

Is there a gender-based fragmentation of communication science? An investigation of the reasons for the apparent gender homophily in citations

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Received: 16 February 2017 / Published online: 20 April 2017
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Abstract Multiple studies report that male scholars cite publications of male authors more often than their female colleagues do—and vice versa. This gender homophily in citations points to a fragmentation of science along gender boundaries. However, it is not yet clear whether it is actually (perceived) gender characteristics or structural conditions related to gender that are causing the heightened citation frequency of same-sex authors. A bibliometric study on the two leading German communication science journals *Publizistik* and *Medien & Kommunikationswissenschaft* was employed to further analyze the causes of the phenomenon. As scholars tend to primarily cite sources from their own area of research, differences among male and female scholars regarding their engagement in certain research fields become relevant. It was thus hypothesized that the research subject might mediate the relationship between the citing and cited authors' genders. A first analysis based on $n = 917$ papers published in the period from 1970 to 2009 confirmed the expected gender-differences regarding research-activity in certain fields. Subsequently, structural equation modeling was employed to test the suggested mediation model. Results show the expected mediation to be a complementary one indicating that gender homophily in citations is partly due to topical boundaries. While there are alternative explanations for the remaining direct effect, it may suggest that a fragmentation of science along gender boundaries is indeed an issue that communication science must face.

Keywords Fragmentation of science · Citations · Gender homophily · Bibliometrics · Intergroup communication

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Introduction

Research on the fragmentation of science is concerned with boundaries in the scientific system that hinder mutual attention, exchange, and integration. Most notably, it has been found that scholars working in certain fields of research and/or on different theories tend to focus on their own field while paying little attention to work in other fields of the same discipline (e.g., Calhoun 2011; Paisley 1984; van Dalen and Henkens 1999). Although this is largely a consequence of specialization, the lack of integration in the findings represents a severe hindrance to a cumulative growth of knowledge and for research findings to reach significance (Calhoun 2011). This situation is worsened by the fact that within a scientific discipline, fragmentation usually exists not only between fields of research but also between other units, such as different disciplinary orientations or schools of thought (Pooley 2016).

For some while now, scientometric literature has hinted at another possible type of fragmentation. Several empirical studies have shown that male scholars cite the publications of male authors more often than their female colleagues do—and vice versa (Davenport and Snyder 1995; Ferber 1988; Håkanson 2005; Lutz 1990; Malianik et al. 2013; McElhinny et al. 2003; McLaughlin Mitchell et al. 2013). Such *gender homophily in citations* has also been detected in Anglophone communication research journals (Knobloch-Westerwick and Glynn 2013).

Partly interpreted as a result of prejudices against female scholars (e.g., Knobloch-Westerwick et al. 2013), the same-sex-author preference in citations challenges the assumption that citations represent payments of intellectual debt and, to that end, would strictly follow the criteria of relevance and quality (cf., e.g., the discussion in Baldi 1998). The phenomenon also represents a potential instance of fragmentation, as citations are an integral feature of the integration of research findings and partly reflect attention and exchange. However, the actual causes for the empirical observation of a gender homophily in citations determine whether using it as an indicator for gendered fragmentation produces valid results.

It is questionable whether attention, exchange, and integration are actually depleted at the gender boundary (exclusively) because of (perceived) *gender characteristics* or (also) because of *structural conditions related to gender*. That is, gender might merely be a surrogate for other variables, particularly the extent of contributions to certain fields of research. Therefore, after specifying the phenomenon of interest, we will discuss gender differences in research interests and activities of communication scholars as an alternative root cause for the apparent gender homophily in citations. Finally, we will present a bibliometric study on two German communication science journals in which assumptions of the potential influence of gendered research fields in the context of citation preferences were tested. Hence, our study not only considers alternative ideas about causal relationships but also extends the knowledge about this phenomenon to a new country context. The latter is particularly relevant in this case, as the relationship between the sexes must be regarded as culture specific.

Gender homophily in citations as an indicator of fragmentation

Until now, the apparent gender homophily in citations has been discussed mostly in the context of studies that were interested in whether female scholars are systematically denied credit for their work (the so-called “Matilda effect,” Rossiter 1993). As citations are an

essential part of giving credit in science, the fact the male scholars cite publications of other male scholars more extensively than publications of female scholars has been interpreted as partial evidence for this underrecognition of female scholars' accomplishments (e.g., Ferber 1988; Knobloch-Westerwick and Glynn 2013; Lutz 1990). While we are discussing gender homophily in citations in a different research context, that is, fragmentation, we still draw on studies on the “Matilda effect” as a resource. However, research on the “Matilda effect” and other research on the relationship of citation rates and gender have dealt with a multitude of different phenomena, which are similar but not equal to gender homophily. Hence, it is necessary to show the distinctions between these phenomena in order to sharpen the understanding of the object investigated in the present case.

Formal description of gender homophily in citations

In the tradition of research on gender disparities in citations, scholars have mainly relied on two types of operationalization, namely (a) whether female scholars receive as many citations per person as male scholars and (b) whether publications from female scholars receive as many citations as comparable publications from male scholars (e.g., Aksnes et al. 2011; Beaudry and Larivière 2016; Brown and Goh 2016). These phenomena have more or less obvious structural reasons. Some studies have shown, for example, that male scholars (used to) show a higher overall productivity (Abramo et al. 2009; Cole and Zuckerman 1984; Davenport and Snyder 1995; Dinauer and Ondeck 1999; Larivière et al. 2013; Prpić 2002; cf. also Bunz 2005 for contradictory results) and that they tend to occupy higher ranking positions in academia, thereby having more resources at their disposal (Fröhlich and Holtz-Bacha 1993; Rush et al. 2005; Schamber 1989). More puzzling is the closely related, but not identical, observation of a general gender homophily in citations.

Basically, the term homophily can be understood as “the principle that a contact between similar people [or groups] occurs at a higher rate than among dissimilar people [or groups]” (McPherson et al. 2001, p. 416). In accord with this definition, but also based on further reasoning, we use the term *gender homophily in citations* to describe instances where male scholars devote a greater share of their citations to publications from other male scholars than female scholars do—and vice versa. This conceptualization meets several important requirements: First of all, research on gender homophily in citations has to account for the possibility that men and women may tend to cite literature in systematically different amounts, which is why homophily should be represented by a higher *relative* (and not absolute) amount of citations given to publications written by same-sex authors. Furthermore, by way of the above-named conceptualization, the phenomenon is kept independent of the existing number of researchers from each gender or the existing number of papers written by members of each gender. Both of the latter are hard to assess but likely to be unequal (see above). Therefore, male and female scholars will have contributed unequally to the available literature, which is again why one of the two groups will be cited more extensively per se. Accordingly, the best reference point for the citation behavior of male scholars is the citation behavior of female scholars (and vice versa). This means that according to our conceptualization, gender homophily in citations would still be given when both male and female scholars cited a higher share of publications from, say, male scholars, if the condition is fulfilled that male scholars preferred publications from male scholars more strongly than female scholars preferred publications from male scholars (or the other way around in case of a general preference for publications from female scholars).

Finally, men and women might differ systematically in the extent at which they cite materials published in the name of an organization, which is why the number of citations made by authors of one gender to authors of the same gender should be put into perspective with the total amount of citations made to publications by men and women rather than the total amount of citations. Therefore, we see gender homophily in citations as given when:

$$F1 : \frac{\text{Total number of citations made to male authors by male authors}}{\text{Total number of citations made by male authors to male and female authors}} > \frac{\text{Total number of citations made to male authors by female authors}}{\text{Total number of citations made by female authors to male and female authors}}$$

Whereas most empirical attention has been on the relationship stated above, studies have shown, but not discussed, the fact that women also cite women more strongly than men cite women. However, if we are able to place every publication in one of the two categories female-authored or male-authored (e.g., based on the first author's gender) and if the above-named condition is fulfilled, it means that it must also be true that:

$$F2 : \frac{\text{Total number of citations made to female authors by female authors}}{\text{Total number of citations made by female authors to male and female authors}} > \frac{\text{Total number of citations made to female authors by male authors}}{\text{Total number of citations made by male authors to male and female authors}}$$

The fact that male scholars seem to prefer publications by male scholars more strongly than female scholars prefer publications by male scholars—and vice versa—suggests the existence of positive and/or negative biases. On this basis, gender homophily in citations points to a fragmentation of (communication) science along gender boundaries.

Fragmentation phenomena in science

Fragmentation is present wherever there is a lack of interrelations. At the content level of science, interrelations are constituted by mutual attention and exchange among scholars, as well as by an integration of research findings. At the same time, science is segregated by a multitude of categories that constitute borders that impair attention, exchange, and integration. Despite interdisciplinary activities and trends like *internationalization* (Domahidi and Strippel 2014), scientific subjects and nations remain entities within which exchange and integration take place quite strongly, while the ties between units belonging to different entities are considerably weaker (cf., e.g., Buter et al. 2011). Other segregating criteria are *fields of research*, *methodologies*, and *research traditions* (such as the humanities and the social sciences), partly because they demand different foci and prescribe different quality criteria.

To some extent, the lack of attention, exchange, and integration has a substantive legitimation in a factual unrelatedness and/or incompatibility. In addition, fragmentation is partly a result of specialization, which develops naturally in all scientific disciplines (Swanson 1993, p. 167). And yet, “fragmentation has long been a concern” (Swanson 1993, p. 167) in communication science, not least because “single fragments are unable to draw a complete picture of the whole... communication process and thus remain somehow limited” (Matthes 2012, p. 248). Therefore, it inherently makes sense to integrate research findings if they are factually and/or logically related. Regrettably, science often fails to

realize this integration, because the logical relationship between findings remains undiscovered (Swanson 1986).

Attention, exchange, and integration are also hindered by many researchers' striving for separation and autonomy. Specialized fields of research, for example, often attempt to "legitimate themselves by developing distinctive theories, methods, or syntheses of multiple disciplinary perspectives that will differentiate them from parent disciplines and from other subfields" (Swanson 1993, pp. 165–166). Furthermore, personal biases, such as attributing general superiority to a personally preferred methodology may also play an important role, as they result in a sweeping neglect of other approaches (Dervin et al. 2005).

Although such reasons for neglecting other findings may already seem questionable, neglecting or considering a finding based on personal characteristics of the respective researcher is downright at odds with the scientific goal of furthering knowledge. At least according to the normative theory of citing (which is opposed by the so-called constructionist view; cf. Baldi 1998 as well as Case and Higgins 2000), scholars are expected to cite publications based on the scientific merit of the findings presented therein, as well as on the relevance of these findings for the problem at hand. As the characteristics of an author are not part of the findings themselves, they should generally be without relevance in this decision. However, contrary to this norm, criteria such as the reputation and/or prominence of an author *do* influence citation decisions (the so-called "Matthew effect"; Merton 1968). Pragmatism as well as publication and persuasion strategies, may, therefore, act as serious antagonists to the content-related norms mentioned above (cf. Case and Higgins 2000 for a summary of reasons for citing literature).

The apparent gender homophily in citations gives reason to assume that the gender of authors represents another such person-related criterion in citation decisions. However, if gender homophily in citations emanates not actually from gender characteristics but from a factor structurally related to gender, the fragmentation of science would thereby occur along this other factor's borders and not along the boundaries between the sexes. Wishing to bring clarity to this matter, we set out to research the fragmentation of science by analyzing the root causes of gender homophily in citations.

Gendered research fields as a structural explanation for gender homophily in citations

Although the existence of the phenomenon has repeatedly been proven, it is not quite certain which mechanisms are behind same-sex citations. Initially, the question arises whether the gender of an author is *deliberately* chosen as selection criterion for scholarly literature. Such an obviously discriminating habitus is indeed supposed to be one explanation, but by far not the only one (e.g., Ferber 1988, p. 86).

In the context of research on the "Matilda effect," unconscious automatic processes are assumed to trigger gender bias. For example, Knobloch-Westerwick et al. base their hypotheses regarding the citation pattern on role congruity theory (Knobloch-Westerwick and Glynn 2013; Knobloch-Westerwick et al. 2013). They state that people commonly link the scientist role to rather masculine characteristics. Correspondingly, female scholars face an inconsistency between gender-based stereotypes and expectations of scientists. In turn, this perceived dissimilarity leads to more negative evaluations of women regarding their scientific performance, which finds expression in a lower recognition of publications

written by female authors (Knobloch-Westerwick and Glynn 2013, pp. 5–6). According to this idea, an author's gender indirectly influences citation behavior, as it functions as a simple cognitive heuristic to assess scientific quality. Additionally, the authors claim that men usually hold more traditional gender-role attitudes than women, which amplifies prejudice and perceptions of role incongruity. Thus, male authors are even less likely to cite female peer scholars (Knobloch-Westerwick and Glynn 2013, pp. 7–8). Here, the concept primarily concentrates on a form of negative bias (nonscitations because of prejudices against female scholars) instead of a form of positive bias (e.g., citing somebody because he is part of an "old-boy network"¹). Although this seems to be a decent explanation for male scholars preferring academic publications written by men to the detriment of women, it does not capture why female scholars cite each other more frequently, too.

Therefore, we try to extend the understanding of possible root causes of gender homophily by focusing on the structural context of citation decisions, which potentially supersedes gender-based perceptions. At the heart of our reasoning is the fact that any decision that researchers take on *what to research* and *how to conduct* research determines the qualities of the literature that is available for citing. Meanwhile, choices of research fields and methodologies do not represent gender characteristics themselves but may be related to gender. According to Cole (1994, p. 146), scholars pick their research objects not only based on normative academic criteria like scientific relevance or theoretic fruitfulness. Especially in the social sciences, personal experience, involvement, and interest regarding certain subjects or fields guide scholars' choices. Gender undeniably shapes a person's experiences, views, and interests. Studies have shown that men prefer working with things and that women prefer working with people. Moreover, men show on average stronger "realistic" and "investigative" interests, whereas women tend to engage in "artistic," "social," and "conventional" issues (Su et al. 2009). Therefore, it seems plausible that research interests and subject foci also vary among male and female scholars, potentially resulting in gender differences with regard to research activities.

In fact, Dupagne et al. (1993, p. 819) identify such gender specifics within mass communication research. According to their analysis of eight communication journals, female authors first and foremost concentrate on message content and media effects on culture and society. Their male counterparts publish more articles related to the media industry, as well as to message production and distribution. Similarly, Applegate and Bodle (2005, p. 161) find that women author more publications on public relations and fewer on media management and economics. Furthermore, women are overrepresented as authors in journals of gender studies (Kretschmer et al. 2012). This indicates that this subject, which has also become a relevant issue in communications (e.g., Creedon and Cramer 2007; Rakow 1986), is predominantly handled by female scholars. In addition, the relatively new field of health communication also seems to be dominated by women, as they exceed male scholars in terms of division membership as well as in terms of written articles about health promotion (Andsager 2007, pp. 115–116).

Accordingly, there is evidence for the existence of gendered research fields within communication science to the effect that scholarly literature on specific subjects is most

¹ While generally old-boy networks are assumed to exist and are presented as a possible cause of the apparent gender homophily in citations (e.g., Davenport and Snyder 1995, p. 409; Ferber 1988, p. 86), some empirical studies have shown that female researchers collaborate as much as (Blake et al. 2004) or even more than (Fell and König 2016) male researchers. However, such results may highly depend on the scientific subject and/or respective subfield analyzed.

notably shaped by either male or female authors. Now, if (communication) scholars do research a certain topic, they tend to cite sources covering that same topic for reasons of relevance (Baldi 1998, p. 843; Porter and Chubin 1985, p. 164). Consequently, a preponderance of either gender in a specific field coincidentally implies a higher citation share of the dominant gender in this very field. In this case, neither male nor female scholars would prefer publications by authors of the same sex as such. Rather, this relationship would be an indirect one, mediated by the similar research foci of the citing and cited authors. In this respect, gender homophily in citations would not (exclusively) be a result of cognitive perceptions and prejudices, but (also) a structural consequence of gender differences in regard to research subjects. In this vein, Håkanson (2005) has already pointed out the need for studies on gender disparities in citations to “uncover the influence of other variables, such as subject content of the articles” (p. 312). Following this suggestion, we set up the following hypothesis:

H1 In communication science, the impact of an author’s gender on the preference for same-sex-author citations is mediated by the engagement in specific research subjects.

Additionally, we aim to test whether, aside from differences based on topic preference, there still is a direct effect of an author’s gender on same-sex-author citations that accounts for alternative explanations for gender homophily (like the above-mentioned gender-based perceptions). That is, we want to find out whether the impact of an author’s gender on the preference for the same sex in terms of citations is fully or partially mediated by the engagement in different research subjects.

Incidentally, a model explaining the heightened citation frequency of same-sex authors should account for the continuous growth of the proportion of women in the scientific community, which is well documented for communication science (cf., e.g., Beasley and Theus 1988; Blake et al. 2004; Dupagne et al. 1993; Fröhlich and Holtz-Bacha 1993; Klaus 2003; Schamber 1989; Viswanath et al. 1993). Because of this development, not only the number of publications by women but also the number of citations of publications by women can be expected to have risen over time. Moreover, it is conceivable that the amount of activity in certain areas of research will also have varied over time due to research trends. However, the root causes of these trends largely determine how they must be accounted for. Among others, Fröhlich and Holtz-Bacha (1993) suggested that the female researchers entering communication science often promote formerly neglected areas of research, because the attribution of relevance to certain fields was gender dependent. If this is the case, it could mean that some research trends are actually caused by the growing number of women in the subject. We will come back to this aspect in due course.

Method

The study is based on a dataset that was first introduced by Potthoff and Kopp (2013). For this dataset, a random sample of 1000 papers was drawn from all 1564 papers that had been published between 1970 and 2010 in the two leading German communication science journals *Publizistik* and *Medien & Kommunikationswissenschaft* (formerly *Rundfunk und Fernsehen*), which represent a highly influential community of communication scientists. For the following analysis, the sample was limited to those papers that had been published between 1970 and 2009 (in order to limit the data to four decades) as well as to those

papers that had a reference list, which left 918 cases in the sample. As one of the 918 papers had been published by an organization without naming individual authors, it was also excluded from the present analysis ($n = 917$).

Among other things, the bibliometric analysis was applied to capture the gender of (a) the two first-named authors of the 917 papers and (b) the two first-named authors of any publication included in the reference lists of these 917 papers. Third- or later-named authors' genders were not captured due to reasons of economy. The intercoder reliability of the gender variable was tested with 100 randomly selected cases and two coders. Intercoder agreement was measured with Krippendorff's alpha, and the resulting value of $\alpha = .954$ was deemed satisfactory.

From the two variables representing the gender of the first- and second-named author of the 917 papers, we built a new variable ("gender composition") that represents the four possible types of author combinations: 1 = only (one) female author(s), 2 = a first-named female and a second-named male author, 3 = a first-named male and a second-named female author, and 4 = only (one) male author(s). We consider this variable ordinal-scaled based on the following reasoning: While in some cases, authors choose to appear in alphabetic order, in other cases, the author who made the largest contribution is named first. As there was no way of reconstructing which mode was chosen in an individual case, the assumption was made that in most cases, the first-named author will have had the largest influence on the contents of a paper. Therefore, higher numbers in the gender variable represent a higher influence of male researchers.

From the 38,341 publications appearing in the reference lists of the 917 articles, we computed the outcome variable of our model (see below). This variable consisted of the percentage of publications by women among all publications that had a person named as author (i.e., not an organization). Citations that likely followed extraordinary criteria (e.g., self-citations) were excluded. If a cited publication had multiple authors of differing genders, it was considered to be a publication by women if the first-named author (who potentially had the largest influence) was female. The choice to use the *proportion of citations made to publications by women* as opposed to using the *proportion of citations made to publications by men* was made arbitrarily, as the other option would have yielded equivalent results.

In order to test the mediating role of specific research subjects in same-sex-author citations, we also captured the topics of the 917 papers, in 81 categories. These 81 categories resulted from considerations of which fields of research receive or used to receive a larger amount of attention in communication science. Seven topics could be identified as gendered research topics (see chapter on preliminary results) and were thus used in our final model (see chapter on results). The reliability scores² of the corresponding variables are as follows: "entertainment": $\alpha = .856$, percentage agreement (pa) = 86.66; "education of professional communicators," "gender-studies," and "power": $\alpha = .780$, pa = 86.66; "health communication"³: $\alpha = .396$; pa = 83.3; and "media law" and "media economy": $\alpha = .724$, pa = 80.

² Several of the binary variables used in the analysis were originally combined in one variable capturing one subject dimension, such as *type of communicator or respective type of content* (categories: journalism, public relations, advertising, entertainment). Where several categories of the same dimension were applicable, coders wrote a remark that was taken into account during the subsequent dummy coding. The intercoder-reliability test was carried out with the non-dummy-coded versions, which is why some of the seven topic variables mentioned above share the same reliability score.

³ The α -value for the variable capturing *health communication* is low, but partly because the variable was strongly skewed. The variable was, therefore, retained, but the coding was carried out by one of the researchers, as a larger degree of expert knowledge in communication science facilitated recognizing fields of research correctly.

Preliminary analyses

To study its potential causes, we first had to test whether gender homophily in citations was actually present in the data used. As Table 1 shows, the share of male authors cited co-varies with the amount of control that male authors potentially had over a paper (and vice versa for female authors).

We conducted a further analysis to examine the assumed time trend in (a) the share of publications from female authors as well as in (b) the share of citations that publications from female authors received. Figure 1 hints at the existence of this trend. Both the share of female authors among the authors of the 917 papers and the share of citations made to publications from female authors⁴ have risen during the 40 years analyzed. The share of women among the authors of the 917 papers roughly matches the share of women in the field, as surveys conducted among German communication scientists reported a share of about 25% female communication scientists in the 1990s (Fröhlich and Holtz-Bacha 1993, p. 537) and of about 40% in the 2000s (Klaus 2003, p. 5). However, while a general trend can be assumed, the share of female authors seems to vary to a greater degree between years. Therefore, we used a variable marking the decade in which a paper was published rather than a variable marking the year, when controlling for the time of publication. As was also expected, publications from female authors seem to be cited disproportionately to women's share among the authors. This discrepancy appears to become larger the more women work in the field. This result must be interpreted with caution, however, as publications from other fields and other countries were cited as well, while the shares of women in these groups of authors are unknown.

As our causal model is partly based on the idea that men and women differ in regard to their interest for certain fields of research, this assumption also had to be tested. A structural equation model (SEM) with mean- and variance-adjusted weighted least squares (WLSMV) estimation was employed for this third preliminary analysis. In order to avoid variables with an *extreme* degree of skew, only those topic variables were included in the analysis that had captured the topic of at least 1% of the 917 papers. This left us with the 31 binary topic variables. In the SEM, these 31 topic variables were specified as endogenous variables, while the decade⁵ and gender composition of the authors of a paper were specified as exogenous variables.

Probit regressions showed (at the 10% level) significant relationships between gender composition and seven of our topics: “entertainment” ($B = -0.13$, $SE = 0.05$, $p = .02$), “education of professional communicators” ($B = -0.18$, $SE = 0.06$, $p = .01$), “gender research” ($B = -0.31$, $SE = 0.08$, $p = .00$), “health communication” ($B = -0.17$, $SE = 0.08$, $p = .03$), “media law” ($B = 0.15$, $SE = 0.07$, $p = .03$), “media economy” ($B = 0.13$, $SE = 0.07$, $p = .06$), and “power” ($B = 0.34$, $SE = 0.20$, $p = .08$). Negative coefficients indicated four subjects to be female-typed (entertainment, education of professional communicators, gender research, and health communication), while positive coefficients pointed to three male-typed topics (media law, media economy, and power). This result is partly consistent with the other studies mentioned above that also found

⁴ More specifically, Fig. 1 shows the share of citations made to publications by female authors among all citations made to publications by male or female authors (i.e., citations made to publications issued by organizations, etc., were excluded).

⁵ As the number of female authors—and likely also the interest for specific fields of research—varied over time, the decade in which each of the 917 papers was published had to be included as a control variable in the respective model.

Table 1 Relative and absolute amounts at which author(-team)s with a certain gender (combination) cited other author(-team)s with a certain gender (combination)

	Cited publications				Sum
	One male author or first and second author <i>male</i>	First author male, second author female	First author female, second author male	One female author or first and second author <i>female</i>	
Citing publications					
One male author or first and second author <i>male</i>	86.3% (<i>n</i> = 18,795)	2.9% (<i>n</i> = 642)	2% (<i>n</i> = 442)	8.7% (<i>n</i> = 1900)	100% (<i>n</i> = 21,779)
First author male, second author female	77.1% (<i>n</i> = 865)	4.5% (<i>n</i> = 51)	3.3% (<i>n</i> = 37)	15.1% (<i>n</i> = 169)	100% (<i>n</i> = 1122)
First author female, second author male	70.1% (<i>n</i> = 748)	6.7% (<i>n</i> = 71)	5.1% (<i>n</i> = 54)	18.2% (<i>n</i> = 194)	100% (<i>n</i> = 1067)
One female author or first and second author <i>female</i>	77.1% (<i>n</i> = 3142)	3.2% (<i>n</i> = 131)	2.5% (<i>n</i> = 101)	17.2% (<i>n</i> = 700)	100% (<i>n</i> = 4074)
Sum	84% (<i>n</i> = 23,550)	3.2% (<i>n</i> = 895)	2.3% (<i>n</i> = 634)	10.6% (<i>n</i> = 2963)	100% (<i>n</i> = 28,042)

Citations made to the portrayed communication scientist in personal portraits as well as self-citations were excluded from the analysis. Pearson's Chi-square = 485.239 (*df* = 9), *p* < 0.001

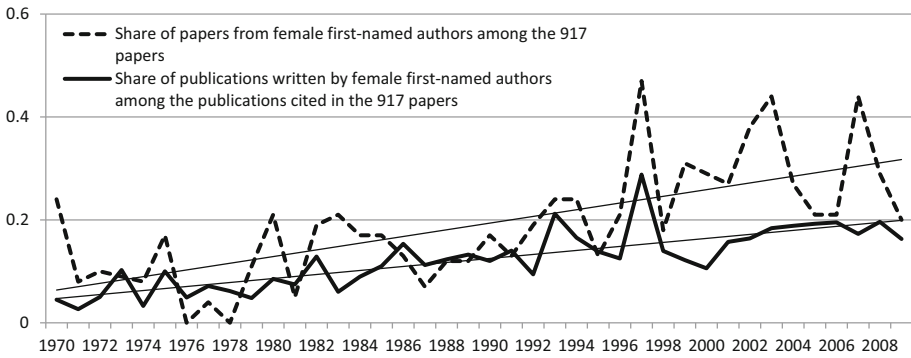


Fig. 1 Share of papers by female first-named authors among the 917 papers in comparison to the share of citations made to publications by female first-named authors

health communication (Andsager 2007) and gender studies (Kretschmer et al. 2012) to be female-typed research topics, while media economics was found to be a male-typed topic (Applegate and Bodle 2005, p. 161). In order to further reduce the skew of the variables in the final model, the seven topic variables were recoded into two binary variables indicating whether a topic was female-typed or male-typed (1 = yes; 0 = no).

Main results

To test our main assumptions, we performed structural equation modeling using the software Mplus (cf. Muthén and Muthén 2015). As our path model contains a combination of continuous and categorical variables that are partly skewed, we used WLSMV estimation with theta parameterization. The model includes “decade” as continuous exogenous variable, as well as “gender composition of authors” (with higher values indicating a higher impact of male authors) and (male-typed and female-typed) “research subject” as categorical endogenous variables. The central outcome is the “proportion of female authors cited.” This variable was defined as censored, as its frequency distribution shows an obvious peak at the lower bound (0%) indicating a censoring from below. The “first author” of a respective paper (i.e., case) serves as second-level cluster variable accounting for any individual preferences.⁶

As shown in Table 2, the initial path model did not provide a sufficiently satisfying fit to the data (cf. Kline 2005), with a χ^2 of 5.91 ($df = 1; p = .02$), a Tucker–Lewis index (TLI) of .83, a comparative fit index (CFI) of .98, and a root mean square error of approximation (RMSEA) of .07 (90% CI .03–.14). To enhance the model, we removed the nonsignificant paths from “decade” to male-typed and female-typed “research subjects.” Subsequently, the global fit of the modified model demonstrated improvement, particularly regarding parsimony: $\chi^2 = 8.16$ ($df = 3; p = .04$), TLI = .94, CFI = .98, and RMSEA = .04 (90% CI .01–.08). As the approximate fit indices, which are robust regarding sample size, show quite a good fit, the model can be classified as valid.

Figure 2 displays the adjusted path model with probit regressions (if the dependent variable is categorical) and tobit regressions (if the dependent variable is censored).

⁶ The 917 papers were written by only 579 different first-named authors.

Table 2 Measures of global fit for all models estimated ($N = 902$)

	χ^2	df	p	χ^2/df	TLI	CFI	RMSEA
<i>Acceptable fit threshold</i>			(>.05)	<3	>.95	>.95	<.08
<i>Good fit threshold</i>			(>.05)	<2	>.97	>.97	<.05
Initial path model	5.91	1	.02	5.91	.83	.98	.07
Modified path model	8.16	3	.04	2.72	.94	.98	.04
Restricted path model	13.69	4	.01	3.42	.91	.97	.05

TLI Tucker–Lewis index, CFI comparative fit index, RMSEA root mean square error of approximation

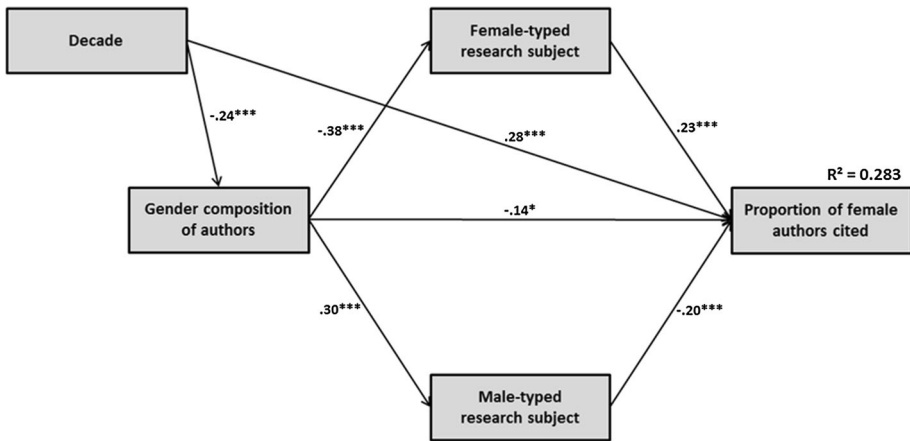


Fig. 2 Adjusted path model with nonsignificant paths removed. Note * $p < .05$. ** $p < .01$. *** $p < .001$. R^2 = coefficient of determination

Regression coefficients were standardized for all paths to allow comparisons between relationships. All of them turned out to be significant at the 5% level. Overall, the exogenous and endogenous variables account for 28.3% of variance in the central outcome “proportion of female authors cited” ($R^2 = .283$, $SE = 0.03$, $p = .00$).

As suggested, “decade” is a negative predictor of “gender composition” ($\beta = -.24$, $B = -0.25$, $SE = 0.05$, $p = .00$) and a positive predictor of “proportion of female authors cited” ($\beta = .28$, $B = 3.03$, $SE = 0.38$, $p = .00$). This points to an increasing number of females entering the scientific field over time both as authors and, as a consequence thereof, academic sources. “Gender composition” exerted a medium negative influence on choice of a female-typed research subject ($\beta = -.38$, $B = -0.40$, $SE = 0.08$, $p = .00$) and a positive influence on choice of a male-typed research subject ($\beta = .30$, $B = 0.30$, $SE = 0.08$, $p = .00$). This in turn affected the “proportion of female authors cited,” with female-typed topics raising ($\beta = .23$, $B = 0.23$, $SE = 0.05$, $p = .00$) and male-typed topics reducing ($\beta = -.20$, $B = -0.20$, $SE = 0.05$, $p = .00$) the citation share of female sources. Accordingly, the respective indirect effects of “gender composition” on “proportion of female authors cited” were $\beta = -.08$ ($B = -1.00$, $SE = 0.27$, $p = .00$) when mediated via female-typed topics and $\beta = -.06$ ($B = -0.68$, $SE = 0.24$, $p = .01$) when mediated via male-typed topics. Thus, the higher the impact of male scholars on a paper,

the higher the likelihood it will address a male-typed topic, which leads to a less frequent citation of female authors compared to male authors. In contrast, the more a publication project is dominated by women, the more female and the fewer male sources are cited due to a higher probability of its covering a female-typed topic. These results provide support for our hypothesis H1: The impact of an author's gender on the preference for the same sex in terms of citations does indeed seem to be mediated by the engagement in different research subjects.

Nevertheless, we found a small but significant direct negative effect of “gender composition” on the “proportion of female authors cited” ($\beta = -.14$, $B = -0.16$, $SE = 0.62$, $p = .01$). This suggests the mediation outlined above is not a full one, but rather a partial, complementary one (cf. Baron and Kenny 1986; Zhao et al. 2010). To test this assumption, we computed a Chi-square difference test (for WLSMV estimation) suited to compare two nested models. That is, we checked our given model against a restricted version where the direct path from “gender composition” to the “proportion of female authors cited” was constrained to 0 (see Table 2). With a $\Delta\chi^2$ of 5.79 ($df = 1$; $p = .02$), the result of difference testing allows us to reject the null hypothesis of assuming no difference between the two models regarding model fit. The unconstrained model fits the data significantly better than the restricted one. Hence, it seems plausible to suppose complementary mediation, as the direct effect of “gender” on “proportion of female authors cited” is different from 0 and points in the same direction as the indirect effect. Therefore, aside from the differences based on topic preference, scholars of a certain gender apparently still cite authors with the same sex more frequently than others. Interestingly, the effect sizes of the indirect and direct paths are nearly the same, so that they finally add up to a total effect of $\beta = -.27$ ($B = -3.27$, $SE = 0.49$, $p = .00$).

Discussion

The empirical observation that male scholars cite other male scholars more extensively than female scholars cite male scholars—and vice versa—could also be made for German communication science. In the materials analyzed, the observed relationship between an author's gender on the share of female (or male) authors cited is partly the result of differences in research interests. In some fields, men have a preponderance among the active researchers and those who produce the available literature, while the same is true for women in other fields. Therefore, our model supports the suggestion made by Fröhlich and Holtz-Bacha (1993, p. 527) that the growing number of female researchers would enrich communication science by contributing research questions from their own unique perspective. The same may also be assumed in relationship to male scholars and male-typed topics. Meanwhile, the exchange between different fields of research is not as strong as the exchange within fields of research (cf. Paisley 1984 for results from communication science and van Dalen and Henkens 1999 for corresponding results from another social science). It may be assumed, therefore, that working in a field of research leads to citing a heightened number of publications from the same field, which in turn accounts for part of the correlation between genders of citing and cited works' authors. This indicates that—at least partly—gender homophily in citations occurs because of the fragmentation along the frontiers between different fields of research.

However, our model shows only a complementary mediation of the relationship between the gender of citing and cited authors, while the strength of the direct effect is equal to the strength of the indirect effect via research subjects. Despite the fact that gender

homophily in citations appears to result from the behavior of male and female scholars alike, this may show that actual gender-based perceptions (like role incongruity) do also exert influence on citation behavior. Therefore, based on the results of our study, a fragmentation of science along gender boundaries cannot be ruled out, meaning that the nonintegration of scientific findings may partly depend on reasons that are essentially irrational.

But although it is definitely possible that the remaining direct effect between the two gender variables is indeed the result of person-related considerations (also, e.g., prejudices against female scientists or the existence of old-boy networks; cf., e.g., Knobloch-Westerwick and Glynn 2013; Davenport and Snyder 1995, p. 409), it might also (partly) result from limitations of our study. Most importantly, the intercoder reliability of the measurement imposed some restrictions. As is typical for a bibliometric study, the topic variable was measured based on the title of the publications, which provided only a limited amount of information. While this was often sufficient, it proved problematic where fields of research had a conceptual overlap (such as media utilization research and media effects research). In such cases, that is, where the reliability of the coding could not be improved, topic categories had to be dropped. Therefore, the categorization of publications into fields of research utilized only a limited number of field categories. While in 785 out of 917 cases at least one of the categories could be applied, other fields of research that men or women have a specific affinity for might have been missed. These could have accounted for additional parts of the gender homophily observed.

Further characteristics of publications that might also make the citation of a female or a male author more likely could not be measured due to methodological or economical limitations. Among other things, future studies should investigate the effects of a *self-similar writing style*. Linguistic studies show that men and women differ significantly in their language use over a variety of dimensions such as quantity, choice of words, and emotionality (Pennebaker et al. 2003, pp. 556–558). Thus, the existence of a rather male-typed and a rather female-typed writing style seems plausible. As self-similarity is one of the most important predictors in social psychology (Montoya et al. 2008), it can further be assumed that men and women find publications composed in their respective type of writing more appealing. Accordingly, scholars could be more likely to unconsciously cite authors of the same sex because of a similar writing style. However, the high degree of standardization in academic writing will level many such differences in writing styles. Empirical studies found at most minor differences between men and women with regard to academic writing (Francis et al. 2001; Hartley 2008, pp. 161–164; Hartley et al. 2003). As mentioned, this is most likely due to highly conventionalized academic standards relating to scientific publications that override prior gender differences in writing (Francis et al. 2001, p. 324).

Yet another content-related differentiator between academic works of male and female scholars relates to methodological orientation. Empirical studies have found, for example, that women have a stronger preference for qualitative methods (Peiser et al. 2003, p. 326). However, considering the reliability problems that surfaced during the coding of the publication topics, one may assume that the coding of characteristics exhibiting more latency will encounter such issues on an even larger scale. Complementing bibliometric studies with experimental studies (such as in Knobloch-Westerwick et al. 2013) does, therefore, seem to be a promising approach to shed further light on fragmentation of science.

The latter represents an important endeavor in science's own interest, as the root causes of fragmentation need to be fully understood. While, regrettably, many more logical

relations than bibliographic ones exist between fields of research (Swanson 1986), such lack of attention, exchange, and integration can *sometimes* be justified by a factual unrelatedness. The gender of a publication's author(s) on the other hand represents an unjustifiable reason (not) to relate the publication with one's own. Should it play any role—and be it only subconsciously—countermeasures are indicated.

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