https://doi.org/10.51408/issi2025_129

Mapping the Social Structure of Philosophy of Science Through Large-Scale Acknowledgments Analysis

Eugenio Petrovich[1], Edoardo Fazzini[2], Lorenzo Gandolfi[3]

[1] *eugenio.petrovich@unito.it*
University of Turin, Dept. of Philosophy and Education Sciences, Via Sant'Ottavio 20, Turin (Italy)

[2] *edoardo.fazzini@unibe.ch*
University of Bern, Institute of Philosophy, Länggassstrasse 49a, 3012 Bern (Switzerland)

[3] *lorenzo.gandolfi@iusspavia.it*
IUSS Pavia, Palazzo del Broletto, Piazza della Vittoria 15, 27100 Pavia PV (Italy)

Abstract

The acknowledgments in scientific publications offer a unique perspective on the complex web of socio-cognitive relationships underlying the production of knowledge. Acknowledgment analysis enables us to highlight the role of funding institutions, reconstruct informal collaboration patterns invisible to co-authorship analysis, and measure a distinct form of prestige beyond authorships and citations. This study leverages acknowledgment analysis to investigate the fine-grained social structure of philosophy of science, a research field whose social dimension has thus far remained unexplored. Specifically, we aim to: 1) identify the scholars who receive the most acknowledgments in the field and examine their roles in professional associations; 2) analyze how acknowledgments are distributed across the community and the factors affecting the number of mentions received; and 3) map the social communities within philosophy of science, exploring whether they are organized around topics, methodological approaches, or professional associations. Our findings reveal that acknowledgments are prevalent in philosophy of science, with 79% of articles including them, and that the average acknowledgment mentions 5.3 individuals—significantly higher than the average number of co-authors per article (1.3). Most acknowledged individuals are prominent philosophers of science who play key roles in professional associations. In terms of distribution, mentions are highly concentrated among a few individuals, with the top 10% of acknowledged scholars receiving nearly half of all mentions. Mentions are most strongly predicted by academic awards, productivity in philosophy of science journals, leadership roles in professional associations, and affiliation with English-speaking institutions, with smaller effects for gender and general publication metrics. Finally, the co-acknowledgment network shows that clusters of frequently co-mentioned individuals are organized around both topics (e.g., philosophies of specific sciences) and methodological approaches (e.g., formal vs. historical philosophy of science).

Introduction

In scientometrics, *acknowledgement analysis* is a relatively underdeveloped field of investigation, especially when compared to well-established domains such as citation analysis or publication analysis.

Still, the acknowledgments of academic publications are a rich source of information, which are able to illuminate streams of research funding (Huang & Huang, 2018), informal collaboration patterns (Cronin et al., 2003; Petrovich, 2021), and prestige dynamics within research fields (Costas & Leeuwen, 2012; Petrovich, 2024). The acknowledgments, in fact, offer an unique perspective on the complex web of *socio-cognitive relationships* that underlie research, highlighting actors and

social processes that remain invisible when the analysis is confined to standard data considered in scientometrics, such as authorships and citations (Cronin et al., 2004). The acknowledgements are especially valuable to investigate *scientific collaboration* in those fields, such as the social sciences and humanities, in which formal co-authorship is less common. Including the persons mentioned in the acknowledgements in addition to formal co-authors reveals, in fact, that the intensity of collaboration in these fields is not different from what is observed in the natural sciences (Paul-Hus et al., 2017). Similarly, acknowledgments networks are able to reveal portions of the social structure of research fields that remain invisible to standard co-authorship networks (Petrovich, 2022).

Moreover, being mentioned in an acknowledgment is a sign of *prestige*: persons that are frequently thanked in the acknowledgments are in fact prominent figures in their respective fields (Cronin, 1995). Among the most mentioned acknowledgees in economics, for instance, there are the editors of the most prestigious economics journals, as well as winners of important economics prizes, including several Nobel laureates (Baccini & Petrovich, 2022). Similarly, the most mentioned figures in biology are respected mentors and recognized experts of specific organisms (McCain, 2024). In this sense, the acknowledgments constitute the third angle of the "reward triangle" of science, along with authorships and citations, and offer a further way to measure prestige in a research community (Costas & Leeuwen, 2012).

The aim of this paper is to provide the first large-scale quantitative analysis of the acknowledgments in contemporary *philosophy of science* in order to shed light on the social structure of this research field.

Philosophy of science is an interesting case study for a four-fold reason. First, it is one of the few areas of philosophy that has been quite extensively investigated through quantitative methods, both via text mining (Malaterre et al., 2021) and citation analysis (Khelfaoui et al., 2021; McLevey et al., 2018; Petrovich & Viola, 2024). Still, a detailed study of the social dimension of the field via acknowledgments analysis is lacking in the literature. Second, acknowledgments data can provide a better estimate of the intensity of scientific collaboration in philosophy of science, a field where co-authorship is relatively uncommon (e.g., only 17% of recent publications in the journal *Philosophy of Science* are multi-authored). Third, philosophy of science has greatly diversified in the last two decades, both from the point of view of social structures and methodological orientations. The Philosophy of Science Association (PSA), founded back in 1933, has been for long time the only professional association of philosophers of science. From 1990s, however, new associations have been established: the International Society for the History of Philosophy of Science (HOPOS) in 1994, the European Philosophy of Science Association (EPSA) in 2005, the Committee for Integrated HPS (&HPS), the Society for Philosophy of Science in Practice (SPSP), both in 2006, and the Consortium for Socially Relevant Philosophy of/in Science and Engineering (SRPoiSE) in 2014, not to mention the numerous associations devoted to the philosophy of specific sciences. All these associations aim to promote and advance philosophy of science, but with slightly different methodological orientations: for instance, HOPOS promotes historical research on the philosophy of science widely

understood, while PSPS promotes the epistemological analysis of scientific practices. Mapping the social landscape of the field can allow us to better understand the impact of these newer associations on the development of the field. Lastly, philosophy of science is itself divided into specialties: along with general philosophy of science, there are philosophies of the different sciences, such as philosophy of physics, mathematics, economics, neuroscience, and so on. To investigate the sociology of the field, it is crucial to understand whether its social structure reflects this specialization, i.e., whether intellectual specialties correspond to social sub-communities, or not.

In the light of these interesting characteristics of philosophy of science, the present study aims specifically to answer the following research questions:

R1) Who are the scholars who receive most mentions in philosophy of science? Do they play key roles in old and new professional associations of the field?

R2) How is prestige distributed in the community? Is it concentrated in few individuals or equally shared among social actors? Is it equally distributed between genders? What factors influence the accumulation of prestige?

R3) What are the social communities in which philosophers of science are divided? Are communities organized around topics, methodological approaches, professional associations?

Data and Methods

Following previous quantitative studies on philosophy of science (Malaterre et al., 2021), we operationally defined the field based on a widely accepted list of leading disciplinary journals. In particular, we focused on the following 8 journals: *Erkenntnis, Philosophy of Science, Synthese, Studies in History and Philosophy of Science, British Journal for the Philosophy of Science, Foundations of Science, Journal for General Philosophy of Science, and European Journal for Philosophy of Science*. Of the 8,327 publications appeared in these journals between 2005 and 2019, we retained research articles ($n = 6{,}826$), leaving aside book reviews, commentaries, editorials, and other minor document types. This set of articles corresponds to our bibliometric delineation of philosophy of science.

All metadata of these articles, including authorship and cited references, were downloaded from Web of Science. The acknowledgments appearing in the articles, on the other hand, were manually collected from the articles' electronic version and attached to the main dataset. We focused only on acknowledgments that were clearly recognizable as such, ignoring minor acknowledgements appearing in the main text and in standard footnotes.

To extract the names of the persons thanked in the acknowledgments (henceforth, the *acknowledgees*), we used Named-Entity Recognition, a Natural Language Processing technique that is able to identify and classify into pre-defined categories named entities occurring in pieces of natural language. Specifically, we used the NER module of the Python library *spaCy* (https://spacy.io) to extract from our corpus of acknowledgement texts around 49,000 mentions to around 20,000 distinct named entities.

The raw output of the NER was then manually cleaned and consolidated. First, misclassifications were manually corrected: false positives, i.e., entities wrongly classified as PERSON ($n = 781$), were excluded from the list of acknowledgees, while false negatives, i.e., entities that were not classified as PERSON even if they were persons ($n = 298$), were added. Second, name variants were identified and consolidated. Due to the informal nature of acknowledgments, diminutives (e.g., "Jon Kvanvig") are often used alongside full names (e.g., "Jonathan Kvanvig"), leading to multiple ways of referring to the same individual. To ensure accurate mention statistics, these variants needed to be standardized. The identification process combined custom Python scripts based on string similarity and fuzzy matching with manual inspection and validation. After this consolidation, we reduced the initial 10,570 entities classified as persons in the raw output to a refined list of 9,029 distinct acknowledgees (-15%).

Authorship data were similarly consolidated, as Web of Science does not provide unique identifiers for authors. Of the 4,835 raw distinct author strings, we build a list of 4,395 standardized authors (-9%). The lists of acknowledgees and authors were finally merged, obtaining a list of 10,980 actors, i.e., persons that appeared as authors and/or acknowledgees in our dataset. This merging allowed us to remove few false self-mentions that occurred when the name of the authors of an article appeared in the acknowledgement as well, for instance when the authors acknowledged some funding body.

Affiliation data with philosophy of science associations were manually collected from their respective websites, focusing on PSA, EPSA, &HPS, SPSP, SRPoiSE, and SMS (Society for the Metaphysics of Science). We focused only on members of governing bodies (e.g., presidents and officials), leaving aside simple membership. Similarly, the names of recipients of the most prestigious philosophy of science prizes (Lakatos Award, Popper Prize, and the Hempel Award) were retrieved from online sources.

Academic affiliations—including institution name, city, and country—were assigned to actors by retrieving their Scopus profiles through an automated search using the Scopus API. To account for academic mobility, the affiliation corresponding to the year of the authorship or acknowledgment was used. 81% of the mentions were successfully linked to an affiliation. Bibliometric statistics of actors (citation counts and publication counts) were also retrieved from Scopus profiles. Lastly, gender was assigned using the *genderize.io* service, based on the actor's first name and primary country of affiliation, to account for names (such as "Andrea") that vary in gender across different countries.

To answer R1 and R2, we developed an indicator M_a that measures the prestige of an actor a in the community, based on the number of distinct acknowledgments in which a is mentioned. The higher the value of M_a, the greater the prestige of a in the community. To answer R3, we constructed an Acknowledgees Co-Mention Network (ACM) using the techniques developed by Petrovich (2022) to map the social structure of research fields. In the ACM, acknowledgees are connected when they are co-mentioned in the same acknowledgement, with the strength of the links equal to the number of acknowledgements in which they are mentioned together.

Clusters of densely interconnected acknowledgees in the ACM correspond to social communities within a research field (Petrovich, 2022).

Results and Discussion

79% ($n = 5{,}376$) of the articles in our dataset included acknowledgments, with the percentage increasing linearly over time from 74% in 2005 to 84% in 2019. The average acknowledgment is 60 words long (st. dev. = 40, median = 52, min = 4, max = 391) and 87% of the acknowledgments ($n = 4{,}660$) mentioned at least one acknowledgee. Considering only this subset, the average number of mentioned acknowledgees per article is 5.3 (st. dev. = 4.4, median = 4, min = 1, max = 44), with some variance across journals. Note that the average number of mentioned acknowledgees per article is significantly higher than the average number of co-authors per article: 5.3 against 1.3. This difference shows that co-authorship severely underestimates the rate of collaboration in philosophy of science.

2,444 actors appear both as authors and as acknowledgees in our dataset, meaning that 55.8% of authors are mentioned also in the acknowledgments, and 27% of acknowledgees write also an article. The high number of acknowledgees that do not appear as authors ($n = 6{,}595$) shows that the population of actors contributing to the development of philosophy of science extends significantly beyond that of formal authors.

To address R1, we constructed the ranking of acknowledgees based on the M indicator. Table 1 shows the acknowledgees with the top-10 highest M.

Table 1. Top-10 most-mentioned acknowledgees in philosophy of science (*=President).

Rank	*Actor*	*Mentions*	*Articles*	*Association(s)*
1	Elliott Sober	104	7	PSA*
2	John Norton	97	15	HPS, PSA
3	Carl Craver	66	7	
4	Anjan Chakravartty	65	8	SRPoiSE, PSA
5	Stephan Hartmann	62	14	EPSA*, PSA
6	David Chalmers	61	0	
7	Alan Hajek	60	7	PSA
8	James Woodward	57	11	PSA*
9	Branden Fitelson	55	8	
10	Hannes Leitgeb	54	8	

The most-mentioned persons in philosophy of science are all academic philosophers playing prominent roles in the profession. Elliott Sober (rank 1) and James Woodward (rank 8) have both served as President of the PSA in 2003-2004 and 2011-2012, while Stephan Hartmann (rank 5) has been President of EPSA in 2013-2015. SPSP, HOPOS, and SMS are not represented in the ranking, suggesting that their officials play a less relevant role in the social landscape of philosophy of science. Interestingly, among the most mentioned philosophers we find also David Chalmers, who is a prominent analytic philosopher rather than a philosopher of

science *strictu sensu* (note that he does not author any article in the corpus). Moreover, all top-mentioned are male. The first woman, Nancy Cartwright is in rank 11, and among the 140 acknowledgees with more than 20 mentions, there are only 10 women (7%).

To address R2, we analysed the distribution of mentions across the entire population of acknowledgees and by gender. In our dataset, a total of 24,912 mentions are distributed among 9,029 distinct acknowledgees. The average number of mentions per acknowledgee is 2.7 (median = 1, standard deviation = 5, minimum = 1, maximum = 104), but the Gini coefficient of 0.53 indicates significant inequality in the distribution of mentions. Specifically, 80% of acknowledgees collect only 37% of all mentions, while the top 10% most-mentioned acknowledgees collect nearly 50%. This skewed distribution is typical of scientometric variables, demonstrating that the form of prestige captured by acknowledgments is, in fact, concentrated among a small number of individuals, similarly to what is observed with citations and authorships. In terms of gender, the overall population of actors is characterized by a significant disparity, with only 22% of women. Note that the proportion of women in the authors (80.4%) is slightly lower than the proportion of women in the acknowledgees (77.9%), suggesting a possible bias against women in accessing formal authorship.

A multiple regression analysis was conducted to examine the predictors of mentions. The number of awards was the strongest predictor, with each additional prize associated with 10.1 more mentions (SE = 0.57, $p < 0.001$). The number of publications in philosophy of science journals, the number of governing roles in professional associations, and affiliation with English-speaking countries also had substantial effects, increasing mentions by 1.56 (SE = 0.034), 1.12 (SE = 0.12), and 1.38 (SE = 0.13), respectively (all $p < 0.001$). Gender showed a smaller but statistically significant effect, with men receiving roughly 0.54 more mentions than women (SE = 0.16, $p < 0.001$). Overall publication count had a small but significant positive effect ($\beta = 0.0060$, SE = 0.0016, $p < 0.001$), while citation count showed a small negative association ($\beta = –0.000044$, SE = 0.000016, $p = 0.006$). The model explains approximately 40.5% of the variance in mention counts (adjusted $R^2 = 0.405$), indicating that academic recognition—particularly in the form of prizes, productivity in philosophy of science, and institutional visibility through professional associations—is a major driver of acknowledgment practices.

Lastly, to address R3, we constructed the Acknowledgees Co-Mention Network including all the acknowledgees receiving at least 10 mentions ($n = 447$). An interactive visualization of the network, created with VOSviewer (van Eck & Waltman, 2010) and supplemented with further statistics and information, is available on-line at https://tinyurl.com/288wkbxt. VOSviewer clustering algorithm identifies 6 clusters at resolution 1, which can be straightforwardly labelled based on the specialization of the acknowledgees they include. Interestingly, cluster 1 includes mainly analytic philosophers rather than philosophers of science; cluster 2 includes philosophers of science working on general philosophy of science, frequently using formal methods such as probability theory; cluster 3 philosophers of science working on integrated history and philosophy of science; cluster 4 philosophers of physics;

cluster 5 philosophers of life sciences; cluster 6 philosophers of mind sciences. Clusters appear therefore to be organized both around specialties (philosophies of specific sciences) and methodological approaches (formal vs historically-informed philosophy of science). Note that, in the overall network, the philosophy of physics cluster is the most isolated, showing that philosophers of physics constitute a tight sub-community with relatively few connections with the rest of the field. Philosophy of physics is also the cluster with the highest average number of mentions as well as the one which includes the highest number of awardees (see Table 2). The cluster with the highest number of officials, however, is integrated history and philosophy of science, with 32 officials (43% of the cluster's members are official in at least one of the associations covered). This cluster is also the one with the highest proportion of women (25.3%). Officials of the PSA, the oldest association, can be found in all clusters, showing the influence of the association on the entire field. Officials of the younger EPSA, on the other hand, are mainly concentrated in the general philosophy of science cluster, while, unsurprisingly, officials of historically- and practice-oriented associations (SPSP, HOPOS, &HPS) can be found mainly in the integrated history and philosophy of science cluster.

Table 2. Cluster-level statistics of the philosophy of science ACM network.

Cluster	*Label*	*Members*	*Avg. Mentions*	*Awards*	*Associations officials (%)*	*Women prop.(%)*
1	Analytic philosophy	117	16.7	0	1 (0.9%)	11.2
2	General philosophy of science	94	19.5	5	20 (21%)	10.6
3	Integrated Hist. & Phil. of Science	75	19.0	7	32 (43%)	25.3
4	Philosophy of physics	73	22.2	13	20 (12%)	16.4
5	Philosophy of biology	58	22.0	9	7 (14%)	10.3
6	Philosophy of mind sciences	29	20.7	1	4 (27%)	10.3

Conclusions and next steps in the research

This preliminary investigation of philosophy of science via acknowledgment analysis has shown that the acknowledgments of academic articles offer precious insights on the social structure of this research field. Our data has allowed us to identify prominent figures in the field (R1), determine how prestige is distributed in the community and the factors governing it (R2), and map the communities in which philosophers of science are divided (R3), highlighting in particular the role that different professional associations play in the field.

The next step in the research is to extend the analysis to the institutional level, in order to identify the most prominent research centers in philosophy of science and to examine the role of homophily (i.e., similarity in characteristics) in shaping the relationships between authors and acknowledgees.

References

Baccini, A., & Petrovich, E. (2022). Normative versus strategic accounts of acknowledgment data: The case of the top-five journals of economics. *Scientometrics, 127*(1), 603–635. https://doi.org/10.1007/s11192-021-04185-6

Costas, R., & Leeuwen, T. N. (2012). Approaching the "reward triangle": General analysis of the presence of funding acknowledgments and "peer interactive communication" in scientific publications. *Journal of the American Society for Information Science and Technology, 63*(8), 1647–1661. https://doi.org/10.1002/asi.22692

Cronin, B. (1995). *The Scholar's Courtesy: The Role of Acknowledgement in the Primary Communication Process*. Taylor Graham.

Cronin, B., Shaw, D., & Barre, K. L. (2004). Visible, less visible, and invisible work: Patterns of collaboration in 20th century chemistry. *Journal of the American Society for Information Science and Technology, 55*(2), 160–168. https://doi.org/10.1002/asi.10353

Cronin, B., Shaw, D., & La Barre, K. (2003). A cast of thousands: Coauthorship and subauthorship collaboration in the 20th century as manifested in the scholarly journal literature of psychology and philosophy. *Journal of the American Society for Information Science and Technology, 54*(9), 855–871. https://doi.org/10.1002/asi.10278

Huang, M.-H., & Huang, M.-J. (2018). An analysis of global research funding from subject field and funding agencies perspectives in the G9 countries. *Scientometrics, 115*(2), 833–847. https://doi.org/10.1007/s11192-018-2677-y

Khelfaoui, M., Gingras, Y., Lemoine, M., & Pradeu, T. (2021). The visibility of philosophy of science in the sciences, 1980–2018. *Synthese*. https://doi.org/10.1007/s11229-021-03067-x

Malaterre, C., Lareau, F., Pulizzotto, D., & St-Onge, J. (2021). Eight journals over eight decades: A computational topic-modeling approach to contemporary philosophy of science. *Synthese, 199*(1–2), 2883–2923. https://doi.org/10.1007/s11229-020-02915-6

McCain, K. W. (2024). Collaboration at the phylum level: Coauthorship and acknowledgment patterns in the world of the water bears (phylum Tardigrada). *Scientometrics, 129*(10), 6089–6125. https://doi.org/10.1007/s11192-024-05036-w

McLevey, J., Graham, A. V., McIlroy-Young, R., Browne, P., & Plaisance, K. S. (2018). Interdisciplinarity and insularity in the diffusion of knowledge: An analysis of disciplinary boundaries between philosophy of science and the sciences. *Scientometrics, 117*(1), 331–349. https://doi.org/10.1007/s11192-018-2866-8

Paul-Hus, A., Mongeon, P., Sainte-Marie, M., & Larivière, V. (2017). The sum of it all: Revealing collaboration patterns by combining authorship and acknowledgements. *Journal of Informetrics, 11*(1), 80–87. https://doi.org/10.1016/j.joi.2016.11.005

Petrovich, E. (2021). Acknowledgments. Informal collaboration and symbolic power in recent analytic philosophy. *Logique et Analyse, 256*, 425–448. https://doi.org/10.2143/LEA.256.0.3290352

Petrovich, E. (2022). Acknowledgments-based networks for mapping the social structure of research fields. A case study on recent analytic philosophy. *Synthese, 200*(3), 204. https://doi.org/10.1007/s11229-022-03515-2

Petrovich, E. (2024). *A Quantitative Portrait of Analytic Philosophy: Looking Through the Margins*. Springer International Publishing. https://doi.org/10.1007/978-3-031-53200-9

Petrovich, E., & Viola, M. (2024). Mapping the philosophy and neuroscience nexus through citation analysis. *European Journal for Philosophy of Science*, *14*(4), 60. https://doi.org/10.1007/s13194-024-00621-5

van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*(2), 523–538. https://doi.org/10.1007/s11192-009-0146-3