

Supplementary Materials for

Peer review and gender bias: A study on 145 scholarly journals

Flaminio Squazzoni*, Giangiacomo Bravo, Mike Farjam, Ana Marusic, Bahar Mehmani, Michael Willis, Aliaksandr Birukou, Pierpaolo Dondio, Francisco Grimaldo

*Corresponding author. Email: flaminio.squazzoni@unimi.it

Published 6 January 2021, *Sci. Adv.* 7, eabd0299 (2021)
DOI: 10.1126/sciadv.abd0299

This PDF file includes:

Data sharing protocol
Figs. S1 to S3
Tables S1 to S11

Data sharing protocol

The journal dataset required a data sharing agreement to be established between authors and publishers. A protocol on data sharing entitled "TD1306 COST Action "New frontiers of peer review" (PEERE) PEERE policy on data sharing on peer review" was signed by all partners involved in this research on 1 March 2017, as part of a collaborative project funded by the EU Commission [27]. The protocol established rules and practices for data sharing from a sample of scholarly journals, which included a specific data management policy, including data minimization, retention and storage, privacy impact assessment, anonymization, and dissemination. The protocol required that data access and use were restricted to the authors of this manuscript and data aggregation and report were done in such a way to avoid any identification of publishers, journals or individual records involved. The protocol was written to protect the interests of any stakeholder involved, including publishers, journal editors and academic scholars, who could be potentially affected by data sharing, use and release. The full version of the protocol is available on the peere.org website.

In full compliance with the signed protocol, data were stored in a server of the School of Engineering at the University of Valencia, under the responsibility of one of the authors as data administrator. We developed specific scripts for data cleaning, preparation and extraction and procedures for standardizing the data format. Each step was executed and independently double-checked by two authors of the manuscript.

The dataset used for this study is available as a SI file (an SV source file) to the main manuscript. This includes all records required to rerun our analysis. To request additional information on the dataset and for any claim or objection, please contact the PEERE data controller at info@peere.org. See <http://www.peere.org/wp-content/uploads/2017/03/PEEREDataSharingProtocol.pdf>.

Supplementary Figures

The sampled journals were identified by publishers so as to maximize a representative coverage of fields of research. Journals from learned societies or having specific legal status were not considered. Although the database included journals not being indexed in WoS-Web of Science and not having been assigned an impact factor, for the sake of comparability, these cases were not considered in this study.

Fig. S1 shows the distribution of the impact factor of all sampled journals in 2016, which was the last year covered by our data. Note that the highest impact factor reached by at least one of our sampled journals in all the time window covered by our data was 10.

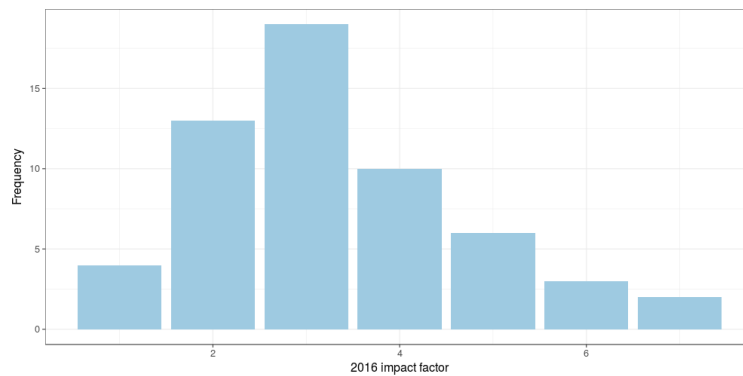


Figure S1: Distribution of the impact factor of sampled journals in 2016; source: WoS).

Fig. S2 shows the number of manuscripts with an editorial decision by date and journal's field of research. The largest proportion of manuscripts were submitted to journals in physical and health sciences, with significant variations in terms of number of submissions over time compared to journals in the social sciences and the humanities.

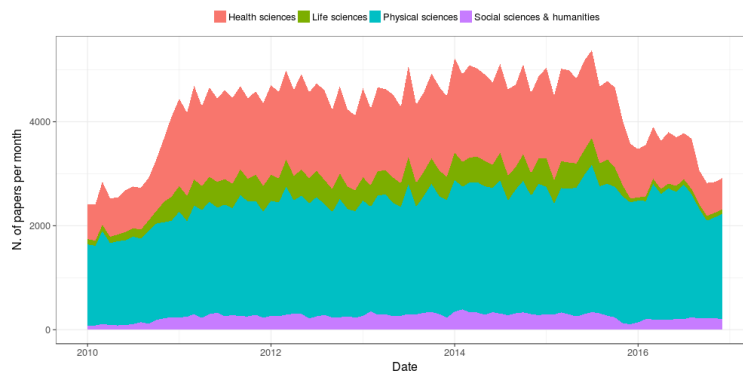


Figure S2: Number of manuscripts with an editorial decision by date and journal field of research.

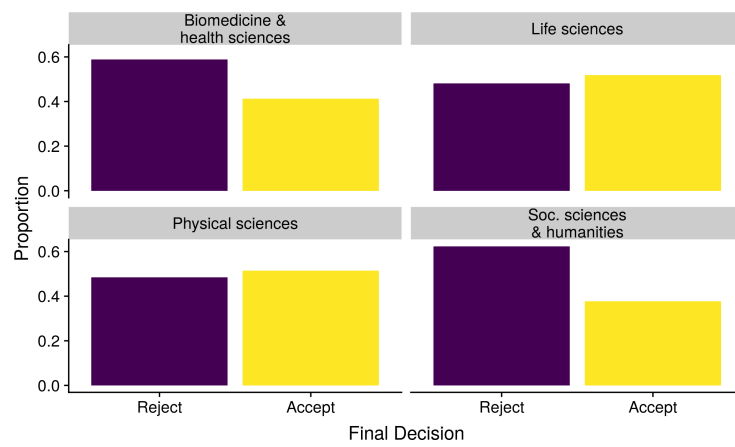


Figure S3: Final editorial decisions by field of research.

Supplementary Tables

Variable	Biom. & health sc.	Life sc.	Physical sc.	Social sc.
(Intercept)	0.350 [0.289,0.409] 20000:1	0.171 [0.112,0.232] 20000:1	0.192 [0.071,0.312] 1428:1	0.341 [0.252,0.431] 20000:1
Women proportion (authors)	0.102 [0.095,0.109] 20000:1	0.072 [0.059,0.084] 20000:1	0.066 [0.061,0.071] 20000:1	0.122 [0.108,0.136] 20000:1
IF	0.010 [0.006,0.013] 20000:1	0.007 [0.00,0.002] 1428:1	0.003 [0.001,0.005] 605:1	0.011 [-0.005,0.026] 10:1
N. of authors	0.000 [-0.001,0.001] 1:1	0.001 [0.000,0.002] 59:1	0.002 [0.001,0.002] 20000:1	0.001 [-0.001,0.004] 5:1
PR type: single-blind	-0.177 [-0.247,-0.103] 1:20000	-0.018 [-0.078,0.042] 1:3	-0.080 [-0.206,0.044] 1:9	-0.221 [-0.415,-0.029] 1:74

Table S1: Linear mixed effects model on the proportion of women among referees. Random effects were included for journals. Reference categories were biomedicine and health journals and double blind peer review. Mean estimate, 95% CI, and Bayes factor ($\beta > 0$) are reported for each variable.

Variable	Biom. & health sc.	Life sc.	Physical sc.	Social sc.
(Intercept)	0.311 [0.277,0.344] 20000:1	0.375 [0.309,0.444] 20000:1	0.284 [0.184,0.384] 20000:1	0.279 [0.219,0.336] 20000:1
Women proportion (authors)	0.010 [0.004,0.017] 2221:1	-0.008 [-0.018,0.003] 1:10	-0.009 [-0.014,-0.003] 1:1537	0.011 [0.002,0.021] 100:1
Women proportion (referees)	0.013 [0.008,0.018] 20000:1	0.011 [0.002,0.021] 82:1	0.000 [-0.005,0.005] 1:1	0.019 [0.009,0.029] 20000:1
IF	-0.001 [-0.004,0.002] 1:2	0.000 [-0.004,0.004] 1:1	-0.012 [-0.014,-0.010] 1:20000	-0.007 [-0.018,0.004] 1:9
N. of authors	0.002 [0.002,0.003] 20000:1	-0.002 [-0.003,-0.001] 1:20000	0.008 [0.007,0.009] 20000:1	0.004 [0.003,0.006] 20000:1
N. of referees	0.018 [0.015,0.020] 20000:1	0.005 [0.001,0.009] 156:1	0.008 [0.006,0.009] 20000:1	-0.005 [-0.009,0.000] 1:38
PR type: single-blind	0.000 [-0.038,0.039] 1:1	0.012 [-0.057,0.080] 2:1	0.053 [-0.050,0.158] 6:1	-0.029 [-0.152,0.099] 1:2

Table S2: Linear mixed effects model on referee recommendations. Random effects were included for journals. Reference categories were biomedicine and health journals and double-blind peer review. Mean estimate, 95% CI, and Bayes factor ($\beta > 0$) are reported for each variable.

Variable	Biom. & health sc.	Life sc.	Physical sc.	Social sc.
(Intercept)	0.318 [0.285,0.351] 20000:1	0.395 [0.326,0.465] 20000:1	0.302 [0.196,0.409] 20000:1	0.289 [0.226,0.348] 20000:1
First author woman	-0.001 [-0.005,0.003] 1:2	-0.010 [-0.017,-0.003] 1:768	-0.009 [-0.012,-0.005] 1:20000	0.004 [-0.004,0.012] 5:1
Last author woman	-0.005 [-0.009,-0.000] 1:59	-0.015 [-0.023,-0.008] 1:20000	-0.01 [-0.014,-0.006] 1:20000	0.001 [-0.007,0.009] 2:1
Women proportion (referees)	0.015 [0.009,0.020] 20000:1	0.018 [0.006,0.029] 1428:1	-0.002 [-0.008,0.003] 1:3	0.019 [0.009,0.030] 4999:1
IF	0.001 [-0.003,0.004] 2:1	0.000 [-0.004,0.005] 1:1	-0.014 [-0.017,-0.011] 1:20000	-0.007 [-0.019,0.006] 1:6
N. of authors	0.002 [0.001,0.003] 20000:1	-0.002 [-0.003,-0.001] 1:20000	0.009 [0.008,0.009] 20000:1	0.004 [0.002,0.006] 20000:1
N. of referees	0.018 [0.015,0.020] 20000:1	0.002 [-0.003,0.007] 3:1	0.006 [0.004,0.008] 20000:1	-0.006 [-0.012,-0.001] 1:118
PR type: single-blind	0.000 [-0.041,0.039] 1:1	0.012 [-0.057,0.082] 2:1	0.050 [-0.059,0.159] 5:1	-0.030 [-0.155,0.097] 1:2

Table S3: Linear mixed effects model on referee recommendations (review scores). Random effects were included for journals. Reference categories were biomedicine and health journals and double-blind peer review. Mean estimate, 95% CI, and Bayes factor ($\beta > 0$) are reported for each variable.

Variable	Biom. & health sc.	Life sc.	Physical sc.	Social sc.
(Intercept)	0.325 [0.292,0.359] 20000:1	0.375 [0.308,0.442] 20000:1	0.272 [0.173,0.373] 20000:1	0.280 [0.219,0.339] 20000:1
Solo woman	-0.004 [-0.021,0.014] 1:2	-0.010 [-0.040,0.020] 1:3	-0.020 [-0.034,-0.006] 1:605	0.006 [-0.009,0.021] 4:1
All men team	-0.018 [-0.029,-0.008] 1:2499	-0.003 [-0.017,0.012] 1:2	0.019 [0.013,0.024] 20000:1	0.000 [-0.012,0.011] 1:1
All women team	-0.014 [-0.027,-0.001] 1:56	0.000 [-0.024,0.024] 1:1	-0.005 [-0.017,0.006] 1:4	0.014 [-0.001,0.029] 28:1
Cross collaboration	-0.006 [-0.017,0.004] 1:7	0.001 [-0.014,0.015] 1:1	0.019 [0.013,0.025] 20000:1	0.006 [-0.006,0.018] 5:1
Women proportion (referees)	0.013 [0.008,0.0180] 20000:1	0.010 [0.001,0.020] 66:1	-0.000 [-0.005,0.004] 1:1	0.019 [0.010,0.029] 19999:1
IF	-0.001 [-0.004,0.002] 1:2	0.000 [-0.004,0.004] 1:1	-0.012 [-0.014,-0.010] 1:20000	-0.007 [-0.018,0.004] 1:9
N. of authors	0.002 [0.001,0.002] 20000:1	-0.002 [-0.003,-0.001] 1:9999	0.007 [0.006,0.008] 20000:1	0.004 [0.002,0.006] 19999:1
N. of referees	0.018 [0.015,0.020] 20000:1	0.005 [0.001,0.009] 203:1	0.007 [0.006,0.009] 20000:1	-0.005 [-0.010,-0.000] 1:36
PR type: single-blind	-0.001 [-0.038,0.038] 1:1	0.012 [-0.055,0.079] 2:1	0.052 [-0.051,0.151] 5:1	-0.029 [-0.153,0.098] 1:2

Table S4: Linear mixed effects model on referee recommendations. Random effects were included for journals. Reference categories were biomedicine and health journals and double-blind peer review. Mean estimate, 95% CI, and Bayes factor ($\beta > 0$) are reported for each variable.

Variable	Biom. & health sc.	Life sc.	Physical sc.	Social sc.
(Intercept)	-6.016 [-6.444,-5.586] [-6.44,-5.59] 1:20000	-4.659 [-6.009,-3.313] [-6.01,-3.31] 1:20000	-7.162 [-8.074,-6.257] [-8.07,-6.26] 1:20000	-5.037 [-5.978,-4.116] [-5.98,-4.12] 1:20000
Solo woman	-0.053 [-0.345,0.234] 1:2	-0.144 [-0.691,0.403] 1:2	-0.129 [-0.379,0.120] 1:5	-0.344 [-0.699,0.005] 1:37
All men team	-0.231 [-0.412,-0.051] 1:174	-0.117 [-0.372,0.141] 1:4	0.166 [0.067,0.265] 1999:1	-0.112 [-0.385,0.156] 1:4
All women team	-0.195 [-0.413,0.021] 1:24	-0.065 [-0.478,0.345] 1:2	0.457 [0.251,0.663] 20000:1	-0.054 [-0.402,0.290] 1:2
Cross collaboration	-0.138 [-0.320,0.041] 1:14	0.031 [-0.224,0.286] 1:1	0.251 [0.146,0.356] 20000:1	-0.114 [-0.397,0.164] 1:4
Women proportion (referees)	-0.149 [-0.234,-0.062] 1:4999	-0.046 [-0.208,0.116] 1:2	-0.038 [-0.117,0.040] 1:5	-0.234 [-0.448,-0.022] 1:65
Referee recommendation	6.018 [5.905,6.13] 20000:1	6.180 [5.939,6.422] 20000:1	6.095 [5.994,6.196] 20000:1	5.825 [5.476,6.178] 20000:1
Agreement	1.214 [1.087,1.340] 20000:1	0.670 [0.452,0.884] 20000:1	0.710 [0.617,0.803] 20000:1	0.195 [-0.125,0.520] 8:1
IF	-0.060 [-0.113,-0.007] 1:73	-0.141 [-0.215,-0.067] 1:20000	0.056 [0.019,0.094] 666:1	-0.144 [-0.401,0.116] 1:6
N. of authors	0.002 [-0.007,0.011] 2:1	-0.044 [-0.058,-0.028] 1:20000	0.034 [0.024,0.045] 20000:1	0.015 [-0.034,0.063] 3:1
N. of referees	-0.183 [-0.225,-0.142] 1:20000	-0.159 [-0.234,-0.084] 1:20000	-0.103 [-0.133,-0.072] 1:20000	-0.299 [-0.420,-0.180] 1:20000
PR type: single-blind	0.536 [0.102,0.968] 119:1	0.131 [-1.218,1.470] 1:1	1.170 [0.269,2.069] 160:1	1.073 [-0.407,2.576] 13:1
N. of revision rounds	4.095 [4.038,4.153] 20000:1	3.673 [3.579,3.768] 20000:1	3.994 [3.950,4.039] 20000:1	3.762 [3.631,3.894] 20000:1

Table S5: Logistic mixed effects models on the final editorial decision (accept) by field of research using the first and last author genders as predictors. Mean estimate, 95% CI, and Bayes factor ($\beta > 0$) are reported for each variable.

		All fields	Health sc.	Life sc.	Physical sc.	Social sc.
Sensitivity	Woman	0.85	0.82	0.90	0.88	0.79
	Man	0.88	0.84	0.89	0.90	0.79
Specificity	Woman	0.74	0.73	0.68	0.77	0.78
	Man	0.76	0.75	0.64	0.77	0.84

Table S6: Model diagnostics of the Bayesian Network for subsets of gender and journal field of research. Manuscripts with more than 50% of men authors were classified as men, the rest as women.

Gender	Authors		Referees	
	Number	Proportion	Number	Proportion
Man	857324	0.51	451594	0.61
Woman	436876	0.26	156770	0.21
Unknown	395744	0.23	137329	0.18

Table S7: Gender identification. Proportion of authors and referees classified as man, woman or unknown.

Gender origin	Proportion of Authors	Proportion of Referees
Salutation	0.04	0.06
Gender-guesser	0.57	0.63
Gender API	0.16	0.13
Unknown	0.23	0.18

Table S8: Sources of gender determination in the three steps- protocol presented in the manuscript.

Outcome	Input	Coefficient				
		Health	Life	Physical	Social	All
N. of authors	IF	0.644	0.258	0.469	0.369	0.563
	PR type: single-blind	0.063	-0.513	0.920	-0.327	-0.121
Women proportion (authors)	N. of authors	-0.005	0.006	0.011	-0.001	0.005
	PR type: single-blind	-0.071	0.003	-0.065	-0.306	-0.144
Review score	N. of authors	0.002	0.000	0.010	0.006	0.005
	Women proportion (authors)	0.014	-0.038	-0.027	0.041	-0.009
	PR type: single-blind	-0.019	-0.002	0.072	-0.023	0.016
	Agreement	-0.097	-0.010	-0.039	-0.080	-0.060
Accept	N. of authors	0.007	0.011	0.007	0.023	0.004
	Women proportion (authors)	0.018	0.049	0.052	0.007	0.026
	Review score	2.178	2.275	2.443	2.712	2.342
	Women proportion (referees)	0.088	0.017	0.020	0.020	0.053
	PR type: single-blind	-0.051	0.071	-0.011	-0.122	0.022
	Agreement	0.325	0.146	0.186	0.219	0.227
Women proportion (referees)	Women proportion (authors)	0.297	0.103	0.158	0.189	0.221
	PR type: single-blind	-0.090	-0.031	-0.060	-0.217	-0.131
	N. of referees	0.025	0.005	0.005	0.010	0.014
PR type: single-blind	IF	0.172	-0.047	0.007	-0.247	0.072
Agreement	PR type: single-blind	-0.010	0.017	-0.084	-0.012	-0.015
	N. of referees	-0.136	-0.107	-0.120	-0.104	-0.123
N. of referees	IF	0.062	0.084	0.045	0.273	0.060

Table S9: Coefficients for the Bayesian network. All coefficients were learned on the same network structure (shown in the main text). This implies that coefficients under *All* do not show the weighted means of the scientific field coefficients, since, with different fields, the variance to be predicted was routed through different paths in the network.

Variable	Biom. & health sc.	Life sc.	Physical sc.	Social sc.
(Intercept)	0.365 [0.330,0.398] 20000:1	0.373 [0.310,0.436] 20000:1	0.309 [0.214,0.405] 20000:1	0.282 [0.240,0.323] 20000:1
Women proportion (authors)	0.003 [-0.009,0.016] 2:1	0.007 [-0.020,0.034] 2:1	-0.012 [-0.062,0.036] 1:2	0.003 [-0.012,0.017] 2:1
Women proportion (referees)	0.004 [-0.004,0.012] 6:1	0.005 [-0.009,0.019] 3:1	-0.006 [-0.013,0.000] 1:56	0.001 [-0.012,0.014] 1:1
PR type: single-blind	0.005 [-0.038,0.048] 2:1	0.018 [-0.049,0.085] 2:1	0.049 [-0.049,0.147] 5:1	-0.029 [-0.140,0.082] 1:2
Women (authors) * Women (referees)	0.021 [0.005,0.036] 178:1	0.019 [-0.015,0.053] 6:1	0.033 [0.016,0.049] 20000:1	0.032 [0.008,0.056] 312:1
Women (authors) * PR type	-0.001 [-0.014,0.013] 1:1	-0.025 [-0.053,0.003] 1:25	0.000 [-0.049,0.049] 1:1	-0.035 [-0.060,-0.010] 1:302

Table S10: Separate linear regression model for important interactions for the prediction of the review score. Mean estimate, 95% CI, and Bayes factor ($\beta > 0$) are reported for each variable.

Variable	Biom. & health sc.	Life sc.	Physical sc.	Social sc.
(Intercept)	-2.84 [-3.034,-2.651] 1:20000	-2.578 [-2.878,-2.279] 1:20000	-2.903 [-3.065,-2.744] 1:20000	-2.974 [-3.234,-2.711] 1:20000
Women proportion (authors)	0.508 [0.403,0.614] 20000:1	0.022 [-0.211,0.256] 1:1	0.112 [0.009,0.216] 56:1	0.105 [-0.088,0.299] 6:1
Review score	7.269 [7.152,7.388] 20000:1	7.66 [7.424,7.903] 20000:1	8.511 [8.418,8.605] 20000:1	8.128 [7.805,8.461] 20000:1
Women proportion (authors) * review score	-1.093 [-1.351,-0.839] 1:20000	0.106 [-0.509,0.718] 2:1	0.212 [-0.088,0.514] 11:1	-0.452 [-1.036,0.134] 1:14

Table S11: Logistic regression model on the acceptance of manuscripts. This model separately tests whether there is an interaction effect between the proportion of women and the review score. Mean estimate, 95% CI, and Bayes factor ($\beta > 0$) are reported for each variable.