

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, elite 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