INTERACTION SCIENCE
A General Meta-Framework for Digital Representation

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The Voice of the Field

In the way of products, language, and way of life, so much has happened in digital culture that, as a growing project emerging more or less through its formative years, it is now worth asking what the scholar of technology can say about the *digital situation* and how such systematic observations (if any) can be stated. When, perhaps around the mid 1970's, digital developments were just emerging from research settings, almost anything seemed possible and little of what was problematic or impractical to implement was talked about much. A swell of new products was followed by what seems like endless advertising, followed by the rise Web, and then dot-com revolution, and finally a huge retrenchment, so that by now, talk of possibilities is rare in comparison to announcements from labs and corporations. If we follow the money, little remains obscure about the evolution or effects of digital culture. Major developments have permeated the corporation as the paradigm of the enterprise system; likewise so in new probing methodologies of science; in pop culture's bandwagon-style advertising; in the sci-fi film and book; and in the new aesthetics of the cyber-artist and hyper-poet. This happened quickly, and its rate of adoption has restructured various professions. Traditional architecture becomes a new, digital architecture; medicine breeds a new bioinformatics; music spawns a new MIDI-world of electronic resonances. Field after field morpho-digitalizes into a new vocation, complicating the aim of scholars aiming to see some cohesion from the sweeping vista.

Even if professions were the only targets of change, the social phenomenon would not be too hard to describe. But since a sort of psychology of digital culture emerged, another challenge is understanding how close this new ethos impinges on inner life. Seen casually, most digital workers, focused in quiet isolation, seem somewhat detached from reality as we know it. Yet the new *information order* arguably steers the outer world because of the sheer number of people who stare at a screen at any moment. There is another class of knowledge workers who one might call *humanities technologists*, because no other label is more accurate, who do exceptionally interdisciplinary work. Accompanying the digital architect, medic, and musician is also the researcher/developer of new media, whose methods are still a black art.

On the research side, humanities technologists understand that something invisible connects digital work, and practices, and trends. The more one looks at new media, the more it feels like many sides of the same coin. How does one connect and define things in a highly diverse realm of new professions, new language, and new work? What is the focus? Should one concentrate on the individual, the group, the methods, or the productions? We are entering the third decade after the popular advent of the digital revolution, and still no satisfactory picture emerges, even though researchers and theorists have made momentous observations in almost every conceivable discipline. To think of one perspective on the psychological side, there were Sherry Turkle's first accounts of social life inside the Internet, illustrating its potential as an alter-ego-creating social network. The insight here was that digital communities had become a stage for relegating the corporeal world to "just one more window, and it's usually not my best one," to quote one user (Turkle 1995). The medium was an infant and yet sophisticated things were already happening. Here was a world of pervasive cyberidentities concealing objectionable facets of personal life becomes a contemporary adaptation to Oscar Wilde's prophetic "Being natural is only a pose, and the most irritating one I know".

A number of other theories of virtual gender, identity, and the body have helped peel the onion to reveal additional surprising facets of digital culture. If there is anything like a grand, eclectic digital landscape, it is bound to be more than mere backdrop for personal self-expression. Correspondingly, a substantial literature also exists on its socio-cultural and philosophical aspects, often with much more cynicism than Turkle observed in her subjects. It is well known that the erudite – philosophers,

psychologists, and authors – have had good reason in this last century of world wars to be cynical of technology. So this isn't unique to new media; it's the latest in a highly dystopian trend whose modern nucleus emerged in the decade roughly from Heidegger's Freiburg lecture in 1938 on *The Question Concerning Technology* to the publication in 1949 of George Orwell's *1984*. The enduring influence of this trend has inspired some of the polemically important world-views of Don Ihde, Langdon Winner, Alvin Toffler, and Neil Postman's (1992) evolution of *technopoly*. The sense throughout is of an ominous reality-defining state possible only through technological thinking causing physical and psychological changes that outpace the possible rate of human adaptation. Proponents find it convenient to remain focused on the possibilities of technology, hoping over time that developments will convert opposing voices to the modern way, but, to be fair, the critics pose a frame too problematic and lasting for mere conversion of opponents. The history of technology follows noticeable patterns, and while optimists concentrate on the possibilities of what is to come, more reflective thinkers bemoan the effects of what has already occurred, often seeing the contemporary as another version of life under previous technologies. Consider Landgon Winner:

> The way television's intrusion has re-shaped household schedules around programs, fragments of programs, and advertisements; the way we are tempted to click through the endless and chaotic doorways presented to us on the web; the vastly greater ease with which one person can approach another through email – an approach we can initiate with less weight of significance or personal presence than before – in these and many other symptoms you will recognize the contemporary forces that would throw us off our own foundations. (Winner 2001)

Social adaptation to technology and its role in personal life are the preferred themes of popular culture, dramatized in films from *You've Got Mail* to *The Matrix*. Either way, we have lost the vital center of old world community in favor of a new world of *ad hoc* objects in a culture that produces them more and more quickly. We might pity the theorist who has to integrate this horizon breadth into a wall-sized portrait – how is this to be accomplished systematically?

If the horizons of the project are widely spread, the analytic languages and methodologies for digital representation are also ambitious and have

long been available. To illustrate the range of analytic methodology, we might consider Peter Andersen's extended and influential semiotic work (especially Andersen 1990); Plotkin's early structural semantics (1981); critical constructionist perspectives (e.g., Landow 1992); Adrian Miles's poststructurally cinematic approaches (e.g., Miles 1998); Howard Rheingold's (e.g. 1993) early views on virtual communities; various substantial debates about machine-level understanding from a hermeneutic standpoint (Winograd & Flores 1986; Mallery & Hurwitz & Duffy 1987) or phenomenological ones (most notably Dreyfus 2001). There is also an independently growing literature of feminist and gender-centric approaches on life and work in the digital domain. Many accounts center on issues of male technologization of the female body in a postmodern era, newly interpreting classic cyborg symbols like Maria the Robot in Fritz Lang's 1926 film, *Metropolis* – and there are numerous celebrated examples of similar fetishisms longing for interpretation in a techno-feminist frame (e.g., Balsamo 1996), probably because converting the body into a narrative is one temptation offered by a highly symbolic medium like the digital domain. Other feminist works convey themes of inclusion, possibilities, and control in a new technosocial reality (e.g., Behar-Molad 2000; Napier et al. 2000). The discourse has opened up into academic areas with names like *feminist science studies* (Cf. Wyer et al. 2001) and *virtual gender* (Green & Alison 2001). There are many insights, some are even self-critical. One captivating example is Christine Fredrick's recent (1999) *Feminist Rhetoric in Cyberspace: The Ethos of Feminist Usenet Newsgroups*. Fredrick followed postings in two feminist newsgroups, *alt.feminism* and *soc.feminism*, and observed how language use in them revolved around gender-sensitive concerns but yet produced a consistent discourse of antagonism and exclusion. Seeing this, and in spite of the digital medium's seeming sense of democracy – it has no hierarchy or structure – Fredrick's view is that its lack of conversational cues is a great disadvantage, potentially leading to a pragmatics of exclusion independent of the content topic. It may be possible to reconcile this type of contradiction if, rather than adopting either a medium-centered or a narrative-centered view of digital culture and digital works (texts, videos, games), humanities technologists focus on what actually happens in communicative exchange (whether as dialogue or as data transfer). Before announcing that this focus on exchange, a discourse-centered examination of digital field phenomena, is exactly the approach that I will advocate, we leave this survey of digitally

savvy disciplines by noticing again how, even in this single area of digital inquiry, much of the work is already classified under several areas, including sociology, women's studies, feminist theory, critical studies, and philosophy. This fact again underscores the need for a unifying approach able to supply both a cohesive language and methods for comparing observations, however imperfectly, under a single field in a way that can translate what is anecdotal into what is systematic. But there are still two larger reasons for the adoption of system in cybertext study, now ready for some clarification.

We began with the question of method, specifically asking, why bother? What is so wrong with the now-customary rhetorical or polemical presentation of digitally relevant observations, prognostications, and beliefs? What makes scholarly chronicles and intellectual reflections on cybertexts methodologically inadequate or deficient? Two considerations are important in response to this reluctance. The first is one of magnitude. There was a time when the penultimate age of modern technology (defined as that set of moments when technology transformed human communication) was built primarily on the goal of efficient analog transmission. This is a time period roughly from the early Industrial Revolution with the emergence of the telegraph in Europe, or perhaps the invention of Morse Code in America around the 1840's, spanning up to the heyday of television in the mid 1950's. At least one traditional academic view sees these developments in technology as a recent chapter in History of Science. Any sense of digital culture, whose dawn came after the computer age, did not yet exist. In this earlier analog world, instances and instruments of change were few: one could point to the telephone – there were few telephone companies; one could see radio, but there were relatively few radio stations; one could look at television, but there was very little initial content; one could look at the evolution of film, but the classics, too, were few. This world of *semi-uniques* made it possible to see most observable cases of technological evolution as extraordinary, most innovations as almost *sui generis*. The magic was that the world was affected *en masse*; the magic of all such technology was its impact as a mass media device, its ability to *transmit* something to the masses instantly. Since, in this one-way world, individual response was not deemed important, the great fanfare that heralded the advent of radio, film, and later television, was not likewise accorded to the telephone, which seeped into cities and towns more gradually, perhaps silently. This meant that the power of multi-mil-

lion multiples of innovation or expression that lay in the hands of popular response would wait until the era of interactivity, when huge segments of the general population undermined what remained of any sense of "audience" and began to *produce and communicate* content, rather than, as with the purchase of radios, televisions, and cars, to merely *consume* it[1]. Today, digital content is not only plentiful, but also self-reciprocating. Traditional web sites and dynamic blogs, to name two diverse digital instances, generate content linked to other content that generates more content linked back to content. And such recursion is not wholly self-contained; the production of non-interactive media such as films and books also adds continually to the production and reproduction of new digital interactive content – advertising, reviews, responses, discussions, games, and other forms of digital expression. This new magnitude of content being produced annually – games, texts, news services, discussions, eLearning sites, and all other kinds of interactive activities – means that previous standalone, *sui generis* reflections are no longer adequate to comprehensively explain digital phenomena. Largely gone are the days of one-offs or original cases, supplanted now by multitudes of similar cases rapidly coming online. This doesn't even account for the two important "re" words: repurposing and remediation, which imply that content and media appropriate to one kind of context are used in another. To fully explain this rising sea of events, inductive arguments alone are self-marginalizing; patterns of empirical observations are also now necessary.

If I have painted digital growth a bit like a river cascading over the edge of a waterfall, then who will properly harness this digital torrent is our next problem, and so, the second consideration arguing for a system of cybertext study is a competitive one. The need for authoritative information about *what is happening* in the digital sphere is dawning with validity requirements beyond those that any single person or argument, however historically venerated, will be able to fulfill. Wisdom is important, but valid conclusions on digital use, usability, promise, possibilities, problems are missing; actual data is just too rare. One cannot deny that any field or discipline to first provide this information will define the analytic debate about digital culture and new media long thereafter. This will be an intellectual problem and although most creators of digital products are not academics but rather corporations targeting consumers (B2C) or other businesses (B2B), it's nonetheless worth examining how the scholar stands to benefit. To be sure, the scholar is as caught up in the industrial

snare as is anyone else; when corporate sponsorship ebbs or flows, it opens and closes entire chapters in technological history, as it did in the age of holographs and lasers (1960's and 1970's); the epoch of the expert system and artificial intelligence (the 1980's), and as it has done more recently in the dot-com era.

Today, cybertext scholars must now grapple with the quickly growing genre of interactive games, whose production (and profit) models are similar to those of Hollywood film studios. A historical aberration prevents us from somewhat disregarding the game publisher as it has been possible (and common) to do with the print publisher, and (to a moderate degree) with the film studio. What, then, is this anomaly? It is the timing of media evolution in proportion to the media's productions. All of the print-based editorial and publishing houses of today emerged centuries after the Gutenberg galaxy of print was already firmly established in literate culture. Print publishers, though important, cannot effectively generate demand for their titles; these works will only gain influence through canonization, acquiring consensual importance with the passing of time. Game publishers, on the other hand, cannot analogously enjoy the stability of a pre-established medium. In order to sell product, game companies must *create and define* that medium proactively, for instance, through game spin-offs of popular films, or by raising the interactivity (which we may take as *intensity*) level of each new game. In a strategic reversal of the print trend, then, the game medium reduces the importance of prior work because, to endure, it *must*. Contrary to the case of print works, then, old age is not an advantage for the digital work. And so, a movement that, for this historical reason must build on the production of eventual obsolescence, turns out to be not a tradition but an industry. It cannot foster a reflective canon, but is instead driven forward by *What's New*, the very latest. As a strange counter-motif to the many intellectual tongues claiming digital study, this industrial craving, rather than being bad news, is ironically fortunate for the cybertext scholar, who can, unlike his professional twins in literary or film theory, assume a position of importance as researcher and theorist influencing the industry's direction for *What's Next*. Since the game industry will continue to define its direction in empirical, not philosophical terms, the exaltation of the cybertext scholar can occur through a disciplinary integration of *What's Happening*, which means that we return to our point of departure: the need for systematic observations and a common language or theoretical framework that can pull it all together for everybody else.

Finally, the multitudes of analytic prisms that now divide digital knowledge are evidence of the ubiquity, influence, and importance of the digital paradigm, something unseen in other fields. It would be absurd, for instance, to imagine a Marxism of chemistry; a hermeneutics of biology, or a semiotics of political science. New media, thriving on ideas, is at the brink of creating an ideology. This doctrine is ostensibly the use of science to create technology that eludes history and transforms previous ideologies and practices, as earlier exemplified in the case of the academy and the professions. Let us properly set the stage for that claim. An unspoken rule of academia maintains that essential distinctions exist between what is *ideological* (like Marxism) and what is *scientific* (like statistics), and we can explore the merger of *ideology* and *science* by asking where and why such theoretical connections have happened. In some fields of study, scholars enjoy diversified approaches because the focus of analysis is abstract and allows for unrestrained reflection; comparative literature is an example of such a pluralistic field. In other cases, a thick mixture of approaches is evidence of a field without a canon, which is to say that no one has yet provided the definitive rules or scope for it. In such fields, there is often widespread disagreement on even elementary language, concepts, and after a while, arguments sometimes end up presenting more a picture of disciplinary confusion than clarity. Ideological conflicts that take place over the use of imprecise scholarly language can often escalate into battles over disciplinary agenda. As an example, for some years, the field of social criticism in the U.S. has itself been the theatre of emotive battles over whether rhetorical criticism is or is not (and whether it should or should not be) *political* in nature, and whether, in their research and practice, social critics construct social realities. Because the unit of analysis (rhetoric) is diffuse and abstract, such battles over semantic intent are destined to lie unresolved, and the battles endemic to the field of rhetorical criticism have been put on show through various issues of the American Communication Journal, the flagship refereed journal of its field.[2] Since it is not difficult to predict the rise of ideological warlords in any field without objective measures for scoping and framing what it analyzes, it makes sense to ask how humanities computing, too, can avoid heading for the quicksand of ideological quarrels. So what is the unit of analysis of all humanistic technology and how do they support the radical ideology claimed earlier?

A Genealogy of Field-formation

Technology has two aims: to perform explicit chores without human intervention and to reduce most everything else to explicit chores. Print, for instance, once was possible only through the arcane craft of typographers and mechanical comp and paste-up professionals, color experts, and film specialists whose production problems defined the field. Now, that work is largely automated by digital techniques and systems – automatic imagesetters, smart page imposition and document management software, and dynamic color calibration systems. The production work isn't altogether precluded; some chores are redefined such that now the tasks are entirely different, but the skills, reduced to chores, have largely disappeared. The pattern is common: the black magic of some labor-intensive specialty is defined and performed automatically by a system now requiring minimal human direction. True enough, this transformation has long been played out in mechanical terms with remarkable effect on the stability of the social order (e.g., the Industrial Revolution, the Atomic Age), but in the last few decades, the evolution of new media has implemented this transformation for more strictly abstract or cognitive tasks.

The study of new media cannot be purely humanistic because designs and implementations are inherently technical; neither can such inquiry reject scientific methodology or thinking, lest its stream of production atrophy. The solution has been to *postmodernize* new media, a painless transcendence, and one that makes a new field possible. While digital works invariably contain text, for instance, the better analytic metaphor in digital studies is that of hypertext. Postmodernizing a genre means to modernize it for the digital medium and to create new structures and experiments not possible with the traditional incarnation of that genre. To revisit another example, the same holds for games; *Tetris* is just not feasible outside the computer screen, but its simple ergodic thrust transforms all we understand about the power of the genre, traditional or new. Each such instance forces one to rethink what is generalizable in participatory genre.

The purpose of systematic language and methodology in a field of study is to filter through a single conduit the progress of diverse research, productions, and experiments so that jointly they may tackle the central problems of that field in a finite and consistent way. This makes possible even the most elementary closure on issues, and propagates the disciplinary worldview. The quandary for any field is that the greater its methodological freedom, the less its systematicity. Although lack of common methodological or linguistic cohesion is not unique to techno-humanistic studies, any unsystematic field can become a target for dismissals, criticisms and deconstructions. Every field craves evidence of progress, either by the final settlement of long-standing conceptual disputes, or by the steady adoption of conceptual verbiage. Absent this, its collective energies dissipate in ideological spirals. Could this happen in fields without a system, such as the study of new media works?

In 1996, an article appeared in Duke University's critical studies journal *Social Text* promisingly titled *Transgressing the Boundaries: Toward a Transformative Hermeneutics of Quantum Gravity*. Its author, Alan Sokal, a professor of physics at New York University, portrayed an ambitious synthesis between postmodern thought and natural science. Although a physicist by training, Sokal espoused a solid neo-critical position against scientists and anyone who privileges an objective, rational world guided by physical laws independent of any observer's subjective position, attitude, or language. Although this had been a long accepted view, new developments in twentieth-century science (assisted by feminist and poststructuralist critiques) have revealed "objectivity" as an ideology, as the fraudulent conspiracy of scientific elites. This shift lends subjective reality a new, inescapable sense of legitimacy:

> It has thus become increasingly apparent that physical "reality", no less than social "reality", is at bottom a social and linguistic construct; that scientific "knowledge", far from being objective, reflects and encodes the dominant ideologies and power relations of the culture that produced it; that the truth claims of science are inherently theory-laden and self-referential; and consequently, that the discourse of the scientific community, for all its undeniable value, cannot assert a privileged epistemological status with respect to counter-hegemonic narratives emanating from dissident or marginalized communities. (Sokal 1996)

Defending the feasibility of a new "future postmodern and liberatory science", Sokal weaves a highly engaging odyssey starting from traditional scientific principles and setting sail repeatedly under the airstreams of modern physics for the shores of critical studies. The first modern insight, he shows, is the pervasive *relativity* of knowledge in opposition to the notion of an omnipresent *objectivity* assumed by the traditional scientific enterprise. From physics, Heisenberg's uncertainty principle propels the relativistic notions of complementarity/dialecticism, discontinuity/rupture. Derrida is likewise shown to critique Einstein's special theory of relativity. Lacan, too, is credited with presaging insights mirrored in differential topology. Driving a sustained critique throughout against the unspoken biases of natural science, Sokal's analysis culminates in a call for the radical reconfiguration of natural science (particularly mathematics), which, with a new bond with critical studies, will become a liberatory science:

> Thus, a liberatory science cannot be complete without a profound revision of the canon of mathematics. As yet no such emancipatory mathematics exists, and we can only speculate upon its eventual content. We can see hints of it in the multidimensional and nonlinear logic of fuzzy systems theory; but this approach is still heavily marked by its origins in the crisis of late-capitalist production relations. Catastrophe theory, with its dialectical emphases on smoothness/discontinuity and metamorphosis/unfolding, will indubitably play a major role in the future mathematics; but much theoretical work remains to be done before this approach can become a concrete tool of progressive political praxis. Finally, chaos theory – which provides our deepest insights into the ubiquitous yet mysterious phenomenon of nonlinearity – will be central to all future mathematics. And yet, these images of the future mathematics must remain but the haziest glimmer: for, alongside these three young branches in the tree of science, there will arise new trunks and branches – entire new theoretical frameworks – of which we, with our present ideological blinders, cannot yet even conceive. (Sokal 1996)

That this paper should have been hailed as the official call for a new, long-awaited alliance of unity between scientists and critical studies scholars was precluded only by the subsequent revelation that it was a hoax. It, only one in a long procession of scathing critiques[3], fueled ferocious de-

bates not merely over the intellectual worth of postmodern abstractions, but also over the seeming incommensurability of the two cultures, science and humanities. Experiencing distress over the "apparent decline in the standards of intellectual rigor in certain precincts of the American academic humanities", Sokal launched a Trojan horse to assess the degree of objective, externally confirmable truth-value of critical discourse in the humanities. He would use the community of critical humanists itself as the experimental subjects. The hypothesis under scrutiny was simple: "Would a leading North American journal of cultural studies – whose editorial collective includes such luminaries as Fredric Jameson and Andrew Ross – publish an article liberally salted with nonsense if (a) it sounded good and (b) it flattered the editors' ideological preconceptions?" (Sokal 1996). The methodology was not complicated: Sokal's article, rifled with conceptual contradictions buried in the belly of pseudo-scientific jargon would be welcomed uncritically through the gates of a postmodern Troy. Once published by *Social Text*, the article was Sokal's proof of how critical disciplines can uncritically replace even physical realities with 100% fact-free jargon:

> What concerns me is the proliferation, not just of nonsense and sloppy thinking *per se*, but of a particular kind of nonsense and sloppy thinking: one that denies the existence of objective realities, or (when challenged) admits their existence but downplays their practical relevance…There *is* a real world; its properties are *not* merely social constructions; facts and evidence *do* matter. What sane person would contend otherwise? And yet, much contemporary academic theorizing consists precisely of attempts to blur these obvious truths – the utter absurdity of it all being concealed through obscure and pretentious language. (Sokal 1996)

For any scientist committed to external verifiability, any claims to reality as a linguistic construct are a reversal of the case, and an affront to truth. This position is not as radical as it seems, for some humanists also concur on the value of concepts based on at least some empirical foundations – and the unfortunate consequences when these conditions are absent. In a notorious example, various accounts now ascribe the demise of Pragmatism in the last century to various inopportune factors, centrally being the artificial perception that

> all human cognition is inescapably verbal or textual and consists of a web of unstable, dancing signifiers having no reference to a reality beyond the text; words full of sound and fury signifying not nothing but almost everything, as though the script were out of control; philosophers assuming they are looking for truth and waking up to realize they are only writing words about words, manipulating metaphors, alternating verbal images. (Diggins 1994, 435)

And here, the denunciation comes not from a highly renowned *physicist* but a highly renowned *historian*. With regard to the unit of analysis and methodology, Sokal's disapproval conveys an undeniable logic:

> If all is discourse and "text," then knowledge of the real world is superfluous; even physics becomes just another branch of Cultural Studies. If, moreover, all is rhetoric and "language games," then internal logical consistency is superfluous too: a patina of theoretical sophistication serves equally well. Incomprehensibility becomes a virtue; allusions, metaphors and puns substitute for evidence and logic. (Sokal 1996)

It's hard to overstate how easily ideological conflicts like this, as old as religious wars themselves, always reduce to competing linguistic claims on reality. Some may have long believed that "In the beginning was the Word", fighting over whether this is permissible as *poetry* or as *Truth*, but in science, the world-as-Text archetype is not convincing. There is reason for caution here, as it is worth remembering (with Frege) that any field should beware two linguistic pitfalls. The first, Sokal's critique, is about *reification*, or the exaggeration of reference, where linguistic imagination can so obscure logical thinking that one cannot discern words from things. The second is about sense, the extent to which there is perceptual consensus in practice, and asks whether everyone collectively discerns the same phenomenon.

In fact, one reason that Sokal's ruse wasn't unveiled is that the article employed both critical and scientific concepts[4]. To be sure, differences in linguistic practice mean are inevitable, and more so during the ambiguous juxtaposition of discourse communities produced by interdisciplinary dialogues. What is evident, however, is that use of popular terminology that is not grounded in fixed conceptual terminology creates to a perception of

understanding that is indistinguishable from *mis*understanding. Nor is it fair to expect that, before reading a text, readers will have had linguistic expertise in the domains referenced there. Hence the task of the author and editorial staff to verify and clarify (a charge, to be sure, that was leveled against the editorial board of *Social Texts*). Having gotten this, the remaining rejoinder against this type of criticism is based on *scope of work*.

Scope, Language, and Method

Psychologist Abraham Maslow's celebrated quote that, "If the only tool you have is a hammer, you tend to see every problem as a nail" indicates that one's working methodology generates its own kinds of solutions. This is exactly Kuhn's observation about the work of normal science. Whereas the scientist works in a field largely defined and (with the exception of certain fields like meteorology and astronomy) experimentally controllable realm, the humanist's sphere of activity has no empirical boundary. Humanistic work is work able to generate both explanation and creativity; work that can comprise analysis and statement blended together; work that is capable of being simultaneously expository and provocative; work that at once defies and invites redefinition. Human studies are necessarily open, and work in them has no objective methods of validity or falsification, except through social consensus relative to community, to place and to time.

Long before science, all human studies were once a large project. Philosophy, architecture, the administration of state, and even cosmology were approached humanistically. With time evolved the so-called human sciences, once a monolithic canvas of all that was neither natural science nor art, and gradually bifurcated into human studies based on philosophy on one hand – which in the case of language led to modern literary theory – and science on the other – which with language led to phonological linguistics. Humanistic studies comprised much more than art, but in fact any non-science inquiry that used insightful speculation as the primary means of discovery. Social science took experimental and subject control methodologies from natural science and used sampling and inference methods as one primary means for hypothesis testing. Hence the situation

today, where we have as much a paucity of philosophical method in economics as a paucity of statistical method in history. Born of these two genealogical branches, the study of new media must now define its own boundaries dialectically:

Scope/Antiscope: what are we investigating; what are we *not*?
Hypothesis/Antihypothesis: what are we ascertaining; what are we *not*?
Methodology/Antimethodology: what are we doing; what are we *not*?

Is the *Study of Cybertexts* analogous to *Humanities Computing*? Initially one might think so. But the latter has become humanistic, something like the study of language, history and culture from a computational perspective whereas the former will no doubt involve itself in different work such as the design simulations, games, and new interactive immersive experiences. The difference is a field with new tools studying old problems versus a field with new tools and wholly new goals. Since we are again brought back to a science-humanities dilemma, we should at least look at the interdisciplinary landscape.

The Problem of Other Hybrid Sciences and Epistemic Indeterminacy

The presence of cybertexts (interactive humanistic works confined inside technological devices) argues that science and humanism are two estranged domains probably destined for an eventual reunion. Hybrid disciplines are not new, some are in fact very successful. *Political Science*, as one example, has widely spread roots in the humanities (social and political philosophy); in social science (sociology, economics); and in "hard" science (mathematics). Another hybrid field is *Cognitive Science*, with equally eclectic roots across the humanities (philosophy, linguistics); social sciences (psychology); and "hard" science (biology). But what accounts for a field's *success*? One way to measure this is to count the number of academic departments dedicated to it; another is to count the number of publications or the amount of annual funding dedicated to the field's topics and problems; yet another measure is the universal adoption of its meth-

ods and language in popular culture; and lastly, the degree to which that field can predict, rather than merely explain trends. By any of these measures, success is a variable outcome, not a guarantee. One interdisciplinary field with less such success is that of *Cultural Studies*. In many schools, there are cultural studies programs, curricula, and research centers, but in most there is no impetus for creating cultural studies *departments* – the litmus test of successful adoption. The same holds for *Humanistic Informatics* ("*hum/inf*"). Although *hum/inf* courses are more in demand among students than are courses in political or cognitive science (and the field is certainly more news-sensitive, dynamic, and equally or better supported by commercial concerns), it is most often found as a *study area* ensconced within a department[5]. The same holds for the field called *Media Studies*. Given that some multidisciplinary fields possess more cohesive, productive identities and methods than others, I refine the question: what can predict the success of an emerging hybrid discipline *at its embryonic stages*? Two relevant criteria immediately stand out: (a) the field's *domain cohesion*, and (b) the discipline's use of *systematic methodology* to predict, rather than explain field phenomena, as mentioned before.

The Notion of Domain in Hybrid Disciplines

Any field's domain can either be framed by a clear physical boundary (e.g., the *brain* in cognitive science) or by an abstract but deterministic *entity, notion or concept* (e.g., the *state* in political science). Not all hybrid fields have clear domains. Media (and communications) studies are an example; the study of a medium is by definition *without* boundary (*anything* can run through it), and anything can *become* a medium, anything is therefore as much an entity as it is a medium. Media studies departments have therefore shown interest in disjunct areas of societal institutions for broad communication; hence the seemingly unconnected range of media studies topics from film studies to journalism.

All hybrid fields must rationalize the span of their domain. This calls for a kind of unifying language with rather specialized terminology. The broadest field of all is semiotics, and the peculiarity of its jargon is correspondingly unparalleled. Although these rationalizations act as disciplinary glue to justify why a field looks at certain kinds of problems, the

genuine value of philosophy remains an unresolved factor in hybrid disciplines. When it comes right down to it, there is little consensus on the relevance of philosophy – basically everyone respects philosophers, but few build or live according to their rules. On the other hand, it is hard to find a discipline that dismisses empirical evidence. This contrast forms the bias that explains the rise of the scientific enterprise. Indeed, the relevance of most sciences is not shrinking; it is growing, both in financial and explanatory terms. The notion of the traditional scientific journal, focusing on biology, physics, mathematics, or materials science has now expanded to include venues for new discoveries that would not seem scientific in the conventional sense. Among these are findings in mood ascriptions (through the brain/chemical-balance perspective) and potential advances in human personality research (witness the now fully-mapped but not-yet-interpreted human genome and its potential for explaining human behavior). And as the scientific journal has broadened its scope, there too have appeared new academic journals for many scientific aspects of humanities topics. In some areas, like electronic music, these publications are abundant. The rise of the humanistic-scientific monograph is possible today because of the pro-science bias noted earlier. Regardless of field, scientists today are equipped with rigorous analytic methods capable of producing reproducible results. But this methodological uniformity doesn't mean that problems in the humanities need only wait idly for *de facto* solutions of science; that won't happen. Scientific decomposition is no more important an approach than humanistic holism; the inability of science to tell the whole story over any human domain proves that no single methodology or paradigm can be definitive by itself. And choosing an approach means sacrificing other solution possibilities in the sense that no approach can be highly precise without being highly reductionistic, just as no approach can be highly inclusive without also being highly ambiguous. If we pursue the humanistic spirit of a specific field or domain of study, then we become subjectively trapped in a mentalism that may not be shared or understood by the uninformed outsider. Yet, if we schematize with scientific precision the workings of its constituent parts, we overlook the importance and implications of the domain on the larger phenomenal world within which it (as does every other domain) unremittingly operates. As there is no one-sided way out of the problem, some aspiration for interdisciplinary synthesis is the last, best, and only prospect for broad and deep knowledge in a successful hybrid discipline.

The problem of epistemic unity has been taken up before, particularly in the intersection of humanistic studies and science[6]. But rather than pose the problem in terms of science or humanities, we could consider a different view on the endeavors collectively scattered across and subsumed under existing fields like computer science, media studies, systems dynamics, operations research, human computer interaction, digital narrative studies, humanities computing, and humanistic informatics. We need a computer science perspective, but we should also embrace media studies, and what transpires in both, the interaction, may hold a promising clue for this new field.

Interaction Science

The stage is now set for integrating our concerns into a new methodology. We need a field that can withstand Sokal-style scrutiny. As we have seen, this rules out pure postmodern approaches; more than blind adulation of Logos is needed. We also need some fixed vocabulary and a steady analytic gaze; this rules out media studies. We may exclude media studies on another count: it is not necessarily, or even primarily, concerned with interactive media; many legitimate media – radio, film, TV, newspapers – are not interactive. We need a *generative* field, one that can help to *generate* or explain *how to structure* interaction, not just study it through existing works. On this count, media studies, film studies, and other fields that still view digital content as a kind of *narrative* lack methods for systematically helping designers put mechanics of meaning in motion and engage the world in real time. I'm referring to *passive techniques* like content analysis, which decomposes semantics of a story, film, or interview but doesn't take the analysis further as a potential element of content design for the writer, programmer, or new media producer. For this reason, although narrative is a stable concept, I think that synthesizing computational methods with another linguistic device, *discourse*, much better describes the actual characteristics of digital interaction. The blend of systematic design with a discourse-centric approach would produce discourse maps not of conversation but of interaction. Extending classical discourse into the study of how to produce and analyze interaction in digital media also transcends the primary limitation of linguistics: its focus on the utter-

ance. If linguistics cannot adequately scale up to the study of whole texts, it won't scale up to cybertexts.

But let us scrutinize this proposal of a digital interaction study under the boundary questions posed earlier. To begin with, let's ask the central scope/antiscope question: what is *not* an interaction? We need to distinguish the category *interaction* from other kinds of activity. For instance, an abstract action *statement* by itself (e.g., *birds fly*) is a *proposition*, not an interaction. Nor is a *narrative utterance* an interaction (e.g., *Tweety flies*). Nor are *inferential chains* (e.g., *if X can fly, then X is a bird*) interactions. An interaction is not a *belief* (*Tweety thinks that Sylvester is suspiciously hungry*). Interaction is not *motivation* (e.g., *Sylvester wants to eat Tweety*)[7]. All of these are outside what is implied by an interaction, although they can occur within interactions. Broadly stated, an interaction is what happens when someone or something changes an observable state, condition or characteristic in someone or something else. It is an action involving any two or more objects.

Sounds promising but it isn't. Without much work, one can find numerous problems in this definition. First, it is still too broad: one *could* say that "a bird flying *through the air*, *above a city*, and *under a cloud*, *in order to find food to feed its offspring*" can entail an endless number of interactions (bird interacting with air by *flying-through*; bird interacting with city by *overflying*; bird interacting with cloud by *underflying*; etc.). The second problem is that we seem only to be asking the King to change clothes. Realizing that any two things can be related in an infinity of ways, interaction can quickly devolve into anything you like, and I again hear Sokal at the door. Moreover, this reification doesn't call for a change in anything. In narrative, for instance, we could claim that a reader-text interaction has long been acknowledged. We cannot exhaust all possible interactions between any two things, particularly since anything can be redefined as anything else (e.g., the *bird* is also operating in the role of *parent*) and then we are constrained by the linguistic tautologies that Sokal correctly criticizes. Can we to escape what appears to be solipsistic thinking? On the contrary, if we extend the problem to everybody else, we begin realizing that every discipline – including science – has exactly the same problem. Physics (Sokal's own profession) can also formally relate any two physical objects in an infinity of ways, depending on the scale of observation (atomically, subatomically, astronomically, etc.). Even the simple mathematical expression 100 + 1 = 101 can be restated in unlimited

ways – all of them true. This multifariousness debunks neither physics nor math. Instead, physicists and mathematicians apply selective parsimony to limit the scope of their observations. We therefore should also limit our notion of interactions to that which is relevant in a context of observation or experimentation. For us, let us begin with the discourse (i.e., rules and outcomes) of elements interacting with (and within) digitally represented surroundings. This discourse view treats the interaction of utterances, of characters, and of data equally and with no inherent bias of abstraction.

Incidentally, utilizing *discourse* as the framework for representing interaction science does not mean that we are speaking about the field of communications studies. Discourse in interaction science is more specific; it is the protocol of interaction between things, which includes human-machine and intra-machine state interactions. As mentioned earlier, *narrative* is a limiting metaphor for interactions that are ergodic, stochastic, not *pre-determined*. Parting ways with the *narrative* paradigm opens the way for objective study without the ideology of narrativity, a tradition from print fiction that is anachronistic and irrelevant to many interaction systems like virtual reality environments. It comes as no surprise that the textual scholars who tried to formulate the most dynamic theories of text were influenced by linguists. Greimas and Barthes, for instance, took much from Jakobson and Saussure. Narrative was extended out toward pro-discourse methods.

The reader will have guessed that, in casting narrative as the horizontal dimension of meaning; discourse a more vertical one, I am revisiting an old distinction without adding anything new. It is true that narrative can be seen as a paradigmatic production and discourse a syntagmatic one. For cybertexts this has already been argued persuasively. Recently, in an illuminating and original monograph, Adrian Miles revealed how aspects of the same relationship are at play in a modal comparison of hypertext and film (Miles 2000). The advantage of seeing digital texts as narratives is that it provides a logical portrait, a panoramic world of both parts and wholes. This perspective can be formal, wholly structural, or poststructural – all along admitting of elements in a work, and of relations between those elements. This theoretical possibility proves that we cannot see narrative as a perspective that excludes interaction, and we must logically ask, why is discourse a better explanatory framework for cybertexts than narrative? One answer is in the relationship – not between narrative and

work, or between discourse and work, but between narrative and discourse. There is in every work a multiplicity of discourses – between *langue* and argument, between reader and author, between functionality and interface – such that narrative can in fact not exist without discourse. Discourse is an invariable precondition of narrative; the dialectic between both leads to a synthesis that is the meaning of the work *precisely because of the interactions* between the levels and entities described. This synthesis is attained on experiential, not textual grounds. In fact, it is not limited solely to fictive/aesthetic frames of portrayal. What attracts the watchmaker, to invoke an experiential instance, is not merely the scientific fitting of gears, but the (aesthetic) totality of the timepiece in proper working order. Understanding digital interaction as a science would admit the former without losing the latter; it is possible to start at either end and work toward the other without an intermediary abstract framework or ideology (i.e., narrativity; Marxist theory; Ellulianism; cognitivism; structuralism; …). The watch is a system but its construction is an art. Time, the language symbolized by the work, is both: at once an ontological basis of philosophical being and the basis for precise systems of measurement. Time is integral to art and to science, and I argue that digital systems are the timepieces, the cyberartist/engineer is the watchmaker, and the interactions in digital realms are the analogue of time itself, as the measurable basis for all action.

Even with all of that, one may still ask, does it have to be interaction *science*? Doesn't the mantle of scientism deny the relevance of creative or subjective processes? I acknowledged earlier that the significance of normal science begins with its techniques and methods of observation and construction. This arrangement is essential to a systematic study of digital interactions. But it is also possible to analyze phenomena systematically without defining reality as *only* an objective, consistent, rational and closed system, something more prevalent in many disciplines than may at first be realized. The persistent systematicity (and increased sophistication) of modern physics proves that such naïve expectations about the world are an unwarranted vestige of 19th century thinking. Side by side with new science, numerous social science disciplines like economics, sociology, and political science now live openly with the inability to predict or even *verify* hypotheses. Systematicity is unrelenting. As we see from the study of nonlinear systems in operations research and chaos theory, researchers have learned to account formally for the coexistence of forces that have

no ascribable causality. Chaotic tendencies in natural phenomena are only part of the new post-formal paradigm. Some social science disciplines claim both social and scientific agendas – anthropology, to name one, incorporates both social anthropology (archaeology, anthropological linguistics) and biological anthropology (paleontology, primatology, demography). Undoubtedly, we live in an epistemic moment that recognizes inescapable limits for even the most rigorous scientific systems. Scientific determinism entered a new era of constraints when Gödel's incompleteness theorem provided proof that no mathematical system, no matter how rigorously self-aware, can prove all the true propositions producible by its internal language. As with Heisenberg's uncertainty principle in physics, science accepts that all systems are characterized by unpreventable indeterminacies, yet can still be scientifically valid. Likewise, computer technology is built on scientific practices; programming design and practice are exceptionally exacting. Program code is scientific in that algorithms are functional hypotheses tested in use. This digital play or work is not *less than* scientific even if it doesn't have to be *exact* science. It joins an already growing branch of knowledge that might be termed descriptive, rather than predictive, sciences.

I have also argued that humanistic study is indispensable because of its ambitious, naturalistic, crucially important aim of describing and reflecting aspects of the life-world as well as of the sublime. There is some compatibility in the overlay of both views. If we minimize the presumed importance of world-view and of conclusions, and if we dispose with any pretense for exactitude (trading it for comprehensiveness), we are again left with the same substrate: interaction. Let us consider aesthetic works. The artist is motivated to create or document a particular kind of interaction (as mentioned earlier, between subject depicted and its world, between artist and his own contemporary world, and between current observer and immediate artwork). This is not a narrative but rather a set of interactions, and in diverse works, the reason for it is different. Sometimes the motivation for uniting such interactions within a single work is political (e.g., Picasso's *Güernica*); sometimes metaphysical (Michelangelo's *The Sistine Chapel*); sometimes cognitive (e.g., the work of Ellsworth Kelly or Piet Mondrian). In the same way, the biologist, the sociologist, and the political historian set out to describe the interaction of units of analysis (cells, groups, nations) with respect to each other and their surrounding natural world. In the same vein, we have seen whole disciplines related to

interaction between humans and computers. The most common of these is HCI, human-computer interaction, also known as *CHI*, which was established by Card, Moran, and Newell's 1983 work, *The Psychology of Human-Computer Interaction*. But, unfortunately, this otherwise ideal designation has become somewhat diluted in two directions: either by *expansion* to the abstracter study of usability and *ergonomic factors*, or by *reduction* to the narrower analysis of *interface studies*[8]. This spectrum seems amply accommodating, but a scholar wishing to report on the non/post/narrative interactions between story and user in a game, for instance, would find monographs on HCI/CHI a rather alien venue and be stopped at the gates of the review committee. Essential proof of this is that HCI/CHI curricula, which also focus on purely empirical areas such as instructional design, do not include critical and neo-literary work, and scholars from these fields would find, as already happens in more computation-centric venues, problematic terrain already inhabited by the agendas of a different audience of scholars, trained through more traditional computer science, engineering, and psychological tracks.

By contrast, a field of study built around a broadly systematic notion of digital interaction could not exclude either humanistic/aesthetic or empirical/scientific tracks, since analyzing the dynamics of interaction is central to the methods of many such disciplines. The idea may seem radical, but it is actually not that new. Interaction study in technological and humanistic forms is already on the rise. Various movements[9] already recognize the need for systematic interaction-centric theory and research. In the new journal *Universal Access in the Information Society* (Springer-Verlag), Stephanidis & Savidis (2001) pose a new engineering paradigm appropriate for the development of adaptation-based user interfaces and investigate issues concerning the interaction technologies required for universal access. Jacko & Vitense (2001) take a similar strategy in their focus on a digital system interaction framework for people with disabilities. An interaction-centric discipline would thus be hard pressed to exclude a science of interaction from its core. And while every field can be considered as interaction-analytical (e.g., the discipline of history analyzes the interactions of selected elements over time), there are theoretical interactions (forms of speculation) and there are real ones. Cybertexts, invoking factual interactions between system and user; content and reader, produce the latter kind. And although there are many forms of interaction, the most productive and natural one reflects the metaphor of discourse.

How then do we see interactions in a digital mechanism, system, or program without reducing them to mechanistic models (e.g., Shannon and Weaver)? For that matter, the proper word might be *environment* or *structure* rather than *system*, if the field of interaction is not systematically bounded or deterministically defined[10]. A non-mechanistic system is one that is not predictively and reductively enclosed, because its interactions are open-ended even though the elements in the interaction may be finite. Even though a Bach fugue consists of a finite number of instruments each with a finite acoustic range, together performing a finite, deterministically describable musical form, the compositional variations are infinite as a result of the universe of interactions. These interactions may be examined at the lowest level (*physically*, e.g., Paul Hindemith's theory of composition uses acoustic harmonics as the basis for chord construction and harmonic progression); at an intermediate level (*theoretically,* e.g., using the harmonic theory of voice leading or the compositional fugue form); or at the highest level, they can be described *aesthetically* (even with thematic references to states of mind, as happens in analyses of operatic works). This is not to reduce interaction analysis to part-whole relationships, since the term "part-whole" implies that one can arrive at a definitive overview of an interaction, in addition to the naïve binary oppositional thinking that part-whole promotes. This last point is precisely why cybertexts cannot be fully understood using a structural approach like that of Lèvi-Strauss: the discourse component of digital interactions is process-based and anti-hierarchical. This subtle ergodicity of cybertexts so clearly documented by Aarseth (1997) is extemporaneous, emergent, and often unique to each work, rather than forming part of a larger cosmology or canon. Let us instead draw up a different approach.

Let us then imagine that this potential discipline of interaction science consists of two primary dimensions – *interaction systems* and *interaction discourse.* An interaction system is necessarily the medium of activity, and includes the elements and methods of an interaction type. Conceptually, an interaction system is something designed for interactions, and we can define systems not by inclusion/exclusion, but rather by *degree of interactionality*, (even outside the bounds of digital phenomena) so that a phone booth is *more* an interaction system than a phone book; an elevator likewise has greater interactionality than a staircase, and a lighted exit sign more interactionality than a light bulb. The latter example is a control against excesses of a sort of *unmediated mediation* that McLuhan could

sometimes make, and which weaken the notion of interaction. His claim that a light bulb carries information is a sign of an undifferentiated understanding of interactionality. A system of interaction is justified to the degree that there are elements in interactions explicitly definable by it. But the field phenomena, the system and its language must all be prudently synchronized to check unwarranted conceptual claims or unfounded linguistic constructions.

Given the presence of an interactionality-possessing system, the concrete dynamics of interactions form the next object of inquiry. This is what I term the *interaction discourse*. This construct investigates what happens between elements in a context almost as a linguistic discourse, a sort of protocol of understanding or *pragmatic conversation of activity* that emerges out of the type of interaction underway. Discourse, as mentioned, is the production of action in context.

For this, we can postulate a first classification involving a *category of interaction* of the following types:

Behavioral interaction, as seen in games and simulations, whose objective is to produce an optimal path or solution based on efficient performance on one or more dimensions (time, velocity), and which could involve other forms of interaction such as movement interaction and combat interaction.

Learning interaction, as seen in computer-aided tutoring/learning systems, whose focus is the assimilation of conceptual complexity into a user's cognitive vernacular.

Analysis interaction, as seen in knowledge management systems and digital libraries, revolving around interactions for the production of conjectures and interpretations.

Creation interaction, as evident in development and authoring systems, for the production of digital content.

Each of these interaction categories involves unique types of interaction strategy and protocols. If they are truly part of a system, they will merge under a taxonomy or a framework for explaining observations and postulating new ideas. Perhaps there is more than one. Here are four framework types for the study of digital interactions:

Speculative Frameworks: analytic approaches for studying what exists without necessarily basing the hypotheses on *empirical* data. The strength is the conceptual structure proposed, within which the scholar makes propositions that are based on rational philosophical arguments. Much of the current theory in the field, including the work of Jim Rosenberg, Adrian Miles, and Gonzalo Frasca, provides examples of speculative framework narratives.

Empirical Frameworks: frameworks in the social science sense, where practical research methods have been applied toward the understanding of an actual digital environment or its social/psychological dimensions. In many such disciplines, it is common to observe large-scale (read, *uncontrollable*) phenomena by measurement. Where the general reality under observation is too large, either by population count or by number and complexity of interactions (or both), it is common either to identify one variable and measure it over time or to provide a qualitative portrait of the subject of study. The former is seen in econometric models as well as in more human studies, such as anthropology and sociology. There are also many frameworks (e.g., systems dynamics, linear programming, operations research) that comprise dynamic models where more than a single variable is measured longitudinally. The latter is seen in Turkle's work, which is exemplary of the *virtual ethnography* kind of research that could be called an empirical framework.

Production Frameworks: explorations of modes of understanding bringing to light how one *creates* or generates something new *as it is being created*. The (typically first-person) narratives based on this framework type are of the design-and-build type whereby one chronicles the construction of a system or work or one explicates the agenda or intention behind an emerging work. These frameworks would best be suited to the artist or programmer who has created a work and needs to explicate the basis for its design. Some of Gonzalo Frasca's recent work (2001) is in fact a social-agenda game production framework and should be recognized as a bold and original effort to extend the bounds and possibilities of the field through a production framework. Michael Mateas, Andrew Stern, and Phoebe Sengers, whose work will be discussed later, implement production frameworks as full interactive dramatic worlds.

Hybrid Frameworks: combinations of the first three framework types. George Landow's hypermedia pedagogy stands out. His work treating classroom teaching case studies with Intermedia as well as the broad potential implications of hypertext in general, is inspiring. My own work (Ricardo 1998; Ricardo 1999), as is that of many others, is a modest attempt to combine both.

Refining the Approach

As mentioned earlier, there is no sense inviting science to the party merely for credibility. Forcing science for respectability leads to absurd results; nobody wants to end up with a *phrenology* of cybertext. But it is hard to argue against the importance of some conceptual constancy, scope, and methodology, and we have already seen some cases of humanistic/scientific synthesis in scholarship. The field needs unification based on a wide and systematic observation of data (whether a corpus of hypertexts or a collection of interactions in a single work) that validates propositional statements about the *nature* of the field of study. Bernstein's memorable "Patterns of Hypertext" (1998) is one example (with seven navigation patterns for literary hypertexts). Another, less celebrated but equally synthetic exemplar is Stephen Morris's *Engineering via Discourse: Content structure as an essential component for multimedia documents* (1999), which proposes a four stage cycle of document production (accounting for authoring activities like comparison, transformation, and reconstruction) and sees the distinction between digital engineering and digital aesthetics of document creation as a distinction of roles and working processes:

> The roles of designer and developer raise general questions about the nature of their working processes, in particular the contrast between the 'dynamic' approach of the former and the 'structured' approach of the latter. The difference between these approaches is characterized by contrasting relationships with the end product. The 'dynamic' views the final nature of the product as uncertain until it is deemed complete by the designer; the 'structured' requires a much greater degree of predetermination and external verification. (Morris 1999)

How do we model an interaction science? Consider the following top-level possibility. Morris & Finkelstein (1993) proposed a production framework with three layers or levels:

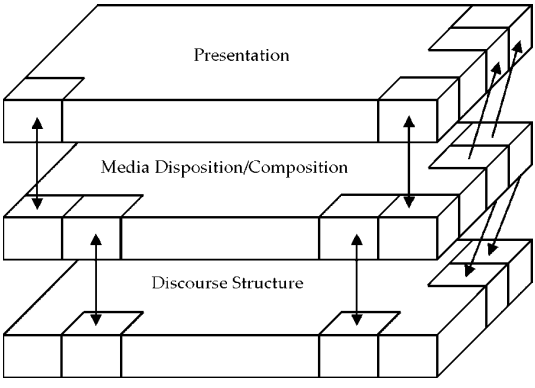

Figure 1. A model for multimedia document creation (Morris & Finkelstein 1993)

In this model, Morris and Finkelstein responded to a scarcity of general rules or guidelines for conceptualizing such cybertexts as multimedia documents. Their model is simple and powerful: it describes a stratum for the theory or *model* behind a system (here labeled 'discourse structure'); a stratum for the internal *architecture* and implementation (i.e., 'media disposition/composition'); and one for the interface and user experience provided with both (i.e., 'presentation'). It would be more complete if, above this model, we added one extra layer, the human as activator and recipient of the experience – in order words, the subjective process of *interpretation*. This fourth layer would make it possible to play out these permutations of interaction:

Model ⇐ ⇒ Media ⇐ ⇒ Presentation ⇐ ⇒ Interpretation

This spectrum is the genesis of any cybertext. Initial conception of a cybertext's design is motivated by some abstract model of the experience. The model is fleshed out in some medium. The discourse structure that

synthesizes the model in the medium is encapsulated as the presentation itself. Finally, this implemented discourse is then experienced and subjected to personal interpretation. This framework produces six possibilities of interaction (represented by the white boxes below) from its four monadic interaction types:

	Model	Media	Presentation	Interpretation
Model				
Media				
Presentation				
Interpretation				

Thus the white boxes are *studies* or zones of interaction; the gray boxes are *definitions* (the black boxes are redundancies). From the interaction types here, we can stratify our understanding of cybertext interaction as a system. Let us look at some of these with the broadest implications and classes of cybertexts in mind.

Model-to-model, model-to-media, and media-to-media interactions as shown above are extensive. There is already an ample range of work in intra-system interaction that falls under the umbrella of *reflexive architectures*. At the middle tier of complexity are recasts of existing methodologies and at the abstract tier are new directions in fuzzy and uncertainty-led research. As an example of the former, the meta-framework of object orientation is an interaction mechanism whose operation, inheritance, is a case of interaction in that it is definable as "relational information" between classes in inter-object relationships as distinct from the more vertical class structure view (Ducasse 1995). An example of the latter includes interaction-centric ways of modeling the dynamics of information systems, such as the steadily growing so-called *belief change* literature[11] for intelligent software agents. These are cyber-entities in constant interaction with their inputs[12]. All this is in addition to the large research on

adaptive hypermedia systems and, on a lower level, real-time systems with adaptive configuration. For example, a recent (September 2001) issue of the Franklin Journal is dedicated to research in interactions among distributed sensor networks (DSNs) for real-time systems with adaptive configuration, and all the monographs put forth a panorama most cohesively understandable from the vantage point of an interaction science. The interactions studied focus on how DSNs evolve from small clusters of large sensors to large swarms of micro-sensors, from fixed sensor nodes to mobile nodes, from wired communications to wireless communications, from static network topology to dynamically changing topology (Qi & Iyengarb & Chakrabarty 2001) – all without the traps of a static structuralist perspective.

If we ask (whether for a machine or a human), "What is involved in an interaction?" we should identify four characteristics present in any interaction[13]:

Protocol: A boundary detection protocol (W*hat were the hypothetical rules for identifying an interaction?*)

Marking: Perceptible and detectible boundary markers for events (*How do we confirm an interaction in real time?*)

Integration: A means for gathering and incorporating new data with existing knowledge (H*ow does this interaction make sense in light of larger experience?*)

Evolution: A means for sharing knowledge as a transaction (*How does this interaction generate new interactions, promoting the specific communicative objective as a whole?*)

The example of DSNs, while not human-centered, meets the requirement for these characteristics:

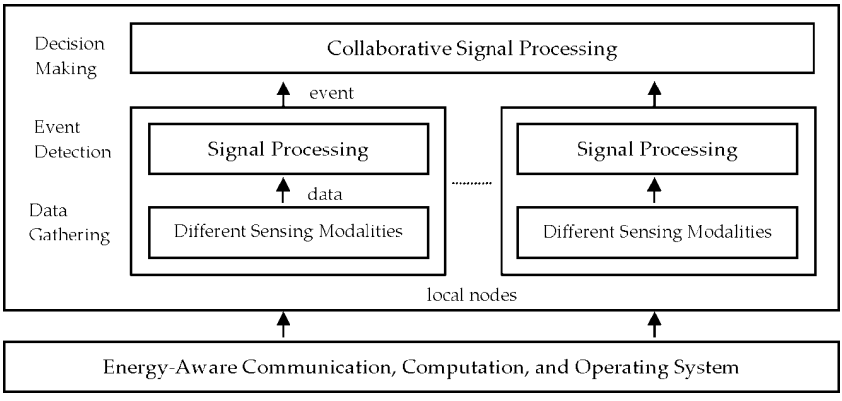

Figure 2. Interactions in distributed sensor networks (Qi & Iyengarb & Chakrabarty 2001)

Here we start to see a new, combined *data-processing/knowledge-sharing paradigm* that is harmonious with the range of hermeneutic approaches of what I call digital social environments (DSE). In the socio-participatory dimension, DSE's include groupware-oriented collaborative work (CSCW) and common workspaces[14], networked and role-playing simulations (we'll shortly consider the work of Michael Mateas), online communities (social interaction), knowledge-sharing interactions arising from distributed intellectual teamwork[15], social writing/authoring settings[16], wireless chat and gaming[17], and weblogs[18].

Everyone who creates a cybertext creates a structure, an architecture of rules. Einstein's conception of his own work, which he saw as a synthesis of intuition and craft is not too far from the ontology of cybertexts:

> The essential thing is the aim to represent the multitude of concepts and theorems, close to experience, as theorems, logically deduced and belonging to a basis, as narrow as possible, of fundamental concepts and fundamental relations which themselves can be chosen freely (axioms). The liberty of choice, however, is of a special kind; it is not in any way similar to the liberty of a writer of fiction. Rather, it is similar to that of a man engaged in solving a well designed word puzzle. (Einstein 1936)

The exclusion of the fiction writer is unfortunate only for the medium of print. Here is a key difference, given that the cybertext fiction writer, simulation engineer, or game designer in fact devise immersive puzzles guided by rules. This is neither science nor art alone; it is both. In a classic work that revisited the role of science in reality-construction, Kuhn's *The Structure of Scientific Revolutions* also made the metaphor between science and "puzzle solving" (Cf. Kuhn 1962, § 2.5). Again, such puzzle solving is a process that closely resembles the experience of readers, users, and authors of digital products. Given this superimposition of puzzle-solving-as-systematic-convergence between art and science, there remains the problem of how to reconcile the open subjective multiplicity of choices with the objective single-right-path systemic view. How does one envision both? This can be approached by formal operations and approaches, including such potentially fruitful investigations as:

– Elemental sets in cybertext (i.e., any well-defined group of objects);
– Series and sequence theory of cybertext (i.e., sequence is some ordinal arrangement; series is a sequence that *builds* to some aggregate unit)
– Principles of stochasticity (i.e., the randomness of one element in the presence of an ordered set of others)
– A chaos theory of cybertexts (i.e., the observation in cybertextual productions of how small changes in early states or circumstances affects eventual development)
– Cybertext Combinatorics (i.e., a systematic enumeration of possible arrangement combinations)
– A list of well-founded and defensible conjectures and corollaries (i.e., statements that are provable but unproved, pending further evidence)

These are new directions, but some have already been explored in three other areas of research close to cybertext study: intelligent agents, artificial life and the synthesis of both: narrative intelligence systems.

Agents, Life and Narrative Intelligence

Interactions figure prominently in the computational study of multi-agent systems, especially in the ways through which groups of agents display intelligence. The same holds for the quasi-field known as *artificial life*, which (although there is much overlap) refers commonly to agent technology operating under the interaction rules of a closed environmental world rather than for a specific purpose like information retrieval. Any of the many permutations for attaining and organizing such intelligence involve either dramatic characters in some interactive behavior within a game environment (e.g., *The Sims*), or info bots sharing data (e.g., intelligent router networks). In the animal world, this constitutes the behavior study known as ethology. There, however, interaction is reduced to a small set of primitive objectives that are relevant in a *competitive* frame but not in a data-sharing one. While there is normally a notion of cooperation, for instance, commitments to cooperation are made only in relation to the agent's ultimate, pre-programmed objective of *survival*. That is, interactions are ruled by explicit *goals* in agent-based research, and this is not a rational given in many digitally based interactions (e.g., chat, email). The structure of activity is informed by the comparison of goals and directed by appropriate criteria (e.g., *compatibility* of goals, *antagonism, cooperation, predation, resource access*). This is a drive-based view of rationally acting systems that fails to adequately account for the dynamics of both many naturalistic as well as non-competitive settings. Of course there are other interaction systems[19]. Also, some agent-based research examines certain types of interactions as behavior whose degree of cooperation can be measured[20]. Agents are defined by various dimensions such as degree of cooperation, hierarchy relations (e.g., *master/slave*), and modularity of behavior[21].

Multi-agent systems and ethology are not the last word in the study of interactions; even more formal approaches have been proposed (cf. Girard 1989). However, none, with one notable exception below, account for the aesthetic and ergodic dynamics of cybertext, narratology or post-narratological interactions in digital worlds. Given this, is there a basis for

some empirical work? In the large, data is already available; we can use it to inform our arguments. Some interaction techniques, such as those for three-dimensional interactive systems, are now fully developed (Mine 1995; Poupyrev et al. 1996). Although these have centered around issues of immersive perceptual walkthrough navigation and handling of objects in simulated 3D space, we can also use them to inform our postulations about navigation and the potentiality of notions like *story* in conjunction with *immersion* in the interactive user experience. They are helpful for digital artists whose productions are explainable as much within the speculative framework proposed earlier as under simulation-based interaction analyses. But in a key exception to this, even more generative is the work at CMU of Michael Mateas[22] and Andrew Stern in a project aptly termed *Expressive AI*.

In a relatively short time, Mateas and Stern have quietly generated some highly important publications and projects demonstrating how cybertexts can manifest intelligence both as aesthetically indeterminate productions, as well as computationally formal ones. They have, for instance, implemented a behavior language for story-based believable agents (Mateas & Stern 2002) that crucially extends in a fresh direction the tradition of script-based intelligence established largely by Roger Schank (Schank & Abelson 1977) and the frame-based work of Marvin Minsky (1974). While knowledge representation schemes based on atomic approaches such as natural language understanding were being formulated (such that the unit of analysis became as small as the single word in a sentence) Minsky and Schank went the opposite way. Rather than create bottom-up semantic formulations from linguistic productions, their approach was to raise this strategy of *chunking* to a more abstract level. Leveraging the fact that many common social situations follow similar patterns every time, frames and scripts were encapsulations of the action in the form of scenario structures. These structures set the unit of meaningful analysis to be the largest single interaction that is likely to take place with little or no variation, regardless of how often it is encountered. Scripts for Schank, for instance, were a form of generalized episodic knowledge listing a chain of events for common activities. The canonical example is the restaurant script, which contains information organized conceptually like this:

Name:	restaurant
Props:	tables, chairs, food, bill, money, tip
Roles:	waiter, waitress, customer, cook, cashier, owner
Requisites:	customer hungry, customer has money
Results:	customer has less money
	owner has more money
	customer not hungry
Scene 1:	Entering
	Customer enters restaurant
	Customer looks for table
	Customer decides where to sit
	Customer sits down
Scene 2:	Ordering
	…
Scene 3:	Eating
	…
Scene 4:	Leaving
	…

This type of information boosts the context knowledge of a system, permitting it to make sense of events, to self-motivate logically toward subsequent actions, and to anticipate and respond to likely discourse and behavior from the outside world (e.g., the waitress asking if she should bring the check). Similarly, Minsky contributed to this "packaged abstraction" strategy through his theory of the *frame*, a chunk of experience or events with pre-packaged assumptions about interactions:

> A frame is a data-structure for representing a stereotyped situation, like being in a certain kind of living room, or going to a child's birthday party. Attached to each frame are several kinds of information. Some of this information is about how to use the frame. Some is about what one can expect to happen next. Some is about what to do if these expectations are not confirmed… Much of the phenomenological power of the theory hinges on the inclusion

> of expectations and other kinds of presumptions. A frame's terminals are normally already filled with "default" assignments. Thus, a frame may contain a great many details whose supposition is not specifically warranted by the situation. These have many uses in representing general information, most likely cases, techniques for bypassing "logic," and ways to make useful generalizations. (Minsky 1974)

To be successful, a frame and a script must anticipate the pragmatic prompts of discourse. Many real-world interactions are in fact so anticipated that they become "default assignments". One could raise chunking even higher up – Minsky correspondingly expanded the frame notion into a level of interaction so wide-ranging that he calls it his Society of Mind theory. This view sees apparently *singular* sources of intelligence like the human brain as an *amalgam* of sub-atomic units in coordinated interaction. Some of these were formalized as simple units called *perceptrons* and became part of the machine-learning paradigm; others remained as purely conceptual constructs without final implementation (for who can tell what comprises the mind?). How one can represent knowledge will remain a long-lingering question for cybertext scholars, but interaction is sure to be the nucleus of any successful discovery.

One shortcoming of these abstraction-organizing structures is their brittleness. They do not learn from events and, because of their very high-level nature, are almost impossible to extend automatically. The work of Mateas and Stern on *A Behavior Language*, or ABL (pronounced *able*) builds on the tradition of scripts and frames and largely solves this problem by accounting for *interaction* and extensibility through the creation of scenes as sets of dynamic goal behaviors. Answering the door for instance, would be programmed as a set of goals:

```
sequential behavior AnswerTheDoor() {
    WME w;
    with success_test { w = (KnockWME) } wait;
    act sigh();
    subgoal OpenDoor();
    subgoal GreetGuest();
    mental_act { deleteWME(w); }
}
```

This fragment creates a working memory element (WME) of behavior whose owner (a virtual dramatic character) waits until the door is knocked, sighs, opens the door, and greets the guest. Earlier we noted that the sense of *autonomy* in intelligent agents is key: any agent should survivably perform its goal rules. To ensure this survival, we saw the tendency to implement agents with simple, selfish, Darwinistic strategies. But intelligent interaction with the world requires more than a mercenary orientation, and so, noticing this earlier on, Mateas and Stern (2000) found it necessary to build coordination into the activity of multiple agents so as to accomplish joint story goals (again, we observe here how the need to extend a pure technological operation with an aesthetic or social one is a hallmark of cybertext design). Thus Mateas and Stern convert interaction into a first class object because, transcending the modifiability limitation of scripts and frames, all ABL behaviors can be synchronized among each other. This notion of *joint behavior* leads to the emergence of coordinated activity with intelligence. As an example, ABL is the language driving *Façade*, an interactive dramatic world inhabited by two married characters, Trip and Grace. Here is how Trip and Grace together – and separately – coordinate to offer their guest a drink (Mateas & Stern 2002):

```
Trip's behavior:
    joint sequential behavior OfferDrink() {
        team Trip, Grace;
        with (post-to OfferDrinkMemory)
        // Individual behavior for initial offer
        subgoal iInitialDrinkOffer();
        subgoal iLookAtPlayerAndWait(0.5);
        with (synchronize) subgoal jSuggestMartini();
        // react to Grace's line about fancy shakers
        with (synchronize) subgoal
        jFancyCocktailShakers();
     }
```

And now Grace's behavior:

```
joint sequential behavior OfferDrink() {
    team Trip, Grace;
    // wait for Trip to say first line
    with (success_test { OfferDrinkMemory
    (CompletedGoalWME name == iInitialDrinkOffer
    status == SUCCEEDED)})
    wait;
    subgoal iLookAtPlayerAndWait(0.5);
    // react to Martini suggestion
    with (synchronize) subgoal jSuggestMartini();
    with (synchronize) subgoal
    jFancyCocktailShakers();
}
```

The readable procedurality of ABL syntax shows that joint behaviors are interactions that can either be sequential (through the subgoal designator) or concurrent (through the synchronize command). This dynamic threaded coordination is the solution to the frame and script problem observed earlier. We can see that in order to make systems that demonstrate human intelligence, it is necessary to implement interactions from the Society of Mind perspective (internal coordination of perceptions and knowledge of goals) as interactions among goal-driven agents in software. And as intelligence comprises social skill, social interaction is necessary, which closely interconnects narrative, discourse, and intelligence, dimensions not previously seen as somewhat synonymous. Agents with discourse interaction for the attainment, assessment, and enhancement of intelligence is a growing trend. At New York University, Ted Repa has been building *The Cave*, an interactive simulation built on a goal-based scenario system for early adolescents. Trapped in a cave, the user must interact with a series of characters, coordinating with them on goals toward an exit strategy. The user's eventual success in finding a way out is dependent on his or her ability to withstand emotional challenges posed by the setting, which

changes in an almost metaphysical way, as well as the characters, which are also frustrated.

We might think that, after so long a sojourn through the digital landscape, we have finally reached our ideological homeland in the shores of narrative intelligence through inter-agent interaction systems. But another new voice in cybertext research, Phoebe Sengers, warns against excessive optimism in this naïve agent model. As we have already seen, autonomous agents are created from independent building blocks, called *behaviors*. Sengers inverts some of Minsky's Society of Mind assumptions (different from the purer top-down frame approach). Minsky is sometimes a Hegelian; he sees intelligence as the emergence of coordinated behaviors that, through countless interactions, reach a new synthesis such that the whole is more than the sum of the parts. This intriguing critical mass perspective has been observed in chaotic and nonlinear systems, for example in the weather, where a small climatological event can engender disproportionately large (often sudden) changes later or elsewhere. But to Sengers, the fact that such emergent phenomena do happen in the physical world is not sufficiently convincing evidence of the way in which something like human intelligence actually comes about. In fact, what Minsky finds promising in the progressive bottom-up self-organization of components is what Sengers sees as the ultimate barrier to understanding and modeling real intelligence in digital systems. At issue is the main principle underlying the bottom-up approach to emergent intelligence: *atomization* – breaking agents into modular chunks with limited interaction. Sengers has thus argued (1998) that atomization is the wrong metaphor: it can produce readable code but not the resilient coherence necessary for full-featured interaction with the environment. In proposing a bold new kind of agent architecture, Sengers reaches into the narrative psychology of Jerome Bruner and object relations psychiatry to understand relations not only among (digital) objects but also between them and the audience. Sengers follows a critical technical practice tradition established by Phil Agre, who sees technical systems as implementations of hermeneutic inquiry. To be avoided at all cost is the "conglomeration of undifferentiated activity" (Sengers 1998, 46) that produces schizophrenic behavior among agents. The conundrum to live with is that we must design systems with agents experiencing meaningful interactions even though all we have are atoms that operate only as discrete reductions of reality. What to do? Sengers finds three directions promising in designing narratively expressive

agents. First of these is *context-sensitivity and negotiability* such that agents interact differently in diverse settings. The second imperative is *intentional state entailment* through which believable agents can explain the reasons and choices for their behavior. This is not considered important in conventional agent research, but for the study of characters in narrative within literary theory has long been absolutely essential. Lifelike qualities accrue from the expression of inner motivation. Lastly, it is important for narrative agents to express *diachronicity*, in that "narrative support in a behavior-based agent requires normally independent behaviors to be able to influence each other, to present a coherent picture of narrative development to the user over time". (Sengers 2000). To me, this sensitivity to robust interaction is the right path.

Flaws and Limitations

Critical questions linger, and I have no desire to make more enemies, who will find all manner of gaps and tribulations in this proposal. Who can resist the temptation to dismiss this mindset altogether with questions like, How do we operationalize *all* subjective conditions in a cybertext? Certainly, we cannot make scientific that which is left openly indeterminate as each reader's idiosyncratic right of interpretation. But we can (non-comprehensively) approach interpretation within a *frame of interaction* and identify forces acting on such interpretation, especially as they precede behavior. Another version of the same skepticism: What is (or could possibly be) the universe of variables in a digital interaction science? What is its unit of analysis? Forgive my obstinacy. I believe that it is the set of boundary interactions – the interaction between systemic components, the interaction between human and system, the interaction between human and self (interpretation). These questions in fact are enormously beneficial: they suggest the difference between *relationship*, *interaction* and *structure*. It is a hierarchical difference: an interaction takes place *on* a relationship between things *in* a structure. That is, a *relationship* is a symbolic means or possibility for the occurrence of an *interaction* between any two or more entities, which can exist in an environment that either has zero or more discernibly conceptual *structures*. Thus, a discernible structure is not required for an interaction to take place, but a relationship is.

The entities and/or the relationship may be named, but not necessarily under a classification within a structure. Interactions are often archetypal things; an interaction can have an ideal, abstract, Platonic form that is understood *as it happens*. For instance, the interaction type known as "conversation" is an archetype; it is universal and context-free. Conversations are not necessarily bounded within either any given structure or relationship; they occur in very rigid contexts (e.g., military, judicial settings) and also occur between total strangers in random places. Equally so, in digital cybertext environments, interactions can emerge from highly deterministic activities or from randomized elements (hence the Chaos Generator of *The Sims*).

Nor is a scientific view the guarantee that all answers will come and all rhetorical weapons laid to rest, for every science, hard or soft, has its ideological mysteries. In linguistics, for instance, phonology has many formalisms, yet cannot explain *why* certain syllables are learned before others. Likewise, there is nothing in quantum mechanics to explain the *reason* for Planck's constant. Many explanations must be left to speculation, and this type of guesswork defines the boundaries between what is and is not known about a field of inquiry. Inasmuch as much as there can be cautious optimism about attempts to establish *some* objective constituents of this field, we should also remember the failed attempts at excessive or unwarranted systematization in other fields.

Conclusion

My aim has been to point out a current vacuum in digital studies that has prevented the definitive statement on many theoretical discussions (e.g., whether games are narratives and vice versa) and has led to a multiplicity of tongues, to a failure to see the integration of work in many research quarters, and to ideological schisms. We must somehow provide objective accounts for the give and take of communication, arguably as digital discourse. We must do this in a non-purely-subjective way. But claims on interpretation of a cyberwork cannot easily be expanded to general truth claims about critical studies in the world, for then we move from the problems of personally understanding of narrative (for want of a better term) to a propositional claim on external things. And without a fixity of terms (e.g., again, what exactly is a cybertext? Is everyone observing and agreeing on the same phenomenon?), we have problems of incommensurability of view. One way out of the Logos trap is to formalize essential aspects of digital discourse and interaction without reducing them to formulas. It is possible to see interaction as the humanistic and scientific way around this. But the proposed study of interaction has to include the humanistic and aesthetic, since these are motivators and drivers of so much cybertextual experience. A decade ago, human computer interaction (HCI) was moved under *cognitive science* as an explanatory framework. Recognition of the limits of this move, especially for the totality of cybertextual interaction, could be solved only by pointing toward a potential constructive integration, which in that case led to post-Vygotskian activity theory:

> We are concerned that the separation of a field of activity such as HCI may not be the best way to proceed, as it tends to emphasize aspects of the interface per se rather than how people can be supported in their work practice. Domain knowledge is crucial as we have noted. A framework such as activity theory, that looks at ongoing human interaction with the world, and encompasses relations with others, and the socio-historical mediation of learning and development, seems to provide an interesting alternative framework if we wish to develop a more comprehensive unit of

> analysis for our studies. Perhaps the real challenge we face is how to combine aspects of these different perspectives so that the end result, or more correctly, the continually evolving applications we develop, can utilize the knowledge gained from differing approaches. (Bannon & Bødker 1991)

Activity theory centered only on human interactions and lacked formalisms according to at least the minimal objective boundary characteristics (protocol, marking, integration, evolution) established earlier[23]. In response to earlier shortcomings, I have proposed a perspective that is equally relevant to the three dimensions of

> the text/narratological/interpretive;
>
> the systemic/computational; and
>
> the social/collaborative/intersubjective.

The proposal is both humanistic (that is, accounts for *some* creative/random/stochastic impulses in a field of active phenomena) and scientific (in that it defines and utilizes fixed concepts and terminology, and that has *some* externally verifiable hypothesis-testing methods and results). Scientific/humanistic syntheses in other fields have been successfully attained, some with long histories[24]. In computational studies that downplay the humanistic and aesthetic in digital interactions, such syntheses have not been as wide-ranging, as borne out by our overviews of approaches influenced by HCI, activity theory, agent-based research, and systems theory. Having journeyed the theoretical horizon, from a received, multi-perspective view of the cybertext studies to a condensation of elements for a humanistic/aesthetic study of digital works, it remains only to hope for further convergent, constructive, and creative steps that artists, engineers, and scholars can take together toward an inclusive interaction science of digital representation.

NOTES

1. This is an exaggeration on my part. The digital revolution is not only about computers and modems, but includes the consumer electronics movement that preceded it by at least two decades. Buying a car and going on the highway is analogous to buying a computer and getting on the information superhighway. We cannot argue that one is a pure consumer play while the other privileges production. World and user are mutably engaged either way.
2. Cf. for instance, Edwin Black's "On Objectivity and Politics in Criticism" (Black 2000) which expresses some of the frustrations with the inability of a systematic discipline to move forward ("We don't want to read criticism that reiterates yet again what we have heard before.") and ends with the sobering note that "[i]n the end, there are no formulae, no prescriptions, for criticism".
3. Sokal (1996) was by no means an isolated example; the debate is protracted. Sokal's article itself was inspired by Gross and Levitt's earlier (1994) *Higher Superstition: The Academic Left and Its Quarrels with Science*. Other works extending this debate include Koertge (1998) and Norris (2000). For a more general exposure to ideological battles underway within women's studies (unrelated to new media), see Patai & Koertge (1994), Sommers (1994), and Patai (1998). It is interesting to note that only some of the critiques mentioned here take issue with the *entire* postmodern project; many of its constituent agendas are seen as liberal and laudable. Rather, the attacks are centered primarily on what are seen as excesses of language and lapses of logic in light of objective evidence, but the list goes on.
4. He acknowledges this, but asserts that the editorial need for scientific revision of the article was precluded because the editors agreed with the ideological *conclusion*, and therefore found no need to question the *methods* of the paper.

5. There are exceptions, such as University of Groningen's Alfa Informatica department. Willard McCarty and Matthew Kirschenbaum maintain a definite hum/inf resource site at http://www.kcl.ac.uk/humanities/cch/wlm/hcu/.
6. See "The Transformation of the Representation and Communication of Scientific Knowledge", held at Schloss Elmau, 31 May to 2 June 1999, http://www.gwdg.de/elmau/.
7. This gets tricky for certain interactions, such as linguistic exchanges, since the pragmatics of Austin (1962) and Searle (1969) define illocutory speech acts (affirming , questioning, commanding) that are behavior-motivated or behavior-motivating.
8. For an example of how HCI was recast into UI studies, see the focus of Dix, Finlay, Abowd & Beale's later (1998) *Human-Computer Interaction*.
9. E.g., the "Design for All" and *Universal Design* thrusts are moving the focus of human-computer interaction from *human-computer* to *interaction*. See Stary (2001).
10. But we are framing a science if we focus on systematic interactions within digital information structures, and as such these interactions are not constrained to improving interfaces or optimizing usability alone, in the same way as ethnography is not normative or attempts to improve or optimize the culture that the ethnographer describes. All the same, my use of the term *system* refers only to an enclosed digital interaction space without systematicity conditions.
11. For an update to this research practice, see http://beliefrevision.org/.
12. If autonomous and distributed agent research analyses digital interactions among virtual entities like infobots, why is that not the model for an interaction science? This research overlooks the functional value of aesthetic characteristics and focuses on narrow behaviors (retrieval, survival, dominance, replication). The paradigm of agent research is the *organic analogy*. It is the core driver for research assumptions as it is for a predecessor, Systems Theory. This analogy characterizes multi-agent social systems mirrors of Nature in many ways. Both favor self-organization, autonomous balance, dynamic but stable order, central goals of survival and dominance, (often brutally simple)

rules for attaining those goals, and an assumption that such collective environments tend to stabilize and sometimes even improve toward optimum operational states – we see this assumption prevalent as much in statistical machine learning as in Darwinian natural selection. Clearly, the paradigm of mercenary rules in competitive behavior ruling this class of digital interactions is of too restricted a type for many cybertexts.

13. Temporality is not strictly an interaction element as much as a delimiter. Its reasonable limits for any interaction type should be defined in characteristics 1 and 2. For further treatment of temporality as a narrative category, see Eskelinen & Koskimaa (2001).
14. For a constructive analysis that moves from a cognitive science to a more integral view of the limits of the former and points toward design in/as interaction, see Bannon & Bødker (1991).
15. For an interaction-centric view of negotiating distributed knowledge in collaborative spaces, see Galegher, Kraut, & Egido (1990).
16. See the WikiWikiWeb architecture as an example of an emerging, open, web-based reader-writable approach (http://c2.com/cgi/wiki?WikiWikiWeb).
17. For an example of the rise of social interaction in productized form within the wireless genre, see Cybiko (http://www.cybiko.com/what.asp/)
18. For a community of blogs, see Blogger.com (http://www.blogger.com/). For a blog webring nexus, see Blogphiles.com (http://www.blogphiles.com/webring.shtml/). It is also noteworthy that the web ring directory (http://www.ringsurf.com) currently (September 2001) lists 1,376 active blogs in the *weblogger* ring.
19. Ferber defines seven interaction types: Simple collaboration; obstruction; coordinated collaboration; pure individual competition; pure collective competition; individual conflict over resources; collective conflict over resources (Ferber 1991).
20. Cf, e.g., the cooperation indicator of Miriad 1992.
21. E.g., Brooks and Connell (1986) implemented a subsumption architecture whereby a robot's agents were more interaction-focused by being divided into simplistic behaviors.

22. Cf. http://www-2.cs.cmu.edu/~michaelm/
23. For a balanced introduction to activity theory, see http://carbon.cudenver.edu/~mryder/itc_data/activity.html/
24. E.g., consider, in social science, Malthus's mathematics of food and population, or Augustin Cournot's mathematics of value and demand.

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