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CRITICAL SYNTHESIS

Studies of Scientific Writing--E Pluribus Unum?

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The rhetorical character of scientific writing currently interests many groups of scholars. These differently motivated groups, working from different conceptual models and using different critical methods, have attended to different aspects of scientific writing. Interdisciplinary awareness remains, moreover, peripheral--a curiousity for the curious and a source of random inspiration. The framing interests and disciplinary contexts of each of the types of work discourages systematic interdisciplinary communication. Nonetheless, this varied work has gathered assorted odd shaped pieces that may, with some interdisciplinary jiggling, be fit together on a new framework. This informal review starts to lay some of the pieces on a shared table, so that the work coming out of different traditions may become more visible to workers in the other traditions. The brief comments offered here are not intended to be adequate summaries or definitive judgments of the increasingly exciting work being done out of the various traditions. Nor should simple characterizations provided here be mistaken to mean that the work has settled into the orderly patterns of disciplinary middle age. The rash judgments offered here are only first approximation descriptions to create some order out of teeming chaos. The highly selected citations only indicate trends and actors and can serve as no more than an entry way into each of the fields discussed. Many noteworthy publications that I am aware of will not be mentioned, as will the even larger number I am not aware of. This essay aspires to openings and does not pretend to closures.

I first turn to the work currently most visible to readers of this journal, the studies of scientific writing coming out of the sociology of science. These studies treat scientific communication as a sub-problem of the social structure and dynamics of scientific communities. Three different approaches to scientific communities have given rise to different concerns with scientific discourse. The first, and founding, approach to the sociology of science is interested in questions of how science operates as a social system to create communal achievements out of the conflicting interests, ideas, and findings of individual scientists. The communication system is seen as crucial to the cumulative, codifying, and integrative aspects of the scientific community. Studies of the general features of the communication system, including the role of citation in the reward system and the emergence of journals and referee system, helped set the context for more detailed studies of textual features emerging from the other approaches which followed.[1]

A second sociological approach, following in the wake of Kuhn's pointing to the role of smaller, local research communities in the emergence of science, is concerned with the structure and interactions within scientific specialties. Citation behavior in articles became a clue to the changing morphology of research communities. Deeper looks at the citation behavior led to examinations of the social and symbolic meanings embedded in reference to the work of others and of the process of consensus formation. This work has generally attempted to establish systematic

patterns involving larger numbers of participants in comparative studies.[2]

The final sociological approach focuses on the individual scientist rather than the specialty or larger social system of science. In order to account for scientific activity without considering science as any different from any of the other communal activities that sociologists study, investigators in this approach have concerned themselves with how individuals and groups advance their interests within the scientific community. Accordingly, analysis has aimed at deconstructing the naive "scientific account" of the meaning of scientific texts, and showing how scientific communications advance personal interests. Features of language indicating persuasion, indexicality, and other forms of social presentation of the self are most readily found in individual texts and case studies, for at this level of analysis we can most readily see the hand-to-hand combat of individual and group advancement.[3]

This latter approach has strong ties to a broader sociolinguistic movement to analyse community organization and interaction through the study of discourse, sometimes associated with ethnomethodology as well as with an interests/power model of interactions. Oral language has generally received most of this kind of attention, but written language has recently been looked at more. Service professions--such as law, medicine, clinical psychology, and social work-- which establish through interactions a power relationship between professional and client have provided the primary research sites.[4] One motive for examining scientific discourse within this tradition is that the scientific community is perceived as one of the major sources of power in contemporary society.

A different tradition of work on scientific writing, not so visible to readers of this journal, comes out of applied language studies. The fields of technical writing, composition, and English for specific purposes, have begun looking into the character, role, and acquisition of written language skills within scientific and technological communities in order to prepare students linguistically for such careers.

Technical writing until recently defined its task in ahistorical, asociological terms: to foster clear, precise, efficient communication in essentially fixed genres. Following this tradition and bolstered by the plain language movement, the Document Design Center in the United States and the Primary Communications Research Unit in Britian promote and disseminate studies into formats and styles most readily understood.[5] Recently in technical writing, however, some attention has turned to the actual role played by writing in technical organizations, the writing choices made by technical writers, and the processes by which they make these choices. Questionnaire, interview, and observation studies have begun to reveal the social dynamics of technical communication--that writers are strategic social reasoners, that texts are indexical forms of social action, and that writing processes are shot through with collaborative and agonistic social processes.[6] Recently, as well, the writing across the curriculum movement has made particular disciplinary forms of writing an issue for all teachers of writing. Studies in composition are beginning, largely following the cognitive psychology model, which

has dominated composition research in the last decade. As in the technical writing studies, investigation into the process has begun to reveal its socially imbedded quality.[7]

English for specific purposes, a specialization of English as a second language, in general follows a linguistic model. It treats scientific English as a special register of standard English, incorporating particular vocabularies and grammatic/syntactic features. Catalogues of such features in different disciplines and professions--gathered with an instructional aim--provide suggestive comparative material about the character of communication in different fields, as do a few explicitly comparative studies. Studies of the strategic rhetorical use of particular linguistic features, such as the use of verb tense in reviews of literature to indicate evaluative attitudes, also shed light on the dynamics of communication.[8] Recent interest in the larger forms of organization and genre and in the kinds of contextual knowledge to be gained from informants, again suggests a growing interest in a historical, socially active understanding of texts.[9]

Literary studies provides a third tradition recently taking notice of scientific writing. Scientific texts, particularly the more overtly evocative ones such as The Origin of Species, are now being examined as special forms of literature, as are scientific popularizations. Studies of the cross-influences of science and literature which previously had been most concerned with the influence of science on imaginative writing have started to look at the influence of literary practice on scientific formulation. This connection between scientific and imaginative literature has seemed particularly poignant in nineteenth century studies. The movement towards seeing scientific writing as literary creations has been aided by contemporary theories of literature which have devalued referentiality and thus returned scientific texts to the realm of human imaginative constructions, though more subtle formulations that go beyond the primitive opposition of naive positivism and naive relativism have yet to be made forcefully. Such more subtle formulations, I believe, are necessary to defined the special characteristics of scientific texts which maintain referential ambitions whether or not they achieve the epistemological magic of referential certainty.[10]

A limited amount of work has attempted to bridge the three approaches presented so far: social studies, applied language, and literary. The purveyors of this work have had literary training and thus are aware of the complexity of textual meaning and the variety of dimensions on which meaning is conveyed. In attempting to address more practical issues of composition, they have seen the necessity of providing a richer description of the kinds of texts the students are being taught to write and of the processes of creating these texts. To help enrich their understanding of text and process, they have turned to social studies of science and have adopted sociological models of scientific community. Their analyses reveal how the complex features of text and textual change embody and realize social dynamics.[11]

Individuals in both the history and philosophy of science have, as well, been drawn to the reexamination of classic scientific texts, driven by issues and dynamics of their own fields. In the history of science,

the deepening understanding of the variety of intellectual projects engaged in by scientists and the changing intellectual and social contexts which individual scientists have worked in has led to a more rhetorical understanding of certain texts. That is, the texts are no longer seen as a series of propositions to be placed within the framework of emerging scientific knowledge, but are rather seen as integrated wholes, imaginative constructs portraying complex world views (which would lead to more humanistic literary readings), but even more, most recently as particular ways of addressing the world, audience and problems (which might be thought of as situated rhetorical readings)--seeing the symbolic formulations as a result of epistemology, local disputes, and social relations.[12]

The philosophy of science has also given rise to a few attempts to look at scientific texts as complex communicative documents, written documents embodying choices. These studies have been driven by the more general philosophic problem of rationality and rational procedures, which seem increasingly hard to find in the complex world of actual human relations and even harder to tie down in the world of abstractions. In the turn to history and actual practice to see what procedures scientists and other people engaged in rational enterprises engage in, the fine grain of textual structure and textual interactions gain new significance. Rather than trying to reduce scientific formulation to a limited set of abstracted "acceptable procedures" there is a new attempt to discover the full complexity and variety. Toulmin, Kuhn, Fleck, and Popper each discuss the production of knowledge within scientific communities, raising central questions about the patterns, habits, and procedures of formulation. Perelman most explicitly reopens rhetoric as the centerpiece in the understanding of human rationality.[13]

In philosophy's rediscovery of the importance of rhetoric, contemporary rhetoricians (in American universities exiled to speech departments for the last half-century) have regained vigor and started to engage in philosophic combat on behalf of their position. In only a few instances however, has this resulted in close rhetorical analyses. Most notable has been Campbell's studies of Darwin's rhetorical situation and rhetorical response.[14]

Perhaps the largest potential impetus for textual studies of knowledge these days lies in practitioners of various disciplines who, by various means, have come to be interested in the discourse of their own field with the aim of somehow improving work in their field. These individuals range in their stance from the meticulous craftsman who simply wishes to understand his linguistic tools, to the sensible human who wishes to get his colleagues to understand they are only speaking in prose, to the ironic critic who would puncture the prose balloons, to the radical reformer who would create new ones. The social sciences have been more interested in this linguistic self-examination than the natural sciences in the past twenty years, largely motivated by internal debates over what the character of a science of human behavior and interaction should be.

Anthropology has undergone the most thoroughgoing self examination of its rhetoric, particularly concerning the character and authority of ethnography. Geertz most visibly reopened the question of how to write ethnography--how to

capture the lives of others on paper, and the effect of different descriptive techniques on the character of anthropological knowledge. The debate opened by Geertz has widened to consider the complex of social and political relations realized in ethnographies. Questions have proliferated. For what communities are the texts written and for what purpose? Where does authority in ethnographical reporting come from? What is the proper literary role (as both author and character) of both anthropologist and informant? What is the kind of cultural knowledge one can properly (intellectually and morally) convey? What are the power consequences of different forms of texts? What is anthropology that it produces ethnographies?[15]

Other social sciences have not produced such a thoroughgoing literary self-examination, but have been the subject of more scattered analyses. In sociology, Brown proposes a more ironic language for sociology; Gusfield understands the literature on drunk driving research in dramatic rhetorical terms--that is, he treats the emergence of a scholarly literature itself as a social-historical phenomenon; Bennett, in a similar vein considers the role of the genre of oral history within criminology. In a series of papers on economics, McCloskey points out, despite an overt disciplinary ideology of scientific objectivity and formal logic, economists actually argue in ways best described by the terms of classical rhetoric. Elsewhere in the social sciences, from political science to theology, the rhetorical issues in the framing of knowledge are being examined.[16]

All the studies I have discussed, in all their variety, see scientific writing as complex and difficult, requiring more detailed study. Scientific writing is no longer seen as a simple, undifferentiated phenomenon that gains its character by a direct correspondence with the facts of nature. The social actions and relations embodied in scientific texts have gained increasing attention, and the knowledge symbolically captured in the text needs to be understood through the intellectual, rhetorical, linguistic, and social procedures by which that knowledge is created and framed. Local context and historical background shape the text and define available choices for symbolic representation. Individual and disciplinary control of the writing seems to require mastery of these social, historical, and symbolic issues as they manifest themselves in the smallest textual features. Scientific writing appears to be a multi-dimensional game, with the game and available moves changing form through time.

Although one can imagine, as I have in the previous paragraph, how the various pieces of work may fit together to suggest a deepened view of scientific writing, none of the separate lines of study can by itself move to such a comprehensive view. As long as scientific writing remains only a secondary problem, subordinated to other disciplinary interests, each field will maintain a narrow focus on specific features and functions of scientific writing. Scientific writing must be seen as a problem area in itself. Furthermore, none of the disciplines has the range of concepts and tools to develop the integrated picture. The study of writing, rhetoric, linguistics, sociology, history, philosophy each has different things to lend to the study, whether in detailed analytical tools, powerful concepts, depth of contextual data, or frameworks for conceiving problems and interpreting data.

The study of scientific writing is

truly an interdisciplinary problem. To claim that the study of any single dimension of scientific communication can provide an adequate account of the entire phenomenon will inevitably lead to distortions on both the practical and theoretical levels--whether by reformists developing new rhetorical prescriptions for their disciplines based on a single-dimensioned model or by philosophers who would reduce claim-making to a single straightforward set of procedures. Sociology--no matter how strong it is, and no matter what essential parts of the game it accounts for--cannot draw the complete picture, nor will its account of sociological dynamics be accurate without taking into account the changing epistemological ambitions of the community or the dynamics of literary traditions and linguistic innovations. Nor can linguists and writing teachers effectively define and teach language features without understanding how these features fit into the social and natural worlds that frame symbolic activity. Thus even the special purposes of each of the interested disciplines would gain from an interdisciplinary perspective.

Awareness of the multiplicity of traditions now finding scientific writing a significant research site constitutes the next stage of developing an interdisciplinary research program into the language of knowledge. If the conjunctions of this review excite greater interdisciplinary reading and deepening research in a range of approaches, occasions for more complete and formal sharing of interests, knowledge, and approaches should lie in the future. The shape of the joint venture will become clearer, when (and if) it unfolds.

Notes

1. Most importantly, R. K. Merton, The Sociology of Science (Chicago University Press, 1973); also W. Hagstrom, The Scientific Community (Southern Illinois University Press, 1965), and N. Storer, The Social System of Science (Holt, 1966).
2. S. Cozzens, "Comparing the Sciences: Citation Context Analysis of Papers from Neuropharmacology and the Sociology of Science," Social Studies of Science 15 (1985), pp. 127-153; H. Small, "A Co-Citation Model of a Scientific Specialty: A Longitudinal Study of Collagen Research," Social Studies of Science 7 (1977), pp. 139-166; H. Small, "Cited Documents as Concept Symbols," Social Studies of Science 8 (1978), pp. 327-340. S. Cozzens reviews the literature on citation studies in "Taking the Measure of Science: A Review of Citation Theories," International Society for the Sociology of Knowledge Newsletter, March 1981. The fields of Bibliometrics and Library Science have continued this investigation of large scale patterns of publication behavior, such as in D. Kronick, "Authorship and Authority in the Scientific Periodicals of the Seventeenth and Eighteenth Centuries," Library Quarterly 48 (1978), pp. 255-275 and L. Sachs et al., "Wissenschaftliche Aufsaetze and Zeitschiften frueher und jetzt: mit einigen Daten zur Aufsatzstruktur von Originalien der 'Klinischen Wochenschrift,'" Nachrichten fuer Dokumentation 31 (1980), pp. 107-115.
3. For example, G. N. Gilbert and M. Mulkay, Opening Pandora's Box: A Sociological Analysis of Scientists' Discourse (Cambridge University Press, 1984); B. Latour and S. Woolgar, Laboratory Life: The Social

Construction of Scientific Facts (Sage, 1979); K. Knorr-Cetina, The Manufacture of Knowledge (Pergamon Press, 1981). A more complete review of social studies of science relevant to scientific writing appears in C. Bazerman, "Scientific Writing as a Social Act," in New Essays in Technical and Scientific Communication, ed. Anderson, Brockmann, and Miller (Baywood, 1983).

4. For example, H. Garfinkel, Studies in Ethnomethodology (Prentice Hall, 1967); W. Labov and D. Fanshel Therapeutic Discourse: Psychotherapy as Conversation (Academic Press, 1977); R. Di Pietro, ed., Linguistics and the Professions (Ablex, 1982).
5. Simply Stated, the newsletter of the Document Design Center (1055 Thomas Jefferson St. NW, Washington D.C. 20007) and the Journal of Research Communication Studies provide advice and studies aimed at writers and editors.
6. For examples see the collections, New Essays in Technical and Scientific Communication, ed. Anderson, Brockmann and Miller (Baywood, 1983) and Writing in Nonacademic Settings, ed. Odell and Goswami (Guilford, forthcoming).
7. The most complete treatments of writing in the disciplines appear in the textbooks, Bazerman The Informed Writer, second edition (Houghton Mifflin, 1985); Maimon et. al. Writing in the Arts and Sciences, second edition (Winthrop, 1985).
8. See the collections, Common Ground: Shared Interests in ESP and Communication Studies, ed. Williams, Swales and Kirkman (Pergamon, 1984) and English for Academic and Technical Purposes, ed. Selinker, Tarone and Hanzeli (Newbury House, 1981). A recent review article is B. Coffey, "ESP--English for Specific Purposes," Language Teaching Abstracts 17 (1984), pp. 2-16. A previous generation of syntactic studies are exemplified by R. D. Huddleston, The Sentence in Written English (Cambridge, 1971); M. Gopnik, Linguistic Structures in Scientific Texts (Mouton, 1972); and K. C. Lee, Syntax of Scientific English (Singapore University Press, 1978).
9. L. Selinker, "On the Use of Informants in Discourse Analysis," IRAL 27 (1979), pp. 189-215; J. Swales, Aspects of Article Introductions (Aston University ESP Research Report, 1981). Relevant conceptually, although not immediately on scientific texts, is V. K. Bhatia An Applied Discourse Analysis of English Legislative Writing (Aston University ESP Research Report, 1983).
10. For example, Victorian Science and Victorian Values, ed. Paradis and Postlethwaite (New York Academy of Sciences, 1981); G. Beer, Darwin's Plots: Evolutionary Narrative in Darwin, George Eliot, and Nineteenth Century Fiction (Routledge and Kegan Paul, 1983); W. Anderson, Between the Library and the Laboratory: The Language of Chemistry in Eighteenth Century France (Johns Hopkins University Press, 1985); S. E. Hyman, The Tangled Bank (Atheneum, 1962). A seminal work in an earlier line of interest is R. F. Jones, "Science and English Prose Style, 1650-75" PMLA 45 (1935), pp. 977-1009.
11. C. Bazerman, "Modern Evolution of the Experimental Report in Physics: Spectroscopic Articles in 'Physical Review,' 1893-1980," Social Studies of

Science 14 (1984), pp. 163-196; C. Bazerman, "Physicists Reading Physics: Schema-Laden Purposes and Purpose-Laden Schema," Written Communication 2 (1985), pp. 3-23; C. Bazerman, "The Writing of Scientific Non-Fiction: Contexts, Choices, Constraints," Pre/Text 5 (1984) in press; G. Myers, "The Social Construction of Two Biologists' Proposals," Written Communication, forthcoming; G. Myers, "Texts as Knowledge Claims: The Social Construction of Two Biology Articles," Social Studies of Science, forthcoming.

12. For example, P. Dear, "The Constitution of Authority in the Early Royal Society," Isis, forthcoming; B. Eastwood, "Descartes on Refraction: Scientific versus Rhetorical Method," Isis 75 (1984), pp. 481-502; S. Shapin, "Pump and Circumstance: Robert Boyle's Literary Technology," Social Studies of Science 14 (1984), pp. 4881-520.
13. J. Agassi, Faraday as a Natural Philosopher (University of Chicago Press, 1971), chapter 5; M.A. Finocchario, Gallileo and the Art of Reasoning: Rhetorical Foundations of Logic and Scientific Method Boston Studies in the Philosophy of Science 61 (Reidel, 1980); L. Fleck, Genesis and Development of a Scientific Fact, Bradley and Trenn, trans. (University of Chicago Press, 1979); T. Kuhn, The Structure of Scientific Revolutions, second edition (University of Chicago Press, 1970); K. Popper Objective Knowledge: An Evolutionary Approach (Oxford University Press, 1979); C. Perelman and L. Olbrechts-Tyteca, The New Rhetoric: A Treatise on Argumentation (University of Notre Dame Press, 1969), S. Toulmin, Human Understanding: The Collective Use and Evolution of Concepts (Princeton University Press, 1972).
14. For example, J. A. Campbell, "The Polemical Mr. Darwin," The Quarterly Journal of Speech 61 (1975), pp. 375-390.
15. For example, J. Clifford, "On Ethnographic Authority" Representations 1 (1982), pp. 118-146; J. Fabian, Time and the Other: How Anthropology Makes its Object (Columbia University Press, 1983); C. Geertz, The Interpretation of Cultures (Basic Books, 1973); C. Geertz, Local Knowledge (Basic Books, 1983); G. Marcus and D. Cushman, "Ethnographies as Texts," Annual Review of Anthropology 11 (1982), pp. 25-69.
16. R. Brown, A Poetic for Sociology (Cambridge University Press, 1977); R. Gusfield, "The Literary Rhetoric of Science: Comedy and Pathos in Drinking Driver Research," American Sociological Review 41 (1976), pp. 16-34; J. Bennett Oral History and Delinquency (Chicago University Press, 1981); D. McCloskey, "The Rhetoric of Economics," Journal of Economic Literature 21 (1983), pp. 481-517; D. McCloskey, "The Literary Character of Economics," Daedalus 113:3 (Summer, 1984), pp. 97-120; a forthcoming issue of Daedalus is devoted to a colloquium on the rhetoric of the human sciences.