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Got Infrastructure? How Standards, Categories and Other Aspects of Infrastructure Influence Communication

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Introduction: Boring Things

Some five years ago, in Palo Alto, California, I joined with several colleagues to found a new professional society[1]. The idea for the society arose from a series of conversations we had about our somewhat unusual research topics -- things that most people would find quite dull. We called it The Society of People Interested in Boring Things. About every other year since then, we have held small conferences with other like-minded academics to discuss our shared research interests, as befits a professional association. Among the boring topics presenters brought to the table were: the inscription of gender in unemployment forms used by the city government in Hamburg, Germany; the difficulties of measuring urine output in a post-surgical ward in the Netherlands, and how to design better cups for metrication; the company mascot and the slogans used by a large Midwestern insurance firm in its attempts to build corporate cultures; and (this was my contribution) how nematologists[2] use computers to keep track of their worm specimens. One must admit that these topics are generally low profile (to put it mildly), and for most social scientists, adequately boring to qualify for membership in our new association. In addition, what they have in common is a concern with infrastructure, the invisible glue that binds disciplines together, within and across their boundaries.

Infrastructure is usually singularly unexciting as a research object for social scientists. It often appears simply as a list of numbers of technical specifications, or black boxes, wires and plugs, in the scientific/disciplinary workplace. (Where is the human behavior side of that?) In my work as a sociologist studying life sciences and medicine, I have found that infrastructure can also be messy and distasteful. For example, in studying museum representations, I found myself up close and personal with the history of taxidermy (Star, 1992). This included tracking down the biological supply houses that had provided items such as standard-sized glass eyes for the different animals in the museum dioramas; home-made devices for shaving and softening animal skins, and other tools for preparing and preserving specimens and habitats.

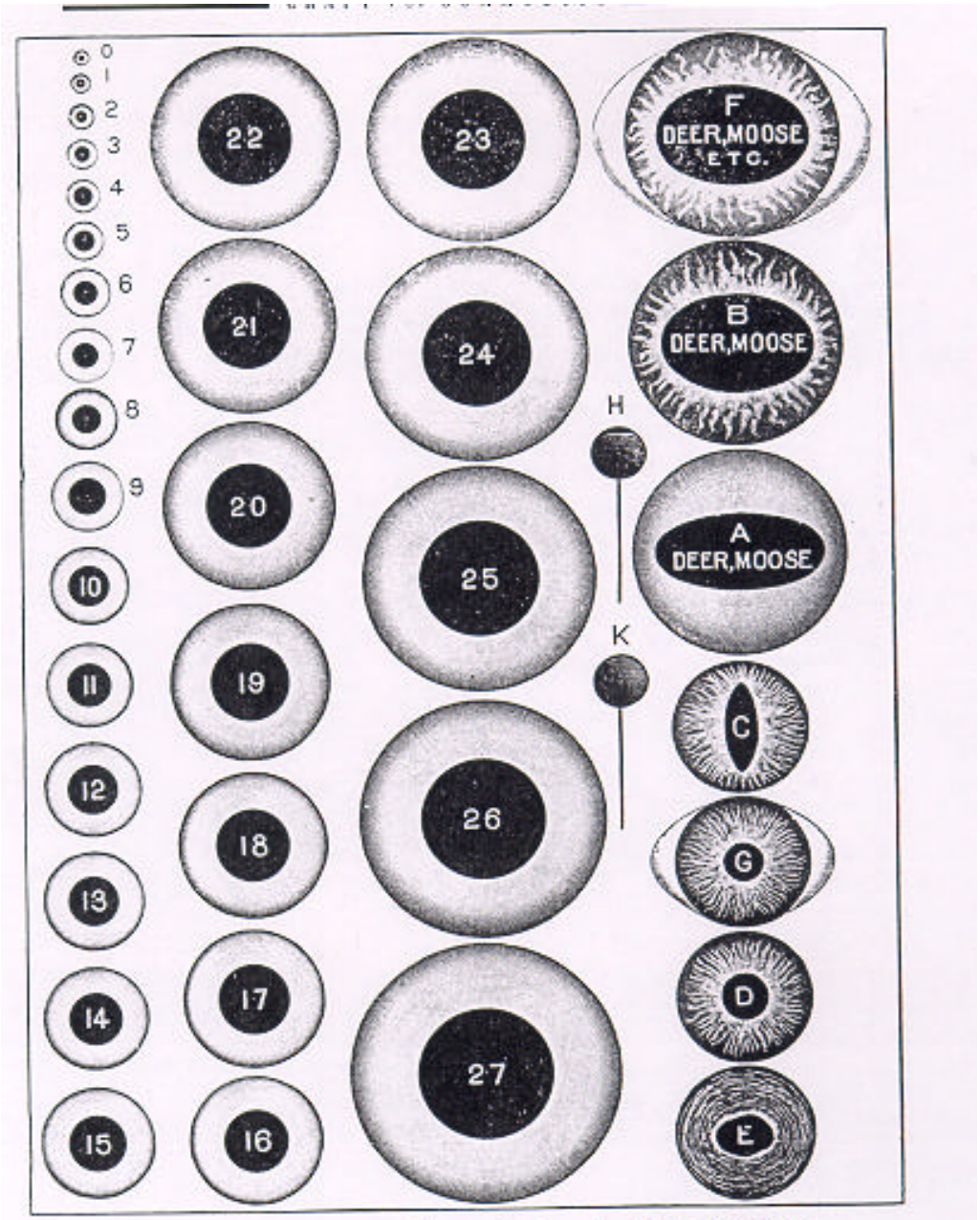


FIGURE 9.1 Glass eyes of different sizes for sale. (Davie 1894:26f.)

In another study, of brain scientists, (Star, 1989), I learned about their difficulties in obtaining (often illegal) and preserving (technically quite a difficult undertaking) brains for study.

These behind-the-scenes, messy or boring items form a crucial part of how scholarly and scientific work is done. Lack of infrastructure directly impacts the flow of interdisciplinary knowledge. For instance, I recently invited a young Dutch colleague to submit an interesting article to a journal I help edit. He replied that he was interested in the journal, and agreed that it would be a good audience for his work. However, his department

had constructed a list of approved journals and ours (a young, interdisciplinary one) was not on the list. The purpose of the list? Not some *imprimatur* of scientific correctness. Rather, the department wanted articles to be published in journals that were indexed, and thus counted, in the science citation index. Then they could prove to their government funders, with hard numbers, that the research had impact according to the citation index. When I inquired about how one gets counted by the science citation index, I was told that one must contact the science citation publishers, and present them with letters and testimony from eminent scholars testifying that the journal is worthwhile.

This sort of infrastructural barrier (or helpful facility, depending on one's viewpoint) is pervasive in scholarly work as well as in all modern bureaucracies. As evidenced by this anecdote, it is biased against new, unorthodox, and interdisciplinary paths, knowledges or approaches that tend to appear first at the margins of disciplines, in social movements, small presses, or in independent media venues open to risk-taking. The barrier is, in this case, inherently conservative. For established fields, however, tools like this are also vital aspects of communication and its quality. Thus, in order to understand these sorts of communication tools, we need to analyze their role in scientific and daily work – and play -- and learn to read these invisible layers of control and access.

In order to understand how this operates, however, it is necessary to "deconstruct" the boring, backstage parts of infrastructure, to disembed the narratives it contains and the behind-the-scenes decisions (such as that performed by the science citation index), as part of material culture. This means overcoming the initial boredom and reading the deeper social structures embedded in these tools. During the last several years, I have been studying such tools, both formal and informal. I have investigated several scientific, medical, ordinary life, and political classification schemes, with an eye to understanding the values and work practices embedded in them.

One of the infrastructures I studied was the International Classification of Diseases (ICD), a global information-collecting system administered by the World Health Organization (Bowker and Star, 1999). It is about one hundred years old, and has been revised every decade or so to reflect changes in medical and epidemiological knowledge. It takes the form of a long list of codes, numerals that stand for diseases and causes of death. The numbers are inscribed in medical and insurance software, death certificates, and other epidemiological and vital statistical tools. The volumewhere these numbers reside is more than 1,000 pages long, basically a very large list with instructions for selecting the numerals. It is not the sort of book that usually compels dramatic reading:

> " Reading the ICD is a lot like reading the telephone book. In fact, it is worse. The telephone book, especially the yellow pages, contains a more obvious degree of narrative structure. It tells how local businesses see themselves, how many restaurants of a given ethnicity there are in the locale, whether or not hot tubs or plastic surgeons are to be found there. (Yet most people don't curl up with a good telephone book of a Saturday night.) (Bowker and Star, 1999, p. ___)

Other kinds of information in a telephone book can be read indirectly -- for instance, a slender phone book indicates a rural area; those that list only husband's names for married couples indicate a heterosexually biased, sexist society.

Many aspects of infrastructure are more difficult to locate, for several reasons. First, people tend to discount this aspect of infrastructure as extraneous to knowledge or to their tasks. They therefore do not tend to include mention of them in official historical narratives (except in passing, see Clarke and Fujimura, 1992, for an excellent discussion of this problem). Second, details such as materials, standards and classification schemes do not always obviously intersect those variables and processes familiar to us in analyzing human interactions: gender, race, status, career, power, innovation trajectories, and so forth.

Unearthing the narratives behind boring aspects of infrastructure does, however, reveal, often in a very direct way, how knowledge is constrained, built and preserved. In addition, historical changes may provide clues. To continue with the phone book example, names and locations of services may change with political currents and social movements. To quote again from Bowker and Star (1999):

> In the Santa Cruz, California, phone book, Alcoholics Anonymous and Narcotics Anonymous are listed in emergency services; years ago they would have been listed under "rehabilitation" if at all. The changed status reflects the widespread recognition of the organizations' reliability in crisis situations, as well as acceptance of their theory of addiction as a medical condition. Under the community events section in the beginning, next to the Garlic Festival and the celebration of the anniversary of the city's founding, the Gay and Lesbian Pride Parade is listed as an annual event. Behind this simple telephone book listing lies decades of activism and conflict– for gays and lesbians, becoming part of the civic infrastructure in this way betokens a kind of public acceptance almost unthinkable 30 years ago... excursions into this aspect of information infrastructure can be stiflingly boring. Many classifications appear as nothing more than lists of numbers with labels attached, buried in software menus, users' manuals, or other references." (In Press, 1999)

In the case of the International Classification of Diseases, mentioned above, Western and middle-class values and foci are inscribed in the list of mortality and morbidity labels. These labels are used, among other things, to fill out death certificates and record epidemics around the globe. They are thus critical, often invisible resources for allocating aid and tracking international health concerns. As an example of Western, middle-class values, one can turn to the part of the classification scheme that encodes accidents. According to the list, one may fall from a car or from a commode, but not from an elephant. One may be a heroin or an absinthe addict[3], but addiction to sniffing gasoline is not represented. This latter is a serious problem among, for example, urban Aboriginal youth in Australia.

ADD THE EXAMPLE OF THE EVOLUTION OF THE METER

Fringes

The philosopher William James used to say that "words have fringes." He was quoted on this point by the sociologist Alfred Schütz in his classic essay, "The Stranger." Schütz spoke of the stranger as "one who comes and stays a while," not a mere passerby. A stranger often has trouble with the fringes of language, the nuances, the historical context, the indexicality. Indexicality is that which cannot explicitly be put into the representation, but requires insider knowledge of history, nuance, and context. To the extent that all representations are incomplete, indexicality fills in the necessary blanks. Schütz says, "graves and reminiscences can be neither conquered nor transferred" and that "to know a language you must be able to pray in it, write love letters in it, and curse in it." (Schütz, 1944) There is no such thing as a stand-alone word. And Schütz was enamored of strangers as windows into our thinking-as-usual, ways of disrupting what he called "thinking as usual." There is a hopeful and often romantic aspect to this – strangers bring new perspectives, trouble our complacency (e.g. Stonequist, 1937).

Large-scale information infrastructures, such as the Web and digital libraries, are making strangers of all of us, both designers and users. We are constantly meeting up with the fringes of other languages, a space where neither keywords nor co-word analysis can supply us with graves and reminiscences.

Some of the fringes come from the necessarily interdisciplinary undertaking of building such large systems. Some come from the indexicality of the content within libraries and their texts -- where words mean one thing in one discipline, and another in another one, for example. This is an old problem, and one of the richest ones in library science, for builders of thesauri and designers of information retrieval systems. New faster, bigger databases and algorithms for disambiguation change some things about the problems -- speed of processing, revising thesauri on the fly, brilliant insights into adjacency issues and modeling of problem spaces. In earlier times, changes to thesauri in print versions, could take years or decades, involve many committees and much heated, but invisible, discussion of revisions. These have by no means disappeared in the digital realm, but take a different form, some of it automated. However, while the smoke may have disappeared from the smoke-filled rooms of committees, the heat has not.

Background

I have worked since 1981 to build partnerships between computer and information scientists and social scientists. I first worked in the area of Artificial Intelligence modeling in the 1980s with Carl Hewitt at MIT, where my job more or less was to find things in nature whose properties could be translated into what was then called a highly parallel open system (Hewitt, 1985; 1986; Star, 1989). I was a purveyor of, in AI terms, "metaphors." In Greek, of course, "metaphor" means moving a thing from one place to another (moving vans are labeled "Metaphoros" for a literal point of view on this). In AI terms, this meant fetching good modelable data from phenomena "out there in the world". This was for me the beginning of finding the fringes between fields. I think of how long it took me to learn the meaning of "transparent" when I was a newbie stranger to the world of computer science, coming as I did from interpretive sociology. It really means opaque, you know.

In working on the Illinois Digital Library Project from 1994-1998 (Bishop, et al., 2000), and earlier on the Worm Community System based at the University of Arizona

(1991-94) (Star and Ruhleder, 1996), I ran into an interesting set of fringes from both the design and use sides of the equation.

On the Worm Community Project, my co-investigator Karen Ruhleder and I found a world of clashing meanings between designers and users of the system. The project came just before the advent of the Web, and just as academe become fully saturated with email users (especially in the sciences), 1991-1994. We studied a scientific community and a custom-made system co-designed with the community. Most respondents said they liked the system, praising its ease of use and its understanding of the problem domain. On the other hand, most did not sign on; many then chose instead to use Gopher and other simpler net utilities with less technical functionality' later, of course, they turned to the Web. Obviously, this was a problem of some concern to us as system developers and evaluators. *Despite good user prototype feedback and participation in the system development, there were unforeseen, complex challenges to usage involving infrastructural and organizational relationships*. The system was neither widely adopted, nor did it have a sustained impact on the field as the resources and communication channels it proffered became available through other (often more accessible) means. It did provide important insights and models for continuing work on the technical side; it also provided insights for us as social scientists into the profound impact of the understanding of infrastructure on group interactions. In short, we found that we had underestimated the problems with local infrastructure; we had underestimated the impact of the colliding "fringes" between users and designers; and in general, we learned a lot about how people feel about and use infrastructure and changes to it, including such (to us then) unlikely things as feeling shame, guilt, fear, rage; lying (to the point of claiming to use the system and not using it) and sneaking around; and what it not at all now surprising, using one system to show the evaluators and then switching back to familiar technology in their routine work.

On the Digital Library Project, and with the advent of the web, other fringes were to be found in the content of documents and web sites which are always, and interestingly, full of these meetings of strangers. There are many types: **homonyms** (again, an old, old problem in library science -- much of the research from that field is ignored by computer scientists and systems builders, unfortunately). I think of the time (in the early-ish days of the Web) when I was looking for a picture of a stag on the web to put on an invitation for a Winter Solstice party. Of course, predictably now, I came up with every dirty movie store featuring "stag films," and numerous NRA and hunting sites telling how to kill deer and why we should be able to. I retreated a bit and started with "wildlife" sites instead, where I was finally successful. Disambiguation algorithms to prevent this are now a major line of work in the search engine and e-commerce industries. Because of the social contexts and their slippery heterarchies, the problem remains fairly intractable.

Another type of strange encounter comes from resistance and social movements that **incorporate and re-appropriate language** at lightning speed. In twenty years "queer" has gone from being a term of loathing and gender boundary patrolling to a positive term (in some circles) denoting radical and challenging approaches to gender roles and sexuality. Of course, on the street, it is usually still derogatory. The term "nigger" is halfway -- it can be the ugliest of racial epithets or a positive re-appropriation by rap singers or African Americans speaking to each other in solidarity. I hardly know what to make of it, however, when I see my white middle class surfer students greet each other on the UC San Diego campus with, "hey nigger, w'as up?" (Of course we have words for this in sociology -- cultural appropriation, the migration of language forms across sub-cultures, and so on. This

research is virtually unknown amongst system builders; even where known, the technical problems and the social research do not match.) Fringes change with context, which is why they are fringes.

The collisions and their politics, and the lack of understanding in the technical community, is why this chapter is dedicated to Sanford Berman, fringe hero amongst librarians and pioneer into the ethics of categories and key words. His now-classic (or infamous, depending on who you talk to) example of the information retrieval problems associated with common objects, such as light bulbs, illustrates colliding fringes between lay users and a professional elite. At talks, he would explain, holding a light bulb over his head, someone trying to find out about light bulbs could never do so using Library of Congress Subject Headings (LCSH) categories. Instead, one would have to know to look under "electric lamp, incandescent." This is minor suffering, in a sense. More urgent are his politically charged challenges to the Library of Congress, such as attempting to remove "the Jewish Question", "primitive," and "Yellow Peril" as unquestioned categories (Berman, 1984; 1993).

Standards as Fringes

I want to turn my attention to an entirely different aspect of fringes here, one that is not usually recognized as co-extensive with the same problems Berman addresses. These are the fringes associated with standards, embedded categories (as opposed to those visibly appearing in LCSH or specific cataloguing systems), sizes, and those now imprinted on almost every object bought, observed, or every process to which we as human beings are subjected (medical tests, GREs, shopping, traveling, eating, giving birth, becoming a US citizen or getting a green card -- and so on, not to mention using the library). They have some of the same characteristics as the others described above; at the same time, they are usually deeply invisible, as is the work involved in creating and using them.

Let me give a couple of examples of standards struggles. First, a mundane example taken from little maps. I recently bought a poppy seed packet at Target. In addition to the bar codes, which encode both price and agricultural information, there is a little map at the bottom telling when to plant the poppies. Mine says Sept-February. It is of very coarse granularity, with four or five degrees of differentiation, and completely excluding Hawaii. However, another map, published by *Sunset Magazine*, and dedicated to the microclimates of the American West, indicates that I live in Zone 24. It takes into account the coastal fog that extends inland about 4 miles in San Diego, and adjusts the planting times accordingly The granularity is different because they are communicating to an audience of gardeners who need finer detail. (They also do not use the USDA Climate Zone, a map used for commercial agricultural purposes.)

Many have argued, include Mark Monmonier, Howard Becker, Nicholas Chrisman, and Babs Buttonfield, that maps encode all sorts of arguments and targeted audiences, and embody just the sort of fringes and standards struggles found in textual documents. Granularity is political, and that is especially important in cartography. Monmonier recounts the infamous story of the argument about the Peters Projection, a politically progressive, and not cartographically very good attempt to remedy the bias toward countries of the North, as shown by the older Mercator projection. Becker gives us the example of maps that do not show elevation. He lives at the foot of Lombard St. in San Francisco, also know touristically

as the “curviest street in world,” surrounded by some of the steepest urban streets in the US (1986). He often finds puzzle tourists on his street staring up 60 degrees and wondering how on earth they will make the climb. These two maps show different kinds of arguments and audiences, and different w ays of dealing with the problem, or not dealing with it.

Saul Steinberg’s conceptual maps of the view from New York City began a whole genre of drawing attention to the cognitive and social dimensions of ordinary maps. There are now cognitive maps of every major city and region, many industries, and many political or diplomatic situations -- all meant ironically, yet seriously. All in some sense subvert, or make visible, the fringes embedded in standard representations.

The U.S. Immigration and Naturalization (INS) form one must fill out in order to apply for citizenship, embeds another kind of example of categorical and standardization fringes. The application for a green card, or resident alien permit, includes questions such as, “are you mentally retarded,” “are you an alcoholic” or (perhaps my ironic favorite) “are you a card-carrying anarchist.” I am married to an alien, who is also an academic, and when we came to one question of this form, “have you every sold your body for profit,” his first reply was, “of course – I’m an academic, aren’t I?” (Many of the questions about mental retardation and prostitution come from the eugenics movement of the early 20th century, which had a strong hand in building immigration laws. This raises the important point about the range and nature of what computer scientists would call "legacy systems" found in everyday life and in formal systems.)

We have recently filled out the U.S. Citizenship form. The instructions come in the form of about one hundred pages of U.S History, from which citizenship questions are drawn in a quiz, where one is allowed short sentences and multiple choice. He also holds a PhD in History and Philosophy of Science. We came to the question, “what form of government does the United States have?” As a good historian, he began to answer, “Well, from post-colonial and globalization point of view, many argue that the form of government is now actually via multi-national corporations and lobbyists, with a distinct media influence... .” "No, no, no," I say. "The answer is bicameral representative democracy." "Oh," he says. Standards are standards, and they embody values, simplifications, and treaties.

The ubiquity of standards cannot be underestimated as a problem in research about heterarchies. Even the rubber band that came with a bunch of asparagus I bought in the supermarket encodes a California number for batches of asparagus. Sending this paper to the workshop organizers entailed thousands, arguably millions, of acts of using standards.

I will take a final example from a world one would not usually think of as standardized. My cat, Watson, herself an immigrant or stranger to the United States from the Midlands of England (my vet and I have long conversations about whether she has an accent. Apparently dogs do have regional barking accents), embodies multiple conflicting standards, categories and information systems. Now the first question of standardization is that she looks and acts like a standardized breed, a Norwegian Forest Cat. I so referred to her for years. However, a cat judge friend told us when she was about 8 that she was really just a “moggie” (British for mixed breed or mongrel). Who is right? Secondly, Watson is a cyborg. She has implanted in her a chip with identification that is linked to a database operated in several cities and linked with veterinarians’ offices. Should she run away, she may be scanned and the data may be returned to my vet via a large network of databases

now linked amongst veterinarians. Finally, I recently discovered that there now exists a software program that looks for standardized paw motions in order to protect one's computer. As any pet owner knows, it is possible for a small pet to activate or turn off a computer by walking on the keyboard. (Watson, like most Norwegian Forest cats, has very large paws, however.) A recently developed product will protect your computer by detecting standard paw motions and refusing to accept that keyboard input. The same company is developing one for small children's undesirable keyboard actions.

Intellectual Background: Science Studies

In the world of science, scholars began to study how laboratories work during the 1970s, work that was later to link with these concerns about infrastructure. In Europe and the US, notably with the 1979 publication of Latour and Woolgar's *Laboratory Life* (1979), people began to explore the laboratory as a kind of anthropological field, with scientists as the tribe. *Laboratory Life* was an ethnographic examination of the production of a scientific fact. It looked at the devices (called "inscription devices" by Latour and Woolgar) used by biologists to record and preserve data and at the gradual deletion of uncertainty and qualifications in the statements emerging from the laboratory. It explicitly tried to eschew the obvious categories that previous, more macro-scale studies of science had produced -- occupational stratification, the role of national cultures in science, and so forth. The idea was to approach science making afresh, to look empirically at knowledge production in a detailed, face-to-face context, much as an anthropologist would approach a new “tribe” (their metaphor).

With the publication of *Laboratory Life,* a window was opened to a more qualitative, intensively observational set of studies of scientific work and practice. Many were produced over the next two decades, examining such interesting phenomena as talk in the laboratory, the acquisition of manual skills in performing tests, the ambiguity of scientific objects, the intersection of heterogeneous viewpoints in making scientific theories, and, by the 1990s, the research community began systematic study of the design and use of information technologies (see e.g. Star, 1995). This development towards the "technical turn" in science studies, that is, the ethnographic study of the design and use of advanced technologies, such as computers, had many research ramifications (Star, cite). It used many of the same techniques as earlier laboratory studies of science. However, it also directly engaged social scientists in studying communicating machines, the emergence of the PC and late the World Wide Web, and to observe attempts to model human behavior. In addition, in the early 1990s, several detailed studies of the materials aspects of scientific work began to appear, many of which began to pick up aspects of "boring things" or infrastructure (see e.g. Clarke, 1998). EXTEND

Recent studies have taken this combination of the technical turn and studies of materials deep into the investigation of infrastructure (see e.g. Star and Ruhleder, 1996). The ethnographic eye that helped reveal the inner workings of science or technology research and development applies no less to the built scientific-technical environment. Arguments about standardization, selection and maintenance of tools, and the right materials for the job of knowledge production have slowly come into center stage via this synthesis (Clarke and Fujimura, 1992). Along with this has come a rediscovery of some of the tools germane to

cognate disciplines that had previously analyzed material culture and the built environment. These have included, *inter alia,* fields such as architecture (where scholars sometimes read the built environment as a kind of text); literary theory (especially those aspects of literary theory that help surface hidden stylistic assumptions and narrative structure), and social geography (where the values and biases inherent in such tools as maps are a lively topic of inquiry). My own work, on categories, boundary objects and standards as structuring knowledge owes much to these fields as well as to cognitive anthropology and linguistics, areas whose scholars have investigated the tool-ness and origin of various category systems.

Let us turn now to the specific role of boundary objects and standards in constituting heterogeneous knowledge.

Boundary Objects and Standards are Imbricated in Infrastructure

> **Imbricate: 1.** *trans.* To place so as to overlap like roof-tiles. Also with *together* (in *fig.* sense).
>
> **1784** tr. *Beckford's Vathek* (1786) Notes 315 Trains of peacocks..whose quills were set in a long stem, so as to imbricate the plumes in the gradations of their natural growths. **1874** COUES *Birds N.W.* 435 Each feather is thus folded or imbricated over the next succeeding. (Oxford English Dictionary, online, UCI)

Infrastructure is composed of a complex matrix of boundary objects and standards, imbricated in the way a stone wall is put together:

Each stands on top of the other, supporting, but not in a smooth or seamless fashion. Some stone walls fall down; some survive for thousands of years. Some are added to and maintained, some neglected.

The metaphor is important for the rest of the volume in addition to its evocative picture of uncemented things producing a larger whole. Imbrication also implies that each part may shift in character over time as the whole is "edited" or rearranged. Thus, a keystone at one time – a rigid standard, say – may become a minor end interchangeable end stone at another time. For example, in the matter of standardizing keys, we currently live in a mixed economy of metal keys and digital keys. For metal keys, any key maker has on hand a supply of standard-sized slugs that may be roughly matched, then hewn to fit a particular door. For digital keys, numbers are programmed into both lock and key. As digital keys become the *de facto* standard (over the next period of years, I predict), the standard metal key slugs will become harder to find – not unlike typewriter ribbons are thus today.

Disciplines and Categories: Disciplines are Commitments to Disagree

Against commonsense belief, scientific and academic disciplines do not constitute a high degree of consensus. On the contrary, one might better define a knowledge discipline as *a commitment to engage in disagreements*. Biologists do not agree on the nature of species; sociologists bicker about the nature of society; literary critics diverge on notions of genre and style. What endures, however, are debates about the categories that constitute the core knowledge of the field. Insofar as these categories are inscribed in material objects, databases, and knowledge management tools such as thesauri and journal indexing terms, they themselves form a kind of glue that acts to keep the discipline communicating. The same is true of interdisciplinary communication. For example, in my earlier studies of neurophysiology and brain research, debates raged from the early nineteenth century to the present day about whether particular functions are localized in a particular part of the brain (Star, 1989). Dozens of careers were made and broken in research on this topic -- both in the search for areas such as the "speech area" and in denunciations of the very idea. Participants came from physiology, surgery, anatomy, psychology, hospital administration, and philosophy. In the end, their disagreements helped to form the basis for neurophysiology as a discipline. In biology, a similar arena emerged around the unit of analysis for species selection: group or individual? Genes or environment? Biologists come in large part to self-define around the stances they take on these issues.

In none of these sorts of debates, however, are the basic *terms* of the debate usually questioned. Localizationists may have disagreed with diffusionists about the localized vs. distributed character of cognitive function, but almost none of them chose to look to the environment, whole body, or elsewhere for the seat of cognition, or to dismiss the question out of hand. Biologists all agree that speciation is a crucial phenomenon, whatever their causal allegiance.

What does emerge with some frequency are two kinds of structures within the debates. First, much of the infrastructural technology is used unquestioningly by everyone in the debate. Both localizationists and diffusionists used surgery, electroencephalographs, and neurological testing to validate their claims, for instance. Second, particular categories (rather than the classification scheme as a whole) become targets for debate. Thus Kirk and Kutchins (1992) describe a fierce debate between gay activists and psychiatrists about the medicalization of the category "homosexual" as an illness in early versions of the Diagnostic

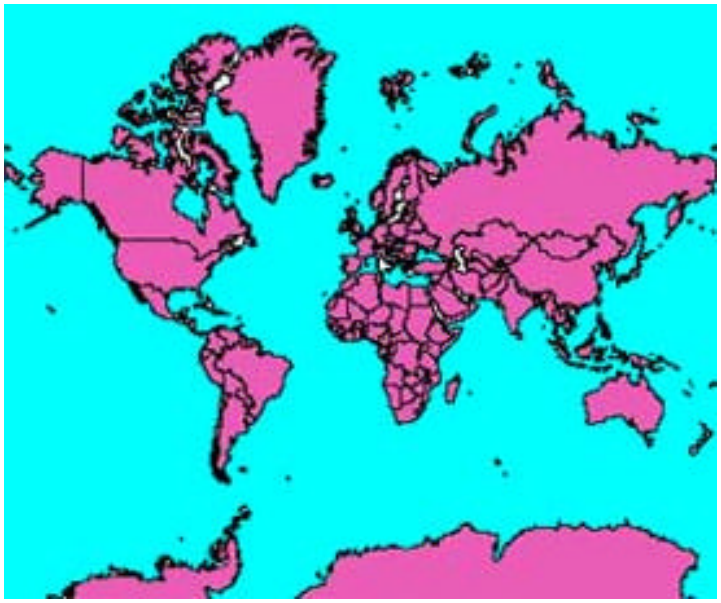
and Statistical Manual (DSM), the psychiatric equivalent of the ICD. The DSM assigns categories to mental illnesses, and is widely used in psychiatric epidemiology as well as in such crucial infrastructural functions as third-party reimbursement for psychiatric care. At the same time, few on either side of the debate quarreled with the basic need for such a category system. Once the system was put into place, it acquired its own inertia and entanglements with the everyday bookkeeping and diagnostic practices of psychiatrists and other mental health professionals.

The job of an analyst of scientific work, therefore, is to raise these second- and third-order questions about the existence and nature of the whole classification scheme, the taken-for-granted tools used in intra- and inter-disciplinary communication. One aspect of this work is to surface embedded biases in representations of knowledge, both blatant (e.g. in advertisements) and subtle (e.g., categories in databases). The critical study of cartography and maps is especially pertinent.

Embedded Biases in Scientific and Technical Representations

One of my concerns in the work of understanding categories has been to explore how these usually-invisible scientific substrates in face encode – in a very powerful way – the moral order of the disciplinary cultures that build and use them. Geographers have demonstrated this very effectively in reading the moral qualities of maps, mapping standards, and the cultural assumptions embedded therein. Let me illustrate here with a few examples.

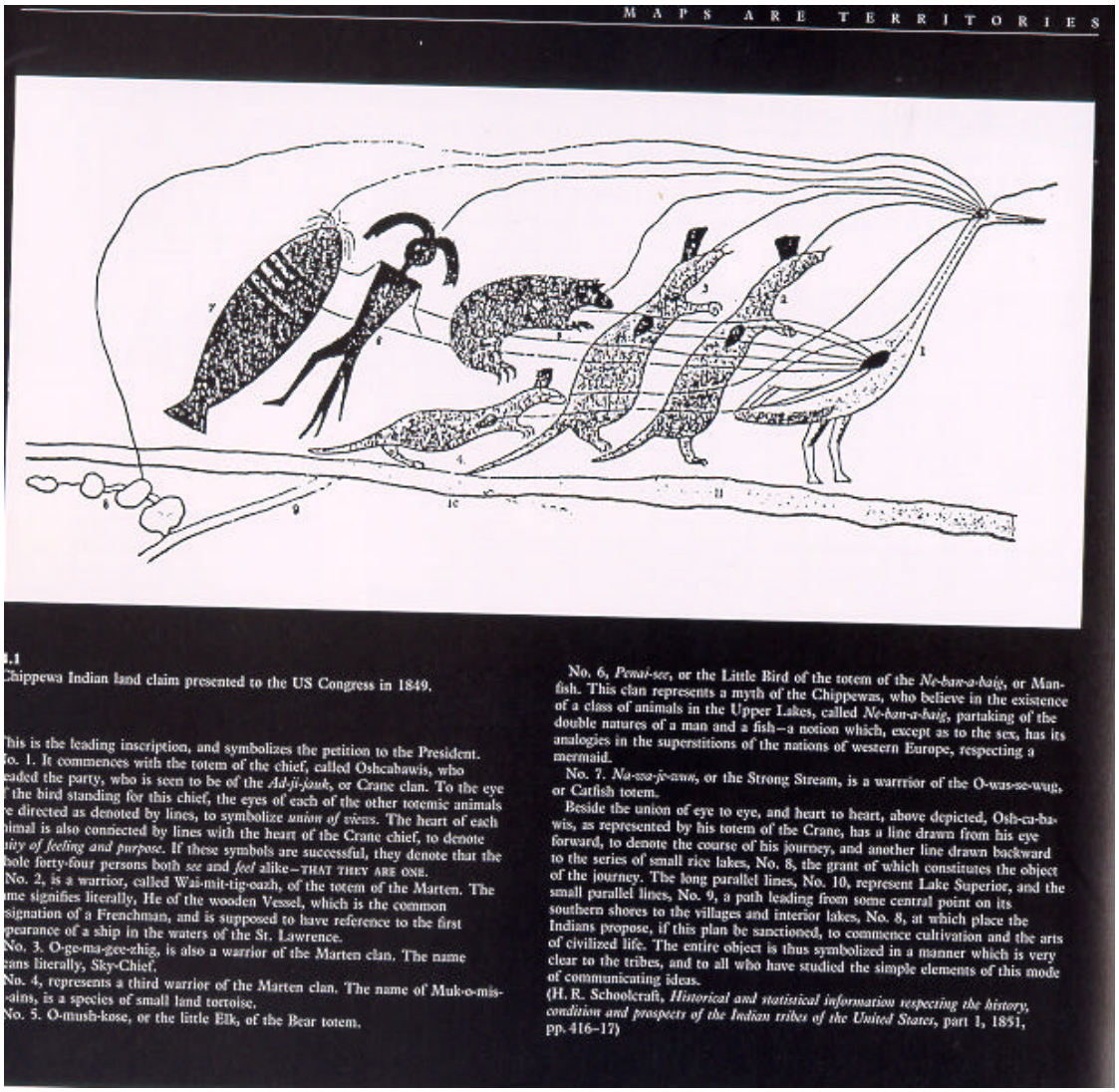
Countries south of the equator have long noted the biases inherent in the once-standard Mercator projection.



This map of the world "adjusts" for a Euro-centric vision of the world, and visually inflates (via flattening) the North and the West, while de-emphasizing the South (Africa and Australia come off particularly badly on this view). The Peters projection is an attempt to correct this, showing land masses of the South and East in more accurate proportion.

At the same time, the convention of ordering of the world with the north at the top of a page or globe, and the south at the bottom, is equally arbitrary and biased. The Earth is a globe spinning in space with no absolute referent. There is no technical reason not to show Australia at the top of the globe, and the North Pole at the bottom. Again, the historical reasons have to do with the hegemony of European maps and map-making. Consider the following illustration, which combines the Peters projection and the "upside" version of the globe. (It is interesting to note here that when I have shown this figure to academic audiences, someone invariably shouts out, "it's upside down!" I have not yet shown it in a talk in Australia, it must be noted!)

Of course, this does not exhaust the cultural boundaries of maps and their biases. Radically different maps derive from non-Cartesian, relational, aboriginal maps, where things like time, emotion, and commitment often appear explicitly as part of the cartography. Consider the map below illustrating an 1849 Chippewa land claim to the United States Congress.



Caption: Chippewa Land Claim, 1849

The first figure below is the totem of the Chief, who is of the Crane clan. From the eye of this totemic bird, a line is drawn to the other figures (also clan symbols), representing unity of vision. Lines are also drawn from the hearts of the leader to the others, indicating union of feeling and purpose. The Chief has as well a line drawn from his eye to the series of small circles at the left, indicating a journey taken. The small circles symbolize the claimed rice lakes, placed near lines indicating Lake Superior and other landmarks.

The cultural-cognitive basis of maps of this sort have been well explored both in anthropological studies of indigenous cartography, and in the humorous series of cognitive maps made famous by the cover of *The New Yorker* magazine in the 1960s. *The New Yorker* cover depicted a Manhattanite's view of the world, with landmarks like Fifth Avenue, Central Park and the East river occupying a substantial proportion of the image, and culturally distant items like "New Jersey" and "California" off in the distance as tiny icons. The joke, of course, is that the typical New York native sees Manhattan as the center of the

universe, and nothing else matters much. The cover has given rise to a series of imitators, including a precisely inverse map from San Francisco with both Los Angeles and New York depicted as tiny distant images.

The cultural values in this sort of representation may be read fairly directly, especially by contrast with "regular" maps. Not so easy to access, however, and crucial for the argument here, are geographical information systems underpinning many of today's maps, especially those representing metadata. Metadata, a term originating in library and computer sciences, means data about data. Metadata about a library collection, for example, will tell you what types of documents may be found in a collection (maps, manuscripts, archives, journals, books), but not the exact titles held by the collection. Metadata is equally imbued with values as are all maps, but these values are much harder to pick out. Sometimes this is because they are embedded in numbers or layout, and at other times, it is because one rarely gets the view of how the metadata are distributed, collected or designed. Consider the "cartogram" below, by geographer Nick Chrisman (Chrisman, 1997).

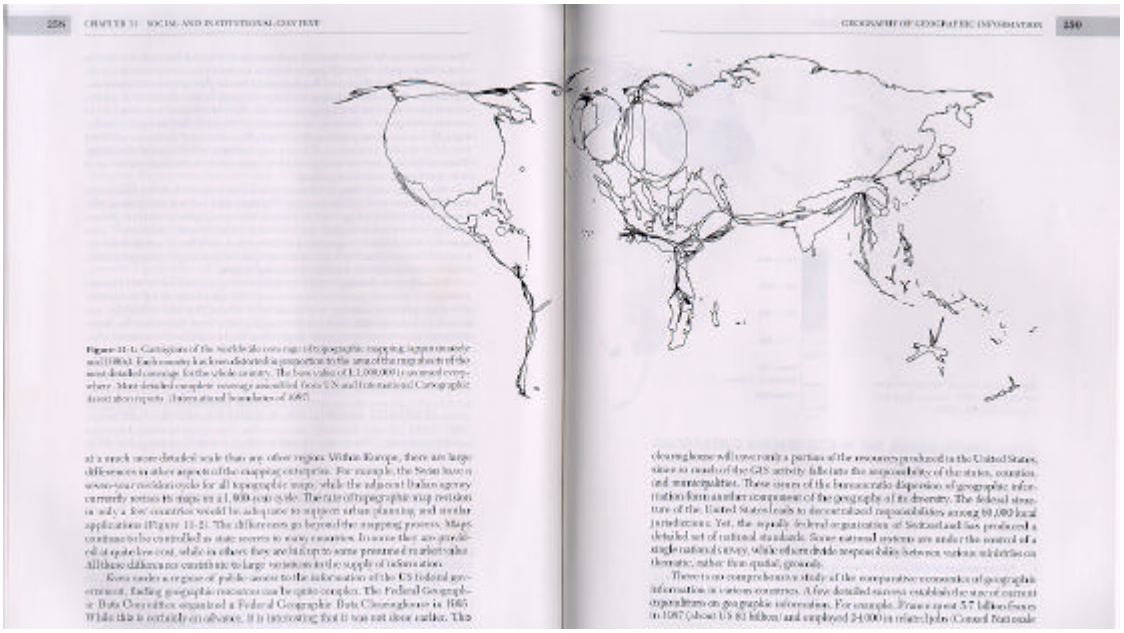


Figure 4: Metadata, A Map of Maps

This is a representation of all countries mapped at a certain granularity from the US DMS coverage of the Operational Navigational Chart. Chrisman took each of these maps, gave it a quantitative value, and then made this map of maps. One can see from this that the bloated size of the United States, England, (formerly East) Germany and Finland contain some narrative structure about the importance of making maps for these areas. The size of East Germany is due to the surveillance data collected during the Cold War; Finland was an

equally strategic point for the Soviet Union. The US and England represent the concerns of the mapmakers for their own turf. The shriveled appearance of South America, and the almost non-existent appearance of Australia, represents the lack of maps for those areas.

Metadata rarely appear in such a stark, readable fashion. Rather, they are distributed over the bureaucratic and military landscapes, appearing as settings, standards, and technical aspects of user's manuals. If we wish to understand more of the deep structure of inter-discipline communication, it is important to develop good tools for parsing metadata – culturally, and politically, as well as technically. Reading the telephone book in the fashion suggested above is one way of getting at this sort of tool – the metadata attributes of the telephone book, such as size, types of listing, and so on provide a first start.

Reading the invisible maps that border disciplines requires new sorts of metadata tools, ones that can help us understand the traffic across disciplinary borders as well as the take-for-granted questions to which disciplinary adherents are committed. A few ideas about how to approach this are sketched below.

Defining Infrastructure

Defining infrastructure is not as obvious as it may seem. I had a commonsense notion of infrastructure when I first started studying the design of interdisciplinary computer systems – infrastructure as something that other things "run on," things that are substrate to events and movements. Railroads, highways, plumbing, electricity, and more recently, the information superhighway. Good infrastructure is by definition invisible, part of the background for other kinds of work. It is ready-to-hand. This image holds up well enough for most purposes– turn on the faucet for a drink of water and you use a vast infrastructure of plumbing and water regulation without usually thinking much about it.

However, in light of a deeper analysis of infrastructure, and especially to understand large-scale technical systems in the making, or to examine the situations of those who are *not* served by a particular infrastructure, this definition is both too shallow and too absolute. For a highway engineer, the tarmac is not infrastructure but topic of research and development. For the blind person, the graphics programming and standards for the World Wide Web are not helpful supporters of computer use, but barriers that must be worked around (Star, 1991). One person's infrastructure is another's brick wall, or in some cases, one person's brick wall is another's object of demolition. As Star and Ruhleder put it, infrastructure is a fundamentally relational concept, becoming real infrastructure in relation to organized practices (1996; see also Jewett and Kling, 1991). So, within a given cultural context, the teacher considers the blackboard as working infrastructure integral to giving a lesson. For the school architect, and for the janitor, it is a variable in a spatial planning process or a target for cleaning: "Analytically, infrastructure appears only as a relational property, not as a thing stripped of use." (Star and Ruhleder, 1996: 113)

In my studies of the development of computer systems and scientific work, I have begun to see infrastructure as part of human organization, and as problematic as any other part. I've done a kind of Gestalt switch, what Bowker has called an "infrastructural inversion" – foregrounding the truly back stage elements of work practice, the boring things (1994). Recent work in the history of science (Bowker, 1994; Hughes, 1983; 1989; Yates, 1989; Edwards, 1996; Summerton, 1994) has begun to describe the history of large-scale

systems in precisely this way. In science as well as in culture more generally, we see and name things differently under different infrastructural regimes. Technological developments are processes and relations braided in with thought and work. In the study of nematologists mentioned above, Ruhleder and I listed the properties of infrastructure as that which is embedded; transparent; having reach or scope; is learned as part of membership; has links with conventions of practice; embodies standards; is built on an installed base (and its inertia); becomes visible upon breakdown; and is fixed in modular increments, not centrally or from an overview.

Struggles with infrastructure are built into the very fabric of technical work, and increasingly other domains of work and play (Neumann and Star, 1996). However, it is often easier to stay within the traditional purview of social scientific studies: talk, community, identity, and group processes as now mediated by information technology. There have been several good studies of MUDs and role-playing, distance-mediated identity, cyberspace community and status hierarchies. There are many fewer on the effect of standardization or formal classification on group formation, the design of networks and their import for various communities, or on the fierce policy debates about domain names, exchange protocols, or languages.

Perhaps this is not surprising, given the invisible and boring nature of many of these venues from the point of view of social science and humanities. The latter topics tend to occur in semi-private settings, or buried in inaccessible electronic code. Theirs is not the usual sort of anthropological strangeness. Rather, it is an embedded strangeness, a second-order one, that of the forgotten, the background, the frozen in place.

Studies of gender bending in MUDs, of anonymity in decision-making, and new electronic affiliations *are* important— they stretch our understanding of identity, status, and community. The challenges they present are non-trivial methodologically. How does one study action at a distance? How does one even observe the interaction of keyboard, embodied groups, and language? What are the ethics of studying people whose identity you may never know? When is an infrastructure finished, and how would we know that? How do we understand the ecology of work as affected by standardization and classification? What is universal or local about standardized interfaces? Perhaps most important of all, what values and ethical principles do we inscribe in the inner depths of the built information environment? (Hanseth and Monteiro, 1996; Goguen, 1997) We need new methods to understand this imbrication of infrastructure and human organization.

As well as the important studies of body snatching, identity tourism and trans-global knowledge networks, then, let us also attend analytically to the plugs, settings, sizes, and other profoundly mundane aspects of cyberspace, in some of the same ways we might parse a telephone book.

The ecological effect of studying boring things (infrastructure, in this case) is in some ways similar. The ecology of the distributed high-tech workplace, home or school is profoundly impacted by the relatively unstudied infrastructure that permeates all its functions. Study a city and neglect its sewers and power supplies (as many have), and you miss essential aspects of distributional justice and planning power (But see Latour and Hernant, 1999). Study an information systems and neglect its standards, wires and settings, and you miss equally essential aspects of aesthetics, justice, and change. Perhaps if we

stopped thinking of computers as information highways, and begin to think of them more modestly as symbol sewers, this realm would open up a bit.

From the History of Ideas and Knowledge Structures, to Shared Objects and Infrastructure and Interdisciplinary Communication

Most of the stories about communication across communities that have been told in the past have excluded analysis of shared infrastructure. Instead, they have emphasized the ideas and techniques that have migrated from one field to another, or, they have looked for structural similarities between disciplines' knowledge structures that could explain affinities. Other theories have looked at the migration of individuals across boundaries, often graduate students moving from one lab to another, or senior researchers beginning a second career. All of these studies provide valuable insights into how science travels across disciplinary boundaries, or how new interdisciplinary fields are established. At the same time, the role of shared material objects and infrastructures is crucial for a full picture.

Shared Objects

One of the kinds of material/infrastructural arrangements that may occur across fields is the development of *boundary objects* (Star and Griesemer, 1989; Star, 1989). These are objects that dwell in more than one community of practice – a discipline, or a line of work, or a voluntary association. They have two important properties: they are loosely structured in common use, and become more tightly bound in particular locations. They are thus both ambiguous and clear, at different moments, for different purposes.

I developed this notion with James Griesemer some years ago when we were conducting a study of the development of the Museum of Vertebrate Zoology (MVZ) at the University of California, Berkeley. Two individuals from different communities founded the MVZ early in the century: biologist Joseph Grinnell and philanthropist/amateur naturalist Annie M. Alexander. Grinnell was one of the founding figures of population ecology. His research questions and methods required the collection of large numbers of specimens from all over the state of California. To do this, he enlisted the aid of dozens of amateur collectors and naturalists, who were interested in the project for its value to the conservation movement, rather than for reasons of scientific accuracy.

One of the interesting things about the development of the museum was the very different visions participants brought to the table. Most of the collectors were uninterested in Grinnell's formal ecological theories, for example. At the same time, however, these heterogeneous groups were able to cooperate, even down to the level of collecting and painstakingly labeling specimens for Grinnell's museum. How did this cooperation occur in the absence of intellectual consensus?

Specimens, maps, even the cases inside the museum grew into boundary objects shared across these different worlds. Thus, a local naturalist could come to the museum with a specimen, learn its name, and feel that he or she was contributing to conservation, via science. Professional biologists could use the collections in another way. The delicate diplomatic structures that composed this set of arrangements included several varieties of boundary object. They also relied on a certain degree of standardization across methods, for example in the collecting of specimens and the description of habitats.

Boundary objects are everywhere, but the concept is especially important in looking at interdisciplinary cooperation and issues of infrastructure. Often an infrastructural device

such as a thesaurus or the science citation index discussed above becomes a boundary object (see e.g. Harvey and Chrisman, 1998). Even people who strongly disagree on theoretical matters come to refer to the tool in a similar fashion, and it provides a lingua franca for exchanges. Where these exchanges are stabilized, boundary objects develop facilitating heterogeneous cooperation.

There is much work to be done to understand all of the ramifications of this approach to interdisciplinarity. We need to understand more, for example, about the behind-the-scenes decisions about things such as encoding and standardizing; tinkering and tailoring activities (see e.g. Gasser, 1986; Trigg and Bødker, 1994), and the observation and deconstruction of decisions carried into infrastructural forms (Bowker and Star, in press, Chapter 3). We need to understand more about how boundary objects develop as well as how they fail to develop in cross-disciplinary work.

Identifying master narratives and 'others.'

A deconstructive reading of infrastructure quickly reveals the presence of what literary theorists would call a master narrative, that is, a single voice that does not problematize diversity. This is the voice of the unconscious center, the pseudo-inclusive generic. An example of this encoding into infrastructure would be a medical history form for women that encodes monogamous traditional heterosexuality as the only class of responses: blanks for "maiden name" and "husband's name," blanks for "form of birth control" but none for other sexual practices that may have medical consequences, and no place at all for partners other than husband to be called in a medical emergency. Latour discusses the narrative inscribed in the failed metro system, *Aramis*, as encoding a particular size of car based on the presumed nuclear family (1996). Band-Aids or mastectomy prostheses labeled "flesh colored" which are closest to the color of white people's skin are another kind of example.

As we learned long ago from Derrida and from feminist linguists such as Wendy Martyna, identifying and subverting these pseudo-generic voices means first identifying that that has been left silent. In Adrienne Rich's words, this means listening first for "lies, secrets and silences." Some of the literary devices that represent master narratives are: creating global actors, or turning a diverse set of activities and interests into one actor with a presumably monolithic agenda ("the United States stands for democracy"); personification, or making a set of actions into a single actor with volition ("science seeks a cure for cancer"); passive voice ("the data have revealed that") and deletion of modalities. This latter has been well described by sociologists of science— the process by which a scientific fact is gradually stripped of the circumstances of its development, and the attendant uncertainties, and becomes an unvarnished truth. In terms of infrastructure, this may mean recovering the narrative before being able to analyze it. Again, this implies digging into the construction sites of infrastructures – standards setting, creating of classification systems, decisions to invest in one sort of system or another.

In the above-mentioned study of systems of classification, Bowker and I attempted to unearth the developmental aspects of infrastructure creation and use. discovered many moments when the master narrative-in-the-making became visible. For example, we studied the creation of the system of race classification under apartheid in South Africa. From 1950 until the end of apartheid in the early 1990s, all South Africans were classified into four racial

groups, European (white), Asian, "Bantu" (black African), and Coloured (mixed race). Of course, millions of people did not fit into such oversimplified designations, which conflated language groups, race and ethnicity, appearance and genetics, and many other factors. This did not stop the government from enforcing totalitarian control over the lives of those so classified, including restrictions on workplaces, residences, voting, and so on.

In order to understand the cracks in the system and how it was enforced, we examined a number of cases of racial reclassification. These were legal cases where the person felt (or sometimes a government informant felt) that they had been wrongly classified. Common instances of this were among light-skinned people classified as Coloured, who felt that they should be classified White (a vastly more privileged category). In the reclassification process, the emergence of the master narrative is clear. There is no room for ambiguity on the form, whatever may be the ambiguities the person lived with in everyday life. One could be assigned only one category, eternal and ahistorical. From this would devolve government statistics on racial groups, Parliamentary and police organizations, and even sports teams. Since the hearings on race reclassification were done in camera, the public face of the master narrative was able to be enforced in a vast system of bureaucracy, forms, and layered "lies, secrets and silences."

Invisible Work

Much of the work that creates both boundary objects and master narratives becomes invisible once it is inscribed in infrastructure. In addition, many information systems represent and encode work processes, directly or indirectly (payroll systems, time sheets, activity reports, and flow charts are among the many infrastructural tools that perform this function in the workplace). Such tools, like language itself, are always incomplete with reference to both the complexity and the indexicality of the processes represented. People are always adjusting, working around the representations to get on with their jobs and their lives.

Again, though, there is an opportunity for social archaeology for the analyst of infrastructure (Star and Strauss, 1999, discuss this in relation to the design of CSCW systems). In some instances, this means going backstage, in Erving Goffman's terms, and recovering the mess obscured by the boring sameness of the information represented. It is often in such back-stage work that important requirements are discovered.

With any form of work, there are always people whose work goes unnoticed or not formally recognized (cleaners, janitors, maids, and often parents, for instance). Where the object of systems design is to support all work, leaving out what are locally perceived as "non-people" means that in fact the system does not work. Most computer systems designers arbitrarily cut off certain support personnel from the systems they are creating – sometimes secretaries (as with executive decision support systems, ignoring how many decisions are in fact made by secretaries for their bosses), usually janitors, cooks, and temporary personnel. The results are layers of silence built into the infrastructures that surround jobs.

The solution to these silences and their negative consequences is not always, however, simply making things visible to all. So, for example, when Bowker and I were

analyzing the attempts by a group of nurses to classify their work processes, we saw them walk a delicate line between visibility and invisibility. They wanted their work to be represented in order to be legitimated. At the same time, if they categorized all the tasks they did, and then built forms into hospital record keeping in order to track that work, they risked having the hospital accountants and HMO officials Taylorize their work and try to fob parts of it off on less expensive paraprofessionals. So leave the work tacit, and it fades into the wallpaper (in one respondents' words, "we are thrown in with the price of the room"). Make it explicit, and it will become a target for surveillance. The job of the nursing classifiers was to balance someone in the middle, making their work just visible *enough* for legitimation, but maintaining an area of discretion.

Much infrastructure is marked with this sort of invisible trouble. In academic departments, the question of what work should be visible and what should *count* for promotions and tenure often brings this to a head. Researchers who develop large information systems, performing and visual artists, those whose work may take a long time to come to fruition (such as architects) are often at a disadvantage with promotion committees, who may not be able to evaluate or understand the invisible work that goes into research that does not culminate in a book or an article in a refereed journal.

Conclusion

Let me conclude with a short millennial story that I think illustrates some of the problems and challenges that come with studying infrastructure, including standards and classifications. It concerns the range of the Y2K problem. At one end of the continuum, some time a few years ago Standard and Poore created a Y2K stock index – a metadata structure – indexing the profitability of firms arising to deal with the infamous millennial computer "bug." Layers upon layers of infrastructure attend this effort – literally, in the case of old code written into the deep workings of inventory control systems and bank accounting, and metaphorically, in thinking of how Standard and Poore sits on top of the NY Stock Exchange, which sits on top of the work of consultants analyzing the computer systems of various firms and making recommendations, which sits on top of the company staff programmers – and so on. It's infrastructure all the way down.

At the other end of the Y2K spectrum is my friend Gert Ryan's problem.[4] Gert is 87. When her husband died 25 years ago, she buried him in the family graveyard with his dates of birth and death. Underneath, she inscribed:

Loving wife Gertrude, 1912 - 19

leaving the last two numerals unspecified. As with many widows, she reserved a place beside her husband.

The problem is that Gert never dreamed she'd live to be 88 or 89 or more. She now, then, has her own form of theY2K problem – this one carved in stone. Both ends of this continuum are important – the end inscribed in bits and bytes, and that inscribed in granite.

We need to be able to theorize across the continuum, seeing both layers of organizational complexity and big historical changes such as changes in life expectancy. The road in to both comes from many sources, through a myriad of exquisitely boring things.

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[1] Including, among others, anthropologists Charlotte Linde and Susan Anderson, historian Geoffrey Bowker, computer scientist David Levy, physician/philosopher Marc Berg.

[2] Biologists who study worms, in this case those who were trying to sequence the genome of the nematode *c. elegans*.

[3] The list began in Paris in the nineteenth century, thus the concern with what today, in most parts of the world, is a relatively minor addiction problem.

[4] Thanks to Gert's daughter, Prof. Kathleen Ryan, for telling me this story.