• ABSTRACT

Hypertext – advanced software for organizing information according to webs of conceptual, rather than symbolic, links – has recently provoked humanists to reconsider post-structuralist semiotic concepts. Debates about the design and uses of hypertext, among both software developers and humanists, reflect a conflict between two problematic views of text: as a medium for social interaction, and as a replication of a cognitive structure. Post-structuralist critical theory (PSCT), in challenging concepts of authorship and univocal meaning, argued that semiotic products were more closely connected to each other than to 'reality', or to their 'original' producers. PSCT's notion of 'intertextuality' captured this hyperactive, social aspect of language products. Theories of social construction of scientific knowledge (SCSK), I argue, have crucially relied upon similar, essentially semiotic concepts such as inscription devices, discourse repertoires and the textualization of heterogeneous resources. As SCSK's practitioners have articulated their programme, they have covertly imported cognitive abilities into ostensibly social processes, creating a kind of theoretical hypertension which surfaces in the similar debates over hypertext. Questions about the status of artificial intelligence, which concerns the capacity of a purely symbolic/syntactic structure – a hyper text – to perform as a social actor, sharply expose the tension between cognitive and social that underlies many of SCSK's key concepts.

Hyper Text and Hypertension: Post-Structuralist Critical Theory, Social Studies of Science and Software

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The word 'hypertext', like the phrase 'artificial intelligence', seems calculated to ring certain cultural bells. It conjures up notions like 'hyperactivity' – the out-of-controlness of children trapped in classrooms and driven to distraction – and 'hyperspace', where Han Solo and Luke Skywalker escape Darth Vader by travelling faster than light. It draws attention to its own 'hype', its over-blown, self-marketing character. And it calls to mind 'hyper' itself, slang for semi-frantic, overcaffeinated, buzzed. What does it mean

for 'text' to be 'hyper' – excessive, above and beyond, more-than-three-dimensional?[1] What happens to 'text' when it goes out of control, when it does drugs, when it makes the jump to lightspeed?

This paper operates on three levels. First, it is a kind of extended intellectual pun – a joke with a serious point about the active nature of language, including scientific language, in the construction of knowledge. Second, it explores the ways in which ideas about textuality from literary theory connect with notions of text and discourse in social studies of science. Finally, it argues that in hypertext and artificial intelligence software, the category of 'text' serves to mediate between contending visions of knowledge as social construction and knowledge as cognitive understanding: hypertext and AI are *hyper texts*, overactive, literally power-driven writing whose frenetic hum animates both social interactions and private meanings.

Thinking about text and software, hyper and otherwise, matters to social studies of science for three reasons. First, hypertext is a new software technology of potentially major importance to the ways people organize and access computerized information. Second, like artificial intelligence, hypertext is being projected by its proponents not only as a utilitarian solution to mundane problems, but as a revolutionary change in the social and political organization of knowledge. Finally, hypertext techniques are beginning to find applications within social studies of science.[2] Since our field is increasingly concerned with reflexive self-analysis, these new techniques need to be critically examined even as they are applied.

Hypertext

Hypertext may be thought of as a kind of automated, embedded index or, alternatively, as a non-linear, weblike organizing technique. It exploits the computer's ability to locate information instantly, at random, based on almost any criterion, but it is far more sophisticated than keyword searching.

Hypertext has a relatively long history as a concept. Its proponents date its origins to Vannevar Bush's 1945 notion of a 'memex' multi-media library system, and to Doug Engelbart's early experiments on 'augmenting human intellect'.[3] Ted Nelson coined the term in 1965, defining it as 'non-sequential writing –

text that branches and allows choices to the reader, best read at an interactive screen . . . a series of chunks connected by links which offer the reader different pathways'.[4] But only since the late 1980s has hypertext been widely applied as software technology. Apple Computer's Hypercard, packaged free with every Apple computer, is perhaps the best known (if the least hypertextual). Hypercard 'stacks' (so-called because the software builds on an index-card metaphor) have become a popular format for presenting reference and instructional material. Library catalogues, tour guides, interactive novels and games, parts and service manuals for mechanics and parts dealers and computerized versions of ancient Greek classics are all arenas where hypertext designs have been employed and/or proposed.[5]
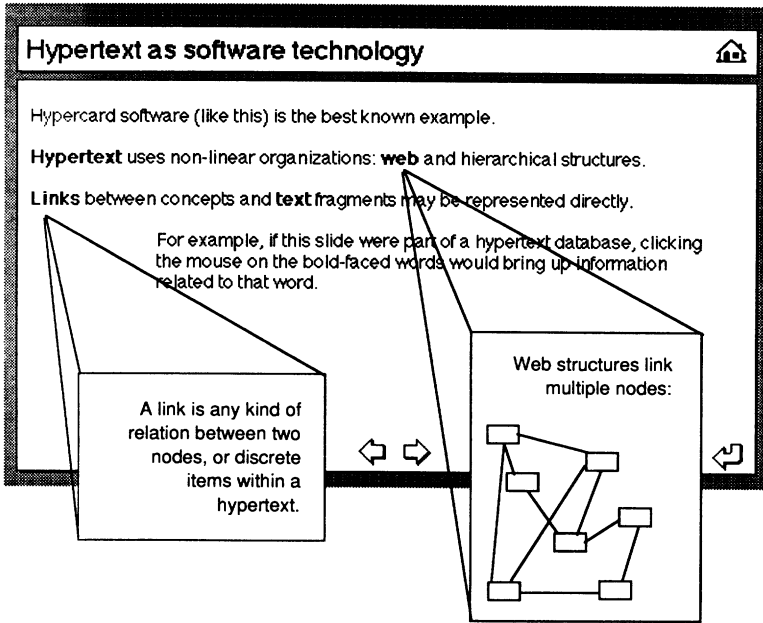
   Hypertext differs from ordinary paper texts in three ways. First, hypertext can create non-linear organizations of material through web and hierarchical structures, something like reading a book according to its index rather than in the order of presentation. Second, interconnections (known as 'links') among documents or other units of text (referred to as 'nodes' or 'lexia') may be represented directly within the text itself, and these interconnections may be rich and intricate to a potentially unlimited degree. Finally, links may be used to represent a cognitive map of the structure of the knowledge contained in the text, thus creating a whole new level of content represented implicitly by the links themselves.[6]

Links

In hypertext, links may be established among any related sets of information, including not only text and graphics but also video, sound and other forms. When non-textual media are incorporated, the result is known as 'hypermedia'. For example, in Figure 1, a screen from an imaginary hypertext version of this paper, words appearing in boldface indicate links to other screens or 'cards', possibly containing definitions, demonstrations or other related information. The inset boxes indicate what might be retrieved by clicking on the boldfaced words.

   One of the crucial elements of hypertext is the possibility, often but not always taken as a given, of readers altering existing links and text and adding their own new links and text as they develop

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FIGURE 1
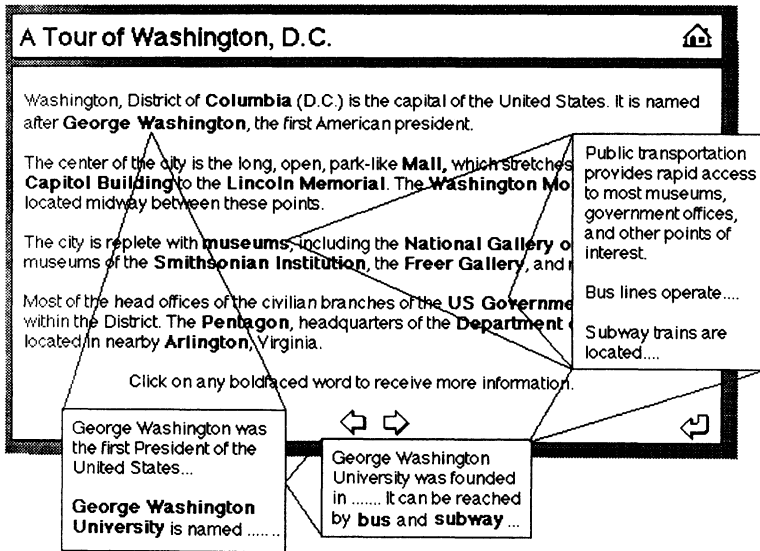**A Sample of This Text in a Hypertext Format**

their knowledge of the domain. This capability is supposed to allow readers to do two things: (a) work actively within the text as productive 'users' rather than mere reader-consumers; and (b) create a structure that reflects their own cognitive system, rather than simply accepting the one offered by the original author. In this way hypertext is fundamentally unstable, open for constant revision. This is why true hypertext depends on the capacity of its electronic medium to make instantaneous copies and to change or add new material in a form that is formally indistinguishable from the 'original'.

Webs

What makes hypertext truly interesting is the richness its inter-connections make possible. In the imaginary tour guide example in Figure 2, clicking on the word 'Washington' at any point in your 'tour' might bring up a choice of screens about George
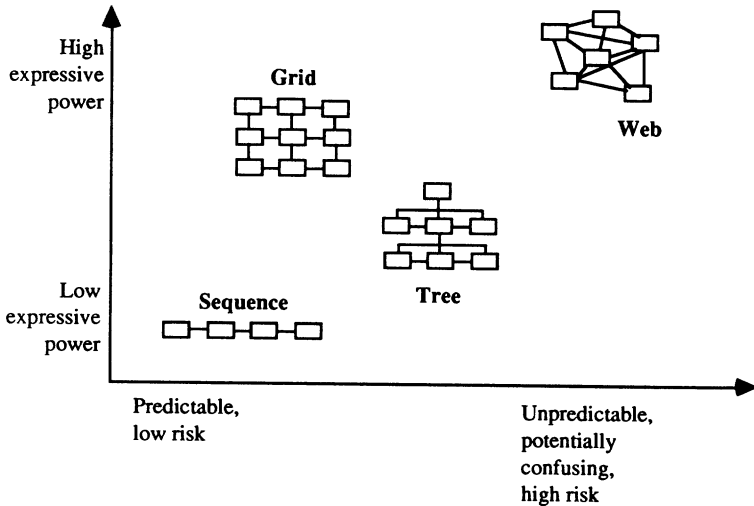
FIGURE 2
One Screen from an Imaginary Hypertext Tour Guide for Washington, DC

Washington, the history of Washington, DC, or other subjects which you would not normally encounter in a sequential order in reading a book. From 'George Washington' you might jump to 'George Washington University' to a list of 'universities in the Washington area' to 'public transportation'. That is, the order of presentation of information is guided more by the user's interests than by the medium's inherent structure.[7] Such a form of organization, with rich interlinkages among information rather than a simpler, sequential structure, is called a 'web' structure. As Figure 3 illustrates, a sequence is highly predictable but low in expressive power, while a web is high in expressive power but low in predictability. In between are various forms of grid and hierarchical structure in which it is easy to call up increasing levels of detail on a particular subject, but more difficult to jump to indirectly related areas.

The problem with the web structure, hypertext's most 'powerful' architecture, is navigation – a metaphor worth noticing.[9] Hypertext designers call this getting 'lost in hyperspace'.[10] In a large web-structure hypertext, it becomes difficult to remember where you began, to know how much of the text you have covered

FIGURE 3
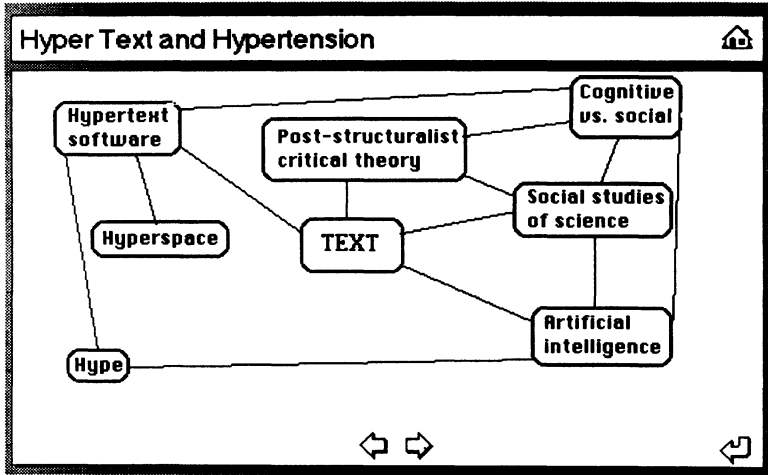**Sequential, Hierarchical and Web Structures[8]**

Source: see note 8.

and to develop an understanding of the organization and structure of the knowledge domain you are exploring. Everything may seem equally important – or equally trivial.

Hypermaps

Hypertext designers are well aware of this problem. The literature in the field is replete with navigational schemes and caveats about overcomplicated structures. One solution is to maintain a 'hypermap' of the knowledge domain: Figure 4 represents a simple hypermap of this paper. The map is a graphical representation of the weblike structure mentioned earlier. Note how the linear presentation of topics in this paper is converted, through the map, into multiple links. Some hypertext systems, such as Brown University's Intermedia, incorporate hypermaps into their onscreen displays, allowing the user literally to navigate through the system using a graphic map of the available pathways. Similar approaches allow the composition of paper-based 'hyperbooks' which, while not true hypertext, allow non-computer-users to taste some of the flavour of hypermedia.

FIGURE 4
A Hypermap of This Paper

Hypertext as Hyper Text

What makes hypertext *hyper text* is its multidimensionality and its hyperactivity. 'Hyperspace' is a fictional 'fifth dimension' through which travellers can jump instantaneously across huge distances. Without hyperspace, fictional space travellers must resort to cryogenics or multi-generational space flight to reach the stars. Similarly, without hypertext, ordinary readers must slog through page after page of irrelevant information to reach their destination. Rich linkages within texts mean that the cognitive distance between any two 'points' in the text is small.

This feature has a literary analogue in the form of 'interactive' fiction and poetry, in which the reader is able to make choices at certain points which determine where the plot or poem will go next – thus to a limited extent exercising creative power in the composition of the text she or he encounters.[11]

Hypertexts are also hyperactive. So-called 'hot' buttons or text create a sense of the immanent presence of other levels and invite the user to jump among them. There is a sense, too, well documented by the designers of hypertext, that the links themselves contain information about semantic structure, and therefore that activating them teaches the user about the conceptual

relationships within the text. Emerging from the hyperspace of hypertext, one may find ordinary documents passive, dull, lacking in a certain intelligence. It's a bit like the struggle of writing with a pen after becoming accustomed to a word processor.

Such at least is the *hype* of hypertext. Every academic knows how to use its index and table of contents to skim a paper book; any child leafing through an encyclopaedia is doing the 'active' reading for which hypertext designers yearn. Still, hypertext makes such a style of reading central, automates its techniques, and creates new ones – like hypermaps and hypermedia – for which printed books have few or no analogues. In the mythology of hypertext, both text and reader are energized, activated, set into a hyperdrive that produces an ultimately political result: 'as long as any reader has the power to enter the system and leave his or her mark, neither the tyranny of the center nor that of the majority can impose itself', writes George Landow.[12] Or as Nelson, originator of the term, preached in 1987:

> Imagine a new accessibility and excitement that can unseat the video narcosis
> that now sits on our land like a fog. Imagine a new libertarian literature with
> alternative explanations so that anyone can choose the pathway or approach
> that best suits him or her; with ideas accessible and interesting to everyone, so
> that a new richness and freedom can come to the human experience; imagine a
> rebirth of literacy.[13]

The Concept of 'Text' in Post-Structuralist Critical Theory

But what exactly is 'text'? We can learn much by turning to literary theory and cultural criticism, where the concept has become increasingly problematic since the 1960s, when the French structuralists, building on the earlier work of Saussure, first explored language as a self-activating field of structured differences rather than a mapping of concepts on to reality.

Clearly, texts – written documents – play a constitutive role in modern societies. They serve not only as vehicles for information but as symbols of authority (like the books on a lawyer's – or an academic's – many bookshelves), as surrogates for the lost presence of the past (for the historian), as tools of persuasion (in politics and advertising), as religious icons (the Bible, the Koran), as metalegal foundations (the Constitution), as rewards and social validations (certificates, diplomas) and as arbiters of objective

reality (as contracts stand to prevent disagreements over commitments). Texts are so important that their production is a central rite of passage and professional qualification (tests, theses, dissertations) and an icon of knowledge itself. As Derrida and others have pointed out, ours is a thoroughly logocentric culture. Small wonder, then, that text and knowledge can seem practically identical (especially to academics!), with polished written products both the measure and the medium of learned skill.

Practitioners of science studies may think of critical theory as essentially opposed to their own views. To a large degree its thrust has been to de-emphasize the historical and social conditions of the production of writing, and to promote purely semiotic concepts of text. Science studies, by contrast, has been engaged primarily in re-emphasizing those very conditions and verifying their constitutive influence on the content of knowledge. But I believe that at a deeper level the efforts of these two fields have much more in common than they realize. In the following pages I want to explore what happens when we apply the insights of post-structuralist critical theories (hereafter abbreviated PSCT) of texts and their production to scientific writing and discourse. First I will review some of the key concepts and methods of the post-structuralists. Then I will explore some of the parallels in the science studies literature.

Barthes: Text versus Work

In the 1960s, Roland Barthes declared an important difference between the emerging concept of 'text' and the traditional idea of the 'work', where 'works' are documents in the traditional sense, fixed in time and space and dependent for their meaning on the intentions and creative powers of their authors. 'Texts', in his view, were constituted in an interconnected field of cross-referencing, differential structures of language, dependent for their meaning on other texts, and detached from personality and intention.

> While the work is held in the hand, the text is held in language: it exists only as discourse. . . . [T]he work itself functions as a general sign and thus represents an institutional category of the civilization of the Sign. The Text, on the contrary, practices the infinite deferral of the signified: the Text is *dilatory*; its field is that of the signifier. . . . [T]he signifier's *infinitude* does not refer back to

some idea of the ineffable (of an unnameable signified) but to the idea of *play*
. . . a serial movement of dislocations, overlappings, and variations. The logic
that governs the Text is not comprehensive (seeking to define 'what the work
means') but metonymic; and the activity of associations, contiguities, and cross-
references coincides with a liberation of symbolic energy. The work (in the best
of cases) is moderately symbolic (its symbolism runs out, comes to a halt), but
the Text is *radically* symbolic. A work whose integrally symbolic nature one
conceives, perceives, and receives is a text.[14]

In other words, texts rely for their functioning on a not-so-implicit
background of other texts – what Barthes once called 'writing
degree zero' – just as words depend for their meaning on the
background of other words against which they are defined. All
writers are of necessity also readers, and each writer gathers the
concepts, narratives, metaphors and other resources that inform
his or her writing from the works of other authors and the play of
language that surrounds him or her. In this sense no writer writes
alone; *text is fundamentally a social and interactive category*. The
boundaries between texts are fuzzy at best, and serve primarily
social functions; to the degree that they are meaningful all texts
are nodes in an intertextual field:

Every text, being itself the intertext of another text, belongs to the intertextual,
which must not be confused with a text's origins; to search for the 'sources of'
and 'influence upon' a work is to satisfy the myth of filiation.[15]

Indeed, sense-making in general, and literary criticism in particu-
lar, are possible only because of this intensive and multi-levelled
cross-referencing, this reliance on the common field of language.

Foucault: The Idea of an 'Author'

Similarly, the notion of an 'author' was challenged by such
thinkers as Barthes, Foucault and Derrida. Foucault, above all,
attempted to problematize such apparently natural categories as
the book and the author. The argument was that while such
categories provide convenient anchor points for intellectual
history, taking them for granted may conceal certain kinds of
social, historical and significative processes. Foucault pointed out
that the social role of the 'author-function' varies over time. For
example, written texts have at times been subject to 'penal
appropriation' (censorship; the punishment of authors and/or

owners) to identify and punish subversion. In Foucault's important essay 'What Is An Author?',[16] after pointing to the various ways 'authors' are constructed in discourse – as authorities, as the owners of copyrights, as subjective centres from which a number of texts emanate and to which explanations of textual characteristics are to be directed – he pointed out that 'we can easily imagine a culture where discourse would circulate without any need for an author',[17] in the sense that the social role and significance ascribed to authorship would not exist.[18]

The question of the relation between an author and a text is thus, precisely, an issue of *authority*. Since readers and social institutions are active in the production of meaning, it remains an open socio-historical question how the meaning and the use of a text will be determined, and by whom.

For these writers and their intellectual descendants, 'text' ceased to be an unproblematic expression of subjectivity, a transparent report of internal events or an 'objective' account of reality. It became instead a primary operator in the *construction* of subjectivities, authors, events, even of truth itself. For Foucault, writing was one of an array of *disciplinary technologies* through which people are transformed from objects into subjects.[19] He spoke of texts as producing 'truth effects' – truth as a product of narrative strategies and deployments of resources rather than of correspondence with reality. His notion of 'power/knowledge' expressed what he saw as an intrinsic link between social control and the production and control of representations. Text became 'decentred', revolving no longer around the central figure of the author's 'authority' (that is, his or her intentions) but instead fragmented among multiple authors and readers (not just individuals, but also the multiple identities and levels of consciousness that exist within and between individuals) and cultures. Rather than defer to the author's 'authority', this understanding of textual activity emphasized the social flow of significance and the shared background of language as texts moved between readers and writers.

Derrida: Truth and Authority

An example of the epistemological challenge posed by this reformulation of traditional concepts of text and language may be

found in the work of Jacques Derrida. In *Limited Inc.*, a debate with the philosopher John Searle, Derrida argued that Searle's reliance on a notion of universal truth was belied by his own textual practices. Notably, Derrida pointed out that Searle's notice of copyright at the beginning of his essay seemed to imply a constitutive linkage between whatever truth Searle spoke and personal qualities particular to Searle, contradicting the putative universality of 'truth'. Searle's acknowledgement of the aid of others in composing his reply, and the presence of Derrida's own words within that text, further problematized the notions of authority and universality on which Searle's text, like most Western discourse, relied. If texts reveal an objective, pre-existing truth, by what right may an author claim 'authority' over these truths? But if truth is private, partial, composed by social groups, or otherwise fragmented and relative, 'authority' cannot be based on universal validity. In this case a copyright may be justified, but then Searle may not rely (as he does) on 'obvious' facts or presumed agreement among readers.[20]

In other work, such as *Glas*, Derrida attempted – like current practitioners of new literary forms in the sociology of scientific knowledge – to decentre his own texts by printing seemingly unrelated commentaries running in separate columns side by side on the same page, using this practice to emphasize the interactivity of text. Derrida has gone to great lengths, for example in *Writing and Difference* and *Of Grammatology*, to show that the very possibility of signification in general depends upon irreducible differences: among signifiers, between signifier and signified, between present, past, and future meanings, between a sender's intention and a receiver's interpretation.[21]

> [T]he writer writes in a language and in a logic whose proper system, laws and life his discourse by definition cannot dominate absolutely. He uses them only by letting himself, after a fashion and up to a point, be governed by the system. And the reading [that is, any critical reading] must always aim at a certain relationship, unperceived by the writer, between what he commands and what he does not command of the patterns of the language that he uses.[22]

It is not that the author's intent has nothing to do with the meaning of a text. But Derrida shows that the very possibility of intended meaning and of an ongoing conversation depends on the simultaneous possibility or even the probability of *mis*-understanding, *mis*-interpretation. It is clear, for example, that if the author of a

novel should publish a secondary article explaining what he or she 'really meant to say', other critical interpretations would hardly be stopped in their tracks. The secondary article would become just another possible interpretation, just another text within the intertextual field surrounding the work – a critic might even argue that the author was actually wrong about what he or she 'meant'. All reading, to quote Harold Bloom, is already misreading.[23]

In a sense, as Bolter, Landow and others have noted, the arguments of the post-structuralists stress that at both cognitive and social levels *all* texts are hypertexts, webs of signification whose contents are open for constant revision, reinterpretation and extension.[24] 'Authority' is one of the *uses* of texts, a social fabrication which requires huge energies for its maintenance and serves social purposes far beyond those of attribution. Texts lie in constant 'danger' of misreadings, formations of new linkages with other texts, erasures of old linkages. Post-structuralists like Derrida, Bloom and Culler show that these processes are inherent in textuality itself.[25] Texts hyperactively (though not intentionally or consciously) rearrange, revise, reveal and conceal.

Thus Foucault could write that 'rather than speaking language we are spoken by it'. This is to say that subjectivity, like textuality, is constituted largely in language and therefore partially governed by 'virtual structures',[26] environments and contexts that are the condition of meaningfulness of individual language. We rely on narratives, stories, fables and tales for our sense of location within the immense structure of differences our language – and our representational culture – weave around us.

Bolter and Literary Hypertexts

Bolter, in *Writing Space: The Computer, Hypertext and the History of Writing*,[27] points out that post-structuralism and deconstruction are oppositional forms in literary theory and philosophy. They are predicated on the historical presumption of the primacy of printed texts, which seem to fix the text in space and time and enable its defence against such 'externalities' as criticism, satires, passing references and marginal notes. Deconstruction sets out to challenge this primacy by demonstrating the availability within any given work of methods and concepts that contradict and transcend it. A key notion is that of the palimpsest, the parchment of

medieval scribes whose original writing was rubbed out again and again for reuse. Like palimpsests, texts, for the deconstructionist, contain the dim but still legible traces of other texts from whose resources they are built. Layers of meaning may be peeled away, always revealing other layers beneath them.

The notion of 'intertextuality' names the necessary reliance of any given text on many others for the construction of its meaning. The contemporary backlash against deconstruction and other forms of PSCT – entwined as it is with the defence of the 'canon' of Western culture against popular culture and new academic multi-culturalist agendas – is an attempt to reassert the power of 'authority' in many forms: the 'common sense' of the importance of the author's intention, the primacy of the original text and the difference between high and low culture.[28]

Bolter's idea – like that of many proponents – is that hypertext, as a new medium, does not make the same imperialistic claims on a reader's understanding as the more rigid printed text.[29] First by presuming multiple readings, without privileging any one, and then by allowing the reader/user to overlay connections and commentary on the original in a form that gives equal authority to the additions, hypertext is the perfect palimpsest, piling up meanings and associations in potentially endless rewritings. Hypertext is self-deconstructive writing.

As I noted above, this reading of hypertext has an essentially political character centred around a Foucauldian notion of authority. 'Hypertext', as Nielsen puts it,

> basically destroys the authority of the author to determine how readers should be introduced to a topic. . . . Authoring takes on an entirely new dimension when your job is changed to one of providing opportunities for readers rather than ordering them around.[30]

Bolter argues that 'electronic writing . . . opposes standardization and unification as well as hierarchy';[31] Landow, following parallels to PSCT similar to Bolter's, goes so far as to claim that

> hypertext . . . thrives on marginality . . . in part because hypertext does not only redefine the central by refusing to grant centrality to anything, to any lexia . . . . [The] hypertextual dissolution of centrality, which makes the medium such a potentially democratic one, also makes it a model of a society of conversations in which no one conversation, no one discipline or ideology, dominates or founds the others.[32]

The utopian character of such pronouncements is predicated upon hypertext proponents' own construction of subjectivity – that is to say, of readers both interested in, and capable of constantly choosing among, many alternative paths. This view, we should note here, is *prima facie* problematic. Lamb concludes that hypertext readers face issues of 'attenuation of attention', while Pea argues that hypertext can generate a state of 'cognitive entropy' where 'users forget what they were supposed to be doing, are confused as to which links they did or didn't follow, etc'.[33]

Discourse and Text

Bolter, like most post-structuralists and deconstructionists, concentrates primarily on literary texts, a location where multivocality and multivalency of meaning may be, if not taken for granted, at least expected and respected. But their arguments need not – indeed, must not, if they are to be taken seriously – be so narrowly focused. One of Derrida's most important efforts, for example, has been to break down the basis for the philosophical priority of the spoken word as closer to truth and speaker's meaning than the written sign. He demonstrates convincingly that the deep structure of written and spoken signs is the same and that, in fact, writing (with its inherent formal difference and temporal deferral from a non-existent 'original' thought or meaning) *is* that structure.[34] Thus for Derrida both written and spoken language operate within the same field of textuality.

The most significant way of operationalizing this concept has been through the notion of 'discourse'. This term has diverse origins in critical theory, sociology and linguistics. It was introduced perhaps most significantly by Foucault,[35] but has also been employed by 'discourse analysis' and other methods.[36] Some schools use a narrow definition in which 'discourse' refers only to speech and conversation, but in general 'discourse' names the whole field of signifying practices, including not only speech and writing but many other 'forms of life' whose effect is the production of meaning.[37]

Bolter's insight is that intertextuality is really the same thing as hyper textuality – active text, with its inherent potential for generating new meaning actuated by juxtapositions, repetitions, incorporations, attacks, defences, citation, invocations and so on.

This may make it sound as if texts interact on their own, without readers, writers, needs, interests or purposes (and this has, in fact, been a perennial criticism of PSCT). But actually this decentring of the subject, in the sense of a unified and originary consciousness, and the attempt to understand the textual field as operating without a subject,[38] is (as I have already noted) part of the point. Like hypertext, PSCT describes meaning as primarily constituted in the *linkages* between words, symbols, social institutions and texts. Like many positions in recent social studies of science, PSCT side-steps psychological theory by describing the generation of meaning as taking place in the interactions of representations with each other. And also like social studies of science, which oppose traditional conceptions of scientific method, individual genius and cognitive objectivity, post-structuralism is a revolt against the canonization of texts and the vesting of authority in a special and particular subjectivity.

Critical Theory and Social Studies of Science: Recovering Multivalence and Plurivocity in Science

Part of the difficulty of interpretive science studies stems, notoriously, from the fact that scientific texts and language have been conventionally interpreted as one end of a continuum that runs from precise univocity to poetic polysemy and plurivocity. This is especially true for the formal languages deployed by science, such as mathematics, biological classification and computer languages. Both cultural stereotypes and claims made by many scientists cleave to the view that scientific texts have a single meaning, or at most a narrow range of meanings within a well-defined field. The univocity of these meanings is tied to their presumed correspondence relationship with an exterior reality, rather than to the intent of their authors.

Social studies of science – in particular the branch of it associated with the social constructivist 'strong programme' in sociology of scientific knowledge – has done a good deal in the last fifteen years to undermine these assumptions. (This discussion is aimed primarily at constructivist science studies, so hereafter I will use the abbreviation SCSK – following Ronald Giere[39] – for 'social construction of scientific knowledge'.) But few social theorists have taken up the conceptual resources of PSCT in the process. One

reason for this may be the widespread perception that PSCT reduces everything to problems of language and semiotics, while SCSK has been at pains to discover and assert the relations between the *practices* of science and its representational products. Yet this view of both PSCT and SCSK is only partially correct, and there are clear parallels between PSCT and many versions of SCSK.

A number of the current theories and methods in social studies of science have been organized (tacitly or explicitly) around theories of scientific language, in the form of both written texts and laboratory discourse. Sociology, history and anthropology of science have attempted to recover a broader sense of the multiple possibilities inherent even in scientific language. Analysts – myself included – have done this by focusing on scientific representational practices,[40] by emphasizing the social construction of texts and meanings,[41] by interrogating the role of metaphor in scientific discourse,[42] and through the various incarnations of the notion of 'paradigm shift', by which a single term may be seen as having multiple meanings for different research communities and for the same community at different times.[43] Social constructivist science studies tend to focus on scientific controversies, rather than 'settled' theories, because these are held to reveal processes of construction which get suppressed once a candidate theory (or inscription device, or technological form) has achieved dominance. The fact that seemingly settled theories, such as physics before Einstein, have occasionally been reopened, and the fact that anomalies and competing theories always exist, are together claimed to constitute evidence that controversies *could* erupt anew at any time, given the right conditions. Attention thus focuses on those moments when existing representational forms lose their stability, revealing multivalency and contingency and opening a space for new voices. Social energies must be continually expended to suppress potential controversies and maintain the stability of accepted theories.

The strong-programme and discourse-analysis schools of SCSK have often appealed to the so-called 'symmetry' principle, under which scientific error may not be explained by social factors unless the production of scientific truth is also explained in this way.[44] This move, foundational for SCSK, can be seen as an attempt to bracket the representational character of language, since it implies that whatever is 'out there' cannot cause the production of representations directly. Such an analysis thinks of representations

as social products and sees their production and exchange as part of a process of action, negotiation and power relations.

Having thus dispensed with the objectivist view of scientific language, SCSK proceeds to dismantle the possibility of a subjectivist alternative (in which language might be seen as referring to internal states of speakers) by insisting on the primacy of the social. When a conceptual justification is offered, it often takes the form of a Wittgensteinian neo-behaviourism,[45] emphasizing the inherently public nature of linguistic meaning, and/or a Habermasian ideal-speech scenario which points to the underdetermination of theory by evidence to foreground the priority of communication over individual belief, perception or intent.[46]

Together, these positions lead SCSK toward a view of language that looks a lot like the PSCT notion of intertextuality. Indeed, as in the case of the critical theorists, the relativist sociologists are acutely aware of the hyperactivity of their own texts. Many now adopt a reflexive approach – an attempt to make their own views self-deconstructing – either at the programmatic level or, in a (sometimes) interesting 'embedded' approach, through using so-called 'new literary forms',[47] that – like hypertext – make the text explicitly multivocal.

Non-constructivist areas of social studies of science have also sometimes used a textual approach. Citation analysis, for example, is essentially a reading of the construction of authority through and within texts.

These various currents in SCSK are directed at revealing the enormous investments required to stabilize scientific texts – to keep them from going, as it were, hyper – and the ever-present possibilities of destabilization, 'revolution' and reinterpretation of both theories and data.

Latour and His Colleagues

One of the chief methods of achieving this end is the recovery of the full range of linguistic and representational practices of scientists. For example, one of the key analytical concepts of Latour and Woolgar's pioneering study of laboratory culture, *Laboratory Life*, was that of 'inscription devices' – laboratory instruments as machines for the production of marks, such as graphs and other writing, and thus for the textualization of

theory.[48] They suggest that the ability to multiply inscriptions by reifying theory in inscriptive instruments is one of the major ways in which scientists accumulate support for their position. Another concept was the alteration in status of knowledge claims via the insertion and deletion of modals into sentences in conversations, memos and laboratory publications. Latour's more recent *Science in Action* suggests that the method and the goal of SCSK should be to illustrate the social and linguistic processes of construction of the 'textbook sentences' that constitute finished, stable scientific facts and theories.

> [W]e start with a textbook sentence which is devoid of any trace of fabrication, construction or ownership; we then put it in quotation marks, . . . place it in the mouth of someone who speaks; then we add to this speaking character another character *to whom* it is speaking; then we place all of them in a specific situation . . .; then . . . situations, localisations, even people start being slowly erased; . . . [finally] we see a new sentence, without any quotation marks, written in a textbook similar to the one we started with.[49]

Latour is talking about the stabilization of scientific theories in terms of the accumulation and use of power. But the *mechanisms* of power he describes bear more than a passing resemblance to those involved in the stabilization of interpretations of any other kind of text. They involve the multiplication of confirming statements (both written and spoken) and of other kinds of inscriptions which form an intertextual network of support with the 'textbook' theory. And perhaps most importantly, they involve the eventual erasure of social context and action from the representations they have produced, just as the deconstructionists note the creation of a non-social, independent, authorizing 'author' through effects of language in literature.

To take another example, in his celebrated article 'Give Me a Laboratory and I Will Raise the World', Latour points out that the political aspects of science are to be sought in its ability to generate and *represent* (in both senses) new sources of power:

> If by politics you mean elections and law, then Pasteur, as I have said, was not driven by political interests, except in a few marginal aspects of his science. . . . If by politics you mean to be the spokesman of the forces you mould society with and of which you are the only credible and legitimate authority, then Pasteur is a fully political man. . . . Who can imagine being the representative of a crowd of invisible, dangerous forces able to strike anywhere and to make a shambles of the present state of society, forces of which he is by definition the only credible interpreter and which only he can control?[50]

Pasteur, on Latour's reading, succeeded in producing a new account of disease which made Pasteur, his Institute and his field laboratories 'obligatory passage points' for all discourse and action concerning it. He did this by connecting his scientific *account* with situations outside the laboratory, transforming the representation of the 'outside' situation so that it required what was 'inside' Pasteur's labs. He constructed new interests – a term taken as primary by traditional sociology – by producing new meanings.

The most recent incarnation of Latourian SCSK, socio-technical analysis, is even more striking in this respect.[51] Latour and his colleagues advocate an inscription device of their own: socio-technical graphs, a graphical/textual representation of the course of a scientific or technological development, implemented in Hypercard software (precisely because of its hypertext capabilities). They invoke the resources of structural linguistics (the paradigm/syntagm distinction) and note that theirs is a mapping technique which 'will never be more than a re-representation in graphic form of an already existing text',[52] namely the set of narratives and documents about the case produced by actors, actants and other interested parties such as historians. Socio-technical graphs implemented as hypertexts provide a means of holding together in a single graphical/textual space a wide range of accounts, including conflicting and divergent narratives as well as complementary ones. Latour and his colleagues are explicit on this point:

> Texts oblige one to choose between the detailed narrative and its simplified and abstracted version, whereas hypertexts allow one to circulate very fast between an abstracted version and the detailed narrative from which it originates. Thus the bare outline that follows will appear abstract, since the actants will be reduced to numbers, but if the readers can 'click' on each of those numbers transformed into 'buttons', they will get back to the narrative, and will get a more concrete feeling for what we are after.[53]

The entire method concerns itself primarily with mapping the changes in definition, meaning and power of 'actants'. The importance of the concept of an 'actant', which flattens the difference between actors (possessed of reasons and intentionality) and artefacts (which may 'act', but without purposes of their own), is that cognitive abilities and private motives are deprived of causal efficacy in favour of a concept of power as derived from the accumulation of supporting linkages.

What is perhaps ironic here is that while Latour and his colleagues *seem* to be arguing for the reinstatement of non-linguistic categories, the central concern with the production of statements and accounts makes all such categories meaningful only insofar as they participate in that production. Constructivism is always, ultimately, about the construction of *meanings* and there-fore a matter of semiotic and textual practice, a point largely acknowledged in the most recent work of the Latourian school.[54]

Actor-Network Theory

Actor-network theory, as developed by Callon, Law, Rip and others (including Latour), may be interpreted in a similar way. In *Mapping the Dynamics of Science and Technology*, programmatic statements foreground scientific texts as a focus of analysis.

> the most important [resource of a laboratory] is the text. . . . It is the text that boxes in and regulates the points of contact between clinicians and researchers, patients and fund-raisers, polymers and livers, laboratories and diseases. In short it is first and foremost the text which imposes a structure on the world.[55]

The reason, according to Law, is that texts perform two key functions. The first source of textual power is the ability of written documents to act at a distance from the laboratory. Because they are so easily copied and transported, texts can disseminate the laboratory's influence almost anywhere, and can multiply its effects by the number of people and places they reach. Empirical findings, disseminated through papers both published and other-wise distributed, project the laboratory's power by creating 'obligatory passage points' through which future researchers must pass in creating new knowledge. Thus the more widely the text ranges, the more power the laboratory collects.

Second, and most important, texts homogenize heterogeneous resources. Inscriptions are, for actor-network theory, a way of reducing a wide array of forces and objects to a single, two-dimensional form that makes them comparable and interconvert-ible – the money of science, as it were. The power of science stems in large part from its ability to gather and orient an especially wide range of resources in the same direction, constructing stable, solid

nodes in the actor-network. The text is the key tool in this process: it

> *displays its structure in a complex 'synchronic translation' of the endlessly heterogeneous.* There they all lie, the bits and pieces, in the same place at the same time, linked together on a sheet of paper. . . . [T]here are no limits to what may be chosen and how this may be juxtaposed, for the power of the text is a function of the fact that it displays and arrays whatever resources may contribute to its strength.[56]

Thus it is precisely because of its ability to bring objects, forces and agents into the semiotic web of representation that the text plays such an important role.

Actor-network theory 'assumes that there is no overall structure – that there is always a multiplicity of actor-networks each trying to impose its own structure on potentially unreliable entities and thereby borrow their forces and treat them as its own'.[57] In this respect its theory of the construction of meaning is similar to PSCT's notion of deconstruction, which emphasizes the volatility of the meaning of an *apparently* stable text because of its constant interaction with other texts. Once again, the notion of socially constructed meanings, ungrounded in a transcendent reality and constantly shifting in a field of semiotic forces, is central.

Gilbert and Mulkay

Gilbert and Mulkay's notion of context-specific linguistic 'reper-toires', in their influential work *Opening Pandora's Box*, is another example of how texts and language have been treated as a central arena of social action in science. Gilbert and Mulkay hoped to improve sociology's grasp of scientific knowledge by focusing on scientific 'discourse' (in their definition, the statements and texts exchanged by scientists in the course of their practice). This, they claimed, had the cardinal advantage of allowing analysts 'to stay much closer to their data'[58] than other approaches which work at the level of the content of scientific knowledge, and which thus force analysts to presume a non-existent access to hidden levels of cognition, interests and so on. It also avoided the problem of unjustifiably assuming a correspondence between scientists' accounts of their work and the 'actual' processes involved.

Gilbert and Mulkay represent scientists as the consumers and

purveyors of linguistic resources which vary with the situation. This enables them to see scientists' descriptions of their own activities as responses to socially-defined situations: they

> conceive of the meaning of social actions, not as a unitary characteristic of acts which can be observed as they occur, but as a diverse potentiality of acts which can be realised in different ways through participants' production of different interpretations in different social contexts.[59]

As with Latour, the apparent reference to a non-discursive 'social context' is misleading, since Gilbert and Mulkay endorse M.A.K. Halliday (who holds that 'the meanings that constitute the social context are realised through selections in the meaning potential of language'),[60] and say that 'reference to the existence of different social contexts in science is simply another way of drawing attention to patterned variations in the discourse through which scientists construct their social world'.[61] True to form, they thus avoid both objectivist and subjectivist poles in their conception of language.

This method leads Gilbert and Mulkay to identify two major repertoires – formal (empiricist) and informal (contingent) – and to show how they are used, for example, to account for error in science. (Most often, but not always, the empirical repertoire of correct experimental practice and theory is invoked to account for successes, while the contingent repertoire of psychological and social causes, such as funding sources or personal pig-headedness, is invoked to account for mistakes.) In other instances, they explore the use of the 'truth-will-out device', a narrative structure in which a speaker, most often at the end of a conversational turn, invokes the principle that, despite distorting social factors, reality will eventually make itself known as it actually is, thus reconciling the apparently contradictory empiricist and contingent repertoires by reconfirming the ultimate dominance of empirical fact. Referring to this as a 'device' makes clear their intent to portray it as a kind of textual machine, a normative form for the production of a standard meaning.

Shapin and Schaffer

Leviathan and the Air-Pump, Shapin and Schaffer's extraordinary historical account of the seventeenth-century debates between

Robert Boyle and Thomas Hobbes, is motivated by the authors' profound awareness of the practical nature of the 'experimental life'. In seeking answers to fundamental questions about the nature and function of experiments in science, Shapin and Schaffer are led to a meticulous analysis of how experimentation came to be defined as the central method of production of facts.

Shapin and Schaffer argue that Boyle's key achievement was to construct a special kind of social 'space', namely the laboratory. Laboratories were a physical location where special apparatus such as Boyle's air-pump was kept, but they were also a 'disciplined'[62] arena into which only men of particular qualifications and acceptable behaviour were admitted. Within this space, the critical activity was the 'multiplication of the witnessing experience'.[63] By both tacit and explicit agreement, Boyle and his colleagues determined that whenever a number of qualified witnesses concurred in their observations, a matter of fact could be said to be known with a very high degree of probability. These consensual 'facts' would form the basis of the new experimental science. Boyle also sought to maintain a rigorous separation between the 'matters of fact' thus established and their causal explanation. In these and other ways, he thus set up a Wittgensteinian language game in which apparatuses, experiences, social status, practices and language played very particular, intricately interwoven roles. To engage in this language game was to gain a privileged form of access to reality.

Hobbes's disagreements with Boyle need not concern us here. Instead, what is of interest in the present context are the mechanisms Shapin and Schaffer use to explain Boyle's success in controversy. They argue that Boyle invented three 'technologies' – material, literary and social – to create the experimental 'form of life'.

His *material* technology, namely the air-pump itself, 'enhanced perception and . . . constituted new perceptual objects';[64] it also forced anyone who might want to participate in an experiment to pass through the restricted channel of the laboratory where this (expensive and delicate) instrument was located. Boyle's *literary* technology consisted of published experimental reports which, through a carefully constructed rhetoric of modest reportage, was calculated to recruit 'virtual' witnesses – that is, readers who, though not actually present, might concur in observations. Virtual witnessing 'involves the production in a *reader's* mind of such an

image of an experimental scene as obviates the necessity for either direct witness or replication'.[65] Finally, Boyle's *social* technology consisted of a set of sometimes explicit rules or 'moral conventions' of discourse, limiting disputes to 'matters of fact' and prohibiting *ad hominem* attacks.[66] These conventions and others like them helped to constitute a space of solidarity in which debates could be conducted calmly, without danger of community disruption, and potential experimental witnesses could be socially validated.

Like other social constructivists, Shapin and Schaffer's founding move is to require that ' "truth", "adequacy", and "objectivity" . . . be dealt with as accomplishments, as historical products, as actors' judgments and categories'.[67] Like Foucault, they want to expose how regimes of truth are constituted. Their central concern is to describe how experiments came to *mean* what they mean in science – how 'experimentally produced matters of fact were made into the foundations of what counted as proper scientific knowledge'.[68]

Much of their analysis appeals to semiotic and linguistic techniques employed by their protagonists. They read the air-pump as an 'emblem' or icon; Boyle's 'literary technology' juxtaposes engravings with piecemeal observational accounts which pretend transparency; the conventions of civilized discourse exclude in advance an entire mode of argumentation. The air-pump itself becomes a 'resource that may be used to factor out human agency in the product';[69] that is, its activities, when channelled through the rhetorical and discursive forms of Boyle's literary and social technologies, acquire the semiotic power of meaning-making.

Shapin and Schaffer's Wittgensteinian concept of a 'form of life', with its focus on practices, embraces a more holistic frame than PSCT is usually thought to bear. But what count as 'practices' for Shapin and Schaffer are often more complex than the habits, conventions and physical actions Wittgenstein frequently had in mind. Like Wittgenstein, they are concerned to mark the conventional status of 'realistic' representation. Unlike him, however, they are interested in the diachronic problem of *how* conventions become established, and this leads them on to different ground, where semiotic practices are pervasive: texts, emblems, icons, discourse. At this point, like the practitioners of PSCT, Shapin and Schaffer become intimately concerned with how language, iconography and the like *work together* to produce multiply articu-

lated, *interrelated* meanings.[70] Thus, like the other scholars discussed here, Shapin and Schaffer's constructivism very often makes a transit through the web of language.

Pinch and Bijker

Pinch and Bijker, in their influential programmatic essay on social construction of technology, argue that technology, like science, may be understood as determined in the last instance by social consensus. They picture constructivist science studies as typically proceeding through three stages: (1) demonstration of the 'interpretative flexibility of scientific findings'; (2) description of social mechanisms that limit this flexibility and 'thus allow scientific controversies to be terminated', which they call 'closure mechanisms'; and (3) relation of these closure mechanisms to a wider social, political and cultural environment.[71]

In their own case study of the development of the bicycle, Pinch and Bijker proceed according to this plan. Having established the variety of 'interpretations' of the bicycle's form and function (focusing variously on considerations of safety, macho display, speed, smoothness of ride and so on), they then seek to identify the closure mechanisms which ended the proliferation of forms and led to a relatively small and stable set of bicycle designs. What they say about this is instructive:

> Closure in technology involves the stabilization of an artifact and the 'disappearance' of problems. To close a technological 'controversy', one need not *solve* the problems in the common sense of that word. *The key point is whether the relevant social groups* see *the problem as being solved.*[72]

So one major mechanism of closure is *purely* semiotic. Another, which they call 'closure by redefinition of the problem', is also essentially a semiotic move. Rather than proceeding, as traditional views might understand it, by confronting a problem defined by empirical conditions with various technical solutions until one 'solves' the problem, social groups essentially begin with technical devices and seek a way of representing problems in which these devices can function as their solutions. In the case of the bicycle, 'the meaning of the air tire was translated to constitute a solution to quite another problem: the problem of how to go as fast as possible'. It is significant that *these are the only closure mechanisms*

Pinch and Bijker offer. Both are essentially textual devices. And when it comes to the (self-admittedly underdeveloped) third stage of the programme, where the role of the sociopolitical milieu is to be integrated, they recommend this method of focusing on meaning-making as a possible avenue of research:

> Obviously, the sociocultural and political situation of a social group shapes its norms and values, which in turn influence the meaning given to an artifact. Because we have shown how different meanings can constitute different lines of development, [our] model seems to offer an operationalization of the relationship between the wider milieu and the actual content of technology.[73]

Haraway

Haraway, among the most complex of the major writers in science studies, defies neat categorization but frequently insists on linguistic categories like 'metaphor', 'story' and 'reading'.[74] At one point she describes her purpose as

> to show how a natural object is constituted in scientific practice *for us*; i.e., made into a technical object with a knowable structure about which fruitful questions may be asked . . . . This technical-natural object can only be constituted on the basis of material practice . . .: field and laboratory custom, machinery, social hierarchies and networks, funding possibilities, contests for privileged model systems, metaphor, struggles over language.[75]

Haraway's work often focuses on what Dear has called 'the literary structure of scientific argument', in which, as Dear puts it:

> an experiment – or more properly, an experimental report – need not necessarily be able to stand for 'what happens' under designated circumstances. Logically, it might function only to stand for 'what happened' on a particular occasion. For the singular experiment to stand for the universal experience, an appropriate kind of argumentative framework needs to be in place, explicitly or implicitly, within which it can play that role. . . . An account of an action is an inseparable part of its meaning, just as the meaning of the account itself relies on its implicit referent.[76]

For historians like Haraway and Dear, there is no history of 'what really happened' apart from how people *read* their experience, in a rich sense that makes language, literary structure and metaphor constitutive elements of reality.

Haraway, Dear and other historians are more resistant than the sociologists of science to the full-scale erasure of reference. In

recent years, Haraway has become increasingly uncomfortable with textual and deconstructive accounts and their accompanying radical relativism because of their destructive political effects, while still holding out for the power of the 'acid tools of critical discourse in the human sciences'. She notes, for example, that 'feminists have to insist on a better account of the world; it is not enough to show radical historical contingency and modes of construction for everything', and that 'relativism and totalization are *both* "god tricks" promising vision from everywhere and nowhere equally and fully, common myths in rhetorics surrounding Science'.[77] Nevertheless, like Dear's, hers remains a fully textualized understanding of science.

Of course, scsk has no single monolithic doctrine or method, so it would be absurd to claim that all work in the field fits this mould. Nor do the figures I have discussed consistently rely upon it. When Callon, Latour, Haraway and others discuss non-human agency,[78] when Law describes contests between natural forces and 'heterogeneous engineers',[79] or when Akrich discusses the ways in which 'technical objects define a framework of action together with the actors and the space in which they are supposed to act',[80] the textual veil is withdrawn to reveal activities and agencies outside the scope of semiotic closure. But quite often it is, as quickly, pulled shut again.

SCSK and PSCT: Parallels

Constructivist social studies of science, then, may be seen as engaged in a project which parallels in many ways the work of post-structuralist critical theory, in the following ways.

- Methodologically, scsk has often used close analysis of the language and representational practices of scientists as a primary method.
- This practice follows from a general commitment to a notion of symmetry by which language is seen not primarily as representation but as a medium of consensus and social action. This commitment is often, but not always, taken either to follow from or to legitimate an explicitly relativist epistemology in which truth is a matter of consensus and/or coherence rather than of correspondence with reality.
- Accordingly, scsk considers scientists' creation of linguistic

(journal papers, books) and other representational products (graphs, charts and the like) to be a key, or even *the* key process in both the construction of theory and the accumulation and use of power. This is a direct consequence of relativism, since, in the absence of a determination of accounts by reality, the accounts themselves are both the object and the medium of contests for truth.

- SCSK seeks to undermine the authority of privileged texts such as scientific journal articles, mathematical symbols and textbooks by juxtaposing alongside them the wide variety of more ordinary representational practices involved in their construction. The latter are held to be operative in, but formally erased from, the final textual product.
- In part because of these methods and assumptions, SCSK has also been led to reconsider the very notion of 'authority' and to question it reflexively in its own productions.

The point at which SCSK *seems* to differ from PSCT is in its invocation of heterogeneous contexts and practices – research communities, power relationships, interests, networks, laboratory techniques and technologies and the like – as resources in the construction of common meanings. But in fact the very notion of 'social construction', taken to its limit, implies that *these contexts themselves are consensual products*. They are meaningful, and function as meaning-giving contexts, only to the extent to which they are taken up in discourse within some community. Contests among groups are seen as struggles over meanings. What matters about a laboratory instrument, for example, is not that it somehow *grounds* theory in observation but that the community talks, writes and acts *as if* it does that – it is 'enrolled' as an 'actant' in various accounts. Contexts and practices are *read* as texts and function as part of the intertext of whatever is foregrounded as 'science'. Thus, unlike traditional and Marxist social theories, in which terms like 'power' and 'interests' are taken as objective forces, in social constructivism these and other terms become semiotic products, ripe for deconstruction.

Hypertension: Cognitive versus Social in Hypertopia

I said earlier that PSCT, like SCSK, focuses on interaction (of texts and discourses) as the locus of the generation of meaning, and so

avoids the need for a psychological theory. But it might be more correct to say, more strongly, that PSCT and SCSK focus on text and discourse *in order* to avoid the problem of psychology. The decentred subject who does not control or even comprehend the meaning of his or her own discourse, and the scientist-as-social-actor whose cognitive abilities play at best a minor role in the success or failure of his or her theory-building, are thoroughly social creatures. Categories and phenomena like 'imagination', 'objectivity' (as a private mental attitude), 'creativity', 'mental images' and 'reasoning' (as a personal skill) are, at a minimum, unimportant in both schemes. At a maximum, they are vigorously rejected.[81]

As Geof Bowker has noted, SCSK owes an unspoken debt to cybernetics, with its ubiquitous lists of heterogeneous processes united through concepts of feedback and information, its program-matic mixing of humans and non-humans, and its vital metaphor – the 'black box'. Bowker calls these three features of cybernetics discourse 'literary devices' and groups them together as the 'Serres effect', a reference to the probable source of their importation into science studies (namely, Michel Serres). All three devices are tropes of a 'universal language' with a political as well as an epistemological aim:

> [P]hysics or biology, . . . as Latour has so convincingly shown, speak the language of obligatory passage points and concentrated translation: if you want to do what you want you have to come through me and let me do what I want (thus the classic example of Pasteur tying the return of French pride to microbes). An interdiscipline that uses a universal language, like cybernetics [or social studies of science – PNE], says: keep doing what you want, but wherever you go you will find me. It speaks the language of distributed passage points. . . . [C]yberneticians tried to move teleology and purpose out into the world of things, much as Latour does.[82]

Structuralism also drew heavily on cybernetics, and PSCT picked up some of the same tropes and epistemology along the way. The reason this (mostly) unacknowledged debt matters here is that the tropes of cybernetics *were constitutively dependent on a behaviour-ist psychology*, a point explicitly mentioned in many of the early articles on cybernetics,[83] but soon dropped from discussion as it became 'common sense' – another move in the discursive construc-tion of cybernetics. Behaviourism, it will be remembered, is essentially a methodological commitment to explanations in terms of observable behaviour. Behaviourism distrusted or even denied

the existence of cognitive (mental) events, attempting to define all activity as responses (R), more or less complex, to environmental stimuli (S), such that $R = f(S)$.[84] PSCT and SCSK, as post-cybernetic interdisciplines, have frequently followed its strategy of systematically avoiding cognitive categories.

This lack – which not infrequently extends to deliberate repudiation[85] – of any explicit cognitive theory has been a source of tension in both fields. On the one hand, PCST and SCSK both make powerful appeals to a trans-individual level of knowledge production under the rubric of such terms as 'intertextuality', 'intersubjectivity', 'discourse', 'collectivity', 'actor-networks' and 'social epistemology'. The use of 'text' and 'discourse' (as opposed to, say, 'representation' and 'conversation') as primary categories in PSCT, for example, focuses discussion solely on these entities as external, visible products. In SCSK, the phrase 'social construction' has become a kind of shorthand or slogan to invoke this apparatus, conceived in opposition to traditional history and sociology of science (which give prominent, indeed dominant, roles to psychological factors).

On the other hand, even if they deny agency in the sense of conscious intentionality, PCST and SCSK both view individuals at least as active *nodes* in social exchanges. Therefore they also rely – implicitly and explicitly – on individuals somehow to produce the discourse which makes up socially constructed knowledge. The mechanisms of this production usually consist, it may be inferred, of vaguely defined socialization processes in which rewards, sanctions or other forms of feedback produce conformity and consensus. When explicit, they are often unabashedly behaviourist, appealing to the primacy of 'conditioning' and training over explanation and reason.[86]

But to pursue power (Latour), individual scientists must be able to *recognize* which strategies, alliances and so on, will and will not be likely to produce more of it.[87] To know which repertoire of discourse to produce at a given moment (Gilbert & Mulkay), scientists must be able to *differentiate* among the contexts in which each is appropriate. To achieve closure by redefining a problem (Pinch & Bijker), innovators must *understand* what can and cannot count as 'problems' and 'solutions'. To mobilize a metaphor or narrative structure (Haraway, Dear), scientists must be able to *comprehend* and manipulate it in recognizable, sense-making ways.

In fact, the ability to mobilize almost *any* of the kinds of resources usually cited (networks, inscription devices and so on) for *any* of the purposes usually mentioned or presumed (power, recognition, knowledge and the like) requires individuals to possess extremely complex skills of recognition, interpretation and response. The abilities to read, write, speak, understand, recognize patterns and plan for the future have, for the last thirty years, been generally recognized by cognitive psychologists to involve extraordinarily complex internal processes and innate abilities not reducible by any stretch of the imagination to behaviourist 'conditioning'.[88] Like PSCT, SCSK usually prefers simply to ignore the literature in this area.

This strategy succeeds only because SCSK covertly imports cognitive abilities into its ostensibly 'social' theories in the form of unexamined assumptions. Scientists are simply presumed to be able to recognize, interpret and respond in the relevant ways, the implications of this (for example, that if cognitive abilities allow them to differentiate valuable from useless resources, individuals might also – by themselves, in their private minds – be capable of imagining new theories, reasoning to conclusions, creating complex long-term strategies for the deployment of resources and so on) being left unexplored because they are insufficiently 'social' in nature.[89] Another, less common, option is to claim that psychological science itself is socially constructed – an idea which, whether true or false, merely begs the questions I have just mentioned.[90]

My point here is not that cognitive science is somehow immune to an SCSK interpretation. Certainly it is not. My own book on post-World War II discourses about minds, machines and subjectivity uses a number of SCSK tools in a historical analysis of the interrelations among computer science, cognitive psychology, artificial intelligence and the US military. Nor do I think cognitive science itself offers some sort of solution to SCSK's problems. I believe, in fact, that cognitive science's implicit metaphors, political commitments and its own covert importation of social terms renders it, despite its mass and sophistication, theoretically rather thin. Nor, finally, do I seek to 'ground' social studies of science in psychological theories. I think a theory of the cognitive and the social as interpenetrating categories is, in the end, most likely to succeed.[91] Of course, many in SCSK have precisely such a goal 'in mind' – as it were.

Instead, I am saying that social constructivism cannot do without *some* psychological theory, because it must somehow account for the bare ability of individuals to play the roles it discerns them as serving. It has such a theory now, and it is an unsubtle behaviourism. This is exceedingly convenient, for it allows the constructivist simply to *dismiss* claims, for example, of important discoveries by isolated individuals, attributions of genius or any other basic mechanisms of traditional history and sociology of science which rely on individual capacities. Just as the behaviourists dismissed introspectionism and consciousness itself as unverifiable if observable, unobservable anyway and (therefore?) non-existent to boot, SCSK not only marks such concepts out of bounds on its intellectual map, but declares them with that very stroke *nulle part*. The behaviourists' rigid commitment to methodological principles – including powerful community-wide taboos against the very mention of internal processes – meant that their experiments ultimately revealed at least as much about the experimenters and their artefacts as about their rats and pigeons.[92] SCSK's equally rigid commitments to very similar principles are unlikely to fare much better.

SCSK has wholeheartedly embraced a reflexivity involving application of its techniques and premises to its own analyses. It has yet to engage the more radically reflexive question of what its analysts' ability to produce any analyses whatsoever might imply.

The analysis I have just given might be viewed as a critique. If it were, at this point I would be expected to say that this consistent lack of a sophisticated psychological theory, combined with the covert importation of cognitive abilities, makes a thoroughgoing 'social epistemology' – and consequently social constructivism itself – unlikely to hold much water. And of course these points have been part of a long-standing debate about the relationship of the cognitive to the social, carried on in part in the pages of *Social Studies of Science*.[93]

But here I want to take a rather different tack instead, relying on an assumption of my own: that tension in theories, as in politics, is a creative force. Following the PSCT strategies I have invoked, we may see theories – including SCSK theories – as articulated within an intertextual field wherein they derive much of their meaning from what they oppose and thus, in a sense, confirm the importance of what they deny. I propose to retain and investigate the tension between explicitly social theories and

implicit cognitive underpinnings, rather than take it as an oppor-
tunity for condemnation of one side or the other. Let us call this
dissonance, facetiously, 'hypertension', and let it also name the
fact that explicitly cognitive theories import implicit social terms in
exactly the same way.[94] This term is the one which finally braids up
the three strands of this paper, since hypertension brings the hyper
texts of PCST and SCSK back to hypertext itself.

Mirror of Nature, or Mirror of Mind?

This is so because an identical hypertension affects hypertext
designers in a decidedly practical way. Hypertexts, like books, are
mostly public products generated for social consumption: they are
touted as a better mode of *communication* of knowledge and
information – an improved form of mediated social interaction.
But, unlike books, many hypertexts are also available for private
reconstruction (in the utopian vision, all of them are). So they are
also touted as a better method for learning, remembering and
organizing *one's own* knowledge and information – an improved
form of mediated cognitive processing.

If I mark a book with underlinings and marginal notes and write
a few pages of typed responses, there remains a visible difference
between all this marginalia and the original text – a difference
which can serve as a resource in the construction of authority and
authorship. But hypertexts may be designed for me to add
unlimited numbers of links and nodes in a form indistinguishable
from the original. Thus, as Bolter notes, hypertext offers the
ultimate in intertextuality: the possibility of endless interpolations,
additions, revisions and linkages with other texts; the limitless
proliferation of versions whose relation to the 'original' may
become *literally* undecidable.[95] Hypertext is thus a sort of oper-
ationalized version of the textual theory common to PSCT and SCSK.

Two central arguments are usually made for the superiority of
hypertext over print media.

The first is that with its rich linkages and associations of
information, hypertext better reflects the fact that human knowl-
edge has not only content but inherent structure – multiple,
overlapping levels and kinds of structure (associative, temporal,
logical, narrative and so on). While this structure may be complex,
it is definable (and public). Hypertext can capture it and make it

explicit.[96] On this view, hypertexts better serve the many specific purposes that require direct access to these frameworks.[97] For example, a highly associative system makes it easier to locate information about which one does not know enough to be specific (like the problem of finding a word in a dictionary when one knows the concept one wants to express but does not already know the word). Furthermore, the structural information contained in the links is actuated and presumably learned by the user as he or she explores the hypertext. So, as a tool of communication and reference, hypertext is assumed to better reflect the 'actual' structure of knowledge.

Under this scheme, hypertext rests on a relatively traditional universalist, empiricist epistemology: it is a better 'mirror of nature',[98] that is, of the nature of the semantic networks that comprise human knowledge. 'Hypertext nodes can be thought of as representing single concepts or ideas, internode links as representing the semantic interdependencies among these ideas, and the process of building a hypertext network as a kind of informal knowledge engineering'.[99] These networks remain stable because they reflect external reality, and hypertext's advantage is that it can better capture the rich structural features of this edifice than linear text: '[h]ypertext makes the deep structure of a knowledge domain explicit'.[100] The problem with traditional media, as vehicles for learning, is that their linear presentations provide too little access to the structural level of knowledge – seen as external, empirical and universal, just as it is seen by the builders of expert systems in artificial intelligence.[101] At its limit, this perspective sees hypertext as the social vehicle of an enlightened cognitive order.

Appearing alongside this view, often simultaneously, is the second argument: that hypertext is superior to written documents because of its malleability. On this view, each user will find a unique path through the text since it does not enforce a predefined structure. Each will also create and modify hypertexts to reflect *his or her own* cognitive framework; the semantic structure of shared knowledge is far too weak to match the wide range of individual cognitive organizing principles.

> Hypertext systems expand the user's accessibility to a wide range of information which may have very little semantic structure. . . . [I]f the conceptual structure of the hypermedia system is a reflection of the user's personal mental model, then selection and navigation become more intuitive for the user. Links from

the node currently being viewed may serve as *memory prompts* for related
concepts. Thus, the explicit model represented in the system reflects the user's
implicit mental model.[102]

Hypertext, unlike ordinary texts or notes, can directly represent
the linkages normally carried only in personal experience.[103] Its
advantage is here seen as precisely the opposite of the mirror-of-
nature viewpoint. Cognitive structures and skills are assumed to
differ widely, if not infinitely, from person to person. Therefore
efficient learning and storing of knowledge requires a medium that
reflects the private system of associations used by each individual.
In the most optimistic theories, mind and hypertext function on
the same (large and individually variable) set of principles,
especially if hypertext is integrated with artificial intelligence
techniques.[104] The problem with traditional media is precisely that
they see the structure of knowledge as universal and leave no room
for individual variation. As Nyce and Bader put it:

> What makes [hypertext] different is the strength of its appeals to notions of
> individualism as enacted through choice. For example, freedom of choice is
> embedded in hypermedia via the selection of material (the user chooses among
> the available files), links among material (the user chooses which links to
> follow) and the interpretation one can draw from the files and links s/he has
> chosen. . . . In the world of educational software, then, programs like 'drill and
> practice' set the backdrop for the supposed virtues of hypermedia, that is, *it is*
> *'structureless' and becomes structured through the choice (therefore action) of*
> *individual users.*[105]

Hypertext mirrors not nature, but the private mind. At the limit of
this discourse, hypertext is the cognitive vehicle of an enlightened
social order that validates each individual's private authority.

    The contrast between these views seems, on the surface,
striking. If hypertext mirrors universal structures of knowledge,
what is the use of its ability to customize linkages? If it reflects the
uniqueness of individual minds, of what value is any one person's
hypertext to anyone else? Hypertext designers, like the prac-
titioners of PCST and SCSK, avoid confronting this hypertension
directly, paying scant attention to the apparent contradiction.

    In fact, hypertext designers rarely see this as a contradiction at
all. As in PSCT and SCSK, the mechanism of unification between
individual and social versions of knowledge is an implicit psycho-
logical theory. In their case, however, the theory is cognitive, not
behaviourist. An associationalism strongly reminiscent of John
Locke is its key metaphor. (As Lamb notes, however, the

associationalist cognitive theory of hypertext is problematic, over-looking 'some of the other crucial ways we consolidate percep-tions, sensations, and experiences . . ., including metaphor, exaggeration, gestalt principles, event schemas, family resem-blance trees, incubation effects, semantic and syntactic cues, etc. Associationalism is only one of a vast group of plausible meta-phors for the mind, metaphors that could move writing technology in other directions than hypermedia . . .')[106] On an even deeper level, as Bolter pointed out in comments on a draft of this paper, most of those writing on hypertext

> accept or tacitly assume that the world can effectively be represented by a
> discrete symbol system. . . . [T]his process of representation is exactly what
> happens in the human mind (in a language of thought that is essentially like a
> computer language). The text of the mind, then is *both* a private expression *and*
> a mirror of nature.[107]

But despite these theoretical justifications, hypertension re-mains unresolved in hypertext discourse. The two alternative visions of hypertext often appear as moments in a larger discourse about social and individual *processes*.

Hypertext, unlike print, is fundamentally process- and context-oriented. Following a basic tenet of artificial intelligence theory, it views representing and acquiring knowledge as a problem of defining and searching information spaces, and it recognizes that these spaces and search methods will vary according to the purposes and abilities of particular users. Hypertext authors must deliberately conceptualize *both* the communicative (structural) features *and* the cognitive content of their work. Just to avoid the possibility of dead ends, lack of sufficient entry points and so on, someone writing a hypertext must lay out and understand the major possible paths through the webwork. At the same time, each possible path must be meaningful – everything cannot be associated with everything else, or the links lose their significance. Thus in composing hypertext authors must envision the entire community of users and imagine the whole variety of possible purposes, skills and cognitive forms. An individual composing or altering a hypertext for his or her own private purposes need not consider these problems as they affect others. But he or she *may* always see his or her work as a new *version* which, with its new

links and information, can be used to make private knowledge public.

Hypertext thus sees cognitive action and social interaction as moments in the continual construction and reconstruction of knowledge. It erases the difference between cognitive and social by creating a container capable of holding both in the same form – hyper text. Hypertexts embody a concept of social interaction as the exchange of texts – unlimited possible versions of cognitive reality. Thus the tension between the two moments is productive. The real hypertension lies between what Foucault might have called a 'truth-effect' of *radical and anonymous sociality* produced by the ceaseless flow of signification from person to person and community to community, in the communicative moment, and a truth-effect of *radical individualism* produced by the composition and consumption of texts by individual persons, in the cognitive moment.[108]

As we have seen, this is a fundamental, and fundamentally political, tension – especially in an individualist political culture such as America.[109] In its communicative/social moment, hypertext represents a faith in the possibility of incorporating all individual perspectives within a single socially constructed whole through multiply articulated structures – a 'society of text', in Edward Barrett's phrase.[110] In its cognitive/individualist moment, hypertext represents the liberation of private cognitive worlds from the oppression of social conformity through a communicative form that equalizes among them.[111] Hypertext is, like PCST, SCSK and cybernetics, a universalist 'language of distributed passage points' which attempts to incorporate both moments in its theory and practice, reconciling the many with the one. Unlike the others, however, hypertext carries a psychological theory that is both explicit and cognitive.

Hypertext has been seen as the technology of post-structuralist critical theory. Many texts within one; the undecidable proliferation of versions; the final dethroning of the author; ultimately, the endlessly self-propagating interlinkage of all texts (even of all signifying media). It reserves a place for the individual subject and his or her cognitive abilities – but the privilege of this place is considerably flattened by the insistence on the equal validity of all other cognitive schemes. PCST, partaking as it has of the behaviourism of cybernetics, has found in hypertext a vehicle for acknowledging its implicit cognitive theory.

Hypertext might also be seen as the technology of constructivist SCSK – indeed, the socio-technical graphs developed by Latour's group make direct use of hypertext technology and philosophy. It embodies the ever-present possibility of renewed controversy; multiple repertoires of discourse appropriate to contexts; the production and exchange of versions, programmes and anti-programmes (of observation, theory and so on) as the work of science; and the possibility of restructuring knowledge by changing metaphors which link observations together into theory. Hyper-maps look a lot like actor-network graphs. (Hyper texts, in fact, might also be called actor networks, that is, networks which act.) Perhaps SCSK, too, will find in hypertext a congenial medium for expressing the implicit cognitive theories upon which it already hangs.

Artificial Intelligence as Hyper Text: SCSK and Hypertension

To close this paper, I want to pursue the pun just a little further in order to show how hypertension affects SCSK as a theory of hyper text. Let me propose, again following Bolter, that artificial intelligence (AI) technology is a kind of ultimate hyper text. Like hypertext itself, AI technology consists of sets of facts (nodes) connected by multiple inference rules (links). Expert systems, the most popular current form of AI, use primarily logical and probabilistic inference rules. But other forms, such as story-understanding programs, use associative structures (for example, scripts) similar to hypertext links.[112] This is not surprising, since many forms of both AI and hypertext explicitly attempt to represent mental models.[113] Unlike hypertext, however, AI tunnels its way through its webs of associations and inferences all by itself. It is text plugged into the wall and 'running', as the metaphor has it.

Beginning in the autumn of 1989, *Social Studies of Science* has carried several iterations of a debate about AI initiated by Peter Slezak.[114] In brief, Slezak claimed that the existence of artificial-intelligence programs supposedly capable of deriving scientific theories from raw data disproved a key element of the 'strong programme' in sociology of scientific knowledge. He theorized (a) that the AI program (called BACON) embodied a cognitive theory of scientific practice; (b) that it produced and confirmed hypotheses

identical to those its (human) scientist predecessors had developed using the same data; and (c) that since the computer was not subject to social influences or historical conditions, individual cognitive abilities were sufficient to account for much, if not all, scientific discovery. Slezak criticized, at some length, the implicit behaviourism of much of the social studies of science community. In terms similar to those I have used above, he pointed out that the behaviourist black-boxing of cognition leaves social constructivism with only the most simplistic of mechanisms for action at the individual level, or simply denies *a priori* any explanation which appeals to the powers of individual minds.

Opponents challenged Slezak on grounds ranging from the (socially influenced) pre-filtering of the data fed to the program to the alleged inability of a machine to construe *any* results as meaningful. In fact, Slezak's choice of example was a poor one, as Herbert Simon (author of one of the programs Slezak cited) later acknowledged. The program did rely on certain forms of social construction in its construal of meaning. From Simon's contribution to the debate it is not obvious that any program could ever avoid this, since he states that 'computer simulations of discovery are compatible with all kinds of social influences' (although 'the actual programs under discussion assume that these influences are overwhelmingly intrinsic – that is, related to the content of the science and independent . . . of the broader economic structures or culture traits . . .').[115]

Semiotic Structures as Social Actors

The vigorous and largely negative response to Slezak's claim about AI (eight responses were published with his original article, and many more in subsequent issues of the journal) exhibits hypertension in action. The SCSK community clearly experienced the challenge of AI as a cognitive theory of scientific discovery as worrisome, and also as an occasion to reinforce its boundaries through articulating its opposition to cognitivism. Yet most of the criticisms, overly focused on Slezak's (incorrect) assertions about the abilities of the AI theorizing program, avoided the really central issues Slezak's essay raised. These concerned the capacity of *a purely symbolic/syntactic structure – a hyper text –* to perform as a social actor.

In the context of hyper text, the issue is not whether an artificial intelligence program can duplicate events in the mind of a scientist and thereby prove a cognitive theory of scientific discovery, but what if anything differentiates it *in principle* from the other producers of texts which count as scientific discoveries. Simon, for example, in a claim typical of the AI perspective, holds that 'a mind . . . contains meanings, *if it contains them*, only in the form of patterns of neural structures and processes, that is, as symbols'.[116] Since programs also contain and process symbols – texts – the AI view is that *a priori* distinctions between programs and minds, as generators and processors of text, are meaningless, mystifying and unworkable. This view bears a remarkable similarity to notions of 'actants' in SCSK.

The work of hypertension is clearly visible here. SCSK is caught between its avowed, behaviouristic emphasis on observables – the production and exchange of texts, discourses and so on as the work of science; its social epistemology; the black-boxing of internal processes; the variable attribution of motives and intentions – and the essentialism of its unacknowledged cognitive theories, which still retain a special place for *human* actors. If science really is socially constructed, nothing prevents it from admitting non-human actors into that process on any basis scientific communities can agree on. Thus what would matter about AI is not whether it captures what goes on inside a scientist's mind, but what conditions are imposed upon the circulation of the texts it produces: whether scientists grant it 'authority', in the extended sense of Foucault, when it is operating as an author of texts.

An AI is the ultimate inscription device – self-powered, capable of interesting mistakes, capable of inferences and reformulations of its own rules, capable of communicating, more or less, in natural language with humans. AI (and, possibly, other kinds of computer programs) thus holds a special place on the border between instrumentation and the discursive activities of human scientists. AI texts are hyper texts

in the sense that they play with the issue of the voice in the text, as all hypertexts (and all texts) do. A hypertext seems to be cut loose from its author; it seems to create itself as text and so to assert its own voice even more forcefully than texts in previous technologies.[117]

If the textual aspects of SCSK theory are correct, AI programs and

other hyper texts *will* be included as agents – as actants – in scientific theory construction.[118]

Lost in Hyperspace

In one episode of Stanislaw Lem's classic science fiction saga, *The Cyberiad*, the cybernetic robot Trurl recounts the story of the entrapment of the lustful and never-satisfied King Zipperupus by the mental engineer Subtillion. Subtillion creates a Dream Machine to satisfy the king's desire for beautiful illusions in which to escape from everyday existence. At first the king enjoys his new machine. But each illusion, like a drug, satisfies the king only temporarily, and when he loses interest he demands more and better. Finally Subtillion realizes that the king's demands are truly limitless. So he programs one final dream into his machine: the Dream of the Mona Lisa.

This dream initially looks just the same as ordinary reality. In it, Subtillion suggests that the king try the Dream of the Mona Lisa, but when he does, the new dream, too, seems the same as waking life. And so the king enters another Dream of the Mona Lisa, and from that one another, and from that one yet another – each indistinguishable from waking life – until he becomes hopelessly lost in a many-levelled maze of completely veridical hallucinations. Even when he by chance passes back into actual reality, he can no longer distinguish it from the illusions produced by the machine, soon passing back into them. Leaving him thus bemused, Subtillion makes his escape.[119]

Post-structuralist critical theory and science studies, perhaps ironically given their attempts to carve out a strictly social realm, lead to the same vision of hyper-textual production of knowledge as hypertext and artificial intelligence. The simulacra (hypertext, AI) could be distinguished from the originals (cognition, social construction) only by introducing non-textual, non-signifying elements (the mute body, experience, emotion) that PSCT and SCSK admit only as subsidiary to the production of text and discourse. Perhaps another hypertension is necessary, one that would oppose both cognitivism and social construction with something new, like the 'experientialism' of Lakoff and Johnson.[120] For the moment, however, not unlike King Zipperupus, we are lost in the hyperspace of hyper text, where what is inside (cognition) and what

is outside (communication, social construction) have become undecidable mirror images.

• NOTES

1. Definitions of 'hyper', according to the *Random House Dictionary* (New York: Random House, 1973).

2. See, for example, Bruno Latour, Philippe Mauguin and Geneviève Teil, 'A Note on Socio-Technical Graphs', *Social Studies of Science*, Vol. 22, No. 1 (February 1992), 33–57, and W. Bernard Carlson and Michael E. Gorman, 'Socio-Technical Graphs and Cognitive Maps: A Response to Latour, Mauguin and Teil', ibid., 81–89.

3. Vannevar Bush, 'As We May Think', *Atlantic Monthly*, Vol. 176, No. 1 (1945), 101–08; Douglas C. Engelbart and W.K. English, 'A Research Center for Augmenting Human Intellect', *AFIPS Conference Proceedings*, Vol. 33, No. 1 (1968). On the history of hypertext, see also Ted Nelson, *Computer Lib: You Can and Must Understand Computers Now* (Chicago, IL: Hugos Book Service, 1974); James M. Nyce and Paul Kahn, *From Memex to Hypertext: Vannevar Bush and the Mind's Machine* (Boston, MA: Academic Press, 1991); and Jeff Conklin, 'Hypertext: An Introduction and Survey', *Computer*, Vol. 20, No. 9 (1987), 17–41.

4. Ted Nelson, cited in George P. Landow, *Hypertext: The Convergence of Contemporary Critical Theory and Technology* (Baltimore, MD: Johns Hopkins University Press, 1992), 4.

5. The best review of existing hypertext applications is in Jakob Nielsen, *Hypertext and Hypermedia* (Boston, MA: Academic Press, 1990). Also see Edward Barrett (ed.), *The Society of Text* (Cambridge, MA: MIT Press, 1989); Karen Ruhleder, 'Knowledge Work, New Media and the Construction of Artifacts for Information Storage and Manipulation', *ACM Transactions on Information Systems* (forthcoming); Ben Shneiderman and Greg Kearsley, *Hypertext Hands-On!* (New York: Addison-Wesley, 1989); and Conklin, op. cit. note 3.

6. Shneiderman & Kearsley, ibid.; Jay David Bolter, *Writing Space: The Computer, Hypertext, and the History of Writing* (Hillsdale, NJ: Lawrence Erlbaum, 1991).

7. John M. Slatin, 'Reading Hypertext: Order and Coherence in a New Medium', *College English*, Vol. 52, No. 8 (1990), 870–83.

8. Graph taken from John R. Brockmann, William Horton and Kevin Brock, 'From Database to Hypertext via Electronic Publishing: An Information Odyssey', in Barrett (ed.), op. cit. note 5, 162–205, at 167.

9. See Slatin, op. cit. note 7.

10. Conklin, op. cit. note 3, 38.

11. See Bolter, op. cit. note 6.

12. Landow, op. cit. note 4, 178.

13. Nelson, cited in Landow, op. cit. note 4, 170.

14. Roland Barthes, 'From Work to Text', in Josué V. Harari (ed.), *Textual Strategies: Perspectives in Post-Structuralist Criticism* (Ithaca, NY: Cornell University Press, 1979), 73–81, at 75–76, emphasis in original.

15. Ibid., 77.

16. Michel Foucault, 'What Is An Author?', trans. Donald F. Bouchard and Sherry Simon, in Bouchard (ed.), *Language, Counter-memory, Practice* (Ithaca, NY: Cornell University Press, 1977), 113–38.

17. Ibid., 138.

18. Of course, such cultures already exist within American society around such semiotic productions as advertising and prime-time television shows, usually composed by large groups of people and disseminated without naming any of them. (Recently, however, there has been a trend toward reattribution even in these media.) And many, if not most documents – technical reports and manuals, memos, letters, advertising copy and the like – written by individuals do not have 'authors' in Foucault's rather literary sense of the term. The English word 'author' loses some of the élite overtones of the French *auteur*, which carries the connotation of 'distinguished literary figure'. *Auteur* would rarely be used to describe, for example, a journalist who had written a book-length treatment of some popular topic.

19. Hubert L. Dreyfus and Paul Rabinow, *Michel Foucault: Beyond Structuralism and Hermeneutics* (Chicago, IL: The University of Chicago Press, 1983), 183.

20. Jacques Derrida, *Limited Inc.* (Baltimore, MD: Johns Hopkins University Press, 1977).

21. Jacques Derrida, *Glas* (Paris: Éditions Galilée, 1974); Derrida, *Of Grammatology*, trans. Gayatri C. Spivak (Baltimore, MD: Johns Hopkins University Press, 1976); Derrida, *Writing and Difference* (Chicago, IL: The University of Chicago Press, 1978).

22. Derrida (1976), op. cit. note 21, 158.

23. Harold Bloom, *A Map of Misreading* (New York: Oxford University Press, 1975).

24. Bolter, op. cit. note 6; Landow, op. cit. note 4.

25. Jonathan Culler, *On Deconstruction: Theory and Criticism after Structuralism* (Ithaca, NY: Cornell University Press, 1982).

26. Anthony Giddens, 'Agency, Institution, and Time–Space Analysis', in Karin Knorr-Cetina and Aaron V. Cicourel (eds), *Advances in Social Theory and Methodology: Toward an Integration of Micro- and Macro-Sociologies* (Boston, MA: Routledge & Kegan Paul, 1981), 161–74, at 170.

27. Bolter, op. cit. note 6.

28. John Ellis, *Against Deconstruction* (Princeton, NJ: Princeton University Press, 1989); Camille Paglia, *Sexual Personae: Art and Decadence from Nefertiti to Emily Dickinson* (New Haven, CT: Yale University Press, 1990).

29. This notion, with its McLuhanesque medium-as-message technological determinism, sits somewhat uncomfortably beside the simultaneous claim that printed text also has hypertextual properties.

30. Nielsen, op. cit. note 5, 71.

31. Bolter, op. cit. note 6, 233.

32. Bolter, op. cit. note 6; Landow, op. cit. note 4, 70. Also see Edward Barrett, 'Introduction', in Barrett (ed.), op. cit. note 5, xi–xix, at xii.

33. See Iain Lamb, *Mythologies of Hypertext: A Call for Disenchantment and Redesign* (unpublished undergraduate thesis, Symbolic Systems Program, Stanford University, 1993), 67 et passim; Kathleen Gygi, 'Recognizing the Symptoms of Hypertext . . . and What To Do About It', in Brenda Laurel (ed.), *The Art of Human–Computer Interface Design* (Reading, MA: Addison-Wesley, 1990), 280–96.

34. Derrida (1976), op. cit. note 21.

35. Michel Foucault, *Discipline and Punish*, trans. Alan Sheridan (New York: Vintage, 1977); Foucault, *The History of Sexuality*, trans. Robert Hurley (New York: Vintage, 1980); Foucault, *Power/Knowledge: Selected Interviews and Other Writings 1972–1977*, trans. Colin Gordon (New York: Pantheon, 1980).

36. G. Nigel Gilbert and Michael Mulkay, *Opening Pandora's Box: A Sociological Analysis of Scientists' Discourse* (New York: Cambridge University Press, 1984).

37. Garrit Curfs, 'Applying Old Meanings of Discourse for a New Rhetoric of Science' (unpublished paper, presented to the Society for Social Studies of Science, Cambridge, MA, 1991); Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in the Cold War* (Cambridge, MA: MIT Press, forthcoming).

38. Foucault said he wanted to write 'history without a subject': see, for example, the 'Foreword to the English Edition' in Michel Foucault, *The Order of Things: An Archaeology of the Human Sciences* (New York: Random House, 1970).

39. Ronald N. Giere, 'The Cognitive Construction of Scientific Knowledge (Response to Pickering)', *Social Studies of Science*, Vol. 22, No. 1 (February 1992), 95–107.

40. Peter Dear (ed.), *The Literary Structure of Scientific Argument: Historical Studies* (Philadelphia, PA: University of Pennsylvania Press, 1991); Donna J. Haraway, 'Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective', *Feminist Studies*, Vol. 14, No. 3 (1988), 575–99; Haraway, *Primate Visions* (London: Routledge & Kegan Paul, 1989); Michael Mulkay, J. Potter and Steven Yearley, 'Why An Analysis of Scientific Discourse is Needed', in Karin Knorr-Cetina and Mulkay (eds), *Science Observed* (London: Sage, 1983), 141–70.

41. Wiebe Bijker, Thomas P. Hughes and Trevor Pinch (eds), *The Social Construction of Technological Systems* (Cambridge, MA: MIT Press, 1987); Harry M. Collins, *Changing Order: Replication and Induction in Scientific Practice* (Beverly Hills, CA: Sage, 1985); Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Cambridge, MA: Harvard University Press, 1987); Latour and Steve Woolgar, *Laboratory Life: The Social Construction of Scientific Facts* (London: Sage, 1979); Woolgar (ed.), *Knowledge and Reflexivity: New Frontiers in the Sociology of Knowledge* (Beverly Hills, CA: Sage, 1988); Michel Callon, John Law and Arie Rip (eds), *Mapping the Dynamics of Science and Technology* (London: Macmillan, 1986); Lucy Suchman, *Plans and Situated Actions: The Problem of Human–Machine Communication* (Cambridge: Cambridge University Press, 1987).

42. Paul N. Edwards, *Technologies of the Mind: Computers, Power, Psychology, and World War II* (Silicon Valley Research Group Working Paper, No. 2,

University of California, Santa Cruz, 1986); Edwards, 'The Army and the Microworld: Computers and the Militarized Politics of Gender', *Signs*, Vol. 16, No. 1 (1990), 102–27; Edwards, op. cit. note 37.

43. Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago, IL: The University of Chicago Press, 1962); Imre Lakatos and Alan Musgrave (eds), *Criticism and the Growth of Knowledge* (Cambridge: Cambridge University Press, 1970).

44. Barry Barnes and David Bloor, 'Relativism, Rationalism and the Sociology of Knowledge', in Martin Hollis and Steven Lukes (eds), *Rationality and Relativism* (Cambridge, MA: MIT Press, 1982), 1–27.

45. David Bloor, *Wittgenstein: A Social Theory of Knowledge* (New York: Columbia University Press, 1983); Collins, op. cit. note 41.

46. Giddens, op. cit. note 26; Karin D. Knorr-Cetina, 'Introduction: The Micro-Sociological Challenge of Macro-Sociology: Towards a Reconstruction of Social Theory and Methodology', in Knorr-Cetina & Cicourel (eds), op. cit. note 26, 2–47; Helen Longino, *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry* (Princeton, NJ: Princeton University Press, 1990).

47. See Woolgar (ed.), op. cit. note 41.

48. Latour & Woolgar, op. cit. note 41.

49. Latour, op. cit. note 41, 15.

50. Bruno Latour, 'Give Me a Laboratory and I Will Raise the Earth', in Knorr-Cetina & Mulkay (eds), op. cit. note 40, 158.

51. See Latour et al., op. cit. note 2.

52. Ibid., 37.

53. Ibid., 46–47.

54. Bruno Latour, 'A Reply to Carlson and Gorman', *Social Studies of Science*, Vol. 22, No. 1 (February 1992), 91–94; James K. Scott, 'Exploring Socio-Technical Analysis: Monsieur Latour Is Not Joking!', ibid., 59–80.

55. John Law, 'Laboratories and Texts', in Callon et al. (eds), op. cit. note 41, 35–50, at 49.

56. Ibid., emphasis in original.

57. John Law, 'The Heterogeneity of Texts', in Callon et al., op. cit. note 41, 67–83, at 70.

58. Gilbert & Mulkay, op. cit. note 36, 14.

59. Ibid., 9.

60. Cited in ibid., 40.

61. Ibid., 40.

62. Steven Shapin and Simon Shaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton, NJ: Princeton University Press, 1985), 39.

63. Ibid., 25.

64. Ibid., 36.

65. Ibid., 60.

66. Ibid., 73.

67. Ibid., 14.

68. Ibid., 3.

69. Ibid., 77.

70. See Chapter 2 of Edwards, op. cit. note 37, for a discussion of Wittgenstein's work as a theory of discourse.

71. Trevor Pinch and Wiebe Bijker, 'The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other', in Bijker et al. (eds), op. cit. note 41, 17–50, at 27.

72. Ibid., 44, italics mine.

73. Ibid., 46.

74. '*Both* the scientist and the organism are actors in a story-telling practice': Haraway (1989), op. cit. note 40, 5. 'Theories are accounts *of* and *for* specific kinds of lives. . . . I would suggest that the concept of constrained and contested story-telling allows an appreciation of the social construction of science, while still guiding the hearer to a search for the other animals who are active participants in primatology. . . . Stories are means to ways of living. Stories are technologies for primate embodiment': ibid., 8 (emphasis in original).

75. Donna J. Haraway, 'The High Cost of Information in Post-World War II Evolutionary Biology', *Philosophical Forum*, Vol. 13 (1981–82), 244–78, at 245.

76. Dear (ed.), op. cit. note 40, 162, 136.

77. Haraway (1988), op. cit. note 40, 577, 579, 584 (italics added).

78. Michel Callon, 'Some Elements of a Sociology of Translation: Domesti-cation of the Scallops and the Fishermen of St. Brieuc Bay', in John Law (ed.), *Power, Action, and Belief: A New Sociology of Knowledge?* (London: Routledge & Kegan Paul, 1986), 196–233; Donna J. Haraway, 'The Promises of Monsters', in Lawrence Grossberg, Cary Nelson and Paula A. Treichler (eds), *Cultural Studies* (New York: Routledge & Kegan Paul, 1992), 295–337; Bruno Latour, 'Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts', in Wiebe E. Bijker and John Law (eds), *Shaping Technology/Building Society: Studies in Sociotechnical Change* (Cambridge, MA: MIT Press, 1992), 225–58.

79. John Law, 'Technology and Heterogeneous Engineering: The Case of Portuguese Expansion', in Bijker et al. (eds), op. cit. note 41, 111–34.

80. Madeleine Akrich, 'The De-Scription of Technical Objects', in Bijker & Law (eds), op. cit. note 78, 205–24, at 208.

81. Witness Latour's response to Carlson and Gorman's critique of socio-technical graphs: 'If there exist documents about [the subject of analysis], then they can be encoded according to the method we described – and they may differ wildly about the *attribution* of goals . . . mental processes . . . or technical efficiency. If, on the other hand, there exists no other document than the one we showed in our Note, then there is no way [to] "map the mental processes" or "detail goals". . . . [A]n instrument is always a re-representation of data. . . . There is no way to diminish the number of mediations. The only possibility is to align some of them in a more or less stable and principled manner. This resurrection of cognitive dimensions, interests and goals in Carlson and Gorman's comments is an indication that they are still trying to recapture Edison and Bell in their "real essence". Our goal is much more modest . . .'. Latour, op. cit. note 54, 94 (emphasis in original).

82. Geof Bowker, 'The Age of Cybernetics, or How Cybernetics Aged' (unpublished manuscript, 1991), 10–11.

83. See, for example, Arturo Rosenblueth, Norbert Wiener and Julian Bigelow, 'Behavior, Purpose and Teleology', *Philosophy of Science*, Vol. 10 (1943), 18–24; Claude E. Shannon and Warren Weaver, *The Mathematical Theory of Communi-cation* (Urbana, IL: University of Illinois Press, 1949); Wiener, *Cybernetics: Control and Communication in the Animal and the Machine* (New York: Wiley, 1948).

84. William K. Estes, 'Toward a Statistical Theory of Learning', *Psychological Review*, Vol. 57 (1950), 94–107.

85. Jeff Coulter, *Rethinking Cognitive Theory* (New York: St Martin's Press, 1983); Collins, op. cit. note 41; Harry M. Collins, *Artificial Experts: Social Knowledge and Intelligent Machines* (Cambridge, MA: MIT Press, 1990).

86. See, for example, Bloor, op. cit. note 45; Collins (1990), op. cit. note 85.

87. I owe this point to Peter Taylor.

88. See, for example, Noam Chomsky, 'Review of B.F. Skinner's *Verbal Behavior*', *Language*, Vol. 35 (1959), 26–58; J.L. McClelland, D.E. Rumelhart and G.E. Hinton, 'The Appeal of Parallel Distributed Processing', in McClelland & Rumelhart (eds), *Parallel Distributed Processing* (Cambridge, MA: MIT Press, 1986), 3–44; Ulric Neisser, *Cognitive Psychology* (New York: Appleton-Century-Crofts, 1967); Neisser, *Cognition and Reality* (San Francisco, CA: W.H. Freeman, 1976); Howard Gardner, *The Mind's New Science* (New York: Basic Books, 1985). It is important to be aware that cognitive scientists often – though not always – recognize that these abilities (such as learning to speak and read) are cognitive *potentials* which can only be realized through extensive social interaction.

89. For an extended exposition of this point, see Peter Slezak, 'Scientific Discovery by Computer as Empirical Refutation of the Strong Programme', *Social Studies of Science*, Vol. 19, No. 4 (November 1989), 563–600.

90. Coulter, op. cit. note 85; Steve Woolgar, 'Reconstructing Man and Machine: A Note on Sociological Critiques of Cognitivism', in Bijker et al. (eds), op. cit. note 41, 311–28.

91. See, as one example of such a theory, Peter J. Taylor, 'Building on the Metaphor of Construction in Science Studies' (unpublished manuscript, Department of Science and Technology Studies, Cornell University, 1993).

92. Brian D. Mackenzie, *Behaviourism and the Limits of Scientific Method* (London: Routledge & Kegan Paul, 1977); also Gardner, op. cit. note 88.

93. Carlson & Gorman, op. cit. note 2; Giere, op. cit. note 39; Slezak, op. cit. note 89; H. Simon, 'Comments on the Symposium on "Computer Discovery and the Sociology of Scientific Knowledge" ', *Social Studies of Science*, Vol. 21, No. 1 (February 1991), 143–56.

94. I will not attempt to demonstrate this point here, but merely refer back to the very literature I was apparently criticizing in the preceding paragraph. See Edwards (1986), op. cit. note 42; Edwards (forthcoming), op. cit. note 37; Collins, op. cit. notes 41, 85; Coulter, op. cit. note 85; Woolgar, op. cit. note 90.

95. See Bolter, op. cit. note 6; Landow, op. cit. note 4.

96. Hypertexts are frequently compared to 'semantic networks', weblike representations of interconnected concepts used in both artificial intelligence and cognitive psychology: see Conklin, op. cit. note 3; Dario Lucarella, 'A Model for Hypertext-Based Information Retrieval', in N. Streitz, A. Rizk and J. André (eds), *Hypertext: Concepts, Systems, and Applications* (Cambridge: Cambridge University Press, 1990), 81–94; Nielsen, op. cit. note 5; Ben Shneiderman, 'Reflections on Authoring, Editing, and Managing Hypertext', in Barrett (ed.), op. cit. note 5, 115–31, at 129.

97. 'Smart interfaces, embedded expert systems, and intelligent filters when applied to a hypertext all share a common purpose: *to help the user select a path through the textbase that is tailored for a particular application or purpose*': Patricia

A. Carlson, 'Hypertext and Intelligent Interfaces for Text Retrieval', in Barrett (ed.), op. cit. note 5, 59–76, at 60, italics in original.

98. Richard Rorty, *Philosophy and the Mirror of Nature* (Princeton, NJ: Princeton University Press, 1979).

99. Conklin, op. cit. note 5, 37.

100. Carlson, op. cit. note 97, 63.

101. On the concept of knowledge in expert systems research, see Collins, op. cit. note 85; Hubert Dreyfus and Stuart Dreyfus, *Mind Over Machine* (New York: Free Press, 1986); Edward Feigenbaum and Pamela McCorduck, *The Fifth Generation: Japan's Computer Challenge to the World* (Reading, MA: Addison-Wesley, 1983); Terry Winograd and Fernando Flores, *Understanding Computers and Cognition: A New Foundation for Design* (Norwood, NJ: Ablex, 1987).

102. David A. Carlson and Sudha Ram, 'HyperIntelligence: The Next Frontier', *Communications of the ACM*, Vol. 33, No. 3 (1990), 311–21, at 315, italics in original.

103. One reads a book, hears a lecture exploring the book, sees a film based on the book, writes an essay about it, reads a review, reads related texts, has many conversations about related themes and thus develops a rich background of associations of ideas, moods, contexts, emotions and so on.

104. 'Hypermedia provides a natural representation for the loosely connected goals and strategies which characterize the mental model for a manager's agenda. The flexible definition of nodes and links allows each manager to build a personalized representation of his/her mental model': Carlson & Ram, op. cit. note 102, 315. Also see Mark Bernstein, 'An Apprentice That Discovers Hypertext Links', in Streitz et al. (eds), op. cit. note 96, 212–23; Frédérique Biennier, Michel Guivarch and Jean-Marie Pinon, 'Browsing in Hyperdocuments with the Assistance of a Neural Network', in ibid., 288–97; Paul Delany and George P. Landow, 'Managing the Digital Word: The Text in an Age of Electronic Reproduction', in Landow and Delany (eds), *The Digital Word: Text-Based Computing in the Humanities* (Cambridge, MA: MIT Press, 1993), 3–28.

105. James M. Nyce and Gail Bader, 'When Freedom of Choice Fails: Ideology and Action in a Secondary School Hypermedia Project', *Bulletin of the National Association for the Practice of Anthropology*, in press, italics added.

106. Lamb, op. cit. note 33, 53.

107. Jay David Bolter, personal communication (17 August 1992), italics added. Note that the assumptions mentioned are those of the AI community, not Bolter.

108. This was the tension upon which Derrida played in his analysis of Searle's copyright.

109. Nyce & Bader, op. cit. note 105.

110. Edward Barrett, 'Introduction', in Barrett (ed.), op. cit. note 5, xi–xix, passim.

111. Nyce & Bader, op. cit. note 105; Nelson, op. cit. note 3; Ted Nelson, *Literary Machines* (Swarthmore, PA: self-published, 1981).

112. '[T]he organization of hypertext more closely resembles AI knowledge representations (for example, semantic networks and procedural frames) than it does classic, static database organizations': Carlson, op. cit. note 97, 77. On scripts, see Roger Schank, *Scripts, Plans, Goals, and Understanding: An Inquiry into Human Knowledge Structures* (Hillsdale, NJ: Lawrence Erlbaum, 1977) and

Schank, *The Cognitive Computer: On Language, Learning, and Artificial Intelligence* (Reading, MA: Addison-Wesley, 1984).

113. See Carlson, op. cit. note 97; Carlson & Ram, op. cit. note 102.

114. Peter Slezak et al., 'Symposium on Computer Discovery and the Sociology of Scientific Knowledge', *Social Studies of Science*, Vol. 19, No. 4 (November 1989), 563–695.

115. Simon, op. cit. note 93, 147.

116. Ibid., 145, italics added.

117. Bolter, loc. cit. note 107.

118. Indeed, the use of non-AI computer programs to 'prove' mathematical theorems by exhaustive search is already a controversial issue in the mathematics community.

119. Stanislaw Lem, *The Cyberiad: Fables for the Cybernetic Age* (New York: Seabury Press, 1974).

120. See George Lakoff, *Women, Fire, and Dangerous Things: What Categories Reveal About the Mind* (Chicago, IL: The University of Chicago Press, 1987); Lakoff and Mark Johnson, *Metaphors We Live By* (Chicago, IL: The University of Chicago Press, 1980); Johnson, *The Body in Mind* (Chicago, IL: The University of Chicago Press, 1987).

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