [1.43, 1.47]; $z = 45.45$; $p < .001$). Together, these results replicate and extend previous work showing a publication gender gap in psychology journals.

Are Female Authors Cited Less?

However, one might wonder whether women—despite publishing less—produce work that is perceived as more impactful and read more broadly and is therefore cited more often (e.g., as suggested by Long, 1992). To analyze citation data, we first examined how many times a publication gets cited based on whether the single, first, or last author is female. Subsequently, a series of regressions examining the average number of citations of each unique author in the database was performed as a way of controlling for the higher number of publications with male authors.

Contrary to the view that women publish less but more impactfully, a publication that is single-authored by a woman is cited an average of 6.44 (95% CI [5.89, 7.00]) times, whereas a single-author male publication is cited 8.41 (95% CI [7.81, 9.02]) times. Similarly, a publication that is first-authored by a woman gets cited an average of 7.93 (95% CI [7.82, 8.05]) times, whereas a publication that is first-authored by a man gets cited an average of 10.58 (95% CI [10.37, 10.80]) times. Finally, a publication that is last-authored by a woman is cited an average of 7.91 (95% CI [7.78, 8.05]) times, whereas an average publication that is last-authored by a man gets cited an average of 9.97 (95% CI [9.80, 10.13]) times.

But, because citation counts are inherently strongly positively skewed, these results could be explained by women's showing lower variance in citations compared to men. Hence, following others (Maliniak et al., 2013), we averaged the total number of citations that each unique author has, and this data were then fit to a negative binomial regression with gender as the independent variable (note that averaging the number of citations—rather than, e.g., summing them—controls for the higher number of publications that male authors have). This analysis showed a significant effect of gender ($z = 30.91$; $p < .001$), with the IRR of 1.19 (95% CI [1.17, 1.20]) higher for male authors. In other words, for every five citations a unique female author receives, a male author can expect to receive six (i.e., 19% more). These results hold when examining the average citations over unique single-author publications (IRR = 1.40; 95% CI [1.29, 1.52]; $z = 8.30$; $p < .001$), unique first-author publications (IRR = 1.36; 95% CI [1.34, 1.39]; $z = 30.94$; $p < .001$), and unique last-author publications (IRR = 1.16; 95% CI [1.13, 1.18]; $z = 13.02$; $p < .001$). Therefore, not only do women publish less, but their work is also cited less by others in the field independent of authorship position.

As an additional method of balancing the number of publications to the number of citations, each unique author's h-index was calculated—that is, the maximum number of publications in the database that are also cited that number of times. This measure—though far from perfect (Eagly & Miller, 2016; Nosek et al., 2010; Symonds et al., 2006)—effectively penalizes authors who repeatedly publish low-citation publications. Therefore, if the publication gap is explained by women simply having higher standards of publication than do men, the citation gap should disappear when h-indices are used as the dependent measure. Contrary to this, however, the average h-index for female authors is 1.36 (95% CI [1.35, 1.37]), whereas the average h-index for male authors is a higher 1.76 (95% CI [1.74, 1.77]). In addition, a negative binomial regression with h-index as the dependent variable found a significant effect

[2] Several colleagues and reviewers have noted that there is significant variability in authorship order practices across subfields, individual labs, and psychology journals. Although practices within individual labs cannot be controlled for, three separate analyses are reported in the online supplemental materials that strongly suggest that—on average—more frequently recurring authors publish in last-authorship positions, consistent with the practice of having senior authors as last authors and more junior authors as first. For example, as authors publish repeatedly across successive years, they do so increasingly as last authors in every subdiscipline except applied and mathematical psychology. In addition, last authors have significantly higher h-indices compared to first authors. Finally, journals published by the American Psychological Association—which explicitly require authorship to be divided by contribution—show a gap for women in *both* first- and last-author positions, suggesting that, even within these journals, female authors are not overrepresented in last-author positions.

of gender ($z = 62.86$; $p < .001$), with an IRR of 1.29 (95% CI [1.28, 1.30]) in favor of male authors. In other words, for each one unit increase in h-index for a female author, a male author can expect a 29% increase. Mean differences in h-index were found for even the highest achieving female authors: Whereas the top female author in the database had an h-index of 32, the highest male author's h-index was 48. In fact, the top female author in the database would be ranked 12th among the men, the 50th highest female h-index would be 212th, and the 100th highest female h-index would be 318th.

Together, these results show that—at the level of all unique authors and across authorship positions—women publish less and their work is also disproportionally cited less by others in the field, even when controlling for the lower number of publications by averaging citations or calculating h-indices.

Is the Gender Gap Accounted for by University Affiliation?

Previous work examining publication and citation gaps across the academic sciences has suggested that at least some differences might be accounted for by the tendency for male authors to work at more prestigious research-intensive universities, the "R1 universities" (Carnegie Foundation for the Advancement of Teaching, 2011), that provide higher financial resources and support for research compared to service, teaching, and so forth (Ceci et al., 2014; Ceci & Williams, 2011; Duch et al., 2012). Maliniak et al. (2013), for example, found that authors in international relations from top R1 universities tend to publish and receive more citations (though they also noted that the publication gap in international relations journals remains even when controlling for university affiliations).

To examine the role of university affiliation, we downloaded the self-reported affiliation of each author in the database. Unfortunately, PubMED did not save affiliation data for non-first authors before 2013. As a result, all the analyses are reported for first and single authors only, maximizing the sample size (nevertheless, if the analyses are extended to include all available authors with recorded affiliations, they remain identical). Each affiliation was classified into either "top-R1" or "other" by using the 2018 Times University Rankings of Psychology programs (Reuters, 2018). This list ranks 103 universities across the world for the quality of their psychology research programs (in 2018, e.g., Stanford, University College London, Princeton, Yale, and Harvard were listed as the first five of the 103 top-R1 institutions). Altogether, the first-author affiliation was successfully categorized as either top-R1 or other for 161,010 publications—79.8% of the total saved publications.

The categorization of affiliations produces the expected advantages for top-R1 universities in terms of publication and citation counts: The group of top-R1-affiliated authors published an average 12.55 publications (95% CI [10.39, 14.71]), compared to 4.56 publications (95% CI [4.33, 4.80]) for the other-affiliated authors. Similarly, the average number of citations for the top-R1-affiliated publications was a higher 7.60 (95% CI [7.10, 8.11]) compared to 5.47 (95% CI [5.20, 5.75]) for the other-affiliated publications. In fact, the unique 103 top-R1 affiliations represent 35.3% of all publications in the database, compared to the remaining 64.7% of publications' belonging to the remaining 30,781 *other* affiliations combined.

But, do university affiliations account for the observed gender publication and citation gaps? To analyze this, we carried out a negative binomial regression with author publication counts as the dependent variable and gender and affiliation (top-R1/other) as independent variables, showing a significant effect of top-R1 affiliation (IRR = 1.10; 95% CI [1.09, 1.12]; $z = 16.42$; $p < .001$) but, critically, a continued publication advantage for male authors (IRR = 1.20; 95% CI [1.19, 1.22]; $z = 32.62$; $p < .001$), suggesting that—even when affiliations are controlled for—male first authors can expect six publications for every five female first-authored publication (i.e., 20% more). Furthermore, the identical effect was found over the average number of citations each unique author receives: A negative binomial regression with citation averages as the dependent variable found a significant effect of affiliation (IRR = 1.53; 95% CI [1.50, 1.57]; $z = 40.76$; $p < .001$) but also a significant advantage for male authors (IRR = 1.31; 95% CI [1.28, 1.34]; $z = 26.88$; $p < .001$), showing that male first authors can expect 30% more citations even when variability in top research university affiliations is accounted for.

Is the Gender Gap Accounted for by Individual Subfields or Journals?

Are the observed publication and citation gaps identical across all of psychology? Psychology, like every scientific field, has many distinct subdisciplines, with some even more strongly dominated by women than others. For example, in 2014−2015, some 92.5% of master's and doctorate degrees in developmental psychology went to women, whereas a more modest 62.1% of master's and doctorate degrees were awarded to women in social psychology (U.S. Department of Education, 2017).[3] To understand whether the gender gap patterns vary by subdiscipline, we catego-

[3] Because the Integrated Postsecondary Education Data System (IPEDS) data system classifies psychology into subdisciplines using its own criteria, they do not fully match the division into the 10 subdisciplines that we identified. Nevertheless, there are more female than male master's and doctorates awarded in *every* psychology subdiscipline listed in the IPEDS database (e.g., 79.1% in clinical, 78.3% in health, 73.6% in applied psychology). This is true in every subdiscipline even if we exclude master's-level students, with the exception of applied psychology, where 47% of doctoral students are women (but, women form the majority of doctorate students in applied behavior analysis, forensic psychology, psychometrics and quantitative psychology, which all form part of what we are calling the applied−mathematical subfield).

rized each of the 125 journals into one of eight primary disciplines of psychology: applied−mathematical, clinical, cognitive, developmental, health, neuroscience, sensation and perception, and social−personality psychology. General interest journals were categorized as either review or interdisciplinary (journals that accept articles from all of psychology), giving a total list of 10 subdisciplines. The complete breakdown of the classification for each of the 125 journals is provided in Table S2 in the online supplemental materials.

Consistent with the widely perceived gender distribution differences among psychology's subfields, some fields show much larger gender publication gaps. Female authors represent only 29.85% of all authors in sensation and perception journals, whereas female authors represent 59.52% of authors in developmental psychology journals (see Table 1 and Figure 1). However, even within fields that are traditionally dominated by women, men perform at least as well as do women in the senior, last-author positions: Female authors account for only 53.56% of last authors in developmental psychology, 40.54% of last authors in clinical psychology, and 34.48% of last authors in cognitive psychology, all fields where master's and doctorate graduate rates for women are well over 70% (National Science Foundation, 2016). Furthermore, as shown in Table 1, male authors are cited more than are female authors in every discipline examined, even those that are strongly dominated by women, such as developmental psychology (see also Eagly & Miller, 2016).

There was also a key relationship between the gender gap size and individual journals' impact factors (see Table 2 and Figure 2). To account for the skew of the impact factor data, we transformed each journal's 2016 impact factor by the natural log (e.g., *American Psychologist*'s 2016 impact factor of 6.68 was log-transformed to 1.90). The results show that the stronger the log 2016 impact factor for a journal, the more likely it is to have fewer female than male authors, $F(1, 123) = 7.23$; $p = .008$ ($\beta = -.05$; 95% CI [−.09, −.01]; $R^2 = .06$; see Figure 2). The same result is found when instead examining the log 5-year impact factor, $F(1, 123) = 7.79$; $p = .006$ ($\beta = -.05$; 95% CI [−.08, −.01]; $R^2 = .06$), and the log total number of citations as of 2016, $F(1, 123) = 10.97$; $p = .001$ ($\beta = -.03$; 95% CI [−.05, −.01]; $R^2 = .08$). Hence, not only is there a general trend for a higher number of male authors but female authors are especially underrepresented in journals that are most often read and cited. This difference is not carried by a few select journals: Even *Eating Behaviors,* the journal with the highest overall prevalence of female authors compared to male ones (68.5%; see Figure 2), shows fewer citations for female first authors compared to male first authors (3.6 vs. 4.6) and for female last authors compared to male last authors (3.8 vs. 4.0). Table S2 in the online supplemental materials shows the complete break-

Table 1
Percentage of Female Authors, Including by Position, in Major Psychology Subdisciplines and Average Number of Citations Female Versus Male First- and Last-Author Publications Received as of 2018

Subdiscipline	No. of journals (unique publications)	% female authors	% female single authors	% female first authors	% female last authors	Average single-author citations (female/male)	Average first-author citations (female/male)	Average last-author citations (female/male)
Applied−mathematical	7 (4,803)	37.5	19.6	37.8	31.7	1.9/5.4	4.4/5.6	4.1/5.5
Clinical	39 (52,181)	48.9	30.6	54.9	40.5	5.2/5.7	7.5/8.8	7.6/8.3
Cognitive	11 (12,972)	42.2	28.0	47.3	34.5	5.3/5.8	6.0/6.5	6.1/6.3
Developmental	13 (14,514)	59.5	50.4	66.7	53.6	6.4/7.1	7.3/8.7	7.3/8.2
Health	15 (17,570)	52.2	36.7	60.3	45.2	5.3/4.6	6.6/8.1	6.7/7.6
Interdisciplinary	8 (17,866)	41.8	27.7	45.0	34.2	3.8/5.8	6.1/8.2	6.4/7.5
Neuroscience	15 (42,272)	36.5	25.4	45.7	26.6	9.5/14.4	10.7/15.2	10.7/14.1
Review	6 (4,548)	30.2	24.2	30.7	25.7	20.3/27.6	26.3/34.9	27.1/33.6
Sensation and perception	4 (9,902)	29.9	13.5	36.5	23.3	7.0/5.5	5.5/6.3	5.7/6.1
Social−personality	7 (7,285)	42.7	29.7	46.2	37.1	4.2/4.6	5.6/7.6	6.9/7.3

Note. Note that first- and last-author percentages and average citations exclude single-author publications.

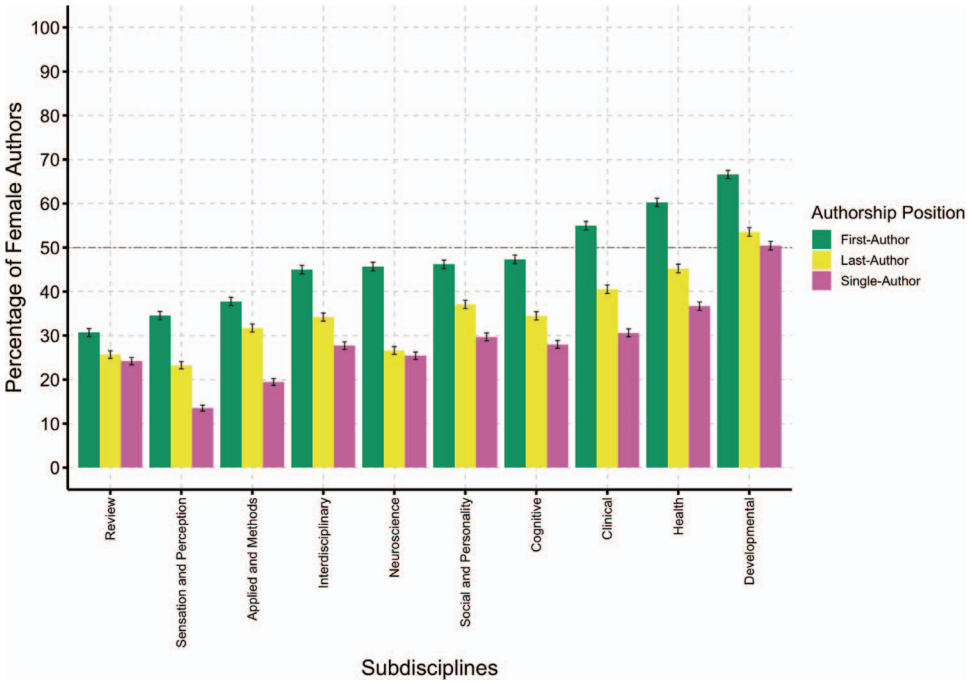

Figure 1. The overall percentage of female first, last, and single authors, sorted by subfield. For each bar, the remaining percentage corresponds to the percentage of male authors in those positions. Error bars indicate 95% confidence intervals. See the online article for the color version of this figure.

down of authorship percentages and citations for each of the 125 journals in the sample.

A particularly troubling aspect of these journal and subfield differences is that one of the largest gender gaps—for both first and last authors—is found in review journals, whose contributors are often leaders in their field and which are consistently the journals with the highest impact factors (e.g., *Annual Review of Psychology, Psychological Bulletin*). Because review articles can influence the direction of research more than do individual empirical articles, the finding that 30.2% of review journal publications include female authors suggests that the direction of scientific progress is steered largely by publications authored by men.

Is the Gender Gap Accounted for by Rate of Publishing?

One possible explanation for the present data is that women tend to work in fields that publish more slowly compared to others, such that the publication gender gap is driven by field choice, and not at the publication level per se. To examine the frequency at which authors publish, we calculated the difference between each unique author's successive publications (excluding authors with only a single publication) in each of the 10 subdisciplines that were examined. The average gap between successive publications across all of psychology was 1.96 years (95% CI [1.94, 1.97]) and was the shortest in neuroscience journals (1.98; 95% CI [1.96, 2.00]) and, unsurprisingly, longest in review journals (3.14; 95% CI [3.01, 3.27]). A linear regression with the percentage of male authors in each of the 125 journals as a dependent variable and the subfield-specific gap in publication as the independent variable found a main effect of the subfield gap but in the *opposite* direction: The higher the subfield-specific gap, the higher the prevalence of male authors, $F(1, 114) = 10.01$; $p = .002$ ($\beta = .11$; 95% CI [.04, .18]; $R^2 = .08$). This effect, however, was largely driven by the high prevalence of male authors in review journals, which, as discussed earlier, also have the highest subfield-specific gap. Indeed, if review journals are excluded from the analysis, there is no effect of subfield-specific gap on the prevalence of male or female authors, $F(1, 114) = .27$; $p = .61$ ($\beta = .03$; 95% CI [−.08, .13]; $R^2 = .002$). Therefore, there is no evidence that the rate of publication for individual subfields can account for the observed publication gap.

Is the Gender Gap Accounted for by the Number of Coauthors?

The next series of analyses focused on whether women tend to publish with a higher number of coauthors, diluting their contributions compared to male authors (e.g., as suggested by Maliniak et al., 2013). Contrary to this, however, the results show that—on multiauthor publications—female authors publish with the same average number of coauthors

Table 2

Percentage of Female Authors, Including by Position, in the Ten Highest 2016 Impact Factor Journals and Average Number of Citations Female Versus Male First- and Last-Author Publications Received as of 2018, Excluding Single-Author Publications

Journal	log 2016 impact factor	% female authors	% female single authors	% female first authors	% female last authors	Average single-author citations (female/male)	Average first-author citations (female/male)	Average last-author citations (female/male)
Annual Review of Psychology	2.99	36.9	32.0	34.6	38.3	44.9/76.5	39.0/47.6	53.2/40.3
Psychological Bulletin	2.82	41.2	27.8	42.1	36.4	28.7/28.5	41.4/40.8	40.9/40.0
Trends in Cognitive Sciences	2.75	27.6	24.5	29.1	27.5	23.1/33.0	34.9/41.9	32.0/42.6
Annual Review of Clinical Psychology	2.49	44.8	24.1	37.9	47.3	62.8/28.5	33.0/40.1	35.6/37.7
Trends in Neurosciences	2.41	25.1	20.3	29.6	18.1	29.3/33.6	37.1/49.2	39.2/46.4
Personality and Social Psychology Review	2.24	36.2	28.3	33.6	34.4	11.6/8.6	11.1/12.4	10.8/12.5
Psychotherapy and Psychosomatics	2.20	38.7	8.0	38.4	24.1	6.3/1.7	4.5/5.7	5.1/5.3
Clinical Psychology Review	2.19	49.3	28.7	61.0	42.1	19.1/20.4	18.4/22.2	19.6/20.1
Psychological Review	2.03	18.1	10.5	15.2	17.9	12.9/15.1	30.3/24.8	25.6/24.8
Perspectives on Psychological Science	1.99	32.7	28.2	29.0	32.4	5.6/7.2	13.9/14.1	10.9/15.2

Note. The remaining journals and data for citations of single-author publications are presented in the online supplemental materials.

(5.98; 95% CI [5.96, 6.00]) compared to male authors (5.95; 95% CI [5.93, 5.96]). Thus, it seems unlikely that the observed publication gap can be attributed to the dilution of contributions. Furthermore, as discussed in the online supplemental materials, male authors are significantly more likely to publish with only other male coauthors, suggesting that, if anything, publications authored by women are maximizing the chance of exposure for other women. Indeed, this analysis supports previous evidence that women are less likely to engage in networking opportunities than are men due to reasons ranging from conflicting family or service responsibilities to a fear that colleagues will misread social cues as romantic or sexual (e.g., Van den Brink & Benschop, 2012).

Has the Gender Gap Changed Over Time?

Finally, the last set of analyses examined the gender publication gap patterns over time, examining all available publications between 2003 and the end of 2017. As shown in Table 3 and Figure 3, the first-author difference between men and women has been declining since 2003, with simple linear slopes showing that the two genders have been at parity since around 2011. However, the last-author gap has stayed much more constant since 2003, with simple linear slopes showing that the gap between male and female last authors will not be bridged across the 125 journals until 2035. Examining this last-author gap within distinct subfields of psychology furthers this pattern (see Table 3): Subdisciplines including cognitive, social and personality, and applied−mathematical show no significant changes in female last-author prevalence since 2003. Others are reducing the gap slowly: At the current rate, neuroscience will not bridge the last-author gap until 2049, and review journals until 2074. Among all the disciplines, only two show positive trends for female last authors over time: Developmental and health psychology have already dramatically reduced the gap between male and female last authors, and clinical psychology will, at the current rate, by 2023.

General Discussion

Women are significantly underrepresented in the academic sciences, and current debates surrounding why this gender gap exists have focused on biological (Ceci & Williams, 2010; Su et al., 2009), sociological (Allison & Long, 1990; Ceci & Williams, 2011; Xie & Shauman, 1998), and outright discriminatory (Aguinis, Ji, & Joo, 2018; Eagly & Miller, 2016; Knobloch-Westerwick, Glynn, & Huge, 2013; Moss-Racusin, Dovidio, Brescoll, Graham, & Handelsman, 2012, but see Williams & Ceci, 2015) factors that may hold women back (for reviews, see Ceci et al., 2014; Dehdarirad et al., 2015; Eagly & Miller, 2016). The aim of this work was to investigate publication patterns within psycholo-

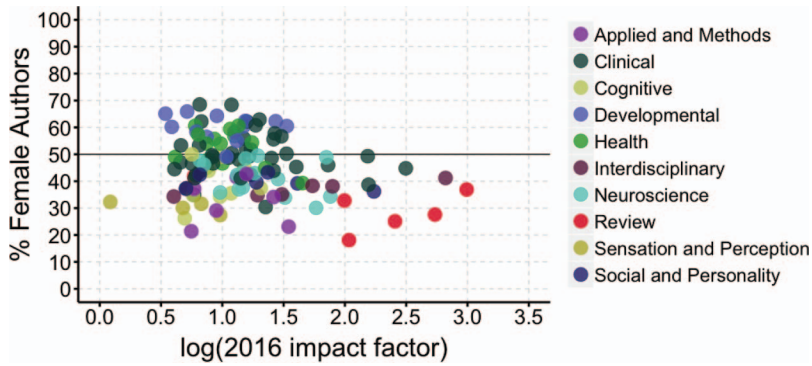

Figure 2. The relationship between the percentage of overall female authors against the log of the 2016 impact factor for each of the 125 journals that we investigated. Each journal is also coded for the subfield to which it belongs. For reference, the journal with the highest impact factor is *Annual Review of Psychology,* the journal with the highest percentage of female authors is *Eating Disorders,* and the journal with the lowest percentage of female authors is *Psychological Science.* See the online article for the color version of this figure.

gy—an academic science that is dominated by women at the undergraduate, master's, doctorate, and assistant professor levels but increasingly dominated by men at associate and full professor levels (American Psychological Association [APA] Wicherski, Auntre'Hamp, & Stamm, 2014), thereby offering unique insight into the causes and consequences of women's lack of progression into senior academic positions. By analyzing 200,000 publications over a 14-year-period in top journals across psychology, we replicated the previously reported publication and citation gap for women in psychology, using negative binomial regressions to account for the positive skew in publication and citation counts (Duch et al., 2012; Eagly & Miller, 2016). In addition, this work was extended by examining patterns across subfields, journals, and time, controlling for a host of potentially explanatory variables, finding evidence that some often-cited factors, such as university affiliation, do not account for the observed gap, whereas others, such as the impact factor of journals, do affect it.

The first major finding is that psychology's publication gap is pervasive but not identical across subfields, journals, or authorship positions. For example, although women are cited less and appear less often as last authors in every subfield, some subfields show a more positive trajectory for women: Developmental and health psychology have already narrowed the last-author gap, while clinical psychology is en route to do so by 2023. Neuroscience journals, on the other hand, show the largest drop between female first and last authors, and review journals are the overall least representative of female authors in the field. This difference among the subfields suggests that explanations for the publication gap that focus on inherent gender differences in lifestyle choices or intellectual ability are unable to fully explain the observed patterns. Unless women in develop-

Table 3
Linear Slopes for Percentage of Male Versus Female Authors from 2003 to 2016 by Subdiscipline

Subdiscipline	No. of journals	Female first-author slope	Est. year of 50/50 first-author convergence	Female/male last-author slope	Est. year of 50/50 last-author convergence
All	125	1.04[a]	2011	.57[a]	2035
Applied−mathematical	7	1.26[a]	2020	−.28	*ns*
Clinical	39	1.26[a]	2007	.75[a]	2023
Cognitive	11	.40[a]	2017	.13	*ns*
Developmental	13	.97[a]	1994	.33[a]	2000
Health	15	1.12[a]	2001	1.12[a]	2015
Interdisciplinary	8	1.45[a]	2016	.47[a]	2047
Neuroscience	15	.74[a]	2017	.62[a]	2049
Review	6	1.28[a]	2026	.38[a]	2074
Sensation and perception	4	.94[a]	2026	.39[a]	2078
Social−personality	7	1.50[a]	2013	.25	*ns*

Note. Linear slopes indicate the approximate percentage change across years for either first- or last-author position. We estimated the year of convergence between the two genders by simply finding the intercept of the two linear models. Est. = estimated.
[a] Significant nonzero slope at $p < .001$.

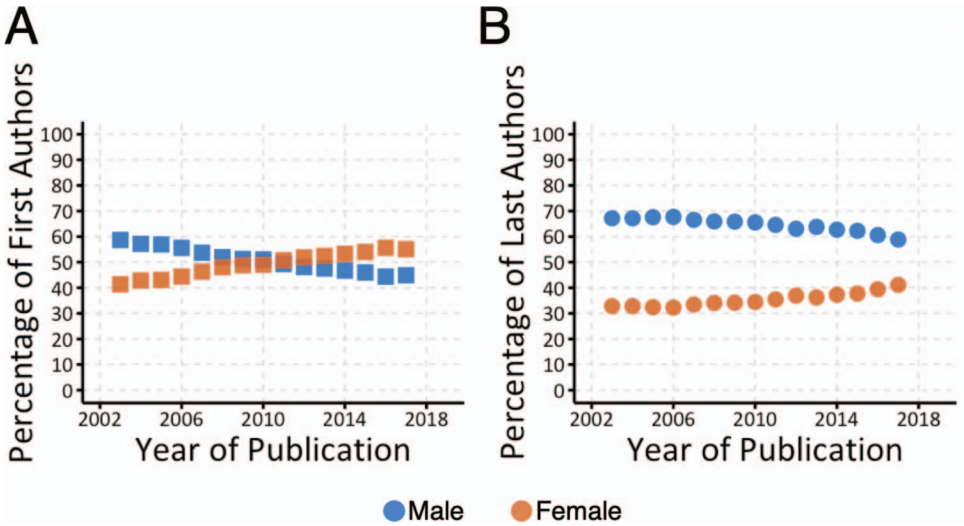

Figure 3. The percentage of male versus female authors who published in each year between 2003 and 2017. Note that 2018 is left out due to incomplete data at the time of publication. (A) The percentage of first authors. (B) The percentage of last authors. See the online article for the color version of this figure.

mental, health, and clinical psychology are, for example, intrinsically less likely to take maternity leaves or inherently more capable as psychologists, there is no biological reason why some subfields should be narrowing the last-author publication gap whereas others retain it. Instead, the source of these subfield differences is more likely to be within the social support systems that members of these disciplines provide. Therefore, future and ongoing work should more carefully examine which social, cultural, and contextual, rather than purely biological, factors may lead variability in the publication gap across individual subfields, journals, and authorship positions.

The differences in the gender gap across individual journals were also partially explained by impact factor: The higher the impact factor of a journal, the smaller the prevalence of female authors across all authorship positions (see Figure 2). In other words, journals that are especially esteemed in research psychology are also those that feature the fewest women as authors. But, even within a single subdiscipline, not all journals are equivalent in the size of the publication gap (see Table S2 in the online supplemental materials). In cognitive psychology, for example, the *Journal of Experimental Psychology: Learning, Memory, and Cognition* shows a relatively large publication gap, with female authors representing only 34.3% of all authors, whereas *Memory* has relatively even rates of men and women across all authorship positions. Therefore, combined with the subdiscipline differences, there is further evidence that the publication gap does not operate identically across all contexts. Future research should examine what underlies these differences across journals, including journal policies, hiring and promoting policies, and both explicit and implicit gender biases at each publication step. One fruitful avenue for future research may be to explore whether journal authorship blinding policies or the representation of women on editorial boards of individual journals interact with the observed variability in the publication gap.

Although the publication gap is wider in some contexts compared to others, the gender citation gap is much less context-dependent: Publications authored by men receive more citations than do those authored by women (see also Dehdarirad et al., 2015; Eagly & Miller, 2016; Larivière et al., 2013), even in subfields that are particularly dominated by women in senior faculty positions, such as developmental psychology. The observed citation gap held for both female first- and last-authored publications, suggesting that it cannot be accounted for by graduate students' and postdoctoral fellows' receiving fewer citations than do established academics. In addition, male-authored publications are cited more than female-authored publications even *within* highly prestigious review journals, suggesting that, even when female authors have their work submitted to and accepted within highly read outlets, their work is ultimately cited less. Although the explanation for why female-authored articles receive fewer citations is unknown (one factor could be that men tend to self-cite more than do women; Larivière et al., 2013), the pattern held in every subdiscipline of psychology and the majority of journals that were investigated—especially for single-authored publications—suggesting that it is not driven by a mere absence of women in particular subfields.

Some of the observed gaps have narrowed since 2003—for example, female authors have overall caught up to male authors as first authors—but other patterns, most notably gaps in last-authorship positions, are more resilient. The present data cannot explain the stability of last-author gap;

future studies should explore the possible mechanisms behind it. For example, this gap may be due in part to increased discrimination against women, leading them to exit the field or produce research at a slower rate, as they move into more senior positions. Indeed, other work has shown that, in STEM fields, male "star" scientists output a much higher volume of work than do female "star" scientists, most likely to due to gender biases (Aguinis et al., 2018). Another potential mechanism is gender differences in author position decisions: Women's contributions to projects may be equal to men's throughout their career, but they may not be slotted into senior author positions, due to either gender biases or gender differences in self-advocacy.

Despite the relative reliability of the last-author gender gap, on average, this gap is narrowing, and if the time frame were extended further back than 2003, one would expect to find substantial improvement in the representation of female authors at all authorship levels since the early 1970s. The conclusions reported here should, therefore, not be taken as evidence that psychology has stagnated in its representation of women but instead as showing that although there have been advances in the prevalence of women in some subfields, journals, and authorship positions, these changes have not been universal. In other words, although there have been advances in the representation of women in psychology since the 1950s onward (e.g., across all faculty positions; see Wicherski et al., 2014), and although women are now strongly represented in graduate school and early career positions, there has been a continued publication and citation gap since at least 2003 to the present that is not accounted for by a variety of often-cited factors, including university affiliations, the number of coauthors, and so forth, deserving ongoing attention and exploration.

Despite the evidence that the gender publication gap is, in general, narrowing in psychology, there is one remaining caveat. The analyses and discussion of the publication gap thus far have assumed that gender equity would be achieved if 50% of published authors in psychology were women and 50% were men. However, if postgraduate attrition rates are assumed to be equal for men and women, then the distribution of publications should theoretically be closer to 70% women, matching the enrollment rates in graduate school (National Science Foundation, 2016). In addition, the size of the citation gap across all subfields suggests that, even when men and women publish in equally prestigious journals, male publications are more highly cited, even in fields that have bridged the publication gap. With this theoretical benchmark in mind, there is a great deal of work to be done to achieve gender equity in research psychology, even in fields like developmental psychology.

In addition to describing the variability in the publication and citation gaps in psychology, the results reported here also shed light on some suggested mechanisms. Given the observational nature of publication records, no definitive causal claims about the sources of these patterns can be made. However, the publication and citation gaps persist even when some often-considered factors, such as university affiliations, number of coauthors, and subfield-specific rates of publishing, are controlled for. Additionally, to our knowledge, there is no evidence that women are biologically less suited or less drawn to psychology (if anything, cultural norms suggest that women should be *more* likely to enter and succeed in psychology). Although none of this is sufficient evidence for a claim that the observed publication gap is due to discrimination, the analyses reported here suggest that biological or sociological explanations are unlikely to fully account for the observed data. With the availability of large-scale publication records data such as ours, our hope is that future work can find convergent links between publication−citation gaps and possible explanatory factors. For example, the gaps may be explained by annual funding and hiring rates for men versus women, journal policies (including the representation of women on editorial boards; blind review policies), and various initiatives attempting to keep women in science.

To conclude, the data reported here suggest that women are strongly attracted to every subfield of psychology, achieving early publication success as first authors, but in turn are cited less and published less, with fewer single- and last-author publications than men. At the same time, these patterns vary across all journals and subdisciplines of psychology, showing that the publication gender gap is mediated by contextual factors. By continuing to track publication gaps across subdisciplines as cultural norms and structural practices change, one can better assess the field's progress in reaching gender equity. The methodological tools used in this work are accessible for free, using open-source tools including PubMED, the RISmed R package, and the OpenGenderTracking database. As a result, the data can be easily updated year after year and extended to academic disciplines outside of psychology. These results and methods can hopefully serve as a launching point for new analyses and experiments to investigate the gender gap in psychology, as well as in other academic fields.

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Received November 21, 2018
Revision received March 26, 2019
Accepted April 1, 2019 ■