John Locke Like This: An Ego-Network Analysis

Introduction

John Locke (1632-1704) is at the earlier end of most narratives of the rise, or emergence, of the public sphere in Britain.[1] This article suggests that Locke's letter-writing practice fostered a highly literate and diverse whole out of many small, apparently discrete, communities. The networked publicity of Locke's sphere of letters was in no way a proto-democractic mass public. But Locke fostered a European intellectual public by providing a link between many separate groups of individuals. The ego-network illustrated and described here shows the composition of those groups, and what their relationships to one-another would have been without Locke's presence to bind them more closely together.[2]

Locke was a prolific letter-writer of the seventeenth and eighteenth centuries. Between 1652 and his death in 1704, he wrote 1251 letters and received 2755.[3] Though Locke's activities as a philosopher, political theorist and doctor have been comparatively well-served by posterity, his letter-writing, in common with the epistolary output of most of his contemporaries or near-contemporaries (barring notable exceptions like Lady Mary Wortley Montagu and, to some extent, Alexander Pope), has been largely overlooked. Locke's letters bear witness to the sheer breadth of his interests; studying the prosopography of their senders and recipients pulls together the many threads of Locke's interests: he corresponded a great deal about agricultural reform, spent considerable effort on expediting the publication of works he felt were important, and was in frequent touch with the Royal Society on matters both administrative and scientific. Locke's letters also show the social diversity of his acquaintance: he corresponds with an extensive network of

politicians as well as with alchemists, ship's captains, arabists, sinologists, metallurgists, spies, servants, and grocers.

I take here a computational approach to Locke's correspondence. Accordingly, I do not (as an analog analysis might) draw out interrelations among the contents of select letters and then use those findings to intervene in (or reframe) a larger historiographical debate. Instead I aim to reveal contours of Locke's social milieu hidden from us if we consider Locke only as the author of selected published works. This approach is enabled by a recent efflorescence of digital resources: the *Digital Locke Project*, *Electronic Enlightenment*, the *Oxford Dictionary of National Biography* and Intellex's *Past Masters* all make it possible to access, synthesize, and analyze information with greater ease than ever before.[4] Other projects have been undertaken with correlated aims: the *Kindred Britain* project and *Six Degrees of Francis Bacon* both conceive of historical time as a frame within which networks of kinship and collaboration can be traced and analyzed.[5] Where this study differs from those excellent projects is in its smaller scope and richer metadata.[6]

This article shows how generative a quantitative approach to Locke's correspondence can be, and I offer some analysis and interpretation of the data that such an approach would yield. Some historical insights can be generated through network and quantitative analysis that are complementary, but unavailable, to traditional qualitative analysis. I offer some preliminary efforts at such an analysis. Completed and thorough analyses of this sort are beyond the scope of this article: I aim instead to show the space within which future analysis could take place. Some of this future work will be on familiar figures and make refined and more quantitatively substantiated arguments on familiar topics: network and quantitative approaches can give heft to prior

intuitions. But other directions will be unfamiliar, because a networked approach can reveal unexpected trends, figures or movements. This article also suggests that, in the manner of other micro-historical efforts, smaller and representative datasets can yield insights applicable to the period in general. Towards the close of the article, I offer two easy-overlooked figures whose historical importance is made apparent by the correspondence network. This is the most literal sense in which digital methods are generative: quantitative analysis can direct fruitful future qualitative analysis.

Aims

This study has several correlated aims. It aims to show that quantitative approaches can generate historical insights unavailable to traditional qualitative analysis. These are of the order of offering a conceptual map of the social spaces of certain sectors of late seventeenth and early eighteenth England, France, and the Netherlands. While these spaces can be taken together as a milieu, that milieu is composed of overlapping constituencies of radically various individuals.

Although this study has its roots in the correspondence of a single author, it aims to desegregate the history of a period. It shows the degree of interpenetration among communities often studied in isolation from one-another; members of the Royal Society, deists and freethinkers, politicians, puritans and booksellers. By proxy it also makes a case for reintegrating our imagination of Locke himself. Rather than considering Locke as a philosopher mostly isolated from historical contingency, or as an educational theorist isolated from cutting-edge agricultural

management, or as an ecumenicist isolated from contemporary pharmacological and surgical debates, network analysis shows the contiguity of all these facets of Locke's life and interests.

The historiographical debates to which this article will, hopefully, contribute, include the extent to which epistolarity did or did not knit together homogenous communities (insofar as such things existed) into heterogenous wholes.

I will first outline my methods in creating the dataset underlying the visualizations that follow. I will then briefly explain how the network visualization software I have used works, and how to interpret the networks. I then present preliminary conclusions: the overall shape of the heart of Locke's ego-network, and then in turn the principle subnetworks that comprise it, beginning with the clearest and most discrete networks and descending to those most embedded in the fabric of the whole. This portion of the article addresses Locke's network as an agented phenomenon, binding together separate communities. I then interpret the network as an historical artifact void of Locke's own intentions as a letter-writer. It is in this, last, portion of the article that I suggest the specific possible future avenues for analog historical research, as well as using the dataset of Locke's correspondents to present micro-historical analyses of the demography of the group.

Method

I began by creating a spreadsheet of Locke's correspondents. I then input whatever biographical data I could find for each of the 335 correspondents, relying on the de Beer edition of Locke's letters, *Electronic Enlightenment*, *Past Masters*, the *Oxford Dictionary of National Biography*, the

Digital Locke Project, and other sources. Each correspondent (or "entity") has a unique identifier ("Entity ID").[7] Whenever I found that one correspondent had met, written to, or worked with another correspondent in the data set, I recorded that relationship by entering the Entity ID of that other correspondent. This created a link between the two entities. I then imported that spreadsheet into Gephi, a network visualization and analysis software package. By setting each correspondent's Entity ID as the "source" and their relationships as the "target", I visualized the relationship between the two. The links (or 'edge') between correspondents (represented by 'nodes') composes the mesh of relationships that comprises the graph.[8] Owing to the difficulty of construing the directionality of a relationship, or owing to the difficulty of applying that concept to business, family, or professional interactions, the graph is "undirected". This means that edges record only the fact of interaction between two nodes, without specifying as to the nature of that interaction.

As a static, rather than a dynamic, network graph, some information is either not captured or is glossed over in the graphs and analysis that follow. The graphs are chronologically flat aggregations: the network graphs that follow represent connections formed over an extended period of time. Therefore correspondents as temporally distant as George Williamson (1599 - 1685) and Francis Cudworth Masham (1686-1731) appear on the same network graphs as though they were contemporaries. Furthermore, nodes form edges within Locke's ego network but after his death. For example, if Sir Isaac Newton and Sir Hans Sloane's connection was formed after Locke's death, it is still represented here since both men corresponded with Locke and so form a

part of Locke's ego-network. As a result, the network graphs that follow trace the consequences of a historical fact — correspondence with Locke — more than a specific chronological span.

The undirected nature of the edges between nodes makes relationships within the network appear reciprocal. Although many were, this is not necessarily the case. There is also no weight given to the edges, so that the edge formed between correspondents who exchanged one letter is here given the same weight as an edge between nodes who exchanged a hundred; that between family members is the same as that between professional acquaintances. Finally, links between correspondents whose relationship was one of professional, political, or intellectual rivalry are represented identically to those between friends, family, and allies. The links on these graphs are binary: they record only knowing vs. not-knowing.[9]

Despite the limitations of, and distortions produced by, a chronologically flat graph, a static graph offers analytic possibilities that a dynamic graph does not.[10] A dynamic network based on letters presents profound difficulties for the would-be analyst. From when does the connection brought into existence by a sent letter begin? The time of writing, dispatch, receipt, or reading? And for how long after that beginning does a connection persevere? Different correspondences have different rhythms, from daily exchange to annual or longer. A static graph allows us to value those different frequencies of correspondence equally. Since the focus of this study is on connections and prosopography, static visualization avoids visual and analytical clutter. Edges formed between nodes by meeting in person present similar difficulties for dynamic graphs: for how long after two nodes meet can they considered to be connected? Are estranged children still considered connected to their parents? The social and material history of interaction is all that this

study can gauge; the fluctuations of intimacy are beyond its scope. The logic of the dynamic network can be extended to demand an ever-increasing amount of information.

The last reason why a static network graph is the best tool to use to investigate the forms of social interaction fostered by seventeenth- and eighteenth- epistolarity is that concepts like community identity exist only in relation to spans time. The sub-communities with which Locke corresponds, and the larger body they form together, are artifacts of labor over time. A chronologically flat graph aggregating material and social records from between roughly 1660 to 1730 is the best way to see those artifacts. Locke's ego-network is especially condign to this sort of analysis because of its size and the demographic variety of its nodes.[11]

General findings

Locke's 335 correspondents are a diverse group. Locke had many talents and interests, and his correspondence network reflects that fact: it contains members of the Royal Society; Dutch, French, Swiss and Belgian philosophers; doctors and theologians; farmers; tailors; servants; bankers; philanthropists; arabists; botanists; clergy of all stripes; merchants and grocers; politicians; civil servants; administrators; courtiers, and experts on miscellaneous subjects such as poison, witchcraft, or ways of life in parts abroad such as Sweden or Bonn. To read Locke's letters is to enter the early Enlightenment in all its heterogeneity and disciplinary blurring. Locke formed a connection, albeit an indirect one, between all these correspondents. The graphs below record how, had these individuals not known Locke, they might or might not have known one another.[12]

The quantitative analysis herein offers empirical evidence for hitherto unsubstantiated intuitions (as described above). For example: there is a strong correlation between membership of

the Royal Society and the occupation of physician; and Mary Clarke, Damaris Masham and Dorothy Countess of Shaftesbury were three of the best connected women of their day in this sphere and were, moreover, better connected to other women than anyone else. Accordingly, new areas of study open up to us. Perhaps because of the institutional support that they tended to require, arabists tended to cluster together (Boyle, also an arabist, knew three of the remaining four himself) whereas lawyers did not. Neither did members of the Royal College for Physicians: of the eight members of the Royal College of Physicians in Locke's ego network, only the two who are also noted collectors, John Woodward and Sir Hans Sloane, appear know one another. A map of book collectors reveals a similar story, as does a map of Locke's pupils. Theologians, however, did correspond with one another. Generally, the more clustered experts in a given specialty are, the less common that expertise is. Examining the distinctness versus the embeddedness of expertises allows us to gauge the overall penetration of that expertise into Locke's intellectual sphere.

Of the 335 correspondents in Locke's network, 131 — almost 37% — knew no-one else in the network. A low level of interconnectivity does not necessarily correlate to a lack of historical importance, but rather a low level of social coincidence with Locke. And correspondingly, neither does a high number of connections to a node — its "degree" — necessarily correlate to that node's importance. John Churchill, 1st Duke of Marlborough, for example, has a degree of 2 in Locke's ego network, but this in no way reflects the extent of the Commander-in-Chief's political influence in the period. The network graph privileges those individuals whose milieu most closely resembled Locke's. The four best connected nodes (just over 1% of the nodes) account for 26.5% of all its edges. While in part this reflects the truth that some agents are more active in history than others,

it also records the isomorphism of those four figures' social interactions with Locke's. Moreover, the quantitive data offered by this study were produced through chains of interpretative decisions, and the objective rhetoric of quantification is to be resisted. Consider the network graph below as an example. Imagine four nodes, labelled A through D. If I were to record the connections between these nodes, their network graph might look like this:

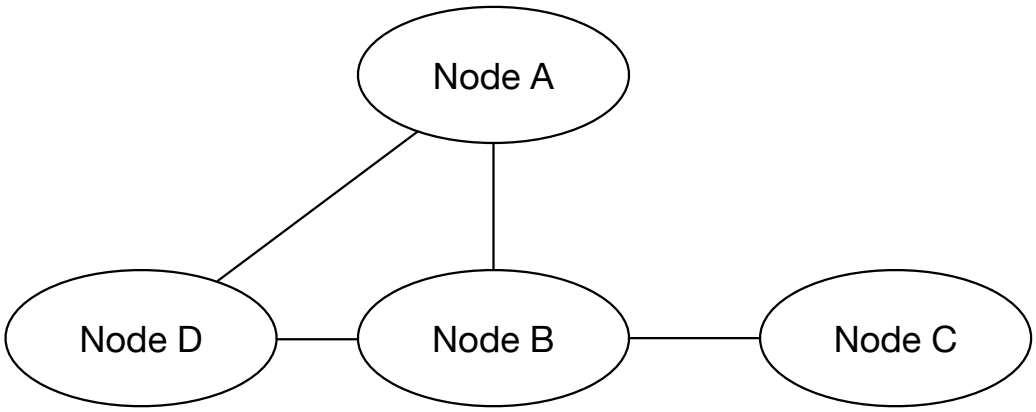


Figure 1: Sample network graph showing imagined relationships between nodes A, B, C, and D

In this graph, nodes A and D have a degree of two, node B has a degree of three and node C has a degree of one. Node B has the highest degree in the network and node C the lowest. As we see, however, "degree" is purely a network descriptor. The graph below shows the degrees of the nodes in Locke's own network:

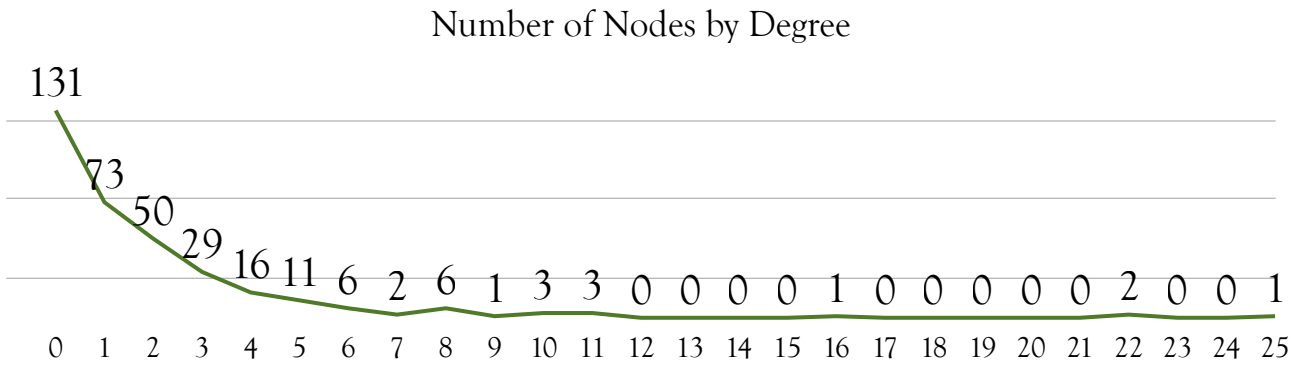


Figure 2: Graph showing degree distribution of nodes

This graph shows that the number of nodes with a given degree decreases exponentially as degree approaches 7, from which point it fluctuates irregularly. This distribution mimics a power law curve, a common descriptor of distribution frequency.[13] Its applicability here implies the similarity of Locke's ego-network to contemporary ego-networks, which typically display the same distribution patterns. This is not to gesture toward a presentist point about Locke's ego-network; rather it is to say that the shape of its distribution is quite usual and replicated across time and media.

I begin with an overview of the ego-network in general, before showing the different sub-communities that Locke's letter writing practice tied together. I treat the interconnectivity of these sub-communities — whether distinguished by common practices, geography, religion, or social class — as an emergent property of Locke's intentions in fostering an early European intellectual public. I then treat the network as a found object, capable of disclosing historical facts void of Locke's intentions or actions.

The most important communities that Locke wrote to are his family, his "Row College", Fellows of the Royal Society, French doctors around Nicolas Toinard, and Dutch anatomists around Philippus van Limborch. More integrated and less easily-discerned networks include the

groupings around the Mashams, a political and aristocratic circle around Anthony Ashley Cooper the 1st Earl of Shaftesbury, and the publishing and puritan community around Awnsham Churchill. Some of these communities carry traces of Locke's life and travels: his acquaintance with the dutch doctors, for example, mostly dates from his period of exile in the Netherlands (1682-8), and his French correspondents from his travels in France (1675-9). There is, inevitably, overlap between the sub-communities. This overlap sometimes manifests within a single node: Awnsham Churchill, for example, was a freethinker, politician and publisher. However, since the majority of his connections in Locke's ego-network owe to his publishing and book-selling activities, I treat him as a publisher first and foremost; in the present context that is his most important role.

The connected center of Locke's network can be seen below.[14] This represents roughly half of the 335 nodes, but over 90% of the edges (this means that nine out of ten of the interactions among the total group of 335 can accounted for by half its members). The other half of the nodes are either in smaller networks or have no connections at all.

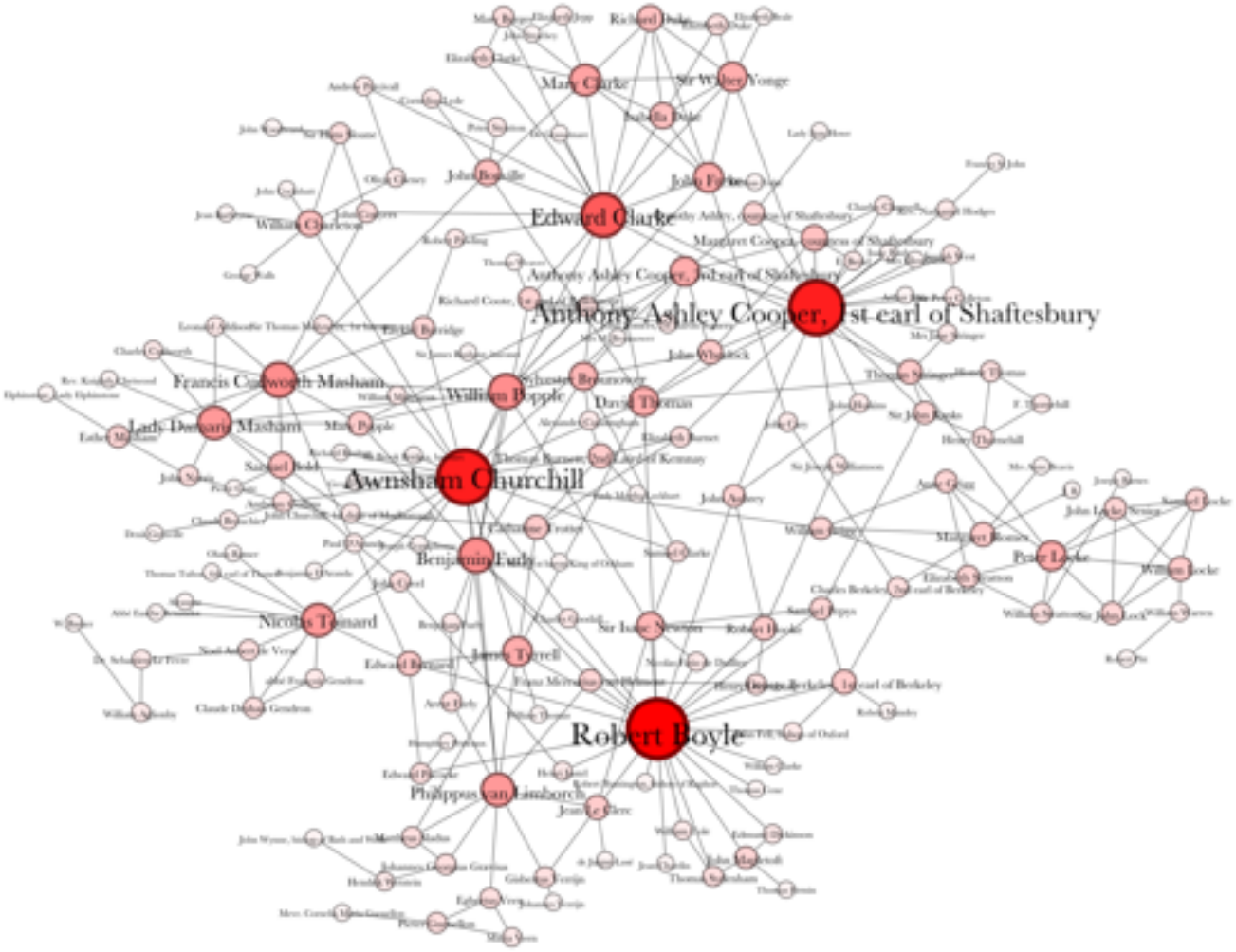


Figure 3: Graph showing the core of Locke's ego-network. Nodes are ranked by degree both in their size and their coloring. For clarity, both redness and largeness correspond to high degree; whiteness and smallness to low.

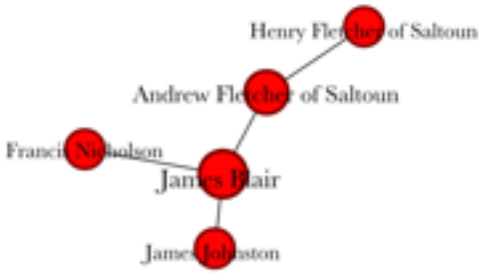
In the above figure, the four nodes with the highest degree are the reddest and largest. As a node's degree decreases in this map, it shades closer to white and shrinks. The four nodes with the highest degree are:

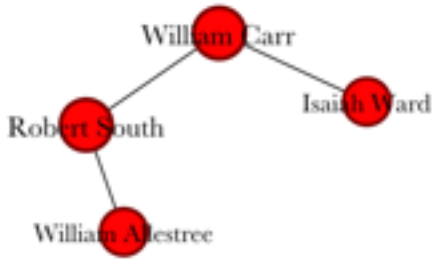
Node	Degree
Robert Boyle	25
Awnsham Churchill	23
Anthony Ashley Cooper, 1st Earl of Shaftesbury	22
Edward Clarke	17

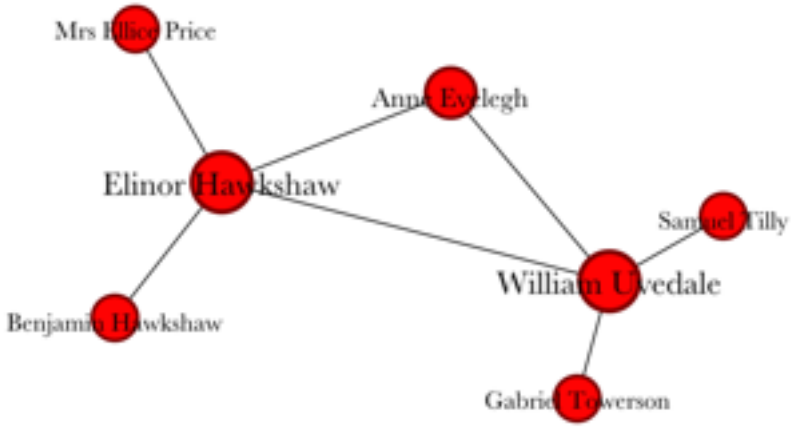
Figure 4: table showing the four nodes in Locke's ego-network with the highest degree

These four men were highly prominent figures in, respectively, science, publishing, politics, and educational theory. As the secretary of the Royal Society, it is unsurprising that Boyle should have the highest degree in Locke's ego-network since his work involved corresponding with the Society's members.[15] On the other hand, Awnsham Churchill's high degree stems from his activities as a printer and bookseller more than from his letter-writing activity. Locke's patron, Anthony Ashley Cooper the 1st Earl of Shaftesbury, owes his high degree to his vigorous political activity and his membership of the titled nobility. Edward Clarke, executor of Shaftesbury's estate, politician, and member of Locke's family (by marriage) received a large proportion of Locke's letters (over four hundred) including the material that would develop into *Some Thoughts Concerning Education* (1693).[16] Clarke's degree owes to his political activity, but also to his membership of what Locke called his "College," comprising the Clarkes, Richard Duke and his wife Isabella, Sir Walter Yonge, and John Freke.

Beyond this large central network, there are small outliers. Four Scotsmen (Andrew Fletcher, Henry Fletcher, James Johnston) and one Englishman (Francis Nicholson) knew one another but no-one else. Elinor Hawkshaw (née Parry, wife of Bishop Richard Hawkshaw), an early love of Locke's, is part of a small network also shown below.







Figures 5, 6, and 7: graphs showing three isolated subgroups within Locke's ego-network

There are several other pairs of nodes in the network, but these are the only substantial networks outside of the central network. This means that Locke's ego-network appears, overall, highly centralized. Those nodes in Locke's ego-network with no edges at all are reasonably unlikely to have been major agents in the during his life-time. Before we analyze the main center of the

network in detail, however, I want to emphasize that nodes that might appear closely connected in network terms, like Elinor Hawkshaw and Gabriel Towerson, above, still did not know one another despite their connection through William Uvedale (and, not visualized but implied, through Locke). The visual rhetoric of the network makes disparate nodes appear more connected than they really are, since nodes with no direct connection to one another, no matter how many other nodes they may have in common, still did not know one another. This is why even though I speak of a centralized core to the network, that core still comprises a balkanized group.

The network in the light of Locke's intentions

I. *Tightly embedded groups*

The clearest single cluster in all of Locke's network is that of his family:

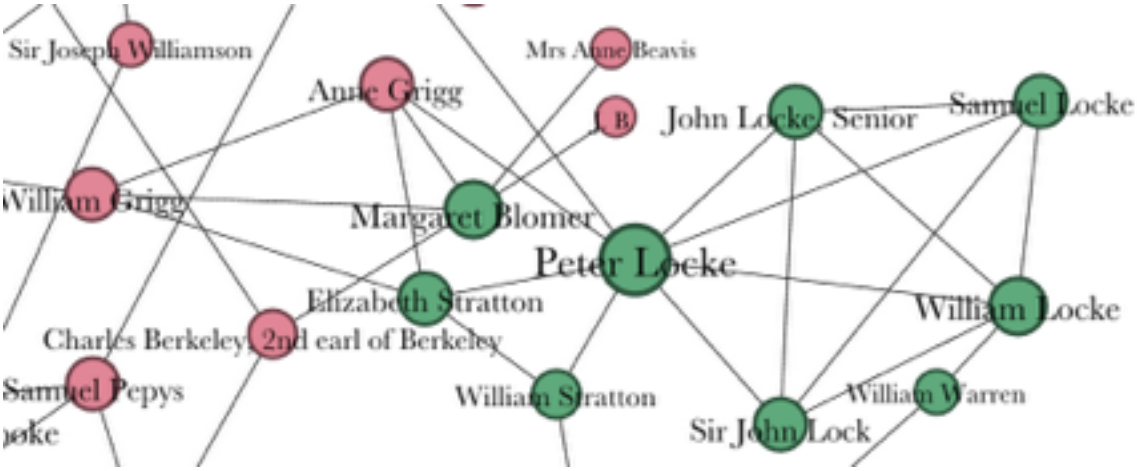


Figure 8: Portion of Locke's ego-network, focused on his family.

In this figure, as in most that follow, green represents nodes that do belong to a category, and red represents nodes that do not belong to a category. Locke's immediate family is shown here: John Locke senior, his father, Samuel Locke, his cousin, Peter Locke, his uncle, William Locke his great-

uncle, William Stratton, his cousin and Elizabeth William's wife, Margaret Blomer (née Beavis), Locke's cousin, and Sir John, Locke's second cousin.[17] The other branch of Locke's family is better enmeshed in the central network, through Locke's cousin Mary Clarke (née Jepp), her daughter Elizabeth, and her husband Edward:

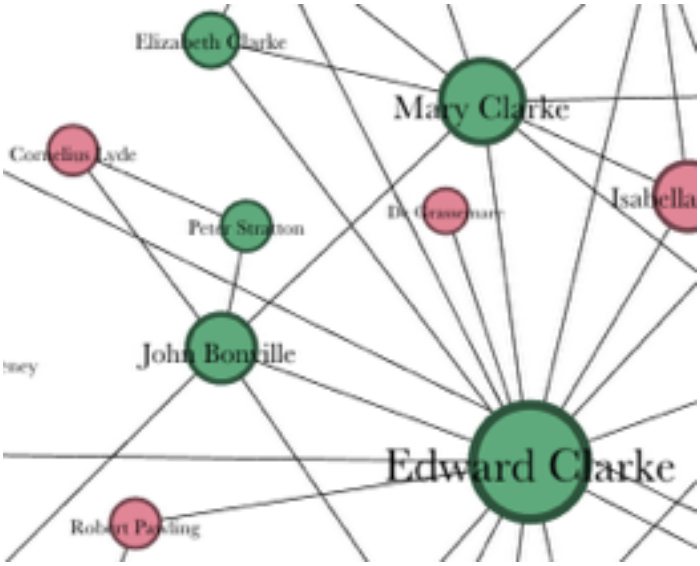


Figure 9: Detail of Locke's ego-network showing other family members in green and non-family in red.

Bonville and Peter Stratton are also Locke's cousins. Edward Clarke is the family member of Locke's with the highest degree and the only nodes in his family to be thoroughly enmeshed in the central network, including as a key member of Locke's own "College," which is shown below:

Figure 10: Detail showing members of Locke's College in green, non-members colored red.

Locke's "college" was a group of Junto Whigs who advised Locke on matters of monetary policy, press licensing, agricultural reform and the recoinage debate. As William Sachse notes, the college "was a miniature club, meeting as such when the members were in London and maintaining a correspondence with Locke during the rest of the year."[18] The college was most politically active during the period from 1694-7. Its clear clustering together in Locke's ego-network corresponds to the college's operation as a distinct social grouping. The distinctness of that group can be measured by their average clustering coefficient (0.485), and comparing it to the mean for the rest of the network (0.102).[19] By one measure at least, Locke's college is more than four times more clustered together than is average among his correspondents. Even excluding those correspondents who knew no-one else in Locke's network and recalculating the average (0.168) shows the college as almost three times more strongly clustered. In this sense Locke's family and his

"college" are unusual groups among Locke's correspondents; and the college's tight clustering should come as no great surprise. But the college's proximity on the network graph to other subgroups — the political circle around Shaftesbury and the puritan/bookselling circle around Popple and Awnsham — is revealing. Since Locke relied on the college both to keep him apprised of policy developments and to exert influence for him by proxy, the closeness of the college to the publishing world as well as to the political group shows that that influence was exerted through print as well as through parliament.

After Locke's family and the College, the clearest-cut networks that Locke joins together are those of the Royal Society, which centers predominantly on Robert Boyle, and the social circles of Nicolas Toinard and Phillippus van Limborch. The first graph below shows the enmeshment of fellows of the Royal Society in Locke's network as a whole.[20] Though fellows are scattered through the network, Robert Boyle is their hub, as the following graph illustrates (as before, green indicates membership of the Royal Society and red indicates non-membership).

Figure 11: Graph of the centre of Locke's ego-network, showing members of the Royal Society in green, and non-members in red.

This second graph shows how fellows of the Royal Society cluster around Boyle. Since Boyle is the secretary of the Royal Society for some of the period tracked by this network graph, this seems entirely logical.

Figure 12: Detail showing the members of the Royal Society clustered around Boyle

The third, below, shows only Boyle's connections, and demonstrates that owing his very high degree, almost half his edges are with non-Royal Society members:

Figures 13 and 14: ego-networks showing only those nodes who knew both Boyle and Locke. 13, left, shows members of the Royal Society as green, non-members as red. 14, right, show scholars as green, non-scholars as red.

Connectivity among those nodes colored green, in figure 13 above, is much higher than connectivity among nodes colored red. This implies that membership of the Royal Society correlates to a higher degree. By comparing figures 13 and 14, however, we see why we should be wary of attributing Boyle's high degree solely to his duties as Secretary of the Royal Society: almost all his correspondents are scholars, whether they are fellows of the Society or not.[21]

The graph below shows the network around numismatist, physicist, theologian, translator, and doctor Nicolas Toinard. This network is most likely a product of Locke's four years traveling through France with Shaftesbury (1675-9). Toinard also forwarded letters for Locke from Paris in the 1680s. In the graph below, while the size of the node still corresponds to its degree, color

indicates country of birth: red corresponds to England, dark blue to France and green to Denmark. Nodes like Toinard (and Boyle) are hubs; points to which multiple other nodes connect.

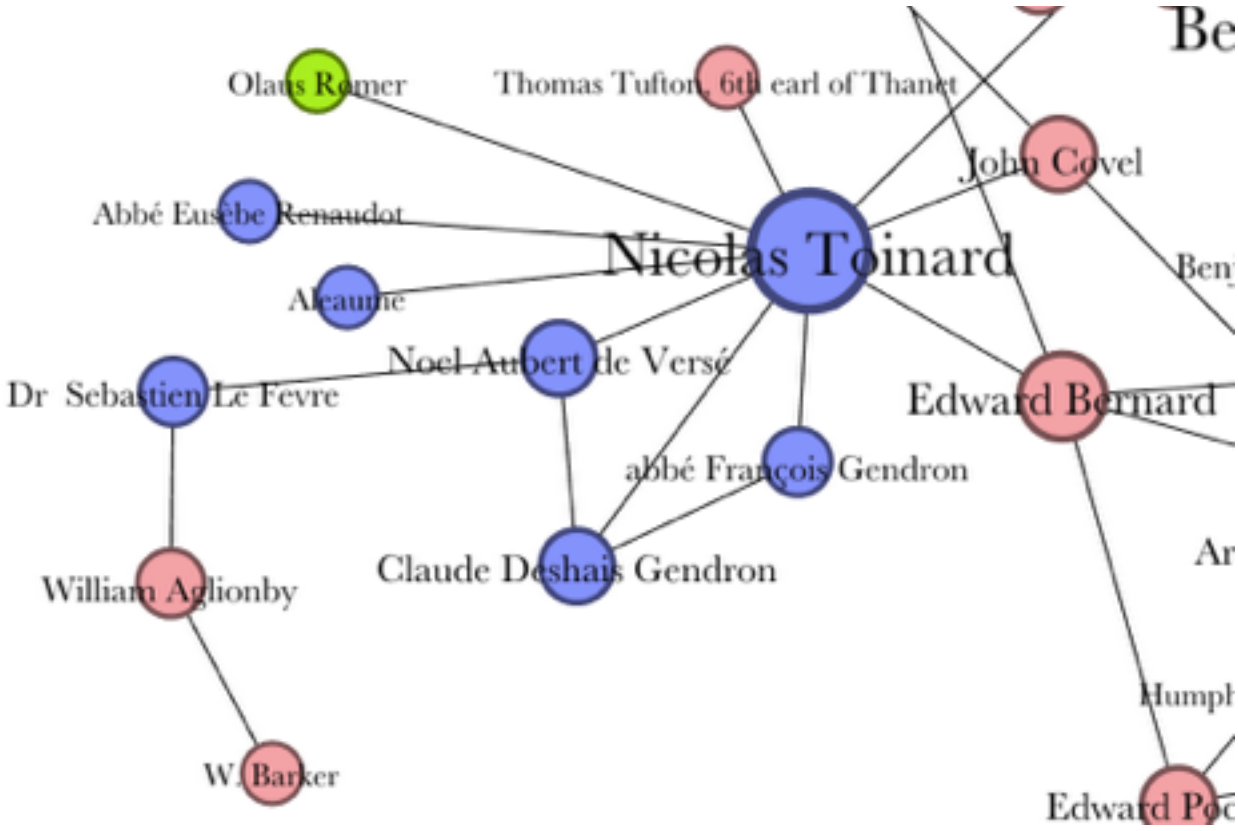


Figure 15: Detail showing nodes around Toinard. Blue nodes are French; red English and green Danish.

Of the nodes in Toinard's network, Abbe Gendron, Claude Gendron, de Fevre, and Brouchier are physicians; along with Boyle, Toinard's ego-network has the highest proportion of physicians. Particularly in his role as Locke's forwarder from Paris, Toinard was Locke's hub of French intellectuals.

The Dutch hub in Locke's ego-network is Phillippus van Limborch. Van Limborch was a theologian, editor, latitudinarian and sometime mouthpiece of the Remonstrant movement (in

texts such as *Theologia Christiana, ad praxin pietatis ac promotionem pacis Christianae unice directa* (1686)) and it was on religious toleration that he and Locke found the most common ground. When Locke went into exile in the Netherlands between 1682 and 1688, he and van Limborch visited each other often and wrote to one another multiple times each day. The graph below shows the portion of Locke's ego-network for which van Limborch was a hub. The colors in this graph below correspond again to country of birth: orange corresponds to the Netherlands, red to England, cyan to Germany, dark blue to France, yellow to Switzerland and pink to Wales:

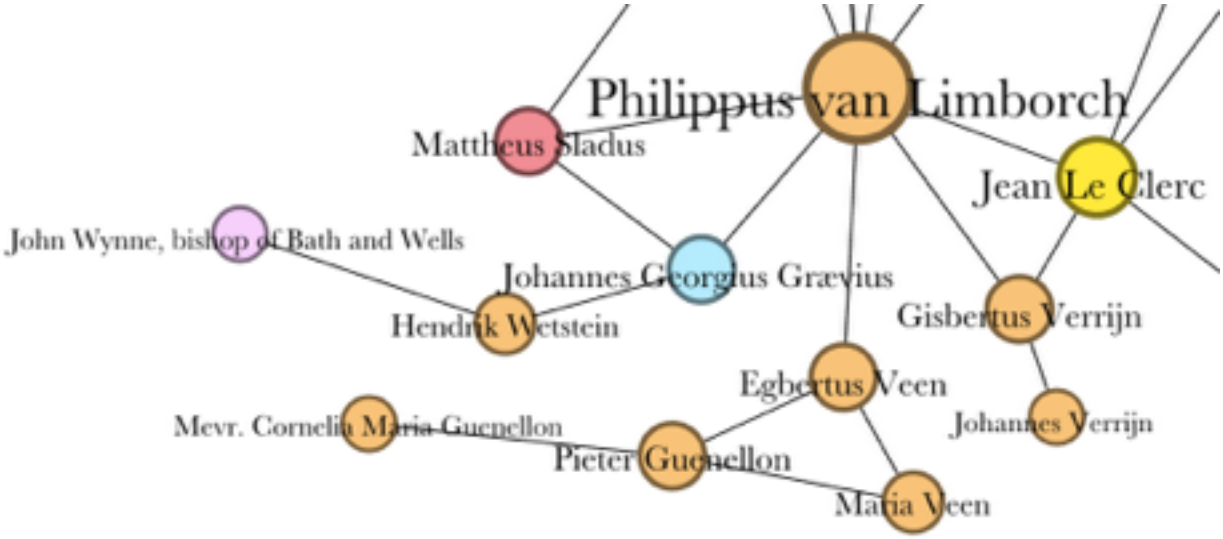


Figure 16: Detail showing nodes around Philippus van Limborch.

Including van Limborch, six of the above were Remonstrant; the Guenellons, the Verrijns and Henrik Wetstein. All but the Veens, Johannes Verrijn and Maria Guenellon were scholars, working as physicians, translators, theologians and classicists. The cosmopolitanism of van Limborch's branch of Locke's ego-network as compared to Toinard's reflects in part its religious diversity. Toinard's network comprises Catholics, Anglicans and a Lutheran (Rømer), while van Limborch's

includes Remonstrants, Reformed, Lutheran, Anglicans, a Freethinker and (not shown) a quaker (Arent Furly). Limborch is more tightly embedded in the larger central hub than Toinard, and perhaps this reflects Locke's own considerable ties with Dutch culture, including his support for the accession of William and Mary to the throne of England in 1688/9.

II. *Loosely embedded groups*

Locke's family, his "college," the Royal Society, and the ego-networks of Limborch and Toinard are all sub-networks that are easily observable and tightly clustered. A few more distinct groupings remain that are loose: the Mashams and their associates, a loose group of politicians and titled nobility around Shaftesbury, and the puritans and pamphleteers around Awnsham Churchill. These networks are less clustered and therefore less easily discerned than the first five that we have seen; they bleed into one another a little and are more part of the same overall social milieu than are they first five groups. Nevertheless, they remain distinct groups whose connections with each other would have been far more attenuated without Locke than they were with him.

Locke lived with Lady Damaris Masham for several years at Oates, from 1691 onward, until his death at the Masham home in 1704.[22] Under Locke's guidance, Lady Masham tested his theories of education in *Some Thoughts Concerning Education* on her son, Francis Cudworth Masham. Lady Masham's network of thinkers derived from her work as a philosopher and Platonist.[23] Though she was connected to Awnsham Churchill through the latitudinarian Samuel Bold, her network is discrete:

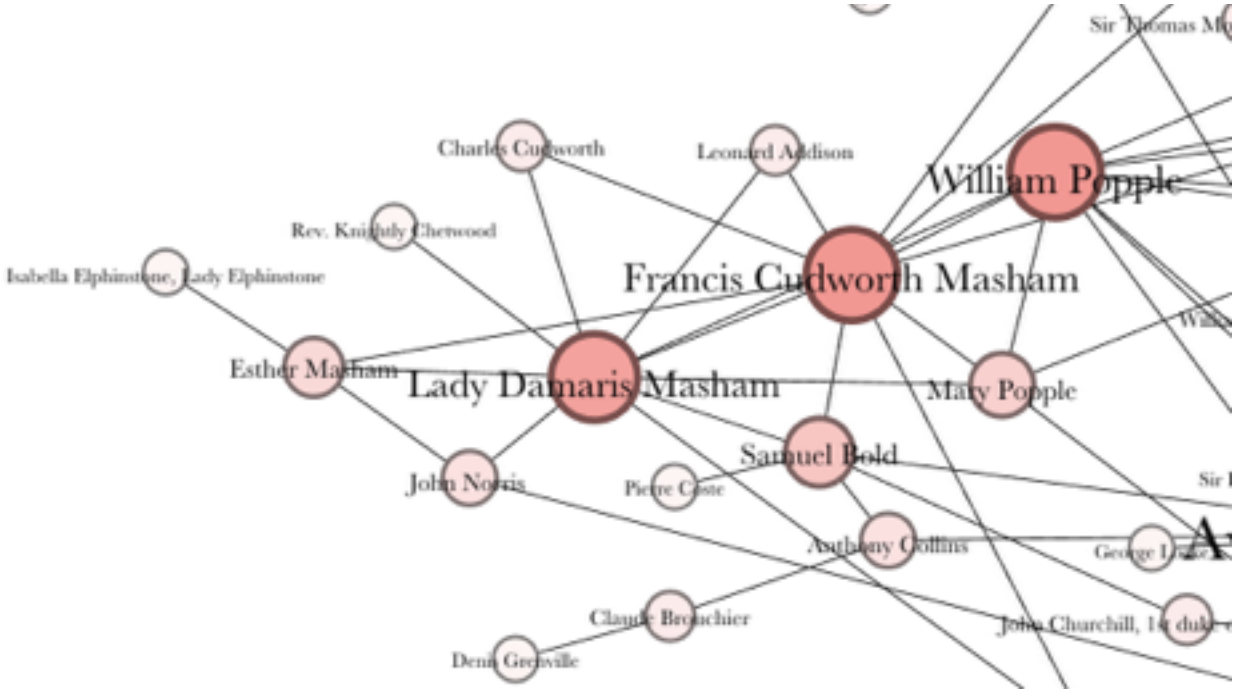


Figure 17: Detail showing nodes around Damaris Masham. Node size and redness correspond to degree.

The theologians in this group include John Covel (not shown), Samuel Bold, John Norris, Pierre Coste, Anthony Collins and William Popple (Andrew Marvell's nephew and the translator for Locke's *Letter on Toleration* (1689) from Latin). The fact that Masham occupies a distinct corner of Locke's network perhaps bears out the circumstances underlying her 1687 remark to Locke that he "might advise me to converse with the dead since here [at Oates] are so few living that are worth it."[24] Masham's relatively retired life at Oates makes her network a relatively clustered one (see discussion of clustering coefficients below).[25]

Locke's patron and friend, Anthony Ashley Cooper the 1st Earl of Shaftesbury, is a hub with an extensive network owing to his vigorous and high-profile political activities. Members of the titled nobility cluster tightly around Shaftesbury; as would be expected, there is a strong correlation between the groups of titled nobility and politician. The clustering of political figures of Locke's acquaintance around Shaftesbury is only to be expected since from their introduction through David Thomas in Oxford in 1667 Shaftesbury was a principal entrée for Locke into Whig politics.

Figure 18: Detail showing nodes around the 1st Earl of Shaftesbury. Nodes colored green are politicians, nodes colored red are not.

The only titled nobility in the graph above not colored green — marked as politicians — are the countesses Shaftesbury. Shaftesbury has a high degree within Locke's overall ego-network but is only loosely embedded in his network (with a correspondingly low clustering coefficient). This is because Shaftesbury's network ties has tend to be, in Mark Granovetter's terms, weak rather than

strong.[26] His strong ties are with his three other family members, all of whom know one another. But his other seventeen ties are weak: to people who don't know one another and who therefore don't form a cohesive network. The preponderance of weak ties to strong ones makes Shaftesbury — like other hubs in Locke's ego-network — Damaris Masham's graph, above, has several very strong ties: Leonard Addison, her husband Charles Cudworth son Francis Cudworth, Mary Popple, and Samuel Bold all know both her and at least one other node who also knows Lady Masham. By contrast, Lady Masham has relatively few weak ties, i.e., those to nodes who form a loose and expansive network. Lady Masham's clustering coefficient is relatively high for a node with a high degree, and her network well embedded. The comparison between Shaftesbury and Lady Masham's networks reveals a possible truth of the networks of politicians as opposed to the networks of philosophers: the politicians in the network tend to know many people and to be less well integrated into those people's ego-networks, whereas philosophers know fewer people but are much more deeply enmeshed with them: the average clustering coefficient for politicians is 0.102; for non-politicians it is more than double, 0.243. Philosophers average slightly higher than non philosophers, 0.264 to 0.206.[27]

Awnsham Churchill's network is the most diffuse of the component parts of Locke's ego network. In part this simply reflects the confluence of Churchill's political and financial interests with Locke's. As Locke's publisher and the publisher for many other writers, and as an active politician himself, Churchill has a very high degree but, like Shaftesbury, very weak ties.

Figure 19: Detail showing only those nodes that knew both Awnsham Churchill and Locke.

The graph of Churchill's ego-network shows that relatively few of his edges know one another. What gives his network cohesion is the series of triangles formed with Popple, Furly, Thomas, Clarke, Tyrrell and van Limborch. Several of these men — van Limborch, Clarke, and also Toinard, are also hubs of their own sub-networks, as seen above. While Awnsham Churchill is a hub in his own right, he is also a connector between hubs. This is a more unexpected result than the networks around Boyle of Shaftesbury; it shows that Churchill connected French and Dutch intellectuals, puritans, and politicians. The sub-network above shows that Locke's publisher is an ideal candidate for further study, as a facilitator in the intellectual world of late seventeenth- and early eighteenth-

centuries. Moreover, apart from Churchill's role as a connector of socially, geographically, and intellectually disparate worlds, his centrality is also revealing about Locke. Students of Locke's work are familiar with his theoretical contributions to Whiggism.[28] But the efficient dissemination of dissenting writing was itself a political act, and the comparative co-extensivity of Churchill's connections with Locke's highlights the practical dimension of Locke's Whiggism.

Gephi, the software I have used to generate all these visualizations, has its own tool for visualizing discrete communities within a network; 'modularity'.[29] The algorithm's authors write that 'A promising approach consists in decomposing the networks into sub-units or communities, which are sets of highly inter-connected nodes. The identification of these communities is of crucial importance as they may help to uncover a-priori unknown functional modules such as topics in information networks or cyber-communities in social networks.' (1001) These highly interconnected sub-units, or sub-networks as I have been treating them, are rendered by Gephi as below:

Figure 20: Graph showing the modularity of Locke's network colored according to Gephi's algorithm's discernment of separate communities within the overall central network

The groups that the algorithm has discerned should now be familiar to us: the orange community at the bottom, around Phillippus van Limborch, the lilac network around Robert Boyle, the olive green network around Nicolas Toinard, the yellow network of Locke's family, the red network around Lady Damaris Masham, the darker purple network around Awnsham Churchill, the light green around the 1st Earl of Shaftesbury and the light blue around Row College. This leaves only two small clusters unaccounted for; the light pink group at the upper left and the central grey cluster. The light pink group is a cluster centered on Sir Hans Sloane, John Conyers, and William Charleton. The grey cluster centers around Thomas and Elizabeth Burnet of Kilkenny, Catherine Trotter, and Locke's amanuensis Sylvester Brounower. The algorithm's discernment of sub-networks leads us to the final portion of the analysis: treatment of the network as a non-volitional artifact.

Network as non-volitional phenomenon

The data I gathered in preparing the set of correspondents for network analysis exceeds that visualizable in network graphs.[30] So far, I have examined Locke's ego-network largely as a volitional phenomenon, in terms of the connections that Locke and his contemporaries forged with one another. I have not yet considered the network as an emergent and contingent object. Rather than focusing on prominent hubs and observable communities of historical actors with shared characteristics, this second approach considers underlying dynamics of the network. This can reveal unexpected avenues of study: for example, an node that appears not to have great importance may be statistically more central than any visually appealing hub.

The most central node in Locke's network, and the node with the strongest weak ties, is David Thomas. Thomas was Shaftesbury's personal doctor, and introduced the two in 1667 when Shaftesbury came to visit Oxford. Thomas is the only node with ties to Locke's ego-network's four most significant hubs; Edward Clarke, Awnsham Churchill, Shaftesbury and to Robert Boyle. David Thomas's importance is of a kind that could only be uncovered through network analysis. Like Awnsham Churchill, Thomas's historical importance inheres in his enmeshment in his society as a facilitator. David Thomas was a doctor with connections to some of leading scientists, politicians, publishers and philosophers of his day; the unusual strength of his connections shows that he was close to the correlated revolutions in those four spheres. Such a figure is ripe for investigation.

I introduced a brief discussion of clustering coefficients above.[31] A clustering coefficient is a measure of how many of a node's ties also know one another; as I said above, a high clustering coefficient (closer to 1.0) means strong ties, and a low clustering coefficient (closer to 0.0) is linked to weak ties. The more ties a node has, the more difficult it is for that node to have a high clustering coefficient, so there is a correlation between low degree and high clustering coefficients.[32] Simply put, a node's clustering coefficient is an expression of the likelihood that connected nodes have other, third party, connections in common.

The nodes with the highest clustering coefficients are, overwhelmingly, those in Locke's college and in his family. These groups are ideal for the algorithm, as they are tightly self-contained, thoroughly inter-connected groups of more than three. Among nodes with degrees in the range 3 -

12, the top eight nodes are from these two groups. This correlates to my earlier claims that these were the two most easily distinguishable groups.

The lowest clustering coefficients in the whole network (among those nodes that actually have a clustering coefficient since a value of 0 indicates no clustering at all) are as follows:

Node	Degree	Clustering Coefficient
Awnsham Churchill	23	0.02767
Nicolas Toinard	10	0.04444
Sylvester Brounower	7	0.04762
Anthony Ashley Cooper, 1st earl of Shaftesbury	22	0.05195
Robert Boyle	25	0.05333

Figure 21: Table showing the least 'clustered' nodes in Locke's network, along with their degree.

It is no coincidence that the three nodes with the highest degree in the network are in the bottom five for clustering coefficient; the more actors you know, the harder it is to be deeply enmeshed in a single network. Awnsham Chuchill has the lowest score because he is the most evenly and diffusely enmeshed in Locke's ego-network as a whole. This affirms Churchill's centrality in Locke's network. The clustering coefficient disproportionately favors nodes with low degree: the nodes with the twenty-eight highest clustering coefficients all have a degree of 4 or lower. The twenty-ninth highest node by clustering coefficient is Isabella Duke (a member of Locke's College), with a degree of 6.

To counteract the bias of the clustering coefficient algorithm, I have devised a weighted clustering coefficient that expresses a value contingent on a node's degree as compared to the overall average weighted degree. The average degree for nodes in the network is 3.463. Therefore we can calculate a node's weighted coefficient like this:

$$\text{weighted coefficient} = (nodedegree/averagedegree)^2 * (clustering\ coefficient)$$

By squaring the relationship between a node's degree and the network's overall average, I am putting my finger stronger on the scales in favor nodes with a higher degree. We could calculate the weighted coefficient of a node with a degree of 3 and a clustering coefficient of 1 like this: $(3/3.463)^2*1$. This would have that node a weighted coefficient of 0.75. This goes some way towards combatting the inherent bias created by counting triangles.[33] Reasonably enough, the weighted coefficient still gives members of Locke's college and his family the highest values, but it punishes nodes with an artificially high coefficient and a very low degree (ie, nodes with degree 2 and a clustering coefficient of 1, which form a single triangle, like Leonard Addison, are displaced from the highest values to the 64th highest). This is the top twenty nodes ranked by their weighted clustering coefficient:

Node	Family or College	Clustering Coefficient	Degree	Weighted Coefficient
Edward Clarke	College and Family	0.133	16	2.839
Robert Boyle		0.053	25	2.762
Mary Clarke	College and Family	0.389	9	2.627
Isabella Duke	College	0.800	6	2.402
Richard Duke	College	0.800	6	2.402
Sir Walter Yonge	College	0.429	8	2.289
Anthony Ashley Cooper, 1st earl of Shaftesbu		0.052	22	2.099
John Freke	College	0.357	8	1.905
William Popple		0.164	11	1.655
Peter Locke	Family	0.286	8	1.526
Lady Damaris Masham		0.178	10	1.484
Benjamin Furly		0.145	11	1.463
Margaret Cooper, countess of Shaftesbury		0.467	6	1.402
Anthony Ashley Cooper, 3rd earl of Shaftesbu		0.250	8	1.334
Sir Robert Eyre		1.000	4	1.334
John Locke, Senior	Family	1.000	4	1.334
Samuel Locke	Family	1.000	4	1.334
Sir John Lock	Family	1.000	4	1.334
Philippus van Limborch		0.156	10	1.301
Francis Cudworth Masha	Family	0.127	11	1.281

Figure 22: Table showing the ranked weighted clustering coefficients.

This weighting rewards Boyle and Shaftesbury for their unusually high degrees. Once again, the college and family show well by this metric. But Edward and Mary Clarke's high ranking shows how remarkable their connectivity is. Even with this very strong weighting, however, Awnsham Churchill is still only the twenty-second clustered node. Accordingly, we can treat the Clarkes as exemplary practitioners of a kind of connectivity that we might call functional, and Awnsham Churchill of a kind of connectivity that we might call (without judgment) opportunistic. But other

figures, with a common diversity of interests and expertises, emerge as possible objects of study: the puritan Popple and Quaker Furly, both non-conformist theologians, merchants, and latinists. This is only a first pass of the kinds of statistical analysis that network visualization makes possible; taken together, William Popple, Benjamin Furly, David Thomas and Awnsham Churchill form a set of individuals correlated and even aligned with Locke's activities, but separate from them. A study of the four would benefit Locke studies as well as the history of the late seventeenth and early eighteenth centuries.

Conclusion

This project centers on Locke's ego-network; its conclusions can be laterally applied only insofar as Locke can be taken as an historically representative case, rather than as an outlier. But the subjects of micro-histories such as this one are chosen paradoxically for their subject's *a*typicality. Locke links disparate communities, many of whose members disagreed fiercely with one another and fought some of the bitterest battles of the Enlightenment. Catholics and Huguenots, bishops and anatomists, Whigs and Tories all correspond with Locke and so are indirectly connected with one another. As Anthony Grafton writes, "The citizens of the early modern Republic of Letters created a virtual community not of those who shared beliefs, but of those who differed. They made up rules for civility: rules that could be used to judge the conduct of all those who offered their intellectual wares for sale in the new, largely free market."[34] Despite its balkanization, the ego-network this article has taxonomized testifies to the well-known force of disinterested discourse and of epistolarity. I have shown here that network analysis can shed new light on the specific contours

of that power and of its exercise, both through major hubs and unexpecteded connectors. In so doing, it allows us to pay a new kind of attention to warp and weft of the historiographical record, and to pick out threads we might never have seen before.

[1] Conventional accounts of the rise of the public sphere in seventeenth and eighteenth-century Britain rely on public – published – writing to build their notions of reciprocal, socially and intellectually inclusive, engaged and dynamic bodies of writers and readers.The writing produced as evidence for the rise of the public sphere has included pamphlets, news books and other periodicals, plays, novels, or poems. Private letters between individuals, however, have been included less often precisely because narratives of the nascent public sphere consider it to be self-constitutively composed of public statements about other public statements. For critiques and refinements of Habermas see (for example) David Norbrook, *Writing the English Republic* (Cambridge: Cambridge University Press, 1999), Jason McElligot's *Royalism, Print and Censorship in Revolutionary England* (Woodbridge, 2007), and in Peter Lake and Stephen Pincus (eds.) *The Politics of the Public Sphere in Early Modern England* (Manchester: Manchester University Press, 2008). Other competing visions of the public sphere have been offered by Keith Baker in "Defining the Public Sphere in Eighteenth-Century France: Variations on a Theme by Habermas," in Craig Calhoun, ed., *Habermas and the Public Sphere* (Cambridge, Mass.: M.I.T. Press, 1991), 181-211, and Michael Warner in *The Letters of the Republic: Publication and the Public Sphere in Eighteenth-century America*, (Cambridge, Mass: Harvard University Press, 1990). Anne Goldgar's *Impolite Learning: Conduct and Community in the Republic of Letters, 1680-1750* (New Haven: Yale University Press, 1995), is especially pertinent to this study.

[2] For corroborating studies, see Candice Delisle's "Accessing Nature, Circulating Knowledge: Conrad Gessner's Correspondence Networks and his Medical and Naturalist Practices," *History of Universities* 23 (2008), and David A. Kronick, "The Commerce of Letters: Networks and 'Invisible Colleges' in Seventeenth- and Eighteenth-Century Europe," *The Library Quarterly* 71 (2001): 28-43. See also forthcoming work by Philip Gleissner on the twentieth-century network of Russian emigré journals.

[3] Here and throughout this article I have relied on the landmark edition of Locke's letters compiled and edited by E. S. de Beer, *The Correspondence of John Locke*. 8 vols. (Oxford: Oxford University Press, 1976–1989). I have also benefited tremendously from *The Digital Locke Project* @ http://www.digitallockeproject.nl/. Only a small number of figures from a roughly similar context have corpora of letters of comparable sizes: Henry Oldenburg, Robert Boyle, Hans Sloane and Isaac Newton. For an analysis of Oldenburg's letters, see Iordan Avramov, "An Apprenticeship in Scientific Communication: The Early Correspondence of Henry Oldenburg," *Notes and Records of the Royal Society of London*, Vol. 53, No. 2 (1999): 87-201. For an overview of Boyle's remaining papers, see Michael Hunter and Lawrence M. Principe, "The Lost Papers of Robert Boyle", *Annals of Science,* 60.3, (2003): 269-311.

[4] Similar tools are being pioneered for comparable figures. For example, The University of Sussex's Newton Project (http://www.newtonproject.sussex.ac.uk/) is working to transcribe and and make every word of Newton's writing digitally available, whether it was printed or not. The Sloane Printed Books project at the British Library is constructing an online database of all the books Sloane owned (http://www.bl.uk/catalogues/sloane/), while London's Natural History Museum is attempting an even more ambitious project by re-gathering together Sloane's non-literary collections (http://www.nhm.ac.uk/research-curation/science-facilities/cahr/projects-partnerships/sloane/index.html).

[5] See *Kindred Britain,* http://kindred.stanford.edu. Accessed December 20th 2015, and *Six Degrees of Francis Bacon*, http://www.sixdegreesoffrancisbacon.com/. Accessed December 20th 2015.

[6] For an example of the historical analysis possible with a rich set of metadata, see Maria Comsa, Melanie Conroy, Dan Edelstein, Chloe Edmundson and Claude Willan, "The French Enlightenment Network," *Journal of Modern History*, forthcoming.

[7] For more information on the categories of metadata I captured, see the online schema document.

[8] The data was refined using Open Refine and analyzed using Refine, Microsoft Excel, Apple Numbers, and, principally, Gephi (version 0.8.2 beta and latterly 0.9). See Bastian M., Heymann S., Jacomy M. "Gephi: an open source software for exploring and manipulating networks." International AAAI Conference on Weblogs and Social Media, 2009.

[9] It is certain that there were connections between nodes that are now lost to history. Neither can I prove that any one node did not know any other node: this graph represents a conservative estimate of the actual historical network of relationships. But the greater the separation between nodes in the network, the more exponentially unlikely such an unrecorded connection becomes. The analysis that follows must be read with this disclaimer in mind.

[10] See for example James Moody, Daniel A. McFarland and Skye Bender-DeMoll, "Dynamic Network Visualization: Methods for Meaning with Longitudinal Network Movies," *American Journal of Sociology* 110 (2005): 1206-1241, and Arnaud Casteigts, Paola Flocchini, Walter Quattrociocchi, Nicola Santoro, "Time-Varying Graphs and Dynamic Networks" in *Ad-hoc, Mobile, and Wireless Networks, Lecture Notes in Computer Science* 6811 (2011): 346-359.

[11] By comparison, among the other most prolific correspondents of the Enlightenment, almost 19,000 of letters to and from Voltaire survive; 5586 of Rousseau's, 3666 of Bentham's, 1001 of Hume's, and 657 of D'Alembert's, (All these figures include totals sent *and* received.) All of these correspondents, however, were writing later than Locke, which makes Locke's connectivity the more remarkable. However, figures like Peiresc and Kircher predated Locke and had much larger bodies of correspondence; they are ripe for this kind of analysis.

[12] Locke's spectral presence in the ego-network makes it a quasi-counterfactual object. Any two nodes separated by more than one node in the graphs below are in truth more closely connected through their common acquaintance of Locke than through the connections recorded in the graph.

[13] Albert-László Barabási, *Linked: The New Science of Networks* (Basic Books, 2002).

[14] Detailed biographical analysis of all nodes, along with larger and better-resolution images of all visualizations can be found online at http://claude.willan.github.io/JohnLocke I have also put up dynamic, interactive and navigable network graphs for readers to browse this data for themselves.

[15] *Electronic Enlightenment Online* records that Boyle wrote and received a combined total of 1996 letters.

[16] Here and throughout, for biographical details crucial to the construction of the dataset I am deeply indebted to *Electronic Enlightenment Project*, http://www.e-enlightenment.com/ Bodleian Libraries, University of Oxford, 2008–2013, on whose metadata much of the early work on this project was based. I also had extensive recourse to the *Oxford Dictionary of National Biography* entries for Locke and his correspondents, http://www.oxforddnb.com/, Oxford: Oxford University Press, 2013, Roger Woolhouse, *Locke: A Biography* (Cambridge: Cambridge University Press, 2007), H. R. Fox Bourne *The Life of John Locke* (New York: Harper, 1876), 2 vols, *The Digital Locke Project* at http://www.digitallockeproject.nl, the entry on Locke by William Uzgalis, "John Locke", in *The Stanford Encyclopedia of Philosophy* (Fall 2012 Edition), Edward N. Zalta (ed.), <http://plato.stanford.edu/archives/fall2012/entries/locke/>, and the voluminous Locke records held at the Penn State Libraries *John Locke Resources* site, at http://www.libraries.psu.edu/tas/locke/, Penn State Libraries, 2009 - 2012. I also drew on Bradford William Short, "The healing philosopher : John Locke's medical ethics" in *Issues in law & medicine,* 20 (2004):103-154.

[17] For an analysis of the identity of 'J.B.' see Charles Bastide, *John Locke: Ses Theories Politiques et leur influence en angleterre* (Slatkine: Geneve, 1970), 54fn1.

[18] William Lewis Sachse, *Lord Somers: A Political Portrait* (Manchester University Press, 1975), 116. See also Henry Horwitz, *Parliament, Policy and Politics in the Reign of William III* (Manchester University Press, 1977), 152-3, and de Beer, *The Correspondence of John Locke,* V:199.

[19] For a deeper exploration of clustering coefficients, please see below.

[20] On the early history of the Royal Society, see Michael Hunter, *The Royal Society and Its Fellows, 1660-1700: The Morphology of an Early Scientific Institution. 2nd edition* (Chalfont St. Giles: British Society for the History of Science, 1994). Hunter has also written extensively on Boyle himself, including *Robert Boyle Reconsidered* (Cambridge: Cambridge University Press, 1994), *Robert Boyle (1627–91): Scrupulosity and Science* (Boydell Press: Woodbridge, 2000), and *Boyle: between God and Science* (New Haven : Yale University Press, 2009).

[21] The four nodes who are members of the Royal Society but *not* scholars are Edward Pococke, Samuel Pepys, Charles Berkeley the 1st Earl, and Jean Chardin.

[22] For a recent enquiry into Masham's influence on Locke, see Terrence Moore, "John Locke and Damaris Masham, nee Cudworth: Questions of Influence" in *Think* 12.34 (Summer 2013), 97-108. See also Frankel Lois, "Damaris Cudworth Masham: A Seventeenth Century Feminist Philosopher" *Hypatia* 4.1 (Spring 1989), 80-90.

[23] See Sheryl O'Donnell's "Mr Locke and the Ladies," *Studies in Eighteenth Century Culture* 8 (1979) and '"My Idea in Your Mind": John Locke and Damaris Cudworth Masham', in Ruth Perry and Martine Watson Brownley, eds., *Mothering the Mind: Twelve Studies of Writers and Their Silent Partners* (N. Y.: Holmes and Meier, 1984), 26–46; and James G. Buickerood, "What is it with Damaris, Lady Masham?: The historiography of one early modern woman philosopher," *Locke Studies* (2005): 179-214.

[24] In D. W. Hayton, E. Cruickshanks, and S. Handley, eds., *The History of Parliament: the House of Commons, 1690–1715*, 5 vols, (2002), cit. Bridget Hill, "Masham [née Cudworth], Damaris" in *Oxford Dictionary of National Biography* online, <http://www.oxforddnb.com> accessed January 2nd 2016.

[25] For the algorithm used to calculate clustering coefficients, see Matthieu Latapy, "Main-memory Triangle Computations for Very Large (Sparse (Power-Law)) Graphs," *Theoretical Computer Science* 407 (2008): 458-473.

[26] For the definitive studies of weak ties, see Mark Granovetter, "The Strength of Weak Ties", *American Journal of Sociology*, 78.6 (1973): 1360 - 1380, and "The Strength of Weak Ties: A Network Theory Revisited", *Sociological Theory 1* (1983): 201-233.

[27] Both these sets of figures exclude nodes with a degree of zero.

[28] See Richard Ashcraft and M. M. Goldsmith, "Locke, Revolution Principles, and the Formation of Whig Ideology", *The Historical Journal*, 26.4 (1983): 773-800.

[29] For the key work on the modularity function, see Vincent D Blondel, Jean-Loup Guillaume, Renaud Lambiotte, and Etienne Lefebvre, "Fast unfolding of communities in large networks", in *Journal of Statistical Mechanics: Theory and Experiment*, (2008): 1000-1012, and R. Lambiotte, J.-C. Delvenne, M. Barahona *Laplacian Dynamics and Multiscale Modular Structure in Networks* (2009).

[30] For alluvial diagrams and other visualizations, please see the online supplement. This includes, for examples, investigations of the correlations between religion at birth or through conversion with expertise or community. Using the dataset and Palladio, the network's development across time can also be traced.

[31] Network visualization also permits us to contextualize the subjects studied in the genre of "microhistory." The rhetoric of the microhistory is that it is, to some possibly undefinable extent, representative of a larger trend. With network visualization we can evaluate the extent of that representativeness, and seek out better candidates for this kind of work. After all, the more compelling the claims for representativeness, the more forceful the microhistory. Using a metric like clustering coefficient, the historian can select a subject near the mathematical average of connectivity and clustering.

[32] The clustering coefficient algorithm devised by Matthieu Latapy counts triangles of nodes: "A triangle in an undirected graph is a set of three vertices such that each possible edge between them is present in the graph. ... In the context of complex network analysis, triangles also play a key role in the study of motif occurrences, i.e. the presence of special (small) subgraphs in given (large) graphs." Latapy, "Main-memory Triangle Computations for Very Large (Sparse (Power-Law)) Graphs," 458. Therefore only nodes with three edges or more are eligible for a clustering coefficient (since a pair of nodes cannot represent a cluster).

[33] Latapy's illustrative example involves a network of millions of Belgian phone and internet users. What is subtle for a dataset of that size is blunt for a dataset of 335.

[34] Anthony Grafton, "A Sketch Map of a Lost Continent: The Republic of Letters", *Arcade*, *Republics of Letters: A Journal for the Study of Knowledge, Politics, and the Arts* (2009): 17-18.