Divide et impera

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DIVIDE ET IMPERA: MODELING THE RELATIONSHIP BETWEEN CANONICAL AND NONCANONICAL AUTHORS IN THE EARLY MODERN NATURAL PHILOSOPHY NETWORK

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This article aims to study the relationship between today's canonical and noncanonical authors in the domain of early modern natural philosophy through the lens of social network analysis. By studying a massive corpus of letters (Electronic Enlightenment project), we examine the structural relationship between several of today's canonical authors in natural philosophy and noncanonical women philosophers operating in the same network. We demonstrate the structure of this network and its effects on noncanonical authors. By modeling the case of women philosophers, we show that our model can be used to identify further noncanonical authors who had similar profiles.

> Quantitative hermeneutics is the art of understanding conventions—forms, genres, styles, practices—better than their society ever did. (F. Moretti, *Patterns and Interpretation*, Stanford Literary Lab, pamphlet 15 [2017])

1. Canonical and Noncanonical Authors

Over the past few decades, the scholarly conversation in history of philosophy and science has witnessed a growing need for rethinking the methodological assumptions that underpin current scholarly practices in the field. A major point in this debate concerns the reappraisal of neglected figures who were previously considered only 'minor' authors and excluded from the canon of the discipline (Shapiro 2016; Beaney 2018). This move was propelled by the seminal work of several historians and philosophers who drew attention to the long-neglected role of women in the development of early modern philosophy and science (Waithe 1991; Atherton 1994; O'Neill 1998; Broad 2002; Rée 2002; Zinsser 2005; Duran 2006; Broad and Green 2009; Mercer 2017; Thomas 2018; Witt and Shapiro 2018). Today this point is sometimes generalized to include not only forgotten women but all unduly forgotten authors (Sgarbi 2013; Ariew 2014). As their colleagues in the field of literature have already realized (Moretti 2005, 2013; De Bolla 2013; Jockers 2013), today's historians of philosophy and science also are becoming increasingly aware that the academic practices in the field are most often built on an extremely selective reading of a few canonical authors and texts, beyond which lurks the immense ocean of the unread. Given this tendency, it is timely to seriously consider how current methods in the field of history of philosophy and science could integrate and benefit from quantitative approaches, which have already provided indispensable tools in other humanities fields to navigate the vast mass of historical materials.

This article aims to study the relationship between today's canonical and noncanonical authors in the domain of early modern natural philosophy through the lens of social network analysis. In very general terms, social network analysis aims to map and measure with mathematical tools the way in which social actors are connected in a certain scenario.[1] In this article, social actors are the authors that are today described as canonical or noncanonical in early modern philosophy and science. The scenario in which we try to map and study how they interacted with each other is a large repository of early modern epistolary correspondence between these authors and a number of other early modern authors. Our overall goal is to use social network analysis to investigate (i) to what extent these epistolary exchanges can confirm today's perception of canonical and noncanonical figures (e.g., the idea that current canonical authors must have somehow been

1. For a methodological reflection on the use of social network analysis in historical fields, see Lemercier (2015).

already relevant in their time) and (ii) what new aspects or facts a network analysis of this corpus can reveal that have not been appreciated thus far. In addressing these points, our study contributes to both historical and methodological discussions raised in current scholarship.

From a historical point of view, the article aims to identify and assess the profile of today's canonical and noncanonical authors within the context of an early modern network in which these authors operated. Existing scholarship tends to assess these authors mostly in a qualitative way, by discussing the philosophical relevance, originality, and cogency (inter alia) of their works. This is, of course, a crucially important task. However, various scholars, driven by distinct research interests and agendas, often reach very different conclusions.

Social network analysis provides a different perspective on the issue of canonicity by investigating how canonical and noncanonical authors were positioned relative to each other in the network in which they operated. Social network analysis does not necessarily provide a more objective perspective (since it is open to a number of biases, as we discuss below). However, it offers a perspective that is not necessarily rooted in any particular research agenda but that allows different researchers to test their own interpretative hypotheses against a shared scenario that can offer a common ground to build and compare multiple interpretations.

Existing scholarship on the status of the canon of early modern philosophy and science seems to have reached some consensus on at least two points. First, many noncanonical figures are highly original, relevant, and philosophically cogent thinkers. The label 'noncanonical' hence refers to something more than the mere fact of not being present in the established canon: a noncanonical author should find a place in the canon since her or his work is no less valuable or interesting than that of the canonical authors already included. The justification for the neglect of noncanonical authors is based on the assumption that their works can be ignored without losing anything particularly significant for our understanding of past debates and intellectual developments. The whole point of the reappraisal of noncanonical authors is that this assumption is wrong.

Second, as a consequence, today's historians have often focused on the role of generations of past historians who progressively built the canon inherited by contemporary scholars (O'Neill 1998; Rée 2002).[2] From this perspective, the neglect of noncanonical authors would be due to the philosophical and cultural

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2. Rogers (2010) helpfully stresses not only that the canon is more dynamic and subject to change than it might seem but also that relevant factors that shape it are connected with religious and national issues, both past and present.

interests and agendas of later generations.[3] Historiography (and the citation patterns that go with it) would work as a gatekeeper to determine who appears as a canonical author and therefore is remembered and who appears as a noncanonical figure and therefore is forgotten. This kind of explanation locates the reason for the progressive neglect of today's noncanonical authors in the generations of historians that came after them.

Our article suggests a different reason that could have contributed to the neglect of today's noncanonical authors and could have subsequently shaped the formation of the canon. This reason has to do with how today's canonical and noncanonical authors were structurally related to each other in the network in which they operated. We do not claim that later generations of historians did not play a role in the neglect of today's noncanonical authors. Our aim, however, is to draw attention to the reasons that were operative in the historical context itself in which those authors worked. We contend that these reasons created the appropriate circumstances for the neglect of today's noncanonical authors. In this way, we aim at adding one further layer of complexity to current discussions of canonicity.

From a methodological point of view, the article aims to present a feasible and potentially exportable way in which quantitative and qualitative approaches can be integrated and adapted to study different facets of early modern philosophy and science. Today almost no scholarship in this field attempts to use quantitative approaches (exceptions are Valleriani [2017] and Sangiacomo [2019]). Unlike a few decades ago, relevant corpora have become more available and ready for quantitative investigations. Within social network analysis, the subfield of historical network research is rapidly expanding (Jockers 2013; Burkhardt 2014; Ahnert and Ahnert 2015, 2019; van den Heuvel 2015; Ahnert 2016; Deicke 2017; van den Heuvel et al. 2017; van Vugt 2017; McShane 2018; Wurpts et al. 2018).[4] However, very little has been done to explore early modern philosophical and scientific networks in particular (see exceptions in Lux and Cook [1998], van den Heuvel et al. [2016], and Bourke [2017]).

This article aims to export and adapt some of the most consolidated methods in social network analysis to the particular setting and research questions that are relevant for the field of early modern philosophy and science. The article

3. Recent research suggests that long-term reputation building and 'scientific memory' were a very important and deliberate activity of early modern authors themselves. For a case study on this point, see Winnerling (2019). For more on Winnerling's current research on the structural conditions for the forgetting of knowledge and authors in early modern and contemporary culture, see "The Fading of Remembrance" at https://fading18-20.hypotheses.org/.

4. Extensive bibliographical resources on historical network research are available at http://historicalnetworkresearch.org/bibliography/.

is exploratory in character, since we cannot rely on already well-established practices, methods, or results. Part of the interest of our exploration derives from the attempt at understanding the main problems and limitations that emerge when using social network analysis as a tool to study early modern natural philosophy. However, our exploration should be relevant both to scholars in the field of early modern philosophy and science and to scholars working on social network analysis.

Scholars in early modern philosophy and science can benefit from reflecting on their object of study from a still-uncommon quantitative perspective. More specifically, social network analysis provides a precise way of operationalizing and quantitatively studying notions such as 'centrality' and 'relevance', which existing scholarship in history of philosophy and science has commonly used in a purely qualitative sense. Our goal is not to dismiss the qualitative use of these notions but rather to show that integrating it with quantitative considerations makes the historical reflection more complete and potentially reveals elements that would not be accessible to a purely qualitative analysis.

The same remark applies to the very notions of 'canonical' and 'noncanonical' authors. These are usually discussed by referring to the authors who, as a matter of fact, happen to be most often taught and debated by today's scholarship. However, it is relevant to investigate whether the current canonization reflects any peculiar feature of how the (future) canonical authors interacted with the (future) noncanonical authors at the time when they were active in the philosophical arena. The relationship between canonical and noncanonical authors is shaped by the structure of the network in which these authors were embedded. The nature of canonicity is thus well suited for social network analysis.

Scholars in social network analysis can benefit from our article by reflecting on the difficulties and challenges that the particular domain of early modern natural philosophy poses to the use and implementation of network analysis methods. We show that a good deal of fine-tuning is required in order to actually use them to study our particular corpus. Moreover, in order to distill an interpretative pattern from our data analysis, we design a model to capture the typical structural features of noncanonical authors in the network we study. By 'model', we understand a conceptual scheme that allows historians to operationalize research hypotheses and test them with quantitative means. In this sense, a model is both a descriptive and a heuristic device used to capture a certain feature observed in the data and support further exploration and interpretation of it. The use of the model approach in the field of history of philosophy and ideas has so far been limited to implementations in which the researcher designs the model before analyzing the data and then uses it as a heuristic tool to study a given corpus and investigate a given research question (De Jong and Betti 2010; Betti and van den Berg 2014, 2016; Betti et al. 2019; Sangiacomo

2019). In this article, we experiment with the opposite approach by distilling from the structural aspects revealed by network analysis those features that seem more promising in profiling different kinds of authors and pointing to a general pattern or trend at work in the network itself.[5]

We develop this model by starting from the case study of women philosophers and scientists in our corpus. In existing scholarship all the women philosophers we study feature among today's noncanonical authors. We use our model to identify other authors in the same network who were in a position similar to that of these women philosophers. In doing so, we do not assume that women philosophers provide a standard profile for noncanonical authors in general.[6] Rather, we presuppose (using existing scholarship) that women philosophers provide an instance of noncanonical authors, and we use their profile to identify whether there are other noncanonical authors in our corpus who have a profile similar to that of women philosophers. In developing our model, our goal is not to offer an a priori exhaustive classification of all potential profiles for noncanonical authors. Rather, we aim at exploring the heuristic potential of the results achieved by existing scholarship about women philosophers in order to investigate how far that profile can be used to uncover further noncanonical authors who have been unduly neglected.

In turn, our model provides further quantitative corroboration for the claim advanced by existent scholarship that women philosophers indeed provide one relevant profile of noncanonical authors. If there were nothing special about women philosophers, we should expect that the model would identify a very large number of other authors in our corpus who had similar profiles. This is not what happens, and our model actually identifies only 25 authors (out of 163) who occupied a position similar to that of women philosophers in the same network. This means that the case of women philosophers applies to some authors, but it definitely does not reflect the majority of them. We interpret this remark as pointing to the existence of a precise form of asymmetry in the position that women philosophers (and other similar authors) occupy in their network and that is embedded in the structure of the network itself. This asymmetry is precisely what makes the case of women philosophers and similar authors a relevant instance for investigating the nature of noncanonicity in early modern natural philosophy.

We proceed as follows. In section 2 we describe the corpus on which we based our study. We draw attention to the corpus composition, its representativeness,

5. For an example of how network analysis can be used to profile different kinds of authors and their role in a historical network, see Ahnert and Ahnert (2019).

6. This assessment would represent a more ambitious goal that falls outside of the limited scope of this article. See further discussion in sec. 4.

and potential biases. We then introduce some basic concepts from social network analysis that we used to study our corpus. We explain how we interpreted them in order to take into account the needs of our research questions and the limits of our corpus. In section 3 we present the results obtained by analyzing the corpus and introduce the model we derived from this analysis. In section 4 we conclude by drawing attention to the implications and limitations of our results and future perspectives for this line of research.

2. Corpus and Methods

2.1. Natural Philosophy in the Electronic Enlightenment Corpus

Our corpus is distilled from the Electronic Enlightenment (EE) project hosted by the Bodleian Library in Oxford.[7] At the time we began this study (December 2017), the EE corpus included 77,629 letters from 10,181 individuals in 11 languages written between the late sixteenth and mid-nineteenth centuries. The EE corpus included 300,000 scholarly annotations on the letters; it also contained 1,729 hot links from authors included in the corpus to the *Oxford Dictionary of National Bibliographies*.

   A disclaimer about how we interpret the EE corpus is in order to avoid misunderstandings about our research. We do not take the EE corpus as a representative sample of the historical early modern Republic of Letters.[8] Given what we know about the actual size of the Republic of Letters, a reasonably complete corpus should include between 20 and 50 times more letters than the EE corpus for the same number of individuals. In dealing with historical materials, it is important to realize that the loss or unavailability of sources is likely an unsolvable problem. Aiming at compiling representative (even if not complete) corpora is surely a crucial goal for quantitative research. However, since this is not the goal of this study, we take a different approach by changing the way in which we interpret the EE corpus.

   The composition of the EE corpus is clearly shaped by the availability of certain epistolary exchanges and by a certain focus on standard canonical figures (e.g., Locke, Boyle, Voltaire, Rousseau). In this sense, we understand the EE

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7. Although EE is updated annually, the corpus has not been further updated during the project itself.

8. The notion of the 'Republic of Letters' usually designates the community of intellectuals who exchanged and shared knowledge and information during the early modern period. The size of this community and the materials produced by it are extremely massive (van Miert 2016). These exchanges are most often embedded in epistolary exchanges, but they include a variety of other items (drawings, books, and so on). For the purposes of our study, we do not aim to enter into the debate about how best to define the 'Republic of Letters' as such. On some of these aspects, see Grafton (2009), van den Heuvel (2015), van den Heuvel et al. (2017), and van Vugt (2017).

corpus as a product of today's scholarship in its attempt to reconstruct a certain perspective on those early modern epistolary exchanges in which today's canonical figures feature prominently. This remark may raise several problems in case one wants to straightforwardly use the EE corpus as the domain for statistical investigations on the Republic of Letters as such.

However, our aim is to study how the relationship between today's canonical and noncanonical figures is rooted in the structural features of the network in which these figures operated at their respective times. In order for this research to succeed, we do not need to have access to a fully representative and complete corpus. It is sufficient to have access to a corpus that is good enough to study how canonical and noncanonical figures discussed by today's scholarship were related in the context of an early modern network. For this more limited purpose, the EE corpus is a valuable resource because it is built by taking into account the current canon and thus includes a number of today's canonical figures and their correspondents. We comment further on the implications of this approach for the interpretation of our results in our concluding remarks in section 4.

The integration of digitized materials and annotated information shows that the EE corpus is not a purely quantitative data set but already includes qualitative aspects, which makes it comparable to a piece of secondary scholarship. The most relevant consequence of this feature of the EE corpus for our investigation is that we could select a subset of authors from the whole EE corpus based not only on the metadata associated with the letters (names, year, and language) but also on the tags attached to the authors (derived from the available biographical information).[9] While this information can surely be improved and enriched, this article simply relied on the tag system already available in the EE corpus at the time of our research. We trust the EE tag system in the same way in which scholars would trust the information contained in secondary literature sources, such as biobibliographic dictionaries. Since this initial decision does not create contradictory or meaningless results, we make the working assumption that the EE tag system is relatively reliable for the purposes of the present research.

The first step in our project has been to select a relevant subset of the EE corpus that can be taken to be representative for the study of canonicity in early modern natural philosophy. Of course, the actual early modern natural philosophy network is not limited to correspondence but also includes various types

9. Annotations are created by the editors of the source text for the EE version of each letter. The information about authors included in the corpus is provided as part of the editorial process. Some information is contributed by the letter editor, while all information is overseen by the EE project itself. All annotations and biographical notes are 'signed' or attributed to an academic involved in the process. This information usually includes adjectives or tags that specify the main activities, professions, and profiles of the authors of the letters.

of publications and other exchanges among authors, groups, and institutions. Nonetheless, it is reasonable to assume that it should be possible to select within the existent EE corpus a subset of EE such that it may be considered as sufficiently representative of the 'EE natural philosophy network' (i.e., the network among authors involved with natural philosophy and included in the EE corpus) and thus be helpful to study the relationship between today's canonical and noncanonical authors. From now on, whenever we refer to the 'natural philosophy network', we understand this expression as implicitly referring to the EE natural philosophy network.

In order to determine the natural philosophy network, we used three main criteria: (*a*) initial selection based on the authors' profile, (*b*) further refinement based on the role of the authors within the epistolary network, and (*c*), based on existing scholarship, qualitative assessment and fine-tuning of the outputs of criteria *a* and *b*.[10]

We implemented criterion *a* by using the tag system that comes with the EE corpus. In the corpus each author is qualified by several tags that specify the profession and interests of the author. The tags used in the EE corpus provide information about the broader spectrum of activities and interests of different authors. To implement criterion *a*, we selected all the authors identified in the EE corpus with any of the three tags 'philosopher', 'scientist', or 'physician', as well as all the authors with whom these tagged authors were in touch.[11] We selected these tags because the description 'natural philosopher' was not available, but in actual practice its meaning overlaps to some extent with the three tags we selected. We then used the tag 'natural philosopher' for all the authors identified in the EE corpus with one of the three EE tags mentioned. We do not intend the tag 'natural philosopher' in a rigid way but rather as an inclusive expression to

10. Since the network is built on the basis of correspondences, we take into account the direction of these correspondences; i.e., our network is a directed network.

11. From a technical point of view, we implemented the following procedure: (i) we prepared a list of tags, (ii) all authors who had at least one of these tags were saved as nodes of the network in the authors database, (iii) all letters addressed to or received from these authors were saved as ties of the networks in the letters database, and (iv) senders or recipients of letters included at step iii but not initially selected at step ii were added to the authors database. This procedure led to an initial network of 4,034 authors and 41,001 letters. The procedure described in the text of the article is meant to narrow down and refine this initial selection. In the process of developing this study, we also experimented with a richer list of tags (academic, academician, anatomist, astronomer, botanist, geologist, intellectual, mathematician, ornithologist, paleontologist, philologist, philosopher, physician, physicist, salon hostess, scholar, scientist, surgeon, zoologist), which resulted in 5,342 authors and 56,164 letters. We decided that this larger selection was too broad and not significantly more accurate, given the scope of this article. The larger selection included the same canonical authors who were already included in the smaller selection. Since our procedure picks out authors connected with each other, this means that all the noncanonical authors associated with these canonical authors were already included in the smaller selection. In turn, the smaller selection is more tractable from a technical point of view. Hence, for the purposes of this study, we relied on it.

point to any author with interests in the broad domain of philosophy or (inclusive) science. This usage reflects the early modern understanding of natural philosophy and the lack (at that time) of any rigid division between philosophy and natural science.

In this research we did not focus on the content of the letters exchanged between the authors selected. It may thus be objected that if these exchanges do not concern natural philosophy in some relevant way, then their authors should not be counted as 'natural philosophers' or as authors belonging to the natural philosophy network. We resist this objection because it is unduly restrictive. Correspondence about natural philosophy is an explicit way of identifying natural philosophers who were active in the network. However, correspondence among early modern authors often covered a wide range of topics, and not all correspondence was preserved or is available. The fact that the content of an epistolary exchange among natural philosophers may not be about natural philosophy itself does not entail that the authors are less relevant for reconstructing the natural philosophy network.[12]

Once we selected all the authors who qualify as 'natural philosophers' and their correspondents, we implemented criterion *b* by determining how the authors directly identified as natural philosophers were actually connected in the corpus. In particular, we distinguished (i) natural philosophers corresponding with other natural philosophers from (ii) natural philosophers corresponding with any other kind of author within the EE corpus.

We assumed that when a natural philosopher corresponds with another natural philosopher, this exchange happens within the domain of natural philosophy since both authors belong to the same group (this assumption should be understood from a social network point of view, even if the exchange as such is not about natural philosophy from a semantic point of view). In contrast, when a natural philosopher corresponds with an author who is not a natural philosopher, this exchange happens across the domain of natural philosophy, since only one author involved in the exchange properly belongs to the domain of natural philosophy (this holds true from a social network point of view even if the exchange might be about natural philosophy from a semantic point of view). Using this distinction, we defined the network of natural philosophers corresponding with other natural philosophers as a 'strict network'. Also, we defined as

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12. Of course, authors not tagged as 'natural philosophers' may also exchange letters on topics relevant for natural philosophy. However, the goal of our study is not to investigate how natural philosophy was debated in the EE corpus as a whole but rather to study how today's canonical and noncanonical authors in natural philosophy interacted in the EE network. For this purpose, it is sufficient to pick a relevant selection of the EE authors who are identifiable as natural philosophers and reconstruct their epistolary networks.

a 'loose network' the strict network of natural philosophers extended to include all the other authors with whom authors in the strict network corresponded (including all those authors who did not have any tag in the EE corpus and were selected because they had a correspondence with authors tagged as natural philosophers).

Given these definitions of strict and loose networks, not all authors tagged as 'natural philosophers' are necessarily members of the strict network and thus also of the loose network. If an author tagged as a natural philosopher does not correspond with any other natural philosopher, then that author is not included in the strict network and thus is also not in the loose network (which includes only the natural philosophers who are already part of the strict network).[13] In this way, we excluded from the focus of our study those authors who may have been included only on the basis of tags provided in the EE corpus (criterion *a*) but for whom there is no evidence in the EE corpus that they were directly in touch with other natural philosophers and thus participated in the dynamics of the natural philosophy (strict) network (criterion *b*).

Belonging to a network requires some kind of active involvement on the part of the authors included. If an author is only tagged as a natural philosopher but does not play an active part by directly interacting with the rest of the network, then the author does not properly belong to that network. Figure 1 provides a visual representation of how these networks relate to one another.

This approach somehow compensated for the very inclusive implementation of criterion *a* based on the EE tag system. Table 1 shows the composition of the strict and loose networks from the point of view of the EE tag system. Once we defined strict and loose networks, we implemented criterion *c* by analyzing the loose network in order to search for canonical and noncanonical authors currently discussed in the secondary literature on early modern natural philosophy but not included in the strict network. We also checked whether any of the authors discussed by today's scholarship were originally included in the whole EE but ended up being excluded from the strict network.[14] We detected that this

13. We are aware that this approach introduces a shortest-path criterion on authors tagged as natural philosophers, which may look too rigid since it excludes from the strict network authors who were indirectly in touch with natural philosophers. For further research, it would surely be interesting to consider indirect connections as well. For this study, however, our focus is on the direct relationship between canonical and noncanonical authors, and thus we accept the shortest-path criterion.

14. In order to get access to lists of early modern natural philosophers, we used the dictionaries of seventeenth- and eighteenth-century philosophers that are available for British, Dutch, German, and French philosophers (Yolton et al. 1999; Pyle 2000; van Bunge et al. 2003; Klemme and Kuehn 2011; Foisneau 2015). We integrated these lists with the current wider database of early modern natural philosophers that is under construction within the ERC Starting Grant project "The Normalisation of Natural Philosophy." One might still wonder whether using the dictionaries would introduce further biases into our study. However, this objection is quite speculative since it equates to saying that relying on the secondary literature in a traditional journal article might introduce biases.
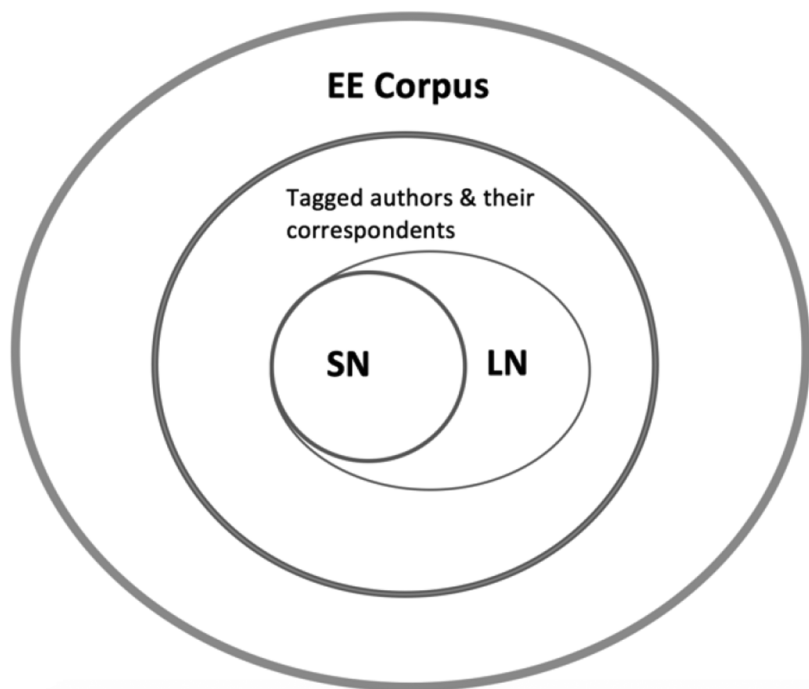
Figure 1. Groups of authors within the EE corpus. Color version available as an online enhancement.

omission happened in the case of five authors: Laura Bassi (included in the loose but not the strict network), Christiaan Huygens (included in the loose but not the strict network), Batshua Makin (included in the loose but not the strict network), Marin Mersenne (omitted because he lacks an EE tag), and Henry Oldenburg

Table 1. Number of Authors in Strict and Loose Networks

Electronic Enlightenment Profession Tags	Authors in Strict Network	Authors in Loose Network
Philosopher	58	81
Scientist	51	86
Physician	163	284
Any other profession tags (including 'unknown')	9	1,282
Authors without tags	0	2,020

(omitted because he lacks an EE tag). We thus manually integrated these authors and their correspondence into the strict network.[15]

After identifying strict and loose networks, we identified two main chronological segments. We created this chronological segmentation by disentangling the two fully connected network components that emerged from our initial reconstruction of the whole strict network. These two fully connected components appeared as relatively independent large continents, with no ties linking them. We observed that the relative independence of these two subnetworks mirrors the fact that most of their authors were operating in either the seventeenth or the eighteenth century. Hence, we loosely refer to these network components as the 'seventeenth-century network' and 'eighteenth-century network'. Table 2 summarizes the relevant figures for the strict and loose networks.

As mentioned at the beginning of this section, the EE corpus is incomplete and biased to some extent. This incompleteness and these biases affect the networks we studied. The incompleteness concerns both authors who are not included in the corpus and the letters of authors who are included but whose correspondence is only partially present in the EE corpus. For instance, with respect to the focus of our study, the corpus does not include Anne Conway (1631–79), who was a relevant early modern philosophical voice and who corresponded with Cambridge Platonist Henry More (1614–87).[16] We also observed that a canonical figure like Descartes has a relatively minor position in the EE corpus, arguably owing to a significant lacuna in the amount of Descartes's correspondence that is included in the corpus (more on Descartes in sec. 3). Further biases concern the fact that the EE corpus contains mostly English (for the seventeenth century) and French (for the eighteenth century) sources, and the most massive and complete data concern the canonical figures of the period (e.g., Boyle, Locke, Voltaire, Rousseau).

In order to address the limitations and potential biases of the EE corpus, it is crucial to keep in mind that our goal in this article is to study the relationship between today's canonical and noncanonical authors. This goal requires that the corpus includes at least some relevant samples of both kinds of authors. The EE corpus does include a good number of canonical philosophers (Descartes, Hobbes, Locke, Boyle, Newton, Voltaire, and Rousseau, among others). Moreover, it includes an even larger array of noncanonical figures (including most of the women philosophers discussed in today's scholarship). The EE corpus would be unusable for our research if and only if these two groups of authors would turn out to be

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15. When we compared the centrality results calculated before and after integrating these authors into the strict network, we did not notice significant differences.

16. At the time we completed this study, the Early Modern Letters Online (EMLO) database (http://emlo.bodleian.ox.ac.uk/) showed 219 entries related to Conway.

Table 2. Number of Female Authors and Their Letters

	Authors	Letters	Female Authors	Letters by Female Authors
Strict network—seventeenth century	163	1,541	6	67
Loose network—seventeenth century	843	6,681	42	260
Strict network—eighteenth century	118	1,353	2	105
Loose network—eighteenth century	2,910	31,426	228	1,444
Initial Electronic Enlightenment corpus subset (criterion *a*)	4,034	41,001	278	1,876

entirely disconnected and thus not to form a network at all. This is not the case, as we show in the rest of our discussion.

Nonetheless, in designing our study, we took the following measures to address the biases of the EE corpus. Concerning the incompleteness of the correspondence included in EE, we decided to focus only on the ties between the authors attested by the correspondence and to disregard the actual number of letters exchanged between them (i.e., the weight of these ties). Although this further aspect may be interesting for future studies, we decided that the incompleteness that affects the EE corpus could easily produce distortions in our results.[17]

Concerning the national bias, we concluded that this is not particularly relevant for our current study. Early modern women natural philosophers discussed in existing scholarship mostly belong to the British and French context (e.g., Broad 2002; Thomas 2018). From this point of view, we understand our study as an attempt to tackle the role of some of the same women natural philosophers discussed by existing scholarship. For this purpose, the EE corpus offers an acceptable (although not ideal) source.

Finally, as we document throughout our discussion, we attempted to double-check the most important results obtained from our analysis of the EE corpus by taking into account other available corpora—EMLO (Uchacz 2019) and ePistolarium (Ravenek et al. 2017; van den Heuvel 2019) in particular—in order to verify that these other corpora do not disprove (at least) the conclusions we reach on the basis of our analysis of the EE corpus.

17. As explained below, centrality measures can be calculated by taking into account the 'weight' of the ties between authors (e.g., the number of letters exchanged between two authors). However, knowing since the beginning that these numbers are not genuinely representative of the strength of the connection between authors, we decided not to consider them in our calculations, since we can already tell that they would distort our results given the gaps we noticed in the EE corpus.

2.2.   Canonicity, Centrality Measures, and the Potential
for Interaction

Social network analysis is a well-established field that has been widely used to study how today's scientific communities behave (Latour 1987; Roth and Cointet 2009, 2010). A few studies have been done on historical scientific communities and on early modern literary networks (Gingras 2010; Valleriani 2017). So far, only one study has focused on the role of women in an early modern network associated with prominent natural philosophers (Bourke 2017). Our study uses well-tested approaches and tools that have proved to be successful in previous research on the specific object of investigation of early modern natural philosophy.

In particular, we use social network analysis as a means of operationalizing and quantifying the hermeneutic concept of 'centrality', which has been often used in more qualitative studies on early modern networks (Pal 2012). Nonetheless, by adapting social network analysis to our specific research setting and questions, we introduce at least one new notion ('centrality legacy') that we did not encounter in previous studies. Before getting into the details of our analysis, it is worth providing some basic definitions of the main centrality measures that we examine and our rationale for choosing them.

In traditional historical qualitative research, the term 'centrality' and its cognates are used to emphasize the important role that a figure (or a group of figures) plays in a certain scenario. Centrality is a multifaceted concept. Centrality can refer to the importance of the conceptual contents discussed by some author that then become widespread topics of discussion among other authors. Centrality can also refer to the mediating or propelling role that some figures play in fostering and supporting a historical network of authors.

In social network analysis, networks are defined as mathematical objects composed by nodes connected by ties. In our case, nodes are the authors included in our corpus, and the ties are their epistolary exchanges. Centrality is a property of nodes dependent on their structural position in the network. A variety of different centrality measures can be calculated for each network. Our aim is to use centrality measures to investigate the relationship between canonical and non-canonical authors in the context in which they operated. In current scholarship, canonical authors are usually taken to be somehow 'representative' of crucial historical trends of the period to which they belong. This (qualitative) idea of representativeness encapsulates at least the three following features of a canonical author: (*a*) the author is sufficiently well rooted in her or his historical context to express some of the crucial topics and interests discussed by her or his peers, arguably in a particularly cogent, interesting, and influential way; (*b*) the author is capable of influencing the debate in which the canonical author takes part; and

(*c*) the author is directly in touch or closely connected with other central figures of the period.[18] We attempt to operationalize these three features of canonicity by focusing on the following three kinds of centrality measures:[19]

> *Betweenness centrality*: This measure captures how often a certain node is 'in between' the shortest path between any two other nodes in the network. A node with high betweenness centrality is a node that acts as a connector between other nodes and may be the only tie between them. Nodes with high betweenness centrality are particularly important since they work as the cement within the network and keep the other nodes in touch with one another (Newman 2010, 185–93). Figure 2 illustrates betweenness centrality in the seventeenth-century loose network.
>
> *Eigenvector centrality*: This measure captures how important the other nodes with which one particular node is connected are. A node with high eigenvector centrality is connected with other nodes that have high eigenvector centrality. While the node itself may not be highly central according to other parameters, it is still a very relevant node from the point of view of eigenvector centrality because, in virtue of its connection, that node is capable of influencing those nodes that are most important in the network (Newman 2010, 169–72). Figure 3 illustrates eigenvector centrality in the seventeenth-century loose network.
>
> *Closeness centrality*: This measure captures the degree to which a node is near all other nodes in a network. Closeness centrality is the inverse of the sum of the shortest distances between each node and every other node in the network. Nodes with high closeness centrality are located at the heart of the network and are proximate to most of the other nodes. Nodes with low closeness centrality are far from most of the other nodes, like leaves at the end of a branch (Newman 2010, 181–85).[20] Figure 4 illustrates closeness centrality in the seventeenth-century loose network.

18. This qualitative notion of representativeness does not entail that a canonical author herself or himself ought to be in touch with most of the other authors in the network (a feature that would be captured by degree centrality). For instance, a canonical figure like Spinoza surely had far fewer ties than a noncanonical figure like Henry Oldenburg (the first secretary of the Royal Society), as even a cursory survey of the amount of their respective correspondence can show. In this study we assume, then, that what is captured by degree centrality does not play a prominent role in the qualitative notion of representativeness that we analyze.

19. All centrality measures and network visualizations included in this article are generated using Gephi (https://gephi.org/).

20. Closeness centrality may run into problems in the case of disconnected networks in which some nodes are not connected to any other node. However, in the strict network, there are no disconnected nodes since all nodes are part of a correspondence with at least one other node.
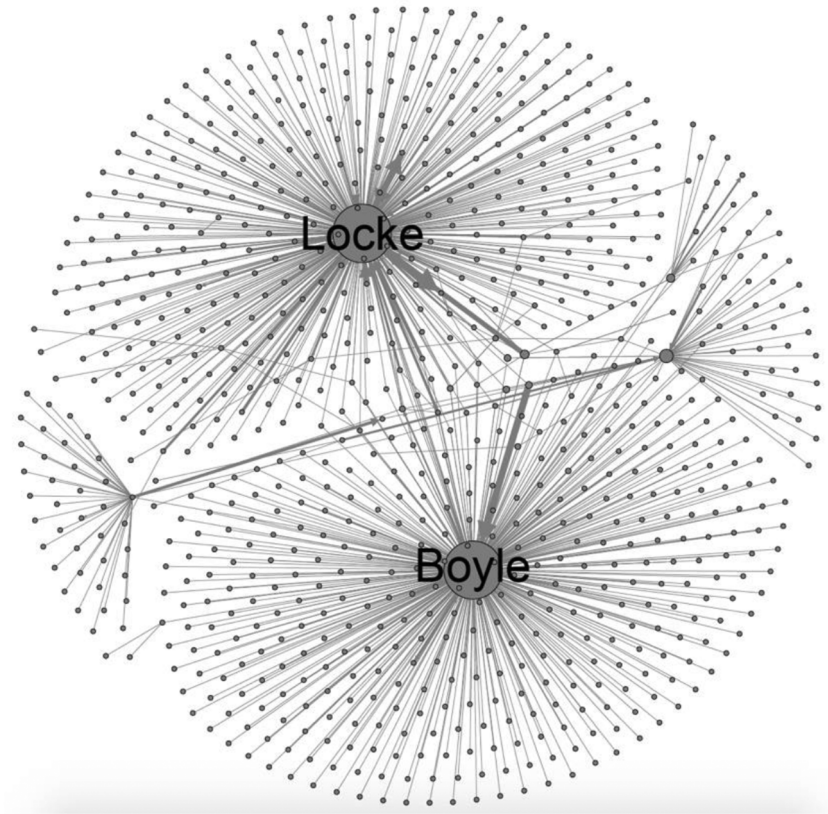
Figure 2. Betweenness centrality in seventeenth-century loose network

Our assumption that these three centrality measures capture some relevant features of today's canonical authors is confirmed (as further discussed in sec. 3) by the fact that today's canonical authors are also those who score higher on these centrality measures, while today's noncanonical authors do not.

These centrality measures offer a first indicator of how canonical and non-canonical authors are related in our corpus. However, this indicator needs interpretation. It would be misleading to assume that these centrality measures directly represent the actual historical relationships that these authors entertained (or not) during their time. Their actual historical relationships might well have been developed outside epistolary correspondence, by direct acquaintance and social frequentation, in correspondence that we do not have access to, or by other means. Nonetheless, our corpus does provide us with some information about who was in touch with whom and how the overall network of these (surviving and accessible) epistolary exchanges worked. In order to capitalize on
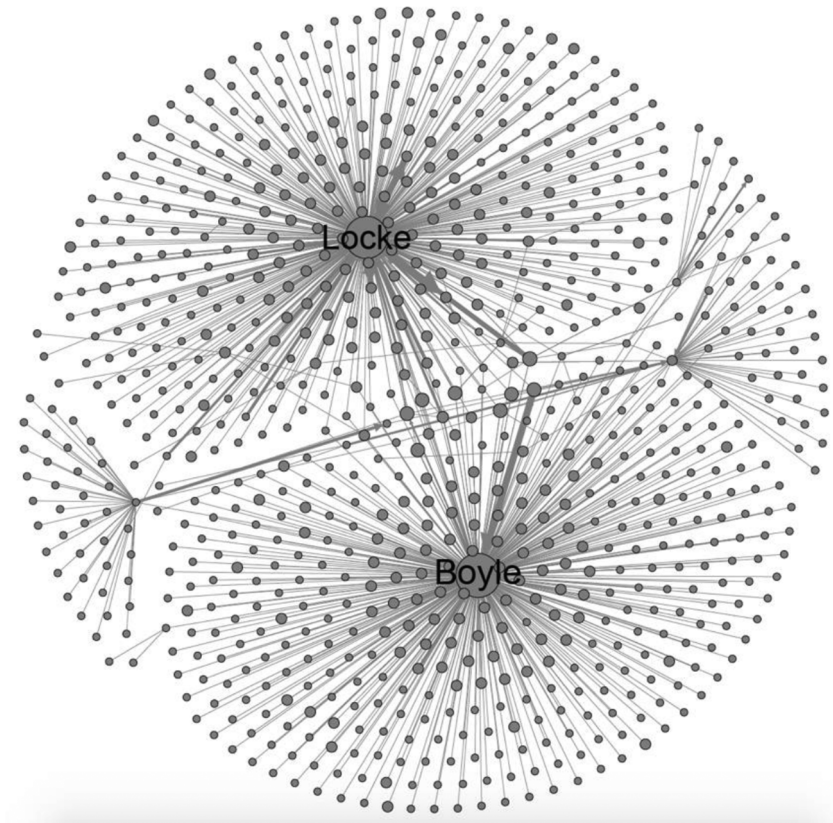
Figure 3. Eigenvector centrality in seventeenth-century loose network

the heuristic power of the connections we have access to, we implement a helpful distinction between actual interactions among authors and the potential for interaction among them, introduced in existing network literature.[21]

In our case, actual interactions are represented by the direct engagement that two authors have in the network through surviving epistolary exchanges included in our corpus. For instance, since Robert Boyle and John Locke exchanged letters with each other, we say that they had an actual interaction at that time. The potential for interaction, however, is subtler and more difficult to trace. This potential for interaction is the possibility that authors belonging to the same network could have developed actual interactions even if our network does not witness

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21. See discussion in Lemercier (2015). See also Borgatti et al. (2013, 164): "It is important to realize that the centralities are not definitions of built-in properties but rather hypotheses about the potential consequences of centrality, either for the actor or the network in which they are embedded."
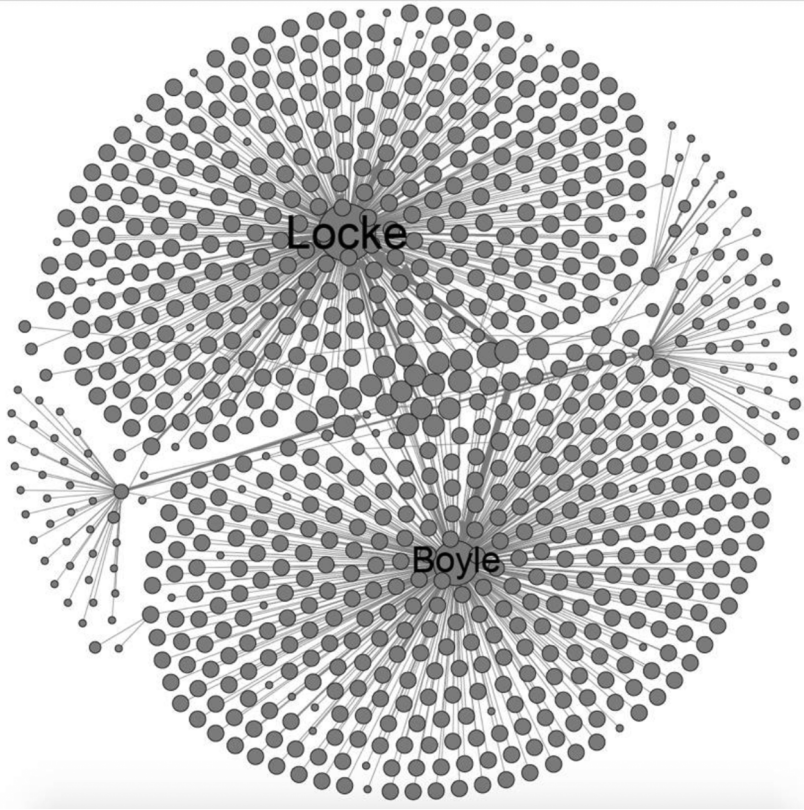
Figure 4. Closeness centrality in seventeenth-century loose network

any actual interaction via epistolary exchanges among them. In the case of potential for interaction, we understand 'interaction' in a much broader sense than epistolary exchanges (which are just one way of interacting).[22] In their historical contexts, authors could have interacted by discussing ideas, even by just mentioning the name of another, or by hearing about an author's reputation or thought, either through written sources or in social contexts. Although a network does not provide direct information about all these kinds of interactions, the actual interactions among the authors in the network can give an indirect indication of their broader potential for interaction. By focusing on the potential for

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22. It must be stressed that although we look at letters (because this is the corpus we have access to), we are not interested here in reconstructing the dynamics of epistolary exchanges as such. Letters are just the means we use to investigate the potential for interaction that authors had in their context. Since interaction can take multiple forms, it is vital not to restrict its meaning to the possibility of actual epistolary exchanges.

interaction, it is possible to read a network as a representation of not only what actually happened but also what could have been possible among the same authors (given what actually happened in the network we can reconstruct).[23]

A network can be used to investigate the potential for interaction only if it provides the ground for that interaction to be possible in the first place. This possibility, in turn, has to be interpreted in terms of network properties. If two authors belong to mutually disconnected networks, these networks cannot be used to prove that those authors had a potential for interaction since (by definition) authors belonging to different and mutually disconnected networks do not appear to be in touch with one another in any way. This means that the potential for interaction in any given network can be assessed only if that network is fully connected, namely, only if it is a network in which all authors are more or less directly connected with all the other authors.

In a fully connected network, it is possible to hypothesize that a certain author could have interacted with another, even if there is no direct tie between the two attested in the network itself. Centrality measures of a fully connected network can be interpreted as a way of discerning which authors have the greater potential for interaction in the network, namely, the authors who are in the best position to interact with any other author in the network. More precisely, we interpret centrality measures as an indicator of the 'power' that an author has of actualizing his or her potential for interaction within a network.[24]

Applied to our study of canonical and noncanonical authors, this entails that canonical authors with high centrality scores have a greater power of actualizing their potential for interaction with the other authors in the network. We interpret this feature as the capacity of central authors in the network to reach out (or be reached) and broadcast more widely their thoughts, their ideas, or just their presence within the whole network. Conversely, noncanonical authors with relatively small centrality have a reduced power of actualizing their potential for

23. See Ahnert (2016, 140): "We need to apply caution when collecting and analysing network data, understanding what is not there as much as what is. We cannot assume that letter data unproblematically records early modern social networks: it tells us primarily about long-range links between literate people. This is valuable for understanding how news might have travelled long distances, but it is less good at telling us how information got into the hands of a royal agent, or military leader, in the first place."

24. In our discussion we use the term 'power' to indicate the ability of an author to actualize her or his potential for interaction. The terminological distinction between 'potential for interaction' and 'actual interaction' plays with the traditional distinction (traceable back to the Aristotelian vocabulary) between potency and actuality. Given this traditional terminological background, one would expect that something is needed within the agent in order to actualize a potency, and this 'something' is traditionally expressed in terms of 'power'. Thus, by adopting this terminology, we do not imply that this power must necessarily be understood as a political, social, or cultural power, although the power of actualizing the potential for interaction might have political, social, or cultural dimensions (concerning why certain authors have such a power or a greater power than others).

interaction with other authors. This means that it would have been relatively more difficult for noncanonical authors to reach out to (or be reached by) other authors in the same network. As demonstrated in section 3, all the noncanonical authors we study were directly in touch with canonical authors. We also expect that canonical authors have high centrality scores, while noncanonical authors have relatively low centrality scores. In our interpretation of centrality, this entails that canonical authors have a greater power of actualizing their potential for interaction than noncanonical authors.

Using these preliminary considerations, we proceed to investigate how the structure of the network affected the centrality of noncanonical authors and how it determined their lower power of actualizing their potential for interaction.[25] Our hypothesis is that noncanonicity can be positively correlated with low centrality values, interpreted as an author's reduced power of actualizing her or his potential for interaction. Since centrality measures depend on the structure of the network itself, it can be argued that this structure plays a crucial role in determining the authors' centrality and hence their power of actualizing their potential for interaction. In short, our general working hypothesis is that noncanonicity can be positively correlated with the structural features of the network in which noncanonical authors worked.

To test this hypothesis, we decided to assess centrality measures from the point of view of two different (albeit related) fully connected networks in which both canonical and noncanonical authors were embedded. The broadest fully connected network is the strict network of early modern natural philosophers (distinguished only in seventeenth- and eighteenth-century components). This broader perspective provided by the strict network is helpfully compared with a narrower perspective provided by the lifetime network of a given author. A lifetime network for author X includes all the other authors in the same strict network who were active (i.e., exchanging letters) between the birth and death of author X.[26] The resulting lifetime network is thus a subset of the strict network, and it is again a fully connected component. This lifetime network gives a picture of the potential for interaction of a given author, restricted to the other authors who were actually alive and active at the same time.

25. By 'structure of the network', we mean all those features that affect the way in which authors are related and information can flow in the network. This entails, e.g., 'full connectedness' (the fact that there are no authors isolated from others within the same network) and the hierarchy of the network (the fact that some authors are markedly more central than others from the point of view of several different centrality measures). Borgatti (2005) suggests that the kind of flow in the network has an impact on whether different centrality measures are more or less capable of making meaningful predictions.

26. The lifetime network for author X is not an 'ego-network' since it does not include only those authors who were directly exchanging letters with author X.

In order to further justify this choice, let us quickly restate the theoretical point about how centrality can be interpreted to study canonicity. Our hypothesis is that canonicity is correlated with certain authors' greater power of actualizing their potential for interaction with other authors. Interactions can take the form of direct exchanges, but in the long run (i.e., after the death of an author), they inevitably take the form of more indirect interactions (e.g., a mention or discussion of an author's ideas). Interestingly, canonicity can work retroactively by making an author of the past look, in the eyes of later generations, much more relevant or important (i.e., central) than the author actually might have been during her or his own time. Hence, canonicity can be studied by comparing the centrality measures of different authors from different perspectives, which should include at least two viewpoints: (i) a broader picture that gives access to the broadest possible scenario to assess the potential for interaction of a set of authors and (ii) a narrower picture that gives access to the potential for interaction that an author had in his or her own time. Our study takes these two viewpoints into account by considering centrality measures of the same author both (i) with respect to the strict network and (ii) with respect to the author's lifetime network.[27]

Our hypothesis is that canonical authors' potential for interaction had a direct impact on their becoming canonical authors. Hence, we expect that the centrality of canonical authors will remain relatively unchanged between the lifetime and the strict network because their potential for interaction was greater. We call this relative stability of centrality measures for canonical authors 'centrality legacy'. In turn, our hypothesis entails that the centrality of noncanonical authors will decline when moving from the lifetime network to the strict network, suggesting that their potential for interaction declined as well.[28] Noncanonical authors had a limited potential for interaction within the narrower network of authors with whom they could have been interacting during their lifetime. This potential can only further decline when we assess their centrality in a broader picture. Hence, our hypothesis is that noncanonical authors do not have centrality legacy.

27. We leave aside the loose network because we aim to study the nature of canonicity and noncanonicity within the domain of natural philosophy, rather than across it. Given our definitions of loose and strict networks, provided in sec. 2.1, the strict network is thus more relevant for our study.

28. Since all noncanonical authors we focus on are actually interacting with canonical authors, this interaction is preserved when moving from the lifetime to the strict network. Hence, when we observe that the centrality of noncanonical authors tends to be smaller when moving from the lifetime to the strict network, this cannot be due to the fact that in the strict network noncanonical authors lose their ties with canonical authors.

Before we move forward, it is important to stress that our discussion does not take into account the problem of the chronological development of the actual correspondence. Given the interpretation of centrality measures we have offered so far, in this study we do not take centrality measures to reflect the relevance of authors within the historical dynamics of epistolary exchanges as such. Rather, we take the surviving epistolary exchanges we have access to as a means of studying the potential for interaction of canonical and noncanonical authors. Also, the criterion we use to discern and compare the strict and lifetime networks is full connectedness (which is a structural feature of the network) rather than any more specific or arbitrary time window, because we are interested in observing how the potential for interaction of canonical and noncanonical authors changed (or not) when assessed from different perspectives.

3.   Results and Model

3.1.   Women in the Early Modern Natural Philosophy Network

Today's reappraisal of neglected figures does not entail that all historical authors were necessarily equally relevant or philosophically interesting. Some relevant canonical figures are present in the strict network (e.g., Descartes, Boyle, Locke, Newton, Rousseau, Voltaire), surrounded by a large majority of today's mostly forgotten authors. In order to select the noncanonical figures relevant for our study, we started by focusing on those women philosophers who have been discussed in recent scholarship as an example of relevant and unduly forgotten noncanonical authors. We note that most of them also feature in the strict network. We then created a model to capture the distinguishing features of the position that these women philosophers had in the strict network and used this model to further investigate which other authors may have occupied a similar position in the same network. As mentioned in the introduction, our goal is not to generalize the case of women philosophers to all noncanonical authors but rather to explore the heuristic potential of their profiles to uncover further noncanonical figures who could be equally relevant. In presenting our data, we first discuss the case of women philosophers and then that of other, similar authors.

Before analyzing the role of women in the strict network, it is worth presenting how women feature in our broader subset of the EE corpus (criterion *a*). Table 3 summarizes the main data, which show that our initial selection from the EE corpus (criterion *a*) witnesses a fair number of women active in the whole network. However, only a relatively small portion of these women actively engaged in correspondence with other women. Table 4 summarizes this point.

Table 3. Female Authors in the EE Corpus

	N	%
Female authors in the whole Electronic Enlightenment corpus subset (criterion *a*)	278	6.9
Female authors in touch with other female authors	10	3.5
Female authors mostly senders (60% or more)	110	39.5
Female authors mostly receivers (60% or more)	146	52.5
Female authors both senders and receivers (41%–59%)	22	7.9

Table 4. Exchanges among Female Authors

Author	Electronic Enlightenment Tags	In Touch With	Letters Sent or Received (*N*)
Marianne Margaret Egerton (1817–88)	English aristocrat, patron, needleworker, author	Charlotte Murchison	1 sent
Charlotte Murchison (1788–1869)	English scientist, geologist, salon hostess	Marianne Margaret Egerton	1 received
Jean Charlotte de Viart d'Attigneville, comtesse de La Neuville (d. 1763)	French aristocrat	Emilie du Châtelet	2 received
Françoise Huguet de Graffigny (1695–1758)	Author, playwright	Emilie du Châtelet	1 sent, 5 received
Marie du Châtelet, marquise du Châtelet (née de Fleming; 1710–48)	French aristocrat	Emilie du Châtelet	1 received
Émilie du Châtelet (1706–49)	French aristocrat, scientist, mathematician, physicist, author	Marie Francoise Catherine de Boufflers	3 sent
		Marie du Châtelet	1 sent
		Francoise Huguet de Graffigny	5 sent, 1 received
		Jean Charlotte de Viart d'Attigneville	2 sent
		Elisabeth Sophie de Lorraine	1 sent
Martha Lockhart (1668–1752)	English courtier	Lady Damaris Masham	1 sent
Damaris Masham (1658–1708)	English philosopher	Martha Lockhart	1 received

Considering now the strict network, we observed that seven women were included in total, five in the seventeenth-century and two in the eighteenth-century strict network:

1. Batshua Makin (1600–1675)
2. Katherine Jones, Viscountess Ranelagh (1615–91)
3. Margaret Lucas Cavendish, Duchess of Newcastle-upon-Tyne (1623–73)
4. Damaris Cudworth, Lady Masham (1659–1708)
5. Catharine Trotter Cockburn (1674?–1749)
6. Émilie Le Tonnelier de Breteuil, marquise du Châtelet (1706–49)
7. Laura Bassi (1711–78)

Several of these authors were contemporaries, as shown in figure 5. It is already apparent that none of these women were in touch with each other.[29] This may seem a trivial remark or a mere historical accident. However, existing scholarship shows that women were generally well connected among themselves in the early modern Republic of Letters (e.g., Pal 2012). Despite its lacunae, the EE corpus does support this point to some extent. However, when it comes to the specific early modern network among natural philosophers, we observe that there were women in the natural philosophy network, but none of them were in touch with one another. We suggest that this fact arguably is not a mere accident but rather a symptom of the way the early modern natural philosophy network, in particular, worked.

As mentioned in section 2, our method consists in comparing centrality measures in an author's lifetime network with the same measures calculated for the same author in the strict network. To begin with, consider the different size of the strict networks compared to the size of the lifetime networks for each of the female authors. Table 5 provides this information.

The differences between the lifetime and strict networks range from small, in the case of Masham, to very significant, in the case of du Châtelet. In general, lifetime networks are smaller than the whole strict network, in terms of both the authors included and the letters preserved. This is not positively correlated with the length of each individual author's lifetime itself, as shown by the table. Masham, who lived only 49 years, has a relatively larger lifetime network than

29. We double-checked this point with the EMLO database. That database includes figures who are not included in the EE corpus (e.g., Anne Conway), but it did not change the results for the figures discussed in this article. We also checked this point based on available scholarship, and there is in fact no trace of any direct correspondence between these women philosophers.
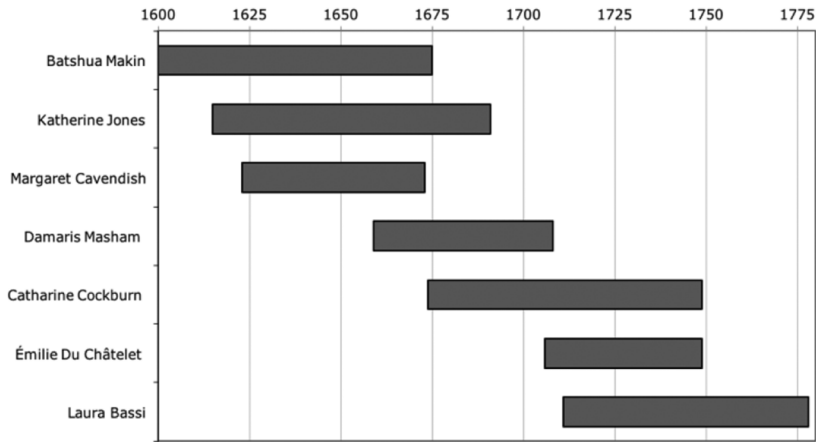
Figure 5. Chronology of women philosophers. Color version available as an online enhancement.

Jones, who lived 76 years. Cockburn and Jones, who lived approximately the same number of years, have rather different lifetime networks.

The standard scenario expected for noncanonical authors is that centrality measures decrease when one moves from the lifetime to the strict network. Since the strict network is usually bigger than any lifetime network, one may expect that the relative centrality (which in our research indicates the author's potential for interaction) that a noncanonical author had in her lifetime will decrease when one takes into account the strict network. As we will see, this is the case for all the female authors.

Table 5. Strict and Lifetime Networks of Female Authors

Name	Lifetime (Years)	Strict Network		Lifetime Network	
		Authors (*N*)	Letters (*N*)	Authors (*N*)	Letters (*N*)
Makin	74	163	1,541	85	719
Jones	76	163	1,541	142	1,031
Cavendish	50	163	1,541	81	629
Masham	49	163	1,541	147	1,351
Cockburn	75	163	1,541	105	887
Du Châtelet	43	118	1,353	25	173
Bassi	67	118	1,353	96	1,093

Table 6 presents the centrality measures for the seven female authors. As a general remark, we observe that female authors in the natural philosophy network tend not to have centrality legacy. This remark needs a few qualifications. In the case of betweenness centrality, all seventeenth-century authors and Bassi have zero betweenness; hence, the value cannot decrease further. Since betweenness captures the ability of an author to be an important mediating bridge in the network and in the flow of information within it, we can already infer that almost all female authors considered here did not play this role. Du Châtelet is the exception: not only does she have positive betweenness, but her betweenness increases dramatically from her lifetime network to the strict network. This latter point might be accounted for by the fact that her lifetime and strict networks show a greater difference in size. Du Châtelet's lifetime network contains only 20% of the authors and 12.6% of the letters included in the eighteenth-century strict network. We further comment on du Châtelet's case later on. With regard to the other measures, eigenvector centrality decreases from lifetime to strict networks in all cases. Closeness centrality also decreases in all cases, with the exception of Jones (for whom closeness moves from 0 in the lifetime network to 0.38 in strict network). Despite these exceptions, all the female authors show that centrality measures tend to decrease when moving from the lifetime to the strict network; hence, we conclude that none of these authors has significant centrality legacy.

The overall place of female authors within the strict network can be seen in figures 6 and 7, which represent the seventeenth- and eighteenth-century strict

Table 6. Centrality Measures of Female Authors

Name	Betweenness		Eigenvector		Closeness	
	Lifetime Network	Strict Network	Lifetime Network	Strict Network	Lifetime Network	Strict Network
Makin	0	0	0	0	.66667	.385965
Jones	0	0	.207819	.1939017	0	.383928
Cavendish	0	0	.079815	.015797	0	0
Masham	0	0	.122253	.115233	.38383	.367521
Cockburn	0	0	.287167	.115233	0	0
Du Châtelet	7	158	.017513	.2777240	.75	.7
Bassi	0	0	.2127526	.205518	0	0

Note.—The strict networks are seventeenth or eighteenth century.
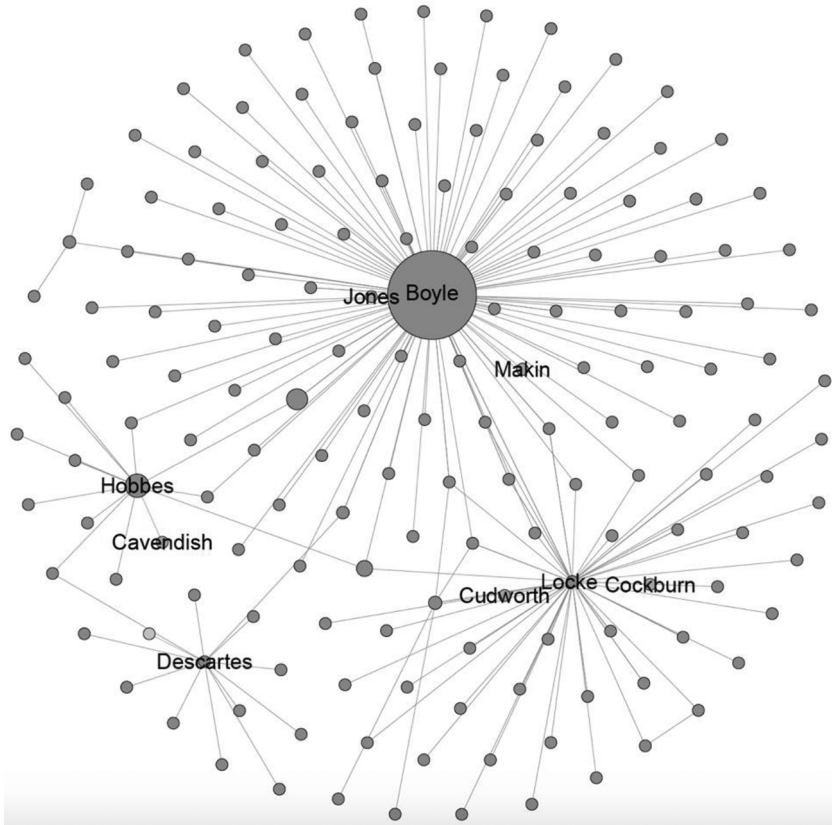
Figure 6. Seventeenth-century strict network

networks respectively.[30] To assess the place of these female authors within the strict network, we observe how their centrality measures in the strict network compare with those of other authors in the same strict network. We comment

30. Figures 6 and 7 show that both seventeenth- and eighteenth-century strict networks lack 'weak ties', i.e., authors who bridge otherwise relatively unrelated subnetworks (see Granovetter 1973; Ahnert 2016). Rather, the most central authors in each network are also those keeping the network together. This remark is probably more telling about the composition of the EE corpus itself rather than the actual historical network of early modern natural philosophy. Since the EE corpus is mostly composed of individual correspondence, it seems to be expected that it will hardly reveal the presence of weak ties. Our network resembles the ego-network studied by Deicke (2017) with respect to Protestant controversies, in which authors are mostly divided in two main groups: "high-degree hubs with a multitude of ties to weakly as well as strongly interlinked persons, and a high number of low-degree nodes engaged in often asymmetric contact to each other, but primarily to the central hubs" (102).
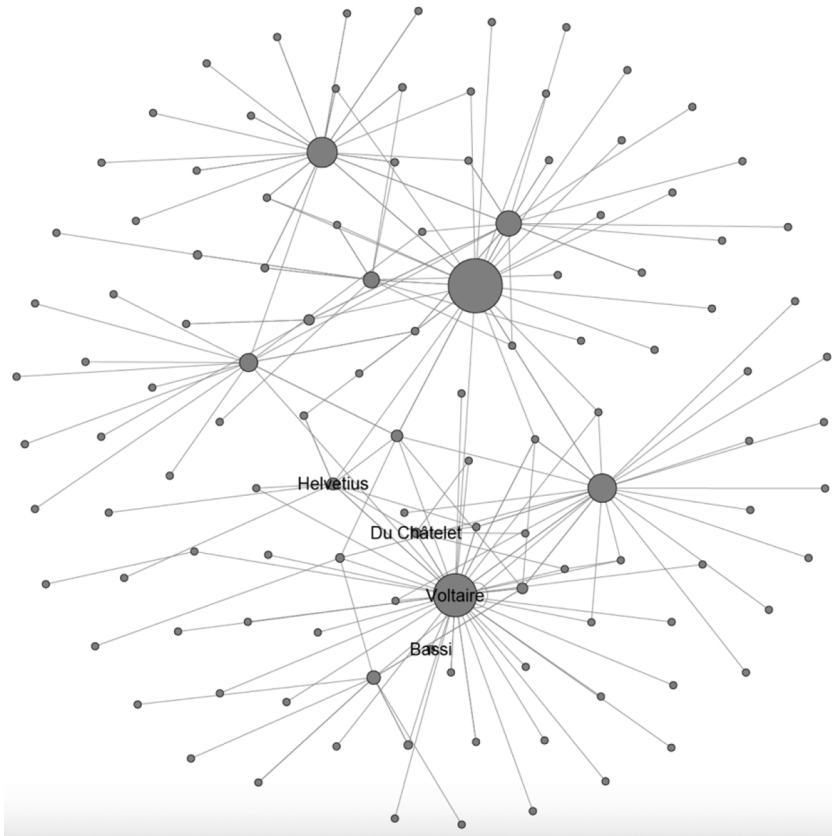
Figure 7. Eighteenth-century strict network

on these values, looking first at the seventeenth-century strict network and then turning to the eighteenth-century strict network.

Betweenness centrality: A zero betweenness centrality is rather typical in the seventeenth-century strict network, and it is not a typical feature of female authors only.[31] This means that the strict network is rather poorly connected, and only a few authors are keeping the network together. The fact of having above-zero betweenness is an exceptional feature of just a few authors. We observe that only 9 authors out of

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31. This point is not surprising since zero betweenness seems to be a common feature in historical sixteenth- and seventeenth-century networks, often dominated by major hubs. For comparison, see Ahnert and Ahnert (2015).

163 in the whole seventeenth-century strict network have a betweenness centrality above zero. They are as follows:

1. Robert Boyle (betweenness 4,668)
2. John Locke (betweenness 2,895)
3. Thomas Hobbes (betweenness 832)
4. Reverend Thomas Barlow (betweenness 629)
5. Henry Stubbe (betweenness 287)
6. John Mapletoft (betweenness 86)
7. Thomas Sydenham (betweenness 45)
8. Marcello Malpighi (betweenness 45)
9. Henry More (betweenness 42)

Eigenvector centrality: With regard to eigenvector centrality, 33.7% of the authors (55 out of 163) in the seventeenth-century strict network have a positive eigenvector value. The top authors are as follows:

1. Robert Boyle (eigencentrality 1)
2. John Locke (eigencentrality 0.62634)
3. Isaac Newton and Thomas Coxe (eigencentrality 0.309135)
4. Henry More (eigencentrality 0.195814)

It is worth noting the significant difference in the measures for a few key names (Boyle, Locke, Newton) and the rest of the authors (all below 0.3). The five female authors considered above all score between 0 and 0.1 eigenvector in the strict network, which positions them very low on the spectrum of positive eigenvector values. Women do not exhibit the worst connections (except for Makin, they do not have zero eigenvector centrality, as other authors do). However, they are definitely not in the best position either. This suggests that in the seventeenth-century strict network, only a few authors operate as the main leaders of the network. Remarkably, the women present in the network were all in touch with some of these main figures. Before elaborating further on this point, let us consider closeness measures.

Closeness centrality: When we look at closeness centrality, the top authors are as follows:

1. Thomas Hobbes and Christiaan Huygens (closeness 1)
2. Robert Boyle (closeness 0.614286)

3. John Locke (closeness 0.57333)

4. Samuel Sorbière (closeness 0.545455)

5. Robert Payne, Pierre Guisony, and François Bonneau Du Verdus (closeness 0.538462)

6. Edmund Dickinson and Thomas Sydenham (closeness 0.447917)

7. William Cole, Nicolas Fatio de Duillier, and Charles Goodall (closeness 0.44444)

8. Isaac Newton and Thomas Coxe (closeness 0.443299)

In general, in the whole seventeenth-century strict network, only 15.3% of authors (25 out of 163) have zero closeness. Among the female authors we considered, Makin, Jones, and Masham have above-zero closeness, although not very high, while Cavendish and Cockburn have zero closeness. Once again, women are not in the worst position within the network, nor are they in the best. These women philosophers have connections with very important nodes (above-zero eigenvector values), but this is pretty much the only way in which they have access to the network itself.

To return to centrality legacy, table 7 offers a comparison of the centrality measures of the authors who appear to be more influential in the strict network according to the three centrality measures we considered. The table shows that the centrality measures for both Boyle and Locke not only are (almost) unaffected when moving from the lifetime to the strict network but sometimes (as in the case of betweenness centrality) increase. Both authors clearly have centrality legacy. Other authors are in a grayer area. Hobbes seems to have some centrality

Table 7. Most Central Authors in the Strict Network

Name	Betweenness		Eigenvector		Closeness	
	Lifetime Network	Strict Network	Lifetime Network	Strict Network	Lifetime Network	Strict Network
Boyle	3,686	4,668	1	1	.6481	.6142
Locke	2,895	2,895	.6263	.6263	.5733	.5733
Hobbes	430	832	.1223	.0679	1	1
Newton	0	0	.3093	.3091	.4432	.4432
Sorbière	0	0	.1385	.0157	.5454	.5454

Note.—The strict networks are seventeenth or eighteenth century.

legacy as well, since only his eigenvector centrality decreases slightly when moving from the lifetime to the strict network. Newton, in spite of having zero betweenness, does have centrality legacy, since his eigencentrality and closeness are unaffected by the shift from the lifetime to the strict network. Sorbière is more likely to lack centrality legacy, since, on top of having zero betweenness, his closeness centrality remains the same, while his eigencentrality decreases.

Table 8 presents the composition of the lifetime networks for each of these authors. At first glance, one may think that the centrality legacy of Boyle and Locke is due to the fact that in their case there is only a very small difference in size between their lifetime and strict networks. Moreover, their lifetimes happen to be those that most closely cover the whole seventeenth century. One may thus wonder whether centrality legacy should not be taken simply as a mark of the difference in size between lifetime and strict networks. The difference in size between lifetime and strict network is one aspect of centrality legacy (the smaller the difference, the more likely the author is to have some centrality legacy). However, centrality legacy cannot be reduced to this difference in size. Consider the case of Newton, whose lifetime network is even closer in size than those of Locke and Boyle to the whole strict network. While Newton does have some centrality legacy, his position in the strict network is significantly less prominent than that of Boyle and Locke, as shown by the fact that Newton has zero betweenness in both the strict network and his own lifetime network. Consider also the case of Hobbes, who, despite having a lifetime network roughly half the size of the whole strict network, manages to have some centrality legacy. These observations suggest that centrality legacy cannot be reduced to a mere

Table 8. Lifetime Networks of the Most Central Authors

Name	Lifetime (Years)	Authors in Lifetime Network		Letters in Lifetime Network	
		N	% of Strict Network	N	% of Strict Network
Boyle (1627–91)	64	130	82.8	730	58.7
Locke (1632–1704)	72	153	97.4	1,215	97.7
Hobbes (1588–1679)	91	93	59.2	530	42.6
Newton (1642–1727)	85	152	96.8	1,232	99.1
Sorbière (1615–70)	55	65	41.4	338	27.1

quantitative difference in size between lifetime and strict networks but rather captures something of the structural position that each author managed to achieve in her or his own lifetime and that somehow remains engrained in the overall strict network.

Among the five seventeenth-century female authors we considered, Cavendish was in touch with Hobbes; Masham and Cockburn with Locke; and Makin and Jones with Boyle. Boyle, Locke, and Hobbes are by far the most dominant figures in the strict network. Female authors in the network are in touch with these dominant figures but occupy a subordinate position in the network. This is the intuition at the basis of the model we present in the next section. Before moving forward, however, let us consider the results for the eighteenth-century strict network.

Overall, the eighteenth-century strict network shows a structure somewhat different from the seventeenth-century strict network.[32] In the eighteenth-century strict network, 20.3% of authors (24 authors out of 118) have positive betweenness (compared with 5.7% in the seventeenth-century strict network). This suggests that the eighteenth-century strict network is significantly more connected. In this case, the only female figure included, du Châtelet, happens to score high in betweenness (158), showing that she is, in fact, a central node in the strict network. We also observe that 61.8% (73 out of 118) of the authors have positive eigenvector values, which is almost double that which registered in the seventeenth-century strict network. With regard to closeness centrality, 25.4% (30 out of 118) of authors have zero closeness. This result shows that slightly more authors are disconnected in the eighteenth-century strict network than in the seventeenth-century strict network.

Consider the two female authors we looked at in the eighteenth-century strict network. Bassi's profile is relatively similar to that of other seventeenth-century women philosophers. By contrast, if we compare du Châtelet's position in the eighteenth-century strict network with the positions of all other female authors, du Châtelet seems to occupy a significantly more dominant position, even if she does not have centrality legacy. Since we have only two female authors in the eighteenth-century strict network, it is difficult to make further comparisons. In the next section, we attempt to create a model to capture the

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32. This is not directly due to the size of the network itself. As shown in table 5, the number of letters and authors in the seventeenth- and eighteenth-century strict networks are relatively similar and comparable. It is true that, with regard to the loose networks, the eighteenth-century corpus is significantly more conspicuous. However, since we do not base our measures on this loose network, we cannot infer that the increased connectivity in the eighteenth-century strict network is due to a larger data set.

essential features shared by most of the seven women philosophers considered and use this model to identify further authors who match this profile.

Before proposing our model, however, we would like to reflect again on the way in which these centrality measures underscore the potential for interaction of canonical and noncanonical authors. So far, we have based our discussion only on the actual ties indicated by the letters included in our corpus. In section 2.2, however, we stressed that the notion of interaction should not be reduced to actual correspondence. One simple way to expand the meaning of interaction among authors is thus to consider the way in which authors were discussed within the network. Discussion of philosophical ideas and concepts is often subtle and difficult to trace. Nonetheless, one more immediate way of assessing explicit discussions of any of the authors we considered consists in observing whether their names were mentioned by other authors. Investigating the mentioning of proper names arguably gives only a coarse-grained overview of the circulation of ideas. Nonetheless, if one takes into account that mentions do not directly depend on network analysis, this can provide an external indirect corroboration of our hypothesis about the relationship between canonical and noncanonical authors.

We searched the texts of our whole EE corpus (not restricted to the strict network) in order to assess whether the names of any of the canonical or noncanonical authors discussed so far were mentioned in letters that were not sent or received by them (hence, letters in which the author was not directly involved). In the case of the seven female authors discussed, only two names are mentioned by other authors. Lady Masham is mentioned in two letters, one from John Bonville to John Locke and another from John Locke to Edward Clarke. Both letters are about family and financial business. The other is du Châtelet, whose name features in 64 letters, 56 of which are sent to or received by Voltaire. This might shed some light on the relatively greater prominence that du Châtelet acquires in the eighteenth-century network, since Voltaire is one of the major hubs within it and he actively promotes her through his correspondence. However, once again, du Châtelet's case is more an exception than the rule in our sample. Most of the noncanonical women philosophers we studied did not have high centrality scores and were not mentioned in other correspondence within the network.

To the contrary, today's seventeenth-century (strict network) canonical authors (Boyle, Descartes, Hobbes, Locke, Newton) are also mentioned in 1,060 letters by other authors (we identified 548 unique authors, belonging to the whole EE corpus, involved in these exchanges, of whom 25 were included in the seventeenth-century strict network). Eighteenth-century (strict network) canonical authors (d'Alambert, Bentham, Helvetius, Hume, Reid, Rousseau,

Voltaire) are mentioned in 5,407 letters by other authors (we identified 1,802 unique authors, belonging to the whole EE corpus, involved in these exchanges, of whom 48 are included in the eighteenth-century strict network).

These findings confirm that the centrality that canonical authors had is positively correlated with the power of actualizing their potential for interaction within their networks (which in this case is reflected by the fact of being frequently mentioned by name in other authors' correspondence), while noncanonical authors lacked such power. Moreover, canonical authors had significant visibility beyond the strict network of natural philosophy, suggesting that their personal networks and interactions were multifaceted and extended to a number of different domains and audiences.

3.2. The *Divide et impera* Model

The centrality measures discussed so far show that a few (today canonical) authors dominate the early modern network. These central authors are the gatekeepers of the network and are responsible for the flow of information within it. By being in touch with these central authors, other authors may have access to relevant information. However, the network is structured in such a way that central figures are mostly responsible for the overall cohesion of the network and the flow of information within it. This entails that noncentral authors are completely dependent on central authors. This situation may not necessarily be the result of an explicit and intentional decision by the more central and dominant authors, but it is nonetheless a structural feature of the network itself. This point is further corroborated by our discussion of centrality legacy, which is a structural feature of the overall strict network that cannot entirely depend on the intentional agency of an individual author.

To capture these features of the early modern natural philosophy network, we propose the following model, which we call *Divide et impera*. We call 'primary actors' those authors who are central in their own network and later become canonical authors. We call 'secondary actors' the authors who were connected with the primary actors and later become noncanonical authors. The model is based on two intuitions:

Divide: Secondary actors are connected to primary actors, but they are not connected among themselves (nontransitivity effect).
Impera: Primary actors operate as the main gateway for the secondary actors to access the network (filtering effect).

These intuitions can be operationalized as follows:

> For any subset S of the nodes that compose the domain C, nodes in S count as secondary actors if and only if the following conditions apply to them:
>
> > a) betweenness centrality is zero or within the lowest values in the whole C;
> > b) eigenvector centrality is above zero but mostly in the low spectrum of the values in the whole C;
> > c) closeness centrality is zero or within the lowest values in the whole C;
> > $d1$) nodes in S do not have centrality legacy;
> > $d2$) nodes in S are directly connected with nodes in C who have centrality legacy.

The kind of noncanonical figures whom today's scholarship tries to reappraise are authors who (i) were sufficiently close to today's canonical figures to share interests, problems, and debates with them and (ii) advanced their own significant and cogent ideas but (iii) have been unduly forgotten. We operationalize this intuition by considering noncanonical figures as 'secondary actors' in the sense defined by our model. The preceding discussion illustrated how most of the women philosophers included in the strict network fit this profile.[33] We use *Divide et impera* to search the seventeenth-century strict network to find whether there are other authors who were in a position similar to that of women philosophers and who could thus be equally seen as unduly neglected noncanonical authors.[34]

Table 9 presents the relevant data. To understand these results, it is important to appreciate that the *Divide et impera* model does not identify groups of authors in the sense of unified and homogeneous collections of authors who shared similar interests and contributed to shared projects. In fact, *Divide et impera* identifies what we call 'familiar strangers', namely, individuals who do not have any direct relationship among themselves and who do not intentionally contribute

33. In terms of how the particular women philosophers we considered deviate from our model, we maintain that the model closely matches the cases of five of the seven authors we discussed. Du Châtelet is clearly an exception, while Makin's case falls slightly outside of the model because her eigencentrality is zero, in contrast to the values of all the other seventeenth-century women philosophers. For this reason, we disregard her case in the following implementation of our model. We calculate that there would be another 40 authors who would have similar values to those of Makin. However, this would make the sample picked by our model relatively too broad for the purposes of this study.

34. We restrict this implementation of the model to the seventeenth-century strict network because it is in this subnetwork that most women philosophers who fit the model are located.

to a shared project or engage with each other but who nonetheless have some features in common and work in the same intellectual space. Consider, again, the instance of seventeenth-century women philosophers. There is no surviving trace of any direct correspondence among them, and they were not working together toward a shared goal or on a joint project. Nevertheless, they were all involved more broadly with the seventeenth-century rethinking of natural philosophy. Table 9 suggests at least two analogous cases.

First, consider some of the authors in touch with Boyle. Worsley (1618–73) was an important member of the Invisible College and of the Hartlib Circle. He was a chemist experimenting on saltpeter (among other things), which is an important focus of Boyle's early research. Sharrock (1630–84) was a botanist who also contributed to the translation and circulation of Boyle's works. Lower (1631–91) was a physician experimenting on blood transfusion, which becomes an important topic in Boyle's later career. Schott was one of the first to experiment on the void, which is again a key focus of Boyle's experimental practice. Glanvill (1636–80) was a latitudinarian (like Boyle) and an early advocate of the Royal Society.[35]

We know that Boyle's own philosophical agenda aimed at the reconciliation of philosophical disputes and the integration of experimental philosophy and religion. Each of the figures just mentioned are today mostly forgotten. Nonetheless, each of them embodied one of several facets of seventeenth-century natural philosophy that Boyle was keen to combine and promote. These authors may well have had some contacts, but we do not have traces of their exchanges in the EE corpus, despite the fact that they were all operating in the same period and in a similar intellectual environment.[36] They could have formed a school of experimental natural philosophers with a keen interest in apologetics. However, it was Boyle himself who embodied and carried over that program and who is today widely remembered for that. This may suggest why Boyle's name was associated with the program of experimental natural philosophy, while people like Worsley and Glanvill were forgotten.

Second, consider the authors who were in touch with Descartes. In the EE corpus, Descartes does not feature as a very prominent author, nor does he appear to have centrality legacy. However, we observe that this is due to a significant lacuna in the EE corpus, which includes only part of Descartes's correspondence. We then take Descartes into account despite the fact that he does not fulfill condition $d2$ of our model because of our background scholarly

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35. For an overview of the context of Boyle's work, see Webster (2002) and Newman and Principe (2005).

36. Sharrock, Lower, and Glanvill studied at Oxford. Lower was also a member of the Royal Society.

Table 9. Authors Picked by the Model *Divide et impera*

Author	Eigenvector Centrality		Betweenness Centrality		Closeness Centrality		Female Author Who Is Similar	Dominant Author Who Is a Connection
	Strict Network	Lifetime Network	Strict Network	Lifetime Network	Strict Network	Lifetime Network		
William Cavendish	.010526	.02702	0	0	0	0	Cavendish, Cockburn	Descartes, Hobbes
Briolay de Beaupreau	.010526	.03125	0	0	0	0	Cavendish	Locke
Sir John Brooks	.010526	.010526	0	0	0	0	Cavendish	Hobbes
Pierre Gassendi	.010526	1.0	0	0	0	0	Cavendish, Cockburn	Hobbes
Jacob Spon	.010526	.013157	0	0	0	0	Cavendish, Cockburn	Boyle
Andre Colvius	.010526	.02439	0	0	0	0	Cavendish, Cockburn	Descartes
Vorster	.010526	.2	0	0	0	0	Cavendish, Cockburn	Descartes
Vopiscus Plemp	.010526	.25	0	0	0	0	Cavendish, Cockburn	Descartes
Lazare Meyssonnier	.010526	.0277	0	0	0	0	Cavendish, Cockburn	Descartes
Jean Baptiste Morin	.010526	1.0	0	0	0	0	Cavendish, Cockburn	Descartes
Henri Le Roy	.010526	.0185	0	0	0	0	Cavendish, Cockburn	Descartes
Van Hogelande	.010526	.2	0	0	0	0	Cavendish, Cockburn	Descartes

Name								
William Avery	.010526	.012195	0	0	.38889	.4074	Jones	Boyle
John Winthrop	.010526	0	0	.45	.38889	.40322	Jones	Boyle
Benjamin Worsley	.010526	0	0	0	.38889	.40322	Jones	Boyle
Reverend Robert Sharrock	.010526	.013888	0	0	.38889	.40277	Jones	Boyle
Reverend Gaspar Schott	.010526	0	0	0	.38889	.38888	Jones	Boyle
Richard Lower	.010526	.010526	0	0	.38889	.40476	Jones	Boyle
Joseph Glanvill	.010526	.017241	0	0	.38889	.4	Jones	Boyle
Isaiah Ward	.010526	0	0	0	.37168	.24754	Masham	Locke
William Molyneux	.010526	.010526	0	0	.37168	.33928	Masham	Locke
Thomas Molyneux	.010526	.010638	0	0	.37168	0	Masham	Locke
Anthony Collins	.010526	0	0	0	.37168	.44680	Masham	Locke
John Norris	.010526	.010638	0	0	.37168	.38095	Masham	Locke

knowledge about his role in early modern natural philosophy. We observe, then, that the five Dutch authors (Colvius, van Hogelande, Regius, Plemp, and Vorster) and two French authors (Morin and Gassendi) presented in table 9 were not in touch with one another, despite all being correspondents of Descartes.[37]

Although Gassendi is not exactly a canonical figure today, his name is surely among the most famous within the group of authors just presented. For our purposes, it is interesting to focus in particular on the five Dutch correspondents of Descartes. In this subnetwork, Descartes seems to play the same role that Hobbes, Boyle, and Locke play in the networks of the women philosophers discussed above. We cross-checked this latter point by using ePistolarium, which includes more sources than the EE corpus when it comes to the Dutch milieu. Figure 8, derived from ePistolarium, confirms that those five Dutch correspondents of Descartes were not directly in touch with one another.[38]

There is significant evidence that Descartes was one of the most controversial and debated figures in the first half of the seventeenth century in the Dutch milieu. Several of these Dutch authors (Regius and Plemp, above all) engaged extensively with Descartes's philosophy. Interestingly, none of these authors would qualify as a Cartesian. The best example is Regius. Although Regius declared himself to be following Descartes, Descartes distanced himself and dismissed the direction that Regius was impressing on his own reworking of Cartesian ideas (Verbeek 1988; Bitbol-Hespériès 1993; Wilson 2000).

Recent scholarship (Ariew 2014; Schmaltz 2017; Kolesnik-Antoine 2018) demonstrates that 'Cartesianism' is an umbrella term that covers a number of very different philosophical orientations and that it is at the center of complex sociohistorical dynamics in the second half of the seventeenth century. Our study presents a complementary perspective on this issue. Secondary authors connected with Descartes remain relatively scattered with respect to one another. This structural feature of the network in which they operate may help to better understand why authors who engage with Descartes did not create a unified school but rather offered different, often divergent, ways of engaging with Descartes's project.

37. We could not find extra sources outside the EE or EMLO corpora providing information about any surviving correspondence among these authors.

38. Figure 8 also shows that ePistolarium too is based on an incomplete database, since correspondence between Descartes and Constantijn Huygens, and between Descartes and Vorstius, is included in Descartes's correspondence (see Descartes 1964–74), thus leading to a greater transitivity in Descartes's circle than what results from fig. 8. However, this only proves that since both Descartes and Huygens are prominent figures in the network, they had greater potential for interaction (as in fact is the case, given that we know that they had actual interactions). This does not entail, though, that the noncanonical authors connected with them had the same power of actualizing their potential, given their significantly lower centrality in the network. The Descartes-Huygens polarity shown here is similar to the Boyle-Locke polarity in the seventeenth-century strict network discussed earlier.
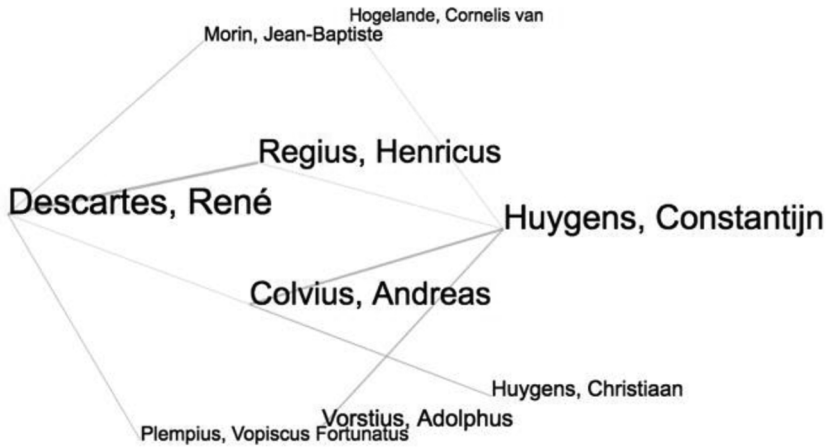
Figure 8. Descartes's network according to ePistolarium

This lack of a common binding ideology or philosophical orientation is even more apparent in the case of women in the British natural philosophy network. They could hardly be grouped together within a single school, orientation, or label. The only feature that these authors share is their philosophical interests, their gender, and their relationship with some dominant male natural philosopher in their network. Mutatis mutandis, this is a pattern similar to that observed in the case of Descartes's Dutch correspondents. Our analysis shows that the fact of being 'familiar strangers' is not an accident but is likely correlated with the position of these authors in the network in which they operated.

The structure of the early modern natural philosophy network tends to prevent a transitive flow of information (the fact that A is in touch with B and B is in touch with C does not lead A to get in touch with C) and makes the primary actors the main gatekeepers who control the transit and flow of information within the network. Our model reveals a pattern that can be operationalized in terms of certain ranges of values for different centrality measures. This pattern can be used as a heuristic to discover multiple groups of authors who are subject to the same model. The examples of Boyle's and Descartes's correspondents show how our model can be used to identify familiar strangers.

4.   Familiar Strangers and Identity Dynamics

Canonicity is a complex phenomenon, arguably shaped by a variety of different concurring factors (including historical circumstances and historiographical trends). In this article we focused on a potentially relevant component of canonicity, namely, the impact that the structure of the network in which authors

operated at their time had on their becoming more or less canonical. We investigated the relationship between today's canonical and noncanonical figures by using social network analysis. We selected a relevant subset of the EE corpus that included samples of today's canonical and noncanonical authors in early modern philosophy and science. The authors who today are remembered as canonical dominated the network at their time. The noncanonical authors whom today's scholars are trying to reappraise were in touch with the canonical authors but also extremely dependent on them for access to the network. By modeling the case of early modern women philosophers, we suggested that several other authors were in a similar position in their network. To conclude our study, we review the implications of our results as well as their limitations.

As we mentioned at the beginning of section 2, we interpret the EE corpus as a piece of scholarship that reflects today's attitude toward canonization. A large part of the corpus consists of collections linked to today's canonical authors. The EE corpus offers a particular perspective on the early modern Republic of Letters by showing what a portion of it looked like from the standpoint of some of today's canonical authors. Interestingly, this same perspective reveals that some of today's noncanonical authors were closely related to the canonical authors. This observation can be interpreted in two complementary ways.

On the one hand, today's relationship of canonicity can be seen as a perpetuation of the way in which authors were connected within specific networks. Deciding which authors are canonical also entails a decision on which authors are noncanonical. Perhaps these noncanonical authors had other ways of getting in touch, and it is just harder for us to reconstruct these connections owing to the loss or unavailability of sources. Nonetheless, from the point of view of a network heavily shaped by the perspective gathered from canonical authors, the noncanonical authors appear scattered and heavily dependent on the canonical authors. The more one relies on the perspective of today's canonical authors, the more noncanonical authors may be dismissed or neglected as 'less central' for the networks to which they belong. This attitude may suggest a further explanation for why noncanonical authors have been neglected by traditional scholarship for so long.

On the other hand, the networks associated with canonical authors allow us to recover a number of noncanonical authors as well. Even if the way in which these noncanonical authors operated is distorted by the fact that we look at them from the perspective of today's canonical authors, the fact that these noncanonical authors were associated with canonical authors allowed them to remain potentially recoverable. Hence, today's canonical figures can be seen not only as authors who came to unduly monopolize the historical scene but also as historical mines in which it is possible to dig and rediscover neglected figures.

We suggest that the relationship between today's canonical and noncanonical figures somehow mirrors a relation of domination at play in the early modern network in which those figures operated. Those authors who today are noncanonical but are the object of intense scholarly reappraisal were the same authors who in their time played the role of secondary actors in their own network. They were close to (future) canonical authors and extremely dependent on them for access to the network. We phrase this structural feature of the early modern network in terms of domination in order to stress the power of certain authors over others (even if this form of domination was not intentionally enforced by any individual author).

The effect tackled by our model *Divide et impera* is that noncanonical authors were scattered, independent of one another, despite the fact that they did share common interests, preoccupations, and ambitions and often lived in geographic proximity to one another. Noncanonical authors never formed a real group, although they had the potential for it. They were 'familiar strangers'. From this point of view, one may venture to suggest that group identity and group membership can be understood (by contrast) as the way in which certain authors manage to free themselves from the effect of the strategy entailed by *Divide et impera*, namely, from domination and control. Philosophical schools, sects, well-defined groups, and other structures of organization among authors in which the opposite of *Divide et impera* takes place (i.e., transitivity of contacts and nonfiltering of information) can be seen as the antidote adopted by certain authors to resist and prevent the arising of domination. Seen from this perspective, the formation of philosophical schools, sects, groups, and other forms of publicly organized and recognizable identities may also be interpreted as a successful survival strategy through which certain authors, in certain contexts, manage to avoid the domination of some primary actors. This also entails that groups and other forms of publicly organized identities were in the beginning assemblages of familiar strangers. Familiar strangers have the potential to give rise to forms of publicly organized identities once they manage to oppose and resist the domination that is exercised on them.

Our results come with two major limitations, one material and the other methodological. Appreciating both limitations can help us to outline a few important points worth adding to the agenda of future research in the computational history of early modern philosophy and science.

The material limitation of our results concerns the source we studied, namely, epistolary correspondence preserved in the EE corpus. Clearly, the EE corpus is far from ideal. However, the results we obtained studying the EE corpus offer some corroboration to the picture that emerged from contemporary scholarship. We found in the EE corpus many of the both canonical and noncanonical

authors discussed by today's scholars. Moreover, the relationship between these authors in the EE corpus is very similar to what today's scholars describe: today's canonical authors were very central in their network, while noncanonical authors were not. Although today's scholarship does not base its assessment on the examination of the EE corpus per se, our study shows that the EE corpus can be used to further corroborate the state of the art emerging in today's scholarship. This suggests that, despite its limitations, the EE corpus is a reliable source for studying the relationship between canonical and noncanonical figures in early modern philosophy and science.

However, our results offer more than a mere quantitative corroboration of today's state of the art. We suggest that what today appears to scholars as a relationship between canonical and noncanonical authors could be seen (at least partly) as the legacy of a relationship of domination at play in the early modern network of natural philosophy. A key aspect that distinguishes noncanonical from canonical authors is their centrality legacy, namely, their potential to remain influential on a relatively larger community. This entails that the lower centrality scores of noncanonical authors can be interpreted as their reduced power of actualizing their potential for interaction. Since noncanonical authors were directly in touch with canonical authors, we suggest that the structure of the network (and its nontransitivity in particular) played a significant role in preventing noncanonical authors from actualizing or improving their potential for interaction and thus positively contributed to making them noncanonical for later generations. This result does not detract from the fact that later generations of historians played a positive role in shaping the existing canon. However, our research adds a further layer to this picture by bringing attention to the way in which the structure of the natural philosophy network contributed to make certain dominant authors more clearly relevant than others in the eyes of later generations.

We reached this conclusion by offering a first generalization of the case of (most) women philosophers by using our model *Divide et impera*. It remains for further research to test whether the same model can be refined and applied to different corpora and still provide a valuable heuristic for detecting neglected noncanonical figures or 'familiar strangers'. Building on a trend in existing scholarship, we designed our model to generalize the case of women philosophers. It would be interesting for further research to see whether the case of women philosophers can really be used as a proxy to profile noncanonical authors in general or (if this is not the case) what made the position of women philosophers different from that of other groups of noncanonical authors.

The methodological limitation of our results concerns the fact that we did not take into account the semantic contents of the letters exchanged between

the authors considered, except for investigating the explicit mention of the proper names of canonical or noncanonical authors. However, our model can be extended to include this semantic dimension as well. The fact that noncanonical authors are highly dependent on canonical authors for their access to the network might entail that noncanonical authors also rely and depend on the technical terminology and semantic conventions enforced by the canonical authors. This entails that with the natural disappearance (in the long run) of the canonical authors from the network, not only do the noncanonical authors no longer have access to the network, but their own work also ceases to be relevant for it because those works are shaped by semantic conventions that no longer have any currency in the network.[39] For those who were dominated, the end of domination is not freedom but oblivion.

In the field of history of philosophy and science, it is still hard to integrate social and semantic analysis. This difficulty is due to two main reasons. First, there are still relatively few relevant large corpora that are available in a digital transcription that is clean enough to allow thorough semantic examination with digital tools. Second, the available tools designed for social analysis often do not allow for a straightforward semantic analysis and vice versa. Despite these difficulties, our study strongly points to the need for proceeding toward such an integration and investigating whether, and to what extent, the *Divide et impera* model may be implemented in the semantic domain as well. This would entail, for instance, studying how the use of a certain conceptual vocabulary may become a means of creating dynamics of inclusion, seclusion, and control over the flow of information within a certain network and how this vocabulary is associated with the dominant authors in the network. For the moment, this further investigation can only be noted on the agenda for future research.

39. For instance, we observed that the term 'spirit' in the English segment of the seventeenth-century EE corpus has a range of different uses that include philosophy, epistemology, moral philosophy, religion, chemistry, and natural philosophy. 'Spirit' can function as a synonym for 'mind' and related terms but also as a technical term in matter theory. However, this is no longer the case for the eighteenth-century segment of the EE corpus, in which 'spirit' remains mostly associated with the domains of philosophy, epistemology, moral philosophy, and religion. Seventeenth-century women philosophers such as Margaret Cavendish and Anne Conway built their systems on the seventeenth-century use of the notion of 'spirit', which was endorsed by canonical figures such as Boyle and Locke. We might suggest that a century later, when this use of 'spirit' became outdated, works that relied heavily on it became less accessible to readers and less cogent for the ongoing debate. This phenomenon has been already observed in traditional scholarship from the point of view of the reshaping of disciplinary boundaries and the way topics now related to theology and religion have been progressively expelled by the domain of philosophy proper by thus leading to a parallel marginalization of several noncanonical authors (e.g., women) who had a keen interest in those topics (see, e.g., O'Neill 1998).

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