

CLOSED CIRCLES OR OPEN NETWORKS?: COMMUNICATING AT A DISTANCE DURING THE SCIENTIFIC REVOLUTION

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As many historians have remarked, the new philosophy of the seventeenth century self-consciously privileged the depiction and description of things and events over discussion and debate between antagonists. But new “matters of fact” were often unpredictable, strange, or anomalous, things that could never have been constructed from learned argument.¹ Because they could be discovered only through observation or investigation, the truth or error of reports about new matters of fact could not be judged according to reason alone. Establishing new knowledge about nature therefore depended upon multiple and sometimes ambiguous ways of judging the reliability of testimony about matters of fact.

One method of establishing reliable testimony has elicited a great deal of historical work in recent years: the creation of strong social bonds among communities of investigators. Robert G. Frank, Jr, for instance, emphasized the techniques of investigation that William Harvey acquired and utilized, which he communicated personally to others in England with whom he worked closely. The people who imbibed his “tacit knowledge” at Harvey’s feet became a circle of Harveians, which slowly broke up after his death.² Other historians have emphasized a somewhat different kind of close community: societies of gentlemen who witnessed demonstrations or observations together and could collectively vouchsafe their veracity. Published communication about what had taken place within these closed circles often stressed the reportage of “virtual witnessing” to create the impression in readers of having been there, too.³ Still others have, in different ways, stressed social status as a guarantor of credibility: whether the gentlemanly status of the main body of Fellows of the Royal Society, the aristocratic status of an investigator’s patrons, the social legitimacy of a religious order or university faculty, or the etiquette and honour of courtly life, social prestige is said to have established the credibility of matters of fact asserted by members of a group.⁴ Such views suggest that an élite established credibility within their powerful but closed circles, and then communicated what

they agreed upon to others as true matters of fact.

Whether intended or not, many of these approaches have implicitly left the impression that the new philosophy was created within closed circles: that like Francis Bacon's "Lamps", "Inoculators", and "Interpreters of Nature", a small cadre of insiders determined what counted as truths of nature. But Bacon's *New Atlantis*, like Hobbes's *Leviathan*, was written for a monarch with pretensions to absolutism and the desire to control ideas and events. As it happened, however, hosts of people, of many different social and geographical locations, were involved in the establishment of matters of fact. For example, despite a reputed disdain for businessmen among the English gentlemen, the straightforward accounts of merchants were on occasion counted among the models of creditworthiness, even for the aristocratic Robert Boyle: "you will be invited to look on this account, though not yet as compleat, yet as very sincere, and on that score Credible", he wrote, not because it was written by a philosopher "to broach a *Paradox*, or serve an *Hypothesis*", but because it was set down "by a Merchant or Factor for his Superiors, to give them an account of a matter of fact".⁵ By emphasizing the relationship between sincerity and credibility, Boyle may have been playing on the ancient notion that simple people were not prejudiced by theory or clever enough to lie credibly.

Michel de Montaigne elaborated this point in his famous essay on cannibals. There he reported as true what his servant told him after having spent ten or twelve years in Brazil, explaining: "This man I had was a simple, crude fellow — a character fit to bear true witness; for clever people observe more things and more curiously, but they interpret them; and to lend weight and conviction to their interpretation, they cannot help altering history a little.... We need a man very honest, or so simple that he has not the stuff to build up false inventions and give them plausibility; and wedded to no theory. Such was my man...."⁶ The mark of truth might come from first-hand reports more generally (as in the case of Gonzalo Fernández de Oviedo's or Bartolomé de Las Casas's accounts of the New World⁷), or from someone who had a maker's knowledge of a thing.⁸ In this spirit of valuing direct and first-hand testimony of the unsophisticated, Boyle might declare that many useful medicines might be found "from the writings of so ingenious a people as the *Chineses*" as well as by following up on the practices of "Midwives, Barbers, Old Women, Empericks, ... and partly by the *Indians* and other barbarous Nations".⁹

It is therefore important to broaden the discussion of credibility to include many factors well beyond those of closed circles or high social status. Formal and informal institutional arrangements, and social relationships, were important in the development of the new philosophy,¹⁰ but as the examples above suggest, élite virtuosi such as Boyle might well accept reports from people he had never met as true, even from those half-way around the world whose writings he could not read, or even from "old women" down the street with whom

he might never exchange a word socially. Boyle's acceptance might indeed constitute acts of appropriation, but he was nevertheless aware of taking knowledge from those outside his immediate social circle.

Attention to the ways in which matters of fact were communicated becomes of especially pressing importance if one wishes to approach the development of the new philosophy as an international movement. Local and personal witnessing of experiments might indeed help to create bonds of trust among members of the Royal Society in London, but different milieux created different patterns of local investigation and reporting elsewhere in Europe.¹¹ Moreover, as the case of Antoni van Leeuwenhoek reminds us, foreigners who had never visited the Royal Society of London — who even spoke no Latin, French, or English, and who had no gentlemanly status — might be made members of the Society. They too might have the results of their investigations read in meetings and reported in the *Philosophical transactions*, and they might be considered to be leading practitioners of the new philosophy. Despite differences among the social sites for the production of knowledge, and despite differences among the social ranks of the virtuosi and *savants*, credible information and ideas spread widely throughout Europe. Without the ability to place trust in reports of matters of fact that had not been personally experienced by people like oneself, the new philosophy would have remained fragmented and isolated in local social and geographical spaces.

The concept of networks suggests an alternative to thinking in terms of circles and classes. Some of Bruno Latour's work, for instance, has used network theory to open up the closed circles of a local laboratory to include a variety of people and products (even non-human actants) in the making of knowledge.¹² A further stimulus comes from modern social network theorists.¹³ Indeed, one of the most useful observations for the analysis below was made by Mark Granovetter over twenty years ago. Granovetter noted that most investigations into social networks have taken strong ties for granted, studying the ways in which close friends and kin of one neighbourhood or another interact and exchange words. He noticed, however, what he termed "the strength of weak ties".¹⁴ When people sought employment, for instance, they often received a great deal of crucial information from acquaintances rather than from those within their inner circle.

One of Granovetter's more intriguing findings on social networks appeared in the observation that information or rumour might circulate quickly among the members of a group, but seldom entered or exited a group by means of strong ties. The explanation for this observation attributes the pattern to the fact that strong social ties often close people in tight circles of interaction. Granovetter noted, therefore, that "whatever is to be diffused can reach a larger number of people, and traverse greater social distance ... when passed through weak ties rather than strong". Drawing on a study of "hysterical contagion" in a southern

textile plant, Granovetter further generalized that the most influential innovators tended to be “individuals with many weak ties”, since they were “best placed to diffuse” their ideas. Put another way, “Weak ties are more likely to link members of *different* small groups than are strong ones, which tend to be concentrated within particular groups”. Paradoxically, then, “weak ties, often denounced as generative of alienation ... are here seen as indispensable to individuals’ opportunities and to their integration into communities; strong ties, breeding social cohesion, lead to overall fragmentation”.¹⁵

Several urban language studies have reiterated the importance of Granovetter’s observation on the significance of weak ties. Sociolinguistic findings in both Philadelphia and Northern Ireland, for instance, “emphasize the need for acknowledging the importance of loose knit network ties in facilitating linguistic innovations”. An inverse correlation appears to exist between stable communities bound by strong ties and linguistic change: linguistic change occurs — and has occurred — most rapidly in communities with multiple weak ties.¹⁶ Linguistic “innovators” tend to be marginal, whereas the “early adopters” are more socially central.¹⁷ Social network theory therefore not only (*à la* Latour) points to the importance of links between people in multiple social and geographical locations, but suggests that new information and ideas, like new words, tend to come from people with many weak social bonds.

In the material that follows, we seek to explore the workings and possible significance of weak ties in the international exchange of scientific information during the late seventeenth century. Our primary aim is to suggest that weak ties furnished the basis for a communication strategy that addressed the problems created by new “matters of fact” reported by observers of untested credibility. In a sense, communications based on weak ties met one of the problems of communicating with “strangers” by incorporating individuals into personal networks of weak ties maintained by correspondence.¹⁸ Effectively, the virtuosi of the late seventeenth century dealt with the difficulties of knowledge reported by strangers by establishing contacts that created at least a minimal level of personal relationship.

Tracing out the workings of communications based on weak ties will lead us to consideration of their significance. Certainly, as the circles, societies, and academies of the late seventeenth century took shape and began to work toward the dissemination of scientific knowledge, we should expect to see some evidence of change in communications networks based on weak ties. In fact, such appears to be the case, as the correspondence of Henry Oldenburg and others reveal in conjunction with the passing of scientific information in the period before and after the founding of the Paris Academy of Sciences. We will examine the importance of weak ties, how they were established, and how they worked not only to convey new matters of fact but to establish their credibility. Our examples focus mainly on how English virtuosi communicated with people across

the Channel, but we also venture some larger generalizations in the conclusion about the significance of these patterns for understanding early modern scientific organization. It is arguable that without the proliferation of weak ties, the international movement called the scientific revolution could never have happened.

TRAVELLING, PERSONAL CONTACT, AND CREDIBILITY

That credibility as well as information flowed from one site to another grew from interpersonal trafficking in the “philosophical commerce” of the day. Just as with the flow of coin, the flow of information needed to be examined carefully before being accepted, for it might well be clipped, debased, forged, or otherwise worth less than it appeared. Moreover, as with merchants, so with philosophers: travel not only brought them in touch with new knowledge and things but established the personal credit upon which international exchanges could take place. During visits, people of learning not only traded information but sized each other up and decided whether to trust one another as accurate judges of natural events. From these personal contacts grew in turn the networks of correspondence that sustained the philosophical commerce over longer stretches of time and place. Travel, more than any other activity, established the weak ties by which knowledge could be exchanged.

Many examples can be brought out to illustrate the ways in which information and credibility flowed through weak ties established by travel. Let us begin with one that linked Java, the Netherlands, and England. It concerns the “discovery” of moxibustion by Hermann Busschoff, a Calvinist minister newly resident in Batavia (now Jakarta), then the capital of the Dutch East Indies. Busschoff had suffered for many years from the gout. He finally allowed his wife to persuade him to seek help from a local “Indian doctress” who reputedly had a method to treat his condition. On his toe, this woman burned moxa, which he described as “a very soft and woolly substance, made by a very skilful preparation out of a certain dried Herb”, formed into “a little pellet ... which is scarce of the bigness of a small white pea, at one end somewhat sharp, and at the other end flat”, placed with the flat end on the skin and then set alight. It quickly burned, leaving only a bit of oil on the skin. He quickly found relief from the pains of his gout by this method.¹⁹

Busschoff sent a manuscript explaining this therapy to his son back in Utrecht, along with samples of the moxa. When his son published the treatise in Dutch in 1674 to develop a market for the moxa, Constantijn Huygens, Secretary to the Prince of Orange, was among those who noticed. He wrote to Henry Oldenburg at the Royal Society, sending along a copy of the book.²⁰ The Royal Society had already heard a vague report about the use of moxibustion in Japan communicated via the Dutch,²¹ so when the virtuosi heard Huygens’s report about Busschoff’s method, they asked that a translation of Busschoff’s treatise

be published (which appeared in 1676 along with a treatise by one of the noted Amsterdam surgeons).²² Huygens also struck up a correspondence with Busschoff himself,²³ while recommending the use of moxibustion for the gout to the English ambassador in The Hague, Sir William Temple, who also experienced relief from it.²⁴ The Dutch microscopist Antoni van Leeuwenhoek quickly turned his attention to investigating moxa with his little lenses, sending a report to the Royal Society.²⁵ The interest among the virtuosi in moxibustion also soon led Thomas Sydenham to mention it favourably in his book on the gout,²⁶ while physicians in Germany began to use it with apparent success, too.²⁷

The story above is generally about how a medical practice used in Asia came to be adopted for a time in England. It began with a minister's willingness to let his wife talk him into trying something new; in a sense, we begin with a strong tie. On the other hand, the name of the local practitioner who treated him was never mentioned, certainly suggesting what might be called a weak tie between the two; the relationship between wife and practitioner is not known.²⁸ The minister transmitted the account of his treatment to his son in the Netherlands, as well as in conversation to friends in Batavia: more close ties. But there it might have ended, had not a web of weak ties, all founded on personal meetings, brought it to the attention of other groups.

Busschoff's treatise was printed and fell into the hands of strangers; some of them in the Netherlands tried it out, tried to find out more about the practice and the reporters of the practice by drawing on their connections to visit the son and strike up a correspondence with the minister. They informed their acquaintances elsewhere and locally, including their English acquaintances, about a new matter of fact; the English in turn used their own ties to gather more information about the practice and about those who reported its success; and after hearing from many credible people about its beneficial results, they accepted the new remedy as a good one. Weak personal ties established between people in England and the Netherlands, between people in the Netherlands and in Batavia, and between the Dutch élite and ordinary local people in Batavia, lay behind the public acceptance of a new medical treatment; these weak ties were in turn founded on personal encounters that developed from geographical mobility.

The geographical mobility of early modern people was great. From the Middle Ages through the early modern period, students and scholars, like merchants, journeymen, and job-seekers, had often taken to the road.²⁹ The *peregrinatio academica* and related kinds of travels were crucial both to individual personal development and to the spreading of knowledge.³⁰ A few prominent examples will remind us of the personal toing-and-froing between England and the Continent to gather knowledge. Large numbers of early modern English and Scottish students travelled abroad for their educations, seeking out Italian, French, Flemish, and Dutch universities. Thomas Linacre and other Henrician humanists brought back the latest scholarly techniques from Italy. A few decades later,

the young John Dee travelled to Louvain to study mathematics with the noted Gemma Frisius. He brought back not only news of novel methods for applying mathematics to nature, but a brass astronomer's staff and brass astrolabe invented by Gemma, and two globes — one of the heavens and one of the earth — made by Gemma's pupil, Gerard Mercator.³¹

Others brought back not only new learning and instruments, but the tacit knowledge learned only from working under the tutelage of an adept. William Harvey learned several important techniques in Italy — such as vivisection and ligation — and brought them back to London. He then passed them on to his followers.³² Knowledge about how to construct an air pump travelled by news-letter from England outward, but its replication and calibration had to be carried out by personal inspection.³³ Travel also stimulated emulation: the London College of Physicians was in part inspired by Italian examples, as the Royal Society may later have been, while a delegation of French and Dutch *savants* in turn visited the Royal Society in 1663, helping to provoke the foundation of the Paris Academy of Sciences.³⁴ Furthermore, the wars of the seventeenth century caused large migrations between Britain and the Continent, transforming the *peregrinatio academica* into something closer to a general movement: Jan Comenius, Samuel Hartlib, and Henry Oldenburg came to England during the Thirty Years' War, and Thomas Hobbes, the Cavendishes, and many others, including Charles Stuart himself, fled to France and the Low Countries to avoid war and revolution in England. The former group brought the latest Central European enthusiasm for grand learned projects with them, while the latter learned about corpuscularianism in France and the Netherlands.³⁵ This massive exchange of people caused many to take up new practices and ideas. For instance, one of the Scottish royalist exiles, Sir Robert Moray, spent his time in Maastricht immersed in alchemy; after his return in 1660, he worked with the king in the laboratory that Charles constructed in the palace at Whitehall.³⁶ The mass royalist exile of the 1640s and 1650s firmly established the English version of the Grand Tour, on which young gentlemen and aristocrats of all sorts (and a few ladies) travelled through France to Italy and back, taking note of worthy matters and sometimes even meeting scholars.³⁷

Travel helped to shape three things: learning, experience, and judgement. The movement of philological techniques of scholarship among European regions during the Renaissance depended upon scholars from northern lands travelling to Italy to learn from the great humanists, so that by the later sixteenth century, northerners like Petrus Ramus and Justus Lipsius made travelling for learning a foundation-stone of their educational views.³⁸ In that spirit, among the committees established by the Royal Society of London in the 1660s was the Correspondence Committee, which not only began to collect information from foreigners; it also began to run through the published reports of voyages in order to collect new matters of fact, and it drew up various questions and

instructions for people travelling abroad so that they would bring back accurate and useful information from their experiences.³⁹ Some even argued that knowledge could be gained through the transformative experience of travelling itself. The Danish Paracelsian scholar Peter Severinus urged his readers to “sell your lands, burn up your books, buy yourself stout shoes, travel to the mountains, search the valleys, the deserts, the shores of the sea, and the deeper depressions of the earth”.⁴⁰ In a similar vein, Francis Bacon declared that “Travel in the younger sort is part of education; in the elder a part of experience”.⁴¹ Meetings with people outside one’s otherwise closed social circles during travel might even cause fundamental shifts in judgement. Marin Mersenne, for instance, became convinced during a trip to the Low Countries that people of good character might be excellent scholars even if they held to a different faith.⁴² Tutors who took the sons of lords and gentlemen on study tours were therefore instructed to make sure that they did not limit themselves to educating their pupils in reading and writing alone; they were to develop their pupil’s judgement. “[I]t was important to ‘study men as well as books’, to use the terms of Edmund Verney’s father, or otherwise his son’s ‘learning [might] make him rather ridiculous than esteemed’. Lord Burghley too informed his son’s tutor [before a trip abroad]: ‘I mean not to have him scholarly learned but civilly trained.’”⁴³

During the course of travel, many new acquaintances were made. Introductions to eminent people would be sought, but more ordinary people were encountered as well. For many, the personal meetings that resulted from travel established multiple weak ties that provided the foundation for later correspondence (to which we turn below).

They also helped people to evaluate matters of credibility. One of the most important ways to judge whether a report was true or not, of course, was to judge the veracity of the reporter. While people naturally included rank and its associated behaviours in the calculus of judging character — seventeenth-century Europeans did not even pretend to equality — they also noted other outward signs (such as bearing, dress, and cleanliness), inward attributes (such as demonstrated reliability, moral probity, experience, or even simplicity), and religious belief.⁴⁴ As Sir Matthew Hale put it, English juries had to judge the credibility of witnesses, noting not only their “Quality” but their “Carriage, Age, Condition, Education and Place of Commorance” [i.e., residence] as well,⁴⁵ and these and other considerations were commonplace for judging people. On the other side of the coin, outward signs of poor character pointed to likely fraud or cheating.

Character and characteristics were linked. Medical quacks, for example, could best be recognized not from bad medicines but from bad behaviour. Doctor Eleazar Duncan advised a gentleman to beware practitioners who exhibited “loquaciousness”, “haste”, “forwardness”, and “boastfulness”.⁴⁶ In the literature of the period, the connections between inner attributes and outward marks were

constantly used to create drama: Shakespeare's Richard III is perhaps only the most nasty physical example of a crafty and mendacious nobleman, while various simpletons who acted as they ought might (like King Lear's jester) speak truth to power. Consequently, in order to know someone's character, judgements needed to be made that ordinarily took shape only on the basis of personal interaction or on the basis of knowledgeable character witnesses. The meetings that took place during travels therefore established acquaintances and friendships that could be mobilized in the interests of establishing the credibility of persons, and by implication the credibility of what they reported.

Consequently, when reports from strangers arrived among groups of virtuosi, they often found it desirable to check on the character of the reporter, which they did by mobilizing their weak ties. For instance, at the meeting of the Royal Society of London on 18 January 1682, one of the Fellows, Theodore Haak, brought in and read a Latin letter from Willem Ten Rhijne, a Dutch physician practising in the East Indies at Batavia, written to the recently deceased Henry Oldenburg.⁴⁷ In it, Ten Rhijne asked to be informed of events in England, and gave a brief account of some observations he had made on the use of moxibustion⁴⁸ and acupuncture among the Japanese, on which he said he could elaborate. He wanted to know whether the Royal Society would be interested in publishing the manuscript he had written on the subjects.⁴⁹ Given the previous interest of the Dutch and English in moxibustion, and the vague reports of acupuncture that had also circulated, the virtuosi pricked up their ears.

Despite their enthusiastic interest, however, they first set out to ascertain whether the letter had come from a person who could be trusted to tell the truth. In anticipation of this, Ten Rhijne had not only signed his letter with his credentials (M.D. and member of the governing Council of Justice for Batavia); he established a person-to-person connection. Ten Rhijne wrote the virtuosi that they could find out more about him by talking to one of his friends, a Dutch physician and surgeon working in London, Joannes Groenevelt. Before they went any further with regard to Ten Rhijne's letter, therefore, the virtuosi instructed one of the Society's secretaries, Francis Aston, to talk to this intermediary.⁵⁰ At the meeting of the Royal Society of the following week, Aston and another Fellow, John Houghton, reported having met with Groenevelt, who both confirmed that Ten Rhijne was a physician holding posts of great responsibility in the Dutch East Indies and added that he had also been a star pupil of the great Leiden chemist and professor of medicine, François de le Boë Sylvius, who was already known to members of the Royal Society. Having thus had assurances of Ten Rhijne's good character and ability, the members of the Royal Society took him up on his offer, began a direct correspondence with him, and printed his book on moxibustion and acupuncture in London.⁵¹

Thus, behind the networks of correspondence that covered much of the globe in the early modern period lay personal contacts, usually weak ties. Given the

real interest of the virtuosi in moxibustion, the Royal Society might have authorized its secretary to reply to Ten Rhijne without any references, but such a practice would have risked placing their faith in someone of an unknown character. While the new philosophy was meant to be demonstrative and public, not all eyes counted equally. The question of whose reports to trust could be best resolved by judging the person. But while social rank and educational credentials counted heavily, trust was best built on personal visits — even at second or third hand, as when character references came from an intermediary who had already been judged worthy. At the bottom of the new philosophy, then, one finds visits, even when letters arrived from half-way around the world.

Written correspondence therefore ordinarily presumed personal connections, even if at one or two removes. For instance, one of the Royal Society's most famous foreign correspondents was Antoni van Leeuwenhoek. Leeuwenhoek had been introduced to the Royal Society by the Dutch physician Reinier de Graaf (already well known to Oldenburg through other intermediaries) in a letter to Oldenburg of 28 April 1673. A fellow citizen of Delft, De Graaf had pressured Leeuwenhoek into putting his early microscopic investigations on paper. Therefore, enclosed with De Graaf's letter of reference was Leeuwenhoek's first written report of an observation with his single lens microscope.⁵²

The virtuosi discussed Leeuwenhoek's letter at their meeting on 7 May, and Oldenburg printed it in his *Philosophical transactions* of 19 May. But true to form, fascinating observations from an unknown person, even someone introduced by a person of De Graaf's stature, would not suffice to assure the virtuosi of the accuracy of his representations. Following De Graaf's letter introducing Leeuwenhoek, then, some influential members of the Royal Society tried to get further information about this unknown amateur observer. Constantijn Huygens, the Secretary to the Prince of Orange, consequently paid a visit to Leeuwenhoek on behalf of his English colleagues — even in the midst of the Third Anglo-Dutch war — and wrote a report about him back to Robert Hooke on 8 August 1673. Huygens had not only a weighty personal reputation because of his position, but was well known personally to many of the English virtuosi, having received many English visitors and having visited England several times himself, most recently as a member of the delegation that visited the Royal Society for a considerable time in June 1663.⁵³ Huygens wrote that he had found Leeuwenhoek to be “a modest man, unlearned both in sciences and languages, but of his own nature exceedingly curious and industrious”. After describing Leeuwenhoek's microscopical method, Huygens returned to a description of the man, saying that Hooke would “not be displeased with confirmations of so diligent a searcher as this man is, though always modestly submitting his experiences and conceits about them to the censure and correction of the learned”. Only after this second personal confirmation of Leeuwenhoek's good character

did Oldenburg invite him to communicate his observations regularly. Leeuwenhoek afterwards sent his observations in letters in Dutch to Oldenburg, which various members of the Royal Society translated into English before publication in the *Philosophical transactions*, while Fellows of the Royal Society visited Leeuwenhoek when travelling in the Netherlands: Thomas Molyneux, Hans Sloane, and Francis Vernon among others.⁵⁴

In addition to establishing personal connections with the London virtuosi (which were clearly of a weak rather than strong variety), Leeuwenhoek and others found it fruitful to mention reputable witnesses of their most important experiences in communications to the Royal Society. Leeuwenhoek's letter of 7 September 1688, for example, was very excited: he announced that he had observed the circulation of the blood in the "external gills of young frog's larvae, in the tail of older larvae and in the ends of the toes of young and adult frogs". The capillaries had been discovered by Marcello Malpighi in 1661, and had been seen by Leeuwenhoek in late 1683 through the examination of dead specimens; in his observation of 1688, however, Leeuwenhoek actually saw the blood streaming through the capillaries. He considered this one of his most important discoveries. Consequently, he carefully mentioned in his letter five witnesses, including his neighbour, the Dutch natural philosopher Cornelis 's Gravesande, the local magistrate Cornelis Vallensis, and Anthonie Heinsius, later the Grand Pensionary of Holland. None of these people were co-investigators or expert microscopists, but all had reputations beyond reproach and therefore stood as character witnesses who could vouch for the credibility of Leeuwenhoek's report.⁵⁵

Once one becomes aware of how important personal judgements of one another were to the virtuosi's pursuit of the new philosophy, the letters and printed texts of the period begin to take on new colourations. An examination of the correspondence of Henry Oldenburg reveals that virtually all of the letters sent to him began through a personal contact. For instance, the printed correspondence for the year from 1 January to 31 December 1665, consists of 114 letters.⁵⁶ Somewhat over half (sixty-seven) were sent to Oldenburg rather than being from him. Of these sixty-seven incoming letters, about a quarter (seventeen) came from eight foreign correspondents, the rest being from Englishmen.⁵⁷ Of these eight foreign letter-writers, three were French: Adrien Auzout wrote Oldenburg six letters,⁵⁸ and Henri Justel and Pierre Petit wrote one letter each.⁵⁹ All three of the Frenchmen had begun their connections with Oldenburg in previous years, during Oldenburg's period of residence in France. Two correspondents were Dutch: Christiaan Huygens and Benedictus Spinoza.⁶⁰ Both the Dutch correspondents had long been known to Oldenburg, the first through Sir Robert Moray, the second from a personal encounter in Holland. Oldenburg also heard from three Germans: Johann Hevelius, Johann Daniel Major, and Philipp Jacob Sachs von Lewenheim.⁶¹ Oldenburg's correspondence with the astronomer

Hevelius had been initiated by him in 1663 at the request of members of the Royal Society who knew Hevelius through personal networks.

Of the eight foreigners writing letters to Oldenburg, then, only two first initiated contact in 1665: the two German physicians, Major and Sachs. Both were members of the German Collegium Naturae Curiosorum, a loose society of investigators of nature from the various German provinces:⁶² Major came from Breslau, Sachs from Hamburg. Both men, however, wrote to Oldenburg only after another member of the Collegium, Theodorus Jacobi, also of Hamburg, had visited the Royal Society at the behest of a Senator, Mr Hofmann of Hofmanswaldau. Jacobi returned from London with news that the virtuosi had heard of the Collegium from Sachs's book,⁶³ and he had told Oldenburg about Major and Sachs. Upon returning, then, Jacobi orally passed on Oldenburg's invitation to begin a correspondence, resulting in the two letters. The two new foreign correspondents of 1665, then, began to write Oldenburg at Oldenburg's own request, following a visit to London on the part of a colleague who could vouch for both sides of the connection.

With this general picture of Oldenburg's correspondence as broadening bit by bit through personal contacts, one can see the correspondence of "the Royal Society" growing not so much from impersonal reputation as from travel.⁶⁴ As people from the Continent visited England, or as English virtuosi travelled on the Continent, new connections were established in a widening network. The Royal Society's foreign correspondence had, then, begun with the (often weak) personal relationships brought by Oldenburg and other foreigners to England, or developed by English royalist exiles living in France, the Netherlands, and Germany during the interregnum.

Gradually, based upon acquaintances vouching for the credibility of others, letters began to be exchanged, widening the network of weak ties. Italy, for instance, was opened to the Royal Society slightly through the residence of John Finch and Thomas Baines in Florence from 1659 to 1672, more by the visit of Magalotti to London in 1668, and the custom of the Grand Tour.⁶⁵ In this sense, the Oldenburg correspondence began like the personal correspondence of the great communicator Marin Mersenne or other *savants*, only gradually becoming something more like the official correspondence of a society.⁶⁶ As his associates in the Society heard of other virtuosi through their own networks, Oldenburg became introduced to new people: but only after they were vouched for by people he trusted. Similarly, there was never any official correspondence of the Accademia del Cimento, since communications were carried on by its members privately with their own acquaintances, or through the diplomatic agents of the Grand Duke.⁶⁷

The overwhelming preference for establishing personal relations in order to establish a correspondence is apparent in the frequent letters of reference that passed among acquaintanceships that constituted networks of weak ties. For

example, during Locke's exile in the Netherlands, one of his Dutch friends asked him to pass on a letter to the noted medical professor of Montpellier, Charles Barbeirac, with whom Locke was corresponding after having previously visited that city. "[T]o which please be kind enough to add a letter of introduction recommending me as a worthy person to such a celebrated medical practitioner, for I should much like to correspond by letter with such a great man."⁶⁸ So it went: friends introduced others into their circles, vouching for them and extending the networks.⁶⁹

One final example is an exception to prove the rule: the case of how Oldenburg began a correspondence with Marcello Malpighi. By 1667, Malpighi had earned a local reputation as one of the most important naturalists of Italy. Several foreigners tried to see him when visiting Italy, including Henry Sampson, an English nonconformist minister and brother-in-law of the noted English naturalist Nehemiah Grew. With a letter of introduction from Girolamo Barbato, Sampson tried to see Malpighi on several occasions, being disappointed each time by finding Malpighi out visiting patients. Called home before he could meet Malpighi personally, Sampson left him a flattering written message asking him to pass on his work to him in England, promising in turn to inform Malpighi of the work being done by the English. Shortly after Sampson's return to England, Oldenburg wrote to Malpighi inviting him to take up a correspondence with the Royal Society — which Malpighi did.⁷⁰ Neither Sampson nor Oldenburg had met Malpighi directly, yet Sampson had gotten close: his scholarly contacts in Italy had told him about Malpighi and obtained for him a letter of introduction. In effect, Oldenburg had good evidence of Malpighi's fine character at three removes — but Malpighi's reputation was so good that even at three removes Oldenburg could invite a correspondence with him. After the correspondence between Malpighi and Oldenburg had begun, when Grew wished to address Malpighi he sent messages through Oldenburg rather than directly, as a Member of Parliament might address the Speaker rather than another Member. Such was the nature of weak ties: they reached many more people than the inner circle of, say, the Royal Society, linking people of different groups as far away as the East Indies, and establishing paths for assessing the personal credibility of reporters as well as conveying information.

SPREADING INFORMATION

Personal meetings therefore often established the weak ties upon which correspondence could be established. Re-reading the intellectual correspondence of the seventeenth century in the light of how such weak ties helped to spread information and credibility points to the importance of certain kinds of information contained in them that would otherwise be missed. By looking at how matters of fact crossed Henry Oldenburg's desk in a particular episode, we can begin to see how networks of weak ties could come to focus on specific

individuals who passed information between different networks of correspondence. These individuals, such as Oldenburg himself, who furnished the points of overlap between correspondence networks seem to have served as nodal points, allowing very broad reach in gathering and disseminating information. The particular case that illustrates this pattern of nodal points in overlapping networks of correspondence extremely well involves an optical instrument known as the “Burning-Mirror of Lyons” that captured the attention of Henry Oldenburg and many others during the summer and early autumn of 1665. Oldenburg was determined to produce an authoritative account of this burning mirror for his *Philosophical transactions*, and his efforts have left a record that clearly shows the workings of both weak ties and the nodal points that could emerge in overlapping networks that spanned very broad geographical areas.

Savants in Paris had already discussed reports of a burning mirror in Lyons and checked the accuracy of the accounts through their own personal networks by the time Oldenburg heard of it through his Parisian correspondents. The first detailed account of the mirror came to Oldenburg in the form of a copy of part of an unsigned letter dated 28 July 1665 [N.S.] that originated in Lyons, in which the Lyonnais correspondent was clearly responding to Parisian queries for more information about the mirror: he named the instrument maker as François Villette of Lyons and offered the Parisians a detailed confirmation of an earlier report they had received.⁷¹ Oldenburg’s correspondent in Paris (almost certainly Henri Justel) had simply forwarded the report to Oldenburg. Before enclosing the account of the mirror with his own letter to Oldenburg on Wednesday 5 August, however, Justel had almost certainly read the letter from Lyons at the Thévenot Academy on Tuesday 4 August 1665 [N.S.].⁷² Thus, Oldenburg’s first report on the mirror was from an eyewitness to its performance in Lyons via the filter of Parisian *savants*. Still, despite the author’s efforts to reassure his reader that “every thing you have heard ... is true”, this account stretched Oldenburg’s credulity at the same time as it piqued his interest. He needed to find out more from the eyewitnesses to such strange happenings.

The letter from Lyons described a spherical mirror that was extraordinarily large and powerful. The combination of an aperture of “two feet six inches and about two lines” with the spherical properties defined in a radius of “four feet eight inches” and a focal length of “two feet four inches” meant that, if the mirror was properly cast and polished, it would give the greatest magnification of any mirror then known. This was a powerful optical instrument. More importantly for Oldenburg, however, the account he had received also detailed impressive performances from this burning mirror. According to the eyewitness in Lyons, it had easily melted copper and silver coins, pieces of brass, “bits of a cast iron kettle”, small bits of steel, and small nails. It had failed to melt a large piece of wrought iron, but did reduce glass, stone, and animal bones to calx. It also lit candles “very quickly”, and the “thick sticks of wood it set afire in a

moment made a pretty sight".⁷³ All in all, a very impressive performance — maybe too impressive — or so at least Oldenburg thought.

Oldenburg activated his end of a correspondence network by relaying all the information he had received from Paris to Robert Boyle, seeking his commentary on the extraordinary report coming out of France.⁷⁴ Boyle owned a much smaller burning mirror, and Oldenburg wanted his patron, employer, and friend to compare its performance with what was reported for the mirror from Lyons. Nor did Oldenburg limit his efforts at confirmation to Boyle. He also wrote to Sir Robert Moray soliciting an opinion,⁷⁵ and more importantly, he also contacted his two primary French correspondents, Adrien Auzout and Henri Justel. From them, Oldenburg wanted further technical details, comparisons with the best Italian mirrors — which common assent rated the best in the world — and further confirmations of this mirror's performance from known and credible people. Above all, he needed to have confidence in the reports, which meant having confidence in the reporters.

In his efforts to solicit opinions and gather information on the burning mirror of Lyons, over the next ten weeks Oldenburg cast his net widely through networks of correspondence based on weak ties. Altogether, from Justel's first (now missing) letter in early August through the end of October when he took the sixth number of the *Philosophical transactions* to press,⁷⁶ Oldenburg wrote at least ten letters (and probably several more) soliciting opinions or detailing his efforts to prepare his account for the *Transactions*. During this same three-month period, he definitely received at least eleven letters (once again, probably several more) giving him advice on the mirror. Of the total of twenty-one known letters, at least five involved cross-channel communications based on weak ties. Oldenburg wrote at least two letters to his Parisian correspondents (both lost), and received at least three responses in return. Nor did the twenty-one letters that definitely crossed Oldenburg's desk constitute anything like the total correspondence generated by this mirror, even in the limited period before Oldenburg published his account. Before Justel had forwarded the confirming report he received from Lyons on to Oldenburg, for instance, the Parisians had carried out at least one round of exchanges with correspondents in Lyons. Then, when Auzout and Justel received their requests from Oldenburg for further information, they both wrote off to their correspondents. In Auzout's case the nature of the information he gathered for Oldenburg suggests that he wrote to Italy and received a response before he passed his confirming details back to Oldenburg.

Other networks were also at work in August and September 1665. André Graindorge, for instance, reported the mirror to Pierre-Daniel Huet in words that very closely parallel the first report Oldenburg received. (Graindorge's letters to Huet, in fact, are what tie Auzout, Justel, and the Parisian correspondence linkage with Lyons so closely to Melchisedec Thévenot's Academy.) Nor is it likely Graindorge was alone in spreading news of the mirror back into the

French provinces. One of his colleagues from Caen, Nicholas Croixmare de Lasson, was also attending the Thévenot at this time, and the discussions there inspired him to brag he could “cast a mirror larger than the one in Lyons”, a feat he never actually performed. Graindorge’s letters also place at least two other provincial intelligencers at the Thévenot during this same period — one from Rouen, one from Dijon.⁷⁷ Unless these provincial gentlemen were absolutely immune to the kind of enthusiasm for the mirror that infected Oldenburg, Boyle, Moray, Justel, Auzout, Graindorge, de Lasson, and Huet, it is virtually inconceivable they would have neglected to report this wonderful mirror to their correspondents at home.

Tracking definite exchanges and likely avenues of exchange for news of the burning mirror of Lyons during the late summer and early autumn of 1665 yields the knowledge that — well before Oldenburg published his account in the *Philosophical transactions* — reports and commentary on the burning mirror of Lyons had crisscrossed back and forth across Europe into various correspondence networks that converged in a nodal point, the Thévenot Academy in Paris. These correspondence networks connected Oldenburg (and thus England) to Paris, Paris to Italy, and Paris to at least four French provincial cities. Weak ties founded on personal meetings allowed credibility to be shaped from written reports. Oldenburg was planning to publish his account of the mirror for a scientific community in which news of the mirror had already spread widely. What he was interested in publishing, then, was not simply the first news of the mirror; rather, what he wanted to publish was an authoritative report on a topic many people in the scientific community were already talking about.

Several characterizations of Oldenburg’s cross-channel conversations during this period of mid- to late 1665 follow from his epistolary efforts with the burning mirror of Lyons. First, his weak ties with Parisian correspondents attending the Thévenot Academy hooked him into a scientific communications network spanning the southern half of scientific Europe. In fact, the Thévenot Academy clearly furnished the Parisian nodal point for this correspondence network,⁷⁸ just as Oldenburg himself furnished a nodal point in London. Second, the communications that crossed his desk, although extensive, almost certainly represented only a part of the total traffic in correspondence that discussions of the mirror generated in the period before he published his account in the *Philosophical transactions*. Third, communications throughout the network involved in supplying information to Oldenburg appears fairly rapid given the scale of the correspondence passing between networks of weak ties.⁷⁹ All in all, this episode indicates that in late 1665 Oldenburg’s Parisian correspondents had connected him with what we can only call a communications network based on weak ties that checked the credibility of the reporters.

This pattern suggests that further study of weak ties and correspondence networks would be repaid. Henri Justel’s communications with Oldenburg, for

instance, take on new colouration. Among twentieth-century historians of science Justel suffers somewhat from a reputation as a gadfly, a superficial commentator on the scientific and literary worlds because of the complex, disparate quality of his letters.⁸⁰ They are full of seemingly the most disparate and unconnected concoctions of news, opinion, and rumour any seventeenth-century intelligencer managed to bring together. Yet through the mid- and late 1660s, Henri Justel served as the most faithful of Henry Oldenburg's French correspondents. Indeed, the more than thirty letters Justel is known to have sent Oldenburg between mid-1665 and the end of 1669 rank him as one of Oldenburg's most consistent and regular correspondents over this period. Moreover, given Oldenburg's habit of retailing news from Justel's letters through his own subsequent exchanges with other *savants*, Justel has to be counted among Oldenburg's most important and valued correspondents on the Continent.

Fifteen letters of Justel to Oldenburg have survived intact for the period from early November 1667 through late March 1668. Five of them recommended Pierre-Daniel Huet as a correspondent;⁸¹ interwoven with them are seven other letters in which Justel chronicled the first months of Huet's Académie de Physique de Caen under royal patronage.⁸² Moreover, in this group of twelve letters, the two sorts of communication are distinct. Justel either chronicled events and passed on news about the new royal academy in Caen, or devoted his comments to Huet's personal qualities as a potential correspondent: no single letter does both. On the other hand, no single letter across this four-month period was given over entirely either to Huet or the Académie de Physique.

Indeed, no single letter was given over entirely to any one subject. Justel's letters to Oldenburg appear at first reading to offer something like a bulletin board — a free-form, very lightly edited posting of incidental news items. No single letter stands alone in conveying a sense of the communications passing between Justel to Oldenburg. Their communication occurred in a running dialogue, in which the ties between the parties allowed for interpretations of meaning that can be pieced together by an outsider only with difficulty. In such a complex correspondence, repeated references of just a single sentence or so can carry as much meaning as a fully developed discussion on a topic that appears only once. Individual letters therefore start to lose their character as discrete entities and take on the character of parts of a dialogue. Treated in this way, an underlying level of coherence and order surfaces that is far greater than what appears in any single letter.

In Justel's letters to Oldenburg, then, the coherence of communication appears not so much in the individual letters as in the run of the correspondence. The 'texts' of individual letters hold together less clearly than several longitudinal 'texts' that emerge from seemingly isolated fragments culled from a dozen or more separate letters. Each letter, then, carried multiplexed information, and as is the case with all multiplexed communications, finding meaning depends