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## Mapping the structure of the intellectual field using citation and co-citation analysis of correspondences<sup>☆</sup>

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## ABSTRACT

This article uses the methods of citation and network analysis to map the global structure of the intellectual field and its development over time. Through the case study of Mersenne's, Oldenburg's and Darwin's correspondences, we show how looking at letters as a corpus of data can provide a global representation of the evolving conversation going on in the Republic of Letters and in intellectual and scientific fields. Aggregating general correspondences in electronic format offers a global portrait of the evolving composition of the intellectual and scientific scene, its changing foci of interests and the fortune of the intellectual discussions as expressed in cited persons in the letters. Such tools help replace a purely metaphorical use of the term "network" by a visible *map* of the intellectual relations between people on which well defined calculations of the centrality of the positions of different actors can be made as well as their evolution over time. These techniques provide welcome additions to the tool kit of scholars in an age where the computer and the web offer new ways of mapping and mining the rich store of information contained in intellectual correspondences.

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For more than a century now, scholars, and historians of ideas in particular, have been used to mine published and unpublished correspondences of major historical figures in order to document particular events, ideas, discoveries or debates.<sup>1</sup> Huge collective efforts have been devoted to publish critical editions of the extant letters of the major intellectual figures from (at least) the 16th to the 20th century, from Erasmus to Einstein.<sup>2</sup> Though extremely

useful, erudite and handy, these printed documents could not offer their full potential until they began to be accessible in full-text searchable format. This major transformation, of which the Oxford University e-enlightenment project with its more than 55,000 letters from more than six thousands actors of the "Republic of Letters" offers a prime example,<sup>3</sup> provide a unique opportunity to go beyond the atomized study of a particular actor or set of letters and construct the whole intellectual field and its changing structure over time. As is well known, before the scientific journals made their first appearance in 1665 and until they became the primary means of diffusion of new scientific discoveries during the 19th century, letters played a central role in the circulation of information and the diffusion of knowledge. Their global analysis would offer a unique access to the ongoing conversations between scholars across the world.<sup>4</sup>

Instead of seeing each letter as a unique document and collected editions as simply a convenient way to access them in libraries, one can look at these collected documents as a global

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<sup>1</sup> David A. Kronick, "The Commerce of Letters: Networks and 'invisible Colleges', in Seventeenth- and Eighteenth-Century Europe", *Library Quarterly*, vol. 71 (2001), 28–43; Wacquet, française, "Les éditions de correspondances et les idéaux de la République des lettres", *XVII<sup>e</sup> siècle*, no 178 (Jan.–March 1993), 99–118; Nellen, H.J.M., "La correspondance savante au XVII<sup>e</sup> siècle", *XVII<sup>e</sup> siècle*, no 178 (Jan.–March 1993), 87–98; Ultee, Martin, "The Republic of letters: Learned Correspondence, 1680–1720", *Seventeenth century*, 2, (Jan. 1987), 95–112; Hans Bots, "Éditions de correspondances aux XIX<sup>e</sup> et XX<sup>e</sup> siècles. Méthodes et stratégies", *XVII<sup>e</sup> siècle*, no 178 (Jan.–March 1993), 119–129; Robert A. Hatch, "Peiresc as Correspondent: The Republic of Letters & the 'Geography of Ideas'", in Brian P. Dolan (Ed.), *Science Unbound. Geography, Space and Discipline* (Umeå: Umeå Universitet, 1998), 19–61.

<sup>2</sup> Michael Hunter, "Whither editing?", *Studies in History and Philosophy of Science*, 24 (2003), 805–820; Nellen, H.J.M., "Editing 17th-Century Scholarly Correspondence: Grotius, Huygens and Mersenne", *Lias*, 17 (1990), 9–20. For a survey of many projects of edition of correspondences see the special issue on this topic in *Revue de synthèse*, third series, nos 81–82, Jan.–June 1976.

<sup>3</sup> See [www.e-enlightenment.com](http://www.e-enlightenment.com).

<sup>4</sup> Pearl, J. L., "The Role of Personal Correspondence in the Early Exchange of Scientific Information in Early Modern France", *Renaissance and Reformation*, 20 (1984), 106–113; René Taton, "Le rôle et l'importance des correspondances scientifiques aux XVII<sup>e</sup> et XVIII<sup>e</sup> siècles", *Revue de synthèse*, 3<sup>rd</sup> série, nos 81–82 (Jan.–June 1976), 7–22; Paul Dibon, "Les échanges épistolaires dans l'Europe savante du XVII<sup>e</sup> siècle", *Revue de synthèse*, 3<sup>rd</sup> série, nos 81–82 (Jan.–June 1976), 31–50; Andrea Rusnock, "Correspondence Networks and the Royal Society, 1700–1750", *British Journal of the History of Science*, 32 (1999), 155–169. Benoit Melançon (Ed.), *Penser par lettre* (Montreal: Fides, 1998).

corpus of data to be treated as a representation of the evolving conversation going on in the Republic of Letters and in the intellectual and scientific fields. Though some work has been done in this direction of a structural analysis of correspondences, it has been limited to the study of the geographic distribution of correspondents<sup>5</sup> and, more recently, to the analysis of the time distribution of responses to received letters.<sup>6</sup> Much more can be done by using techniques developed for the citation analysis of scientific papers and for the analysis of social networks.<sup>7</sup> One can for instance follow the evolution of cited persons over time. Highly cited individuals give us a clue about the actors involved in the conversations of the times, their emergence and disappearance as recorded in these letters. In this way, one also gets an idea of the number of people involved in these exchanges not only through writing letters but as persons worthy of being discussed. Even more interesting than citations are co-citation networks, based on the fact that two different names mentioned together in many different letters strongly suggest the existence of a connection (social or intellectual) between the two.<sup>8</sup> As the co-citations of authors in scientific papers provide an entry into the conceptual map of disciplines and specialties,<sup>9</sup> so too the co-citations of persons in correspondences offers the possibility to really map the intellectual structure of the Republic of letters by providing measures of proximity between authors, through their being cited frequently together in many different letters. Using these methods, the letter become the bearer of information on the actors of the intellectual and scientific fields and the frequency of their presence in different letters as well as their connectedness with others an index of their centrality in a given field (intellectual or scientific) at a given time.

In this essay, we would like to give some examples of the kind of results that can be obtained using bibliometric and social network techniques applied to a large corpus of letters. These techniques could easily become an integral part of the electronic editions of aggregated correspondences and serve as tools for mining and analyzing simultaneously several thousands letters covering many decades and even centuries. Aggregating general correspondences like those of Nicolas-Claude Fabri de Peiresc (1580–1637), Marin Mersenne (1588–1648), Henry Oldenburg (1615–1677), which were central nodes of intellectual exchanges, with more personal or specialized ones like those of René Descartes (1596–1650), Robert Boyle (1627–1691) Isaac Newton (1643–1727), Voltaire (1694–1778) and Lavoisier (1743–1794), to name a few major figures, would offer a global portrait of the evolving composition of the intellectual and scientific scene, its changing foci of interests and the fortune of the intellectual discussions as expressed in letters and indexed through proper names like Aristotle, Galileo, Newton or Lamarck. We could already cover a period from at least 1600 to about 1800 by using existing editions and thus get a dynamic view of the evolving discussion between philosophers, natural or not, and

other actors of the intellectual field. For in addition to the thousands of scholars writing and receiving letters, analyzing cited persons in these letters give access to many more actors – many being dead but still alive in the intellectual conversations. We could also make visible generational patterns as few actors remain central more than 15 or 20 years.<sup>10</sup> The more we would add letters, the more the analysis of a given year would be representative of the state of the field at that time. Many obstacles preclude the immediate realization of such a project, such as copyrights or formatting issues, but the already existing databases make it clear that such a goal is near in sight and giving some examples of the kind of global or structural analysis that could be made on such a large quantity of letters can also contribute to its development. For, as we will see, we now have the tools to replace a purely metaphoric use of the term “network” by a visible *map* of the intellectual relations between people on which well defined calculations of the centrality of the positions of different actors can be made as well as measures of the extension and density of the network itself. Moreover, such global analysis could also resurrect figures that were, at least for a given period of time, locally central though they now appear minor to the historian.

Since a general database of letters covering a long time period does not yet exist in the form we suggest here, we will use the cases of Mersenne, Oldenburg and Darwin, to give concrete examples of how we can analyze the changing landscape of cited and co-cited authors and show how this approach, which is complementary to the usual micro-analysis of the detailed content of each letter in its context, can help to better describe and understand the global changes of the intellectual field as reflected in the correspondences.

### The correspondences of Mersenne and Oldenburg: The Decline of Scholastic and the Rise of Galileo and Descartes

Covering a period of about 30 years (1617–1648), the Mersenne’s correspondence is not yet available in electronic form. That period being central in the emergence of modern science and being already well-studied, it can serve as a test-bed for the validity of the methods that we will present in this paper. We have thus manually constructed a list of the most cited authors in each of the 1880 letters written by 328 individuals during the period covered. On average, the letters mention two persons living (i.e. Galileo) or dead (i.e. Aristotle).<sup>11</sup> Given that the distribution of citations in letters is highly skewed and that many individuals are mentioned only once over the period, we have limited the analysis to those who are mentioned at least 10 times over the 30-year period. This limitation could be dropped once a complete electronic version is accessible. In all cases, though, there will be a strong concentration of the citations onto a small proportion of the total number of persons mentioned in the letters. Though much more are cited at least once, there are only 86 individuals cited more than ten times and they of course include the usual figures of the intellectual field at the beginning of the 17th century namely, Descartes, Galileo, Gassendi, along with comparatively lesser known ones like Roberval or Saumaise. The limited number of central figures is also evident in that 50% of the total number of citations is concentrated among 15 individuals, that is less than 20% of the total. These results are in

<sup>5</sup> For a recent survey, see Christiane Berkvens-Stelinck, Hans Bots and Jens Häselser, *Les grands intermédiaires culturels de la République des Lettres. Études de réseaux de correspondances du XVI<sup>e</sup> au XVIII<sup>e</sup> siècles* (Paris: Honoré Champion, 2005).

<sup>6</sup> João Gama Oliveira and Albert-László Barabási, “Human dynamics: Darwin and Einstein correspondence patterns”, *Nature*, 437 (27 October 2005), 1251.

<sup>7</sup> Eugene Garfield, *Citation Indexing. Its Theory and Application in Science, Technology and Humanities* (New York: John Wiley & Sons, 1979), 81–97.

<sup>8</sup> Small, H.G., “Co-citation model of a scientific specialty – Longitudinal study of collagen research”, *Social Studies of Science*, 7 (1977), 139–166; Gmür, M., “Co-citation analysis and the search for invisible colleges: A methodological evaluation”, *Scientometrics*, 57 (2003), 27–57.

<sup>9</sup> Börner, K., Chen, C., Boyack, K.W., “Visualizing knowledge domains”, *Annual Review of Information Science and Technology* 37 (2003), 179–255; Gingras, Y., “Revisiting the ‘Quiet Debut’ of the Double Helix: A Bibliometric and Methodological note on the ‘Impact’ of Scientific Publications”, *Journal of the History of Biology*, vol. 43, no 1, 2010, 159–181.

<sup>10</sup> Gingras, Y., “Mapping the Changing Centrality of Physicists (1900–1944)” in Daniel Torres-Salinas and Henk F. Moed (Eds.), *Proceedings of the 11th Conference of the International Society for Scientometrics and Informetrics (ISSI)*, (Madrid: Spain, 2007), 314–320.

<sup>11</sup> *Correspondance de Marin Mersenne*, de Waard, Cornelis (Ed.), 18 vols, (Paris: Presses universitaires de France & Éditions du CNRS, 1945–1988).

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