KEYNOTE ADDRESS

Warm Bodies, Cold Facts: The Embodiment and Emplacement of Knowledge Claims

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Abstract
The texts we write and the texts we cite bear the marks of the epistemic cultures, socio-cognitive networks and physical places to which we belong at different stages of our professional lives. Scholarly texts emerge from webs of social relationships, yet there is no trace of these relationships in the formal, scientific record. The social substrate of science may be largely invisible—and for very good reason—but it is by no means inconsequential. In this talk I argue the case for a tighter coupling of bibliometrics with biography and of scientometrics with sociometrics. In so doing I raise a number of questions: 'How do personal connections and affective ties in the workplace influence or prefigure the depersonalized data that furnish the raw material of scientometrics?' 'What is the epistemic significance of collegiality and context?' 'How important are physical proximity and place in the construction of knowledge claims and, ultimately, in the allocation of credit?' The issues foregrounded by these and related questions constitute the stuff of socio-scientometrics.

Introduction
The Society's full name quite properly and multiply foregrounds metrics. But what do the abstractions, mathematical formulae, statistical distributions and citation maps that populate our scholarly publications tell us in aggregate about the underlying dynamics of socio-cognitive interaction and the materiality of scholarly communication? How do the plots and projections we routinely produce relate to and reflect events, places and people rooted in the real world? In this presentation I limit my ambitions to gently probing the soft underbelly of scientometrics and raising a few questions about the nature of the relationship between 'objective' data and 'subjective' lives, questions such as, 'How do personal relationships and affective ties in the workplace influence or prefigure the impersonal data that constitute the raw material of scientometrics?' 'What is the epistemic significance of collegiality and context?' 'How important are physical proximity and place in the construction of knowledge claims and, ultimately, in the allocation of credit?'

My principal focus will be the institutional arrangements and social relations that are imperceptibly etched in the plots and visualizations that emerge from our investigations and modeling efforts. To what extent are co-authorship clusters and co-citation maps semantic representations and to what extent are they statistical agglomerations of "authors known to each other as warm bodies rather than as labels on literature" (Price, 1970, p. 4)? Of course, one intuitively knows that these various representations reflect an admixture of social (professional and personal) and semantic (intellectual and scientific) influences—hence the title of my talk—but one nonetheless has the sense that the bibliometric data are supposed to speak for themselves and that social relations are of secondary interest to ISSI members.

The messiness of action
In their landmark book, *Laboratory Life*, Latour and Woolgar (1979, p. 88) describe how "rats had been bled and beheaded, frogs had been flayed" in the service of science. They portray laboratory activity at the Salk Institute "as the organization of persuasion through literary inscription." The end result of the spilling of blood and guts is the journal article, a sanitized and impersonal artifact far removed from the messiness of what went before: "A laboratory," they aver, "is constantly performing operations on statements; adding modalities, citing, enhancing, diminishing, borrowing, and proposing new combinations" (Latour & Woolgar, 1979, pp. 86-87). Ultimately, these literary operations mask the literal operations carried out on experimental rats and frogs by scientists in wet labs. In a

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subsequent book, *Science in Action*, Latour (1987, p. 33) takes these ideas several steps further, noting how authors co-opt other actors, both embodied and disembodied, to buttress their hypotheses and assertions: "A document becomes scientific when its claims stop being isolated and when the number of people engaged in publishing it are many and explicitly indicated in the text…The number of external friends the text comes with is a good indication of its strength." And Latour is not just referring to co-authors and trusted assessors (those professional friends and colleagues who preview one's work prior to its submission to the formal refereeing process [Mullins, 1973]), but also to the array of "friends" paraded in the list of references attached to the paper. These battalions of significant others act as legitimating agents on the author's behalf, stacking (to use one of Latour's pet terms) the odds in his favor, for the simple reason that "attacking a paper heavy with footnotes means the dissenter has to weaken each of the other papers, or will at least be threatened with doing so…"

Along with the messiness of the lab and other investigative sites, authors are also (understandably) silent on "research scribbling," the miscellany of activities, ranging from laboratory sketching to preliminary calculations, that lies in the interstice between "the materialities of the experimental systems and the various written communications that are eventually released to the scientific community" (Rheinberger, 2003, p. 314). It occurs to me—and I say this without positing any form of conspiracy or strategic silencing of the social on the part of scientometricians—that the messiness of professional and human relations is elided in like fashion from standard scientometric accounts of knowledge growth, diffusion and exchange.

Descriptions of place, too, are typically absent from research papers and technical reports: labs and investigative sites of all kinds are air brushed out of the final account, as if the particulars of a place mattered not at all in the formulation and shaping of knowledge claims. There is a (largely legitimate) presumption of standardization (of facilities, layout, equipment, etc.) and a collective trust in operational and procedural equivalence across scientific sites: "Scientists trust the claims from other laboratories as they would their own 'home-truths' because they can safely assume that whatever environmental factors are left out of a scientific paper from over there are essentially the same as the environmental factors they leave out of their own papers" (Gieryn 2002, p. 127). In short: common infrastructures + common protocols = common sense (-making).

This situation, though, is not without irony, as Gieryn (2002) has pointed out in his discussion of the notion of a "truth-spot," which he defines as a place that somehow makes us believe that knowledge claims from there hold universally. The particularities of place and time are, in fact, instrumental in the establishment and acceptance of specific knowledge claims at specific moments in history. Place clearly can help confer credibility, yet, as Gieryn (2005, in press) observes, it is only recently that the "*where* of science" has attracted serious scholarly scrutiny.

Norms and trust

My aim today is to steer a careful course between the Scylla of uncritical normativism and the Charybdis of naive constructivism, while at the same time advocating a stronger commitment to what I'm terming socio-scientometrics. Let me illustrate my general point with reference to citation behavior. Despite the continuing debate on the validity and utility of citation analysis, it is hard to take issue with White's (1990, p. 9) pragmatism. "[W]hen one sees that scores, hundreds, and even thousands of citations have accrued to a work, an author, a set of coauthors, it is difficult to believe that all of them are suspect. Why not believe there is a norm in citing…and that the great majority of citations conform to it?" I, for one, am willing to believe there are norms underpinning the conduct of science, but that belief does not preclude me from wanting to know more about the material and social reality of science and, in particular, the ways in which collocation influences collaboration, co-production, co-authorship and, by extension, literature consumption and citation behavior. In short, I would like to see a tighter coupling of bibliometrics with biography and of scientometrics with sociometrics.

Social constructivists may decry the lack of attention given to individual practice, materiality, grounded observation and situated action in sweeping functionalist interpretations of science, but I confess that I am happy to live with the 'noble fiction'—Plato's idea of the useful lie—as far as citation behavior is concerned if only because the alternative is repugnant to common sense and at variance with the observed conduct of most scientists. Garfield's (1955) legacy is a not just a scientifically valuable insight, but a foundational tool (ISI's citation indexes), one that reveals "the

extent to which scientific progress depends upon the pervasive and persistent constitution of trust among a truly heterogeneous population of social actors" (Davenport & Cronin, 2000, p. 522). Trust, though constructivists may not like to hear this, is the ghost in the scientific machine. But that was true long before Garfield conceived of the *Science Citation Index*. In his superb study of science in seventeenth-century England, Shapin (1994, p. xxv) writes as follows: "Knowledge is a collective good. In securing our knowledge we rely upon others, and we cannot dispense with that reliance. That means that the relations in which we have and hold our knowledge have a moral character, and the word I use to indicate that moral relation is *trust*." It is the mutual reliance of which Shapin speaks that confers credibility upon authors' citation behaviors. And that mutual reliance is both grasped in the abstract and lived in the flesh, I contend.

Support for the so-called normative position comes from two noteworthy studies of recent origin. Kurtz and colleagues have used the NASA Astrophysics Data System to compare the obsolescence function as measured by "reads" of records in the system with the obsolescence function as measured by citations (e.g., Kurtz et al., 2005, p. 111). Their statistical analyses show that reads and cites measure the same thing, namely, the usefulness of an article." Pertinently, Kurtz et al. (2005, p. 116) conclude that "the private act of reading an article entails none of the various sociological influences that the public act of citing an article does [which] suggests that in the mean these factors do not influence the citation rate." Citation, in other words is about what one knows, not whom one knows. These results would seem to confirm the earlier findings of Baldi's (1998, p. 843) multivariate analysis of citations in the literature of celestial masers, a sub-field (coincidentally) of astrophysics, namely, that epistemic factors (topicality of knowledge claims, theoretical orientation) mattered more that the personal characteristics of the cited author: "…one's position in the stratification structure of science is likely to be the result of the worth and usefulness of one's scientific contributions rather than the reverse, as social constructivists would have us believe."

A commitment to the normative view of citation does not preclude one's having an interest in the social and biographical minutiae of scholarly communication. For example, Mählck and Persson (2000, p. 81, 84) have introduced the term "socio-bibliometric mapping" and demonstrated, inter alia, that collaboration leads to citation. Likewise, Rowlands (1999, p. 543) has shown that recognition, social ties and collaborative forms of activity are associated, as, too, has Zuccala (2004) in her study of singularity theory research in mathematics.

Our social networks provide easy entry points into the knowledge base and literature of a field. In life, generally, we readily draw upon what is to hand, what is foremost in our memory; social psychologists talk of the primacy effect or availability heuristic (e.g., Tversky & Kahneman, 1974). And so it is with citation. Given that potentially relevant citations are "structurally abundant" (Goldfinger, 2000), and given, too, the limitations of our cognitive processing capabilities— "bounded rationality," to use Simon's (1957) term—it is only natural that we employ the social availability heuristic. But there is nothing wrong with that: "The vast majority of citer decisions are motivated by what Vinkler (1998) calls "professional' (as opposed to 'connectional') concerns…" (White, 2004, p. 111).

A consequence of my sometimes citing my inner circle (colleagues, mentors, protégés, friends) is that it reduces the likelihood of others in the potential author pool from being selected for citation. All other things (e.g., the citeable work's topicality, relevance, currency) being equal, strong social ties will presumably trump weak or non-existent ties (see Granovetter, 1973 and 1983 for general discussion of weak and strong ties). Call it preferential attachment, a statistical fact of not only scholarly but also social life. Truth be told, we invariably struggle to cite the most precise and most relevant work on a given subject, for the simple reason that few, if any, of us are wholly and authoritatively familiar with the scattered literature of our specialties, let alone the wider scientific literature. And even if we were familiar with the entire corpus of relevant literature, we would still have to make choices. But there is no need to fret; as Grafton (1997, p. 18) noted in his engaging history of the footnote, "a historical work and its notes can never, in the nature of things, reproduce or cite the full range of evidence they rely on."

Merton (1977, p. 84) made a related point with regard to citer motivation: "*By itself*, citation analysis cannot trace all the complex sources of cognitive influences upon a particular work since explicit citations, which are ordinarily the only kind entered into quantitative citation-analyses, do not adequately reflect the story…A fine-grained analysis would have to be supplemented by focused interviews with scientists reporting on contexts of what they have set in print." It seems clear that mere

mortals lack the wherewithal to make perfectly rational, objective choices about what to cite and what not to cite in any given instance. Using the language of Schwarz (2005, pp. 77-79), the maximizer, in his search for perfection, would never complete his bibliography while the satisficer would produce a good enough list of references. The necessarily contingent nature of citation neither invalidates the practice not vitiates its analytic utility.

The significance of the social can also be seen in the acknowledgments attached to this paper. The four individuals I thank have been known to me both personally and professional for some time. Each of them has, in her own way, contributed to the shape and content of this presentation. On this admittedly limited parochial and anecdotal basis it would be churlish to deny that social and biographical ties play some part in the shaping of one's intellectual choices and outputs. Allowing that is not, however, tantamount to privileging the constructivist (interpretivist) position over the normative (structuralist) position, a point well made in another context by Borgman and Furner (2002, p. 46). I shall return to this issue later.

Information space

I want now to revisit some early (and also more recent) research that deals with the different dimensions of information space, both physical and virtual, in order to show why it may be helpful to add the prefix "socio" to "scientometrics." I begin with physical space (how distance influences the degree of informal communication between scientists/scholars), move on to intellectual space (conceptual/intellectual mapping of science) and conclude by suggesting, somewhat optimistically I concede, that hybrid spatial analyses combining social and conceptual dimensions are needed to faithfully capture the multiplex nature of scholarly communication. In the process, I raise a number of related questions: (i) How are social relations—forged largely in physical or "real-space" (Dourish, 2001a)— mirrored in the architecture of intellectual space? (ii) Do co-citation maps of science depict purely intellectual networks, or webs of socio-cognitive interactions? How, to put it otherwise and to paraphrase Suchman (1987), might we represent socially-situated semantics? (iii) Are there other paratextual elements (Genette, 1997a, 1997b) apart from citation and co-authorship data, which could be used to map socio-cognitive ties? (iv) Can social and affective ties be practicably captured and visualized? And would the end result be of any practical worth, or merely of interest to a very small number of biographers and historians of science?

Bibliometrics has long been interested in representing and mapping intellectual space. Price's (1965) article, *Network of scientific papers*, was a seminal attempt to use citation data to reveal the intellectual structure of a scientific sub-field. Recent advances in information visualization techniques and related statistical methods have greatly facilitated the depiction of semantic spaces and networks of scholarly interaction. The lexicon of information visualization is spatially explicit and metaphor-rich—maps, landscapes, terrain, peaks and cities—and the use of cartographic techniques to show the relationships amongst groups of scholarly publications is now well established (e.g., Börner, Chen, & Boyack, 2003; Skupin, 2002). According to Heimeriks and van den Besselaar (2002, p. 11), bibliometric maps of science "are landscapes of scientific research fields created by quantitative analysis of bibliographic data. In such maps the 'cities' are, for instance, research topics. Topics with a strong cognitive relation are in each other's vicinity and topics with a weak relation are distant from each other."

Skupin (2000, p. 91), a geographer, has recognized the early contributions of information science to the use of cartography in the information visualization domain: "Map metaphors have been associated with the handling of non-geographic information for a long time. They can be traced as far back as the late 19th century when Otlet, regarded by many as the father of information science, made explicit reference to mapping of intellectual domains. Otlet envisioned the use of maps in the exploration of unknown information terrain and even pondered the role of scale in such exploration."

Mapping techniques are now commonly used to lay bare the intellectual structure of disciplines (e.g., White & McCain, 1998), reveal intra-departmental networks (Mählck & Persson, 2000), and create real-time, interactive author maps (Lin, White & Buzydlowski, 2003). They have also been used for social network analysis (e.g., Koku, Nazer & Wellman, 2001). Recently, White (information science) and Wellman (social network analysis) have collaborated to explore the socio-cognitive structure of specialty groups (e.g., White, Wellman, & Nazer, 2004). This is a pioneering attempt at what I call socio-scientometrics.

Physical place

More than three decades ago, Allen (1969) carried out seminal studies on the problem solving and communication behaviors of engineers and scientists and the role of the technological gatekeeper in facilitating information flow. He found that "[c]ommunication probability decreases with the square of distance and…reaches its asymptotic level within 25 yards" (Allen, 1969, p. 11). Contrary to popular belief, the emergence of virtual networks and online communities has not diminished the importance of physical proximity in the conduct of research, just as online trading does not mean the dematerialization of commerce or the death of real estate. Presence continues to matter in both real and virtual space. Confirmatory evidence comes in a variety of forms and from a variety of contexts.

Katz (1994, p. 31) found that the number of intra-national collaborations "decreases rapidly as a function of distance separating research partners," while Thelwall et al. discovered that the "extent of academic web site interlinking between pairs of U.K. universities decreased with geographic distance… neighboring institutions were very much more likely to interlink than average" (see Thelwall, Vaughan & Björneborn, 2005, p. 106). Börner and Penumarthy (2004, p. 1) found that the "citation linkages between institutions fall off with the distance between them," which suggests that "increasing usage of the Internet does not lead to more global citation patterns." In her ethnographic account of the culture of high-energy physics, Knorr Cetina (1999, p. 212) discovered that "collaborators not continually at CERN…feel left behind, as if they were chasing after something that is always two steps ahead. In principle, almost everything is accessible to everyone at all times—but in practice, information circulates through local discourse at the center, which one must be physically plugged into…to be up to date." An essentially similar picture is painted by Biagioli (2003, p. 272) who describes the CDF (Collider Detector at Fermilab) Collaboration as "a relatively close and inclusive community." To be where the action is, if I may appropriate the title of Dourish's book, counts (Dourish, 2001b), even in an age of hyper-connectivity.

We humans have a well-documented penchant for minimizing resistance and economizing on effort. Zipf's "Principle of Least Effort" and Allen's "30-Metre Principle," alluded to earlier, neatly encapsulate such near-universal satisficing behaviors. One should not underestimate the spatial determinants of social interaction, specifically how physical distance affects frequency of informal communication. Physical connectivity and degrees of presence matter, even in an age of electronic publication, online communities and digital networks. Geographers recognize that the space of flows and the space of places are co-constitutive: the geography of the Internet is a case of now inextricably intertwined worlds, the physical and the virtual (e.g., Zook, 2003). In similar vein, media complementarity (*not* media substitution) is a defining feature of contemporary scholarly communication. Email has not displaced other means of information exchange and interaction; in fact, email use correlates positively with face-to-face exchange, phone, fax and mail communication (Koku, Nazer & Wellman, 2001, p. 1750).

All of this is a prelude to saying that social relations are subtly etched in the tracery of the scholarly communication system. Many academic domains/specialty groups combine near year-round conference caravanning with intensive electronic communication via email, listserv, chat rooms, etc. Virtuality has not diminished the importance of in-group membership and regular face-to-face contact. But changes have occurred. The "invisible colleges" described three decades ago by Crane (1972) are being progressively reconstituted as "visible colleges" (Koku, Nazer & Wellman, 2001). Today, digital communications media make it easier to track sociometric stars than in Crane's or Price's day; we can see who posts, downloads, blogs and responds; who generates a buzz and attracts attention, citations and online hits, but we still have some way to go to develop tools that can systematize the data harvesting process across disciplines (Brody et al., 2004; Harnad & Carr, 2000). Current efforts to deal with the problems of "teleidentity" and visualize social environments and patterns of interaction, such as those conducted by the Sociable Media Group at MIT (e.g., Boyd, Lee, Ramage & Donath, 2002), may help increase communicative transparency and group participation rates, but the traces left in the ether certainly don't describe the full spectrum of social relations that structure specialty groups and personal networks.

The rationale underpinning citation mapping has been expressed succinctly by Small (1973, p. 265): "If it can be assumed that frequently cited papers represent the key concepts, methods, or experiments in a field, then co-citation patterns can be used to map out in great detail the relationships between these key concepts." The reality of science emerges—is constructed—from these

representations (Wouters, 1999, p. 129). This leads on to the following questions; (a) are the resultant maps reflective of purely ideational interactions, and (b) are citation behaviors normatively governed or idiosyncratic in nature (see Cronin, 1984 for a review of much of the relevant literature on citer motivation)? More specifically, to what extent do social and psychological factors influence the selection of citations by an author—the citations which become the coordinates of intellectual space? To what extent are social, personal and affective relations imbricated in such maps? To what extent should the semantic spaces described by citation maps be viewed as *socio*-cognitive spaces?

Polycephalous science

White (2001) has undertaken a study of scholars' *recitation* patterns; analyzing the identities of those authors who are cited recurrently by a given author over time. Working with a small sample of information scientists, he teased out some of the social, collegiate and institutional ties that might influence citation (i.e., intellectual) choices. At the risk of stating the obvious, this kind of authorial exegesis is only possible if one is familiar with both the subject domain and the focal set of authors. White concluded (p. 93) that most members of his sample are "affected by social networks—that is, they cite authors whom they know personally from school, the workplace, or an invisible college (defined as researchers with similar interests who communicate and collaborate although their institutional bases differ and are possibly far apart)." Thus, one's location in intellectual space to some extent reflects one's place in the physical world. As a rule, bibliometric and sociometric analyses ignore the social substrate, focusing on, in the words of Douglas (1986, p. x), the "idea of a suprapersonal cognitive system"—one seemingly unanchored in the physical world.

For an earlier ISSI conference we (Cronin & Shaw, 2001) employed a variant on White's approach, looking closely at the citation profiles (based on 20-years' worth of ISI data) of three information scientists whom we knew extremely well. We constructed their citation identities (those whom they cited) and their citation images (those who cited them), identified the top-25 names on each list and probed the underlying social relationships. The mesh of collegiate and mentor-advisee relationships we unearthed may be imperceptible to most observers, but it is nonetheless real. And that is before trying to assess the impact of affective or romantic workplace liaisons. Since physical place and sociality clearly play important roles in shaping cognitive choices and intellectual spaces, how might we go about visualizing these social linkages?

Physical presence and professional familiarity are factors that influence citation behavior, though, of course, personal acquaintance is neither a necessary nor sufficient reason to cite an author. That said, the work of one's associates and friends might be more accessible and no less pertinent than the work of others, and thus warrant citation on merit alone. It is reasonable to imagine that social ties will have some influence on citation choices. One of the reasons for working together (for setting up collaborations, local or distributed) is to build a common cause, combine talents and resources, energize a collective research agenda, promote a particular paradigm, or pursue a shared epistemic goal; in other words, to achieve some kind of multiplier effect, or what economists refer to as returns to specialization.

Being together in a common place, or meeting regularly face-to-face, helps determine the intellectual spaces in which scholars' work is subsequently located. The central issue has been formulated thus: "Is it primarily *who* citers know (social structure) or *what* they know (intellectual structure)?" (White, Wellman & Nazer, 2004, p. 111). This is a complex issue, as White et al. (2004, p. 125) concede: "Who you know pays off only if the people you know have something worth knowing— something plainly relevant to your own claims." But unraveling the social (not to mention biographical) dimensions of citation links is still not the whole story. Citations are merely the most visible part of the influence iceberg; acknowledgments are the part hidden below the water line. Scholastic contributions and debts are routinely recorded in a variety of ways; citation data just happen to be relatively easy to capture and display. In short, citation-based maps are necessarily partial representations of scholars' interactions. A comprehensive register of credits and connections would require the inclusion of acknowledgment data. Heretofore, that has been impracticable (see Cronin, 1995), but the situation is set to change (see Giles & Councill, 2004).

Acknowledgements are deceptively valuable indicators of informal collaboration and networks of trust in science. Systematic analysis of those whom we acknowledge and those who acknowledges us throws further light on the social networks to which we belong and which, to some degree, define

our intellectual identity (Cronin, 1995; Giles & Councill, 2004; Hyland & Tse, 2004). Acknowledgment data can be used alongside publication and citation data to develop a more nuanced undrstanding of scholarly communication and interaction. By way of illustration, we are at present 'de-blackboxing' the bibliographic and bibliometric life of our late colleague, Rob Kling, in an effort to better understand the social and intellectual forces, and also the physical places, that animated this animator *extraordinaire* throughout his career (Cronin & Shaw, 2005).

Much of art and science is collective activity, an historical fact elegantly captured by Steiner (2003, p. 133) in his book, *Lessons of the Masters*: The artist's atelier (think of the Flemish baroque painter, Peter Paul Rubens) is sometimes suggested in the acknowledgments that accompany scholarly journal articles. The support networks implicitly described in acknowledgments reinforce the idea that research and scholarship are socially embedded rather than inherently individualistic activities. Acknowledgments bear witness to the myriad ties—social, technical, intellectual, affective—that bind scholars together in loosely coupled coalitions (or invisible colleges). Indeed, academic writing, as I have argued elsewhere (Cronin, 2004), is a compelling instance of distributed cognition (see Hutchins, 1995); or, to use Clark's (2003, p. 8) phrase, "an extended cognitive system."

The growth in acknowledgments was an important, if underappreciated, development in scholarly publication during the second half of the twentieth century (Cronin, 1995; Cronin, Shaw & La Barre, 2003, 2004). In fields as diverse as astrophysics, chemistry, cell biology and psychology, almost every scientific paper includes (often meaty) expressions of gratitude to a distributed population of peers, informal collaborators and trusted assessors; individuals whose material contributions (technical, instrumental, etc.) and/or conceptual inputs have made a difference to the work being reported. In the language of ANT (Actor-Network Theory), acknowledgments make infrastructure visible; they show how scientists routinely enroll heterogeneous elements (actants), such as specimens, colleagues, instruments and grants, to mobilize their research endeavors and advance their epistemic goals.

Scientists are connected, socio-technically, and with the progressive "collectivization of academic science" (Etzkowitz & Kemelgor, 1998)—what Ziman (2000) has termed "post-academic" science—those distributed socio-technical networks will both increase in importance and intensify. Connectedness is not, however, something new; as Collins (2003, p. 150) put it: "Rapid-discovery scientists have always owed their reputations, and their ability to make new discoveries, to being connected to evolving generations of equipment…Modern science has always been a cyborg network in this sense."

Collaboration in science is routinely investigated via co-authorship, yet co-authorship data do not by any means fully capture scholars' functional and social interdependencies. If the intellectual structures of knowledge domains are to be mapped with fidelity, then acknowledgment data should be taken into account. Many of those mentioned in acknowledgments will be known personally to the author, something which is much less likely to be the case with those cited in a paper's bibliography. If we want to understand the interdependencies—the socio-cognitive ties—that link scholars, we should not overlook the wealth of detailed, if inconveniently scattered, information contained in acknowledgments. More specifically, we might want to look at the geographic spread of trusted assessors to further determine the influence of physical space on patterns of both intra- and inter-disciplinary collaboration. In practical terms, however, the explicit mapping of networks and development of sociograms is an extremely laborious undertaking, though developments in automated social network analysis (e.g., Fitzgerald, 2004) and automated acknowledgment extraction (Giles & Councill, 2004) hold considerable promise.

The importance of social ties can also be seen when we examine instances of communication breakdown. Let me illustrate by again resorting to thick socio-bibliometric description at the level of self. Biagioli (2003) included an essay (*Rights or rewards? Changing frameworks of scientific authorship*) in his co-edited book, *Scientific Authorship*, which examined trends in multiple authorship, contributorship, credit allocation and related topics. The essay addressed a pot pourri of topics that I had touched on in an earlier article on hyperauthorship (Cronin, 2001). The topical overlap was reflected in the level of bibliographic coupling: our papers had seven references in common and, additionally, we cited five other authors in common, though in each case a different work was chosen. Yet, like two ships in the night, our publications had passed one another by. I subsequently found that Biagioli had published a paper with the identical title in the *Journal of*

College and University Law (JUCL) in 2000, a paper that I had failed to cite in my 2001 article. Biagioli may (or may not) have seen my article in the *Journal of the American Society for Information Science and Technology* (*JASIST*) article; I had missed his 2000 article and no one had drawn it to my attention in the subsequent four years. For the record, I have never met Biagioli. He is an historian of science at Harvard and I am an information scientist at Indiana University. It is apparent that our cognitive worlds may overlap on occasion, but our socio-professional circles have not intersected heretofore. He may not read *JASIST*; I do not read *JUCL*. This is a trivial illustration of what Swanson (1989) has called "logically related but non-interactive literatures," a phenomenon caused in part by the difficulty of keeping track of the mass of potentially relevant literature and in part by the lack of any pre-existing social ties between Biagioli and myself: we inhabit, for now, non-intersecting worlds. Physical separation (east coast and mid-west) and institutional stratification (Ivy League vs. Public), coupled with social separation, resulted in a blind spot. Hardly the end of the world, but a simple illustration of why it pays to be networked and how easy it is for "structural holes" (Burt, 1992) to open up in communication space.

The contouring of conceptual space

The conceptual spaces defined by authors' citation behaviors reflect the importance of place-based proximity and personal acquaintanceship in shaping patterns of information exchange, informal collaboration, co-production and knowledge diffusion. It is clear that physical proximity does play some kind of role, be it direct or indirect, in molding citation behavior, even if the conduits and connections are typically unseen to all but privileged insiders or bibliometric researchers immersed in the target literature. Of course, it is hardly surprising that if researchers are collocated in the same department, and have cognate or converging research interests, that those latent ties will become manifest and strengthen, resulting in greater reciprocal exchange of resources, ideas and citations over time. A shared physical site (lab, office complex) or virtual space (collaboratory, listserv) can act as an incubator or accelerator of ideas, which, of course, is precisely why we attend conferences and professional meetings. One is not here referring to the forging of purely personal, or "content-neutral" (White et al., 2004, p. 125) ties, but the natural co-development of social and professional relationships and practices in and across work places and workspaces—the aforementioned ties that bind. In sum, ideas and knowledge claims are often associated with, and (to re-invoke Gieryn) legitimated by, particular places.

Social and locational links between scholars and researchers spawn trusting and "knowable communities" (Brown & Duguid, 2000, p. 169), a phenomenon that has been observed in a variety of contexts. For instance, von Hippel (1987) has described patterns of informal know-how trading between (competing) firms and Allen (1983) has identified a complementary phenomenon, namely, "collective invention." The importance of social networks to innovation is now widely recognized. In recent years, the significance of industry clusters (think of Silicon Valley or Silicon Glen) has been analyzed intensively in the business strategy and economic development literature, most notably by Porter (1998). The evidence shows that geographic concentration of interconnected companies can create local, regional or national comparative advantage. Something similar appears to hold in academia, where the space of place (research sites, science parks) and the space of knowledge flows are tightly linked. In their analysis of the strengths, interrelations and nodality of global research centers, Matthiessen et al. (2002, p. 903) found that despite the "declining importance of physical distance... research and knowledge come out of local culture and tradition and have a strong territorial affinity." Scientists may be globally interconnected, but "[s]ynergies between ideas and direct face-to-face communication between scientists are still major factors of productivity" (p. 904).

My colleague Katy Börner's (2003) goal is to help create an information-rich 'Map of Science' screensaver in the tradition of ISI's prototypical *Atlas of Science.* Such an interface might get close to answering Otlet's question: "How could the intellectual domains be adequately, continuously mapped?" (quoted in Rayward, 1992, p. 59). Börner envisages an automatically updated, 2-D, layered map based on data fed from all major publication, patent and grant funding databases. Users would be provided with a global overview of topic areas, data on the size and composition of fields, evidence of disciplinary emergence and merging, bird's-eye views of specific knowledge domains, highly-influential papers, funding flows, etc. Such a development would be of practical value to career scientists as well as science policy analysts, sociologists, and historians of science.

It is an attractive notion, but despite advances in information visualization, present generation toolsets and techniques cannot capture the biography of scholars' communicative practices, the complex webs of collegiate relationships and "patronage networks" (Baber, 2003, p. 96) that interleave with the purely cognitive ties to create the double helix of scholarly communication. "Social translucence" (Erickson, et al., 2002) may be attainable within small, clearly bounded work groups, but it is hard to see how such a goal could be achieved in the essentially unbounded, multidisciplinary world of scholarly communication. The social ties that bind scholars are often implicit, imperceptible and evanescent. In exceptional cases it may be possible to generate "thick description" (Geertz, 1973) of a kind that would faithfully describe the admixture of social, affective and scholastic ties that exist within and between communities of scholars, but, again, scalability remains a seemingly insurmountable obstacle. Indeed, it may well be that the "infrasociality" of science, to hijack Knorr Cetina's (1999, p. 13) term, is effectively indescribable.

The combination of next generation search engines, OAI-compliant archives and sophisticated information visualization tools should make it possible to automatically capture and display the sociometric webs inscribed in acknowledgments (Giles & Councill, 2004). But even if large-scale, socio-semantic mapping of science were technically feasible, it is unlikely that our forensic tools would reveal, to use White et al.'s (2004, p. 125) vivid metaphor, "an orgy of back scratching." That, however, is no reason for not trying to conceptualize and develop innovative tools (e.g., a "social search engine" [Barabási, 2003, p. 39]) to harvest and graphically display socio-cognitive influences within and across scholarly tribes and disciplines— a first step, if you will, towards "an epistemology of messiness" (Rheinberger, 2003, p. 316).

Such visualizations would certainly bring us closer to generating high-fidelity maps of scholarly trade routes and to understanding how social relations, often forged in physical space and reinforced in virtual space, are reflected in the architecture of intellectual spaces. They would also help us expose the "kinship" structures underpinning co-citation maps. And even if you are not of the view that such mapping approaches would be of much utility, I hope you will allow that the blending of bibliometric and biographical data could have value for historians of science and selected others, and that the range of measures could extend beyond citations to acknowledgements and perhaps other potential indicators of socio-cognitive interaction. Such a concession would align research in scientometrics more closely with theoretical developments in cognate domains such as science and technology studies, social studies of science, history of science, social informatics and socio-technical systems analysis.

Conclusion

Jasanoff (2004, p. 274) coined the phrase "the idiom of co-production" to capture the fact that "knowledge and its material embodiments are products of social work and, at the same time, constitutive of forms of social life…that lived 'reality' is made up of complex linkages among the cognitive, the material, the normative and the social." That is the message I have been trying to convey. We may view the ubiquitous graphs and two-dimensional maps that are emblematic of scientometrics research as objective representations of reality, but the epistemic claims they aim to depict are sometimes both messier and more complex than we imagine. Our intellectual and social worlds are inextricably intertwined, yet, as we have seen, classic bibliometric measures necessarily privilege the former at the expense of the latter.

Recently, in making the case for a tighter coupling of science and technology studies (STS) and the field of information studies (IS), van House (2004, p. 73) argued that STS "translates the taken-for-granted into objects of study, and questions assumptions" in a way that IS traditionally has not. Whether or not you see scientometrics as a sub-set of IS or as an independent field of inquiry, there are good reasons to draw on investigative methods and theoretical insights from the world of STS and related areas. Citations and other forms of scholarly recommendation are produced by actors who are embedded in, animated by, social networks. The texts we write and the texts we cite bear the marks of the epistemic cultures, the social networks and the physical places of which we are more or less persistent members in the course of our professional careers (Cronin, 2005). These intellectual products emerge from a lattice of relationships, which are largely imperceptible to the untrained eye. Their invisibility, however, should not be construed as inconsequentiality. It is time to acknowledge

the role played by warm bodies and physical place in the conduct of science and also in our representations of knowledge growth and exchange dynamics within and across disciplines.

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Warm Bodies is a zombie romance film based on the novel of the same name by Isaac Marion. It is set for release on February 1st, 2013. R is a zombie. After a zombie apocalypse, he shambles across an America filled with collapsed buildings, rusted cars, shattered windows, and abandoned high-rises. He can only grunt or moan and craves human brains to get high on their memories. After eating the brains of a suicidal teen, R is overcome with love for the teen's companion, Julie Grigio. R rescues Julie 'How important are physical proximity and place in the construction of knowledge claims and, ultimately, in the allocation of credit?' The issues foregrounded by these and related questions constitute the stuff of socio-scientometrics. Do you want to read the rest of this article? Request full-text. Advertisement. Citations (7). References (6). Knowledge organizing systems (e.g., classification systems, thesauri, and ontologies) should be understood as systems basically organizing concepts and their semantic relations. The same is the case with informationâ€¦ CONTINUE READING.Â B. Cronin. P. Ingwersen & B. Larsen (Eds), Proceedings of the 10th International Conference on Scientometrics and Informetrics (Karolinska University Press, Stockholm, 2005), 1â€“12. 2005. VIEW 1 EXCERPT.