Humanities Computing

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INTRODUCTION

Consider a rough intellectual map of humanities computing (Fig. 1). At the center of this map is a large ''methodological commons'' of computational techniques shared among the disciplines of the humanities and closely related social sciences, e.g., database design, text analysis, numerical analysis, imaging, music information retrieval, communications. Picture the disciplines ranged above the commons in groups, such as literary and linguistic studies, historical studies, material culture, musicology, performance studies, and so on. Connecting each disciplinary group to the relevant techniques are double-headed arrows indicating that these techniques are variously exported from individual fields of study into the commons and from the commons into others. The agency that sees to this import/export trade is humanities computing in its dual role as collegial service to the disciplines and as research enterprise directed to investigate their evolving methodologies, devise new computational approaches, study the effects, and tease out the implications. Below the commons are broad areas of learning that such interdisciplinary work calls on: philosophy (especially epistemology, ontology, and the philosophy of mind), historiography and ethnography, science studies, sociology of knowledge, media studies, literary criticism, linguistics, and aspects of computer science, including markup technologies, digital library research, and the language industries.

Such is one version of the picture that has emerged from half a century of work in the field. During this half-century, if the publication record is any guide, scholarship in the field has grown exponentially.[1] A recent survey of institutional models shows that the activity has spread around the world, diversified, and at key places moved into the academic core.[2] As in other domains to which computing has been applied, numerous claims have been made for its transformative effects. The following gives strong reasons to think the effects are indeed profound. As Cherry said in reference to the telephone, however, ''Inventions themselves are not revolutions; neither are they the cause of revolutions. Their powers for change lie in the hands of those who have the imagination and insight to see that the new invention has offered them new liberties of action, that old constraints have been removed, that their political will, or their sheer greed, are no longer frustrated, and that they can act in new ways.''[3] The primary question here is *how* our insight is sharpened and imaginations empowered to gain genuinely ''new liberties of action'' from computing, and how these liberties may be used in refurbishing the humanities for an electronic age.

NOTES TOWARD A HISTORY

This question is grounded in a rich and complex half-century of practice in the humanities. Although its history has yet to be written,[a] the moral seems clear enough: that computing belongs within the humanities because it accords with their central project: in the playful words of the classicist Don Fowler, not to solve problems but to make them worse[7]—or less playfully, to help scholars ask better questions.

The Historiographical Problem

Mahoney argues that the primary difficulty in writing a history of computing is not the fragmentary record, rather its undefined scope: ''We don't yet know what the history of computing is really about . . . . We still cast about for historical precedents and comparisons, unsure of where computing fits into the society that created it and has been shaped by it.''[8] A history of humanities computing faces these difficulties too and also must seek its precedents and comparisons. But a *humanities* computing, with its different context, necessarily has different precedents, and the differences are telling. Indeed, the identification of precedents is neither random nor neutral, not intellectually, politically, or professionally.

''History,'' Mahoney points out, ''is built into current practice.'' We write the history of a practice thus to make clear ''what we are doing or at least . . . what we think we are doing.''[8] Whether precedents are discovered or

[a]Various retrospectives may be found especially in the pages of *CHum*, for example, Ref. [4]. A desultory but helpful source is Ref. [5]. The most comprehensive recent attempt is Ref. [6].

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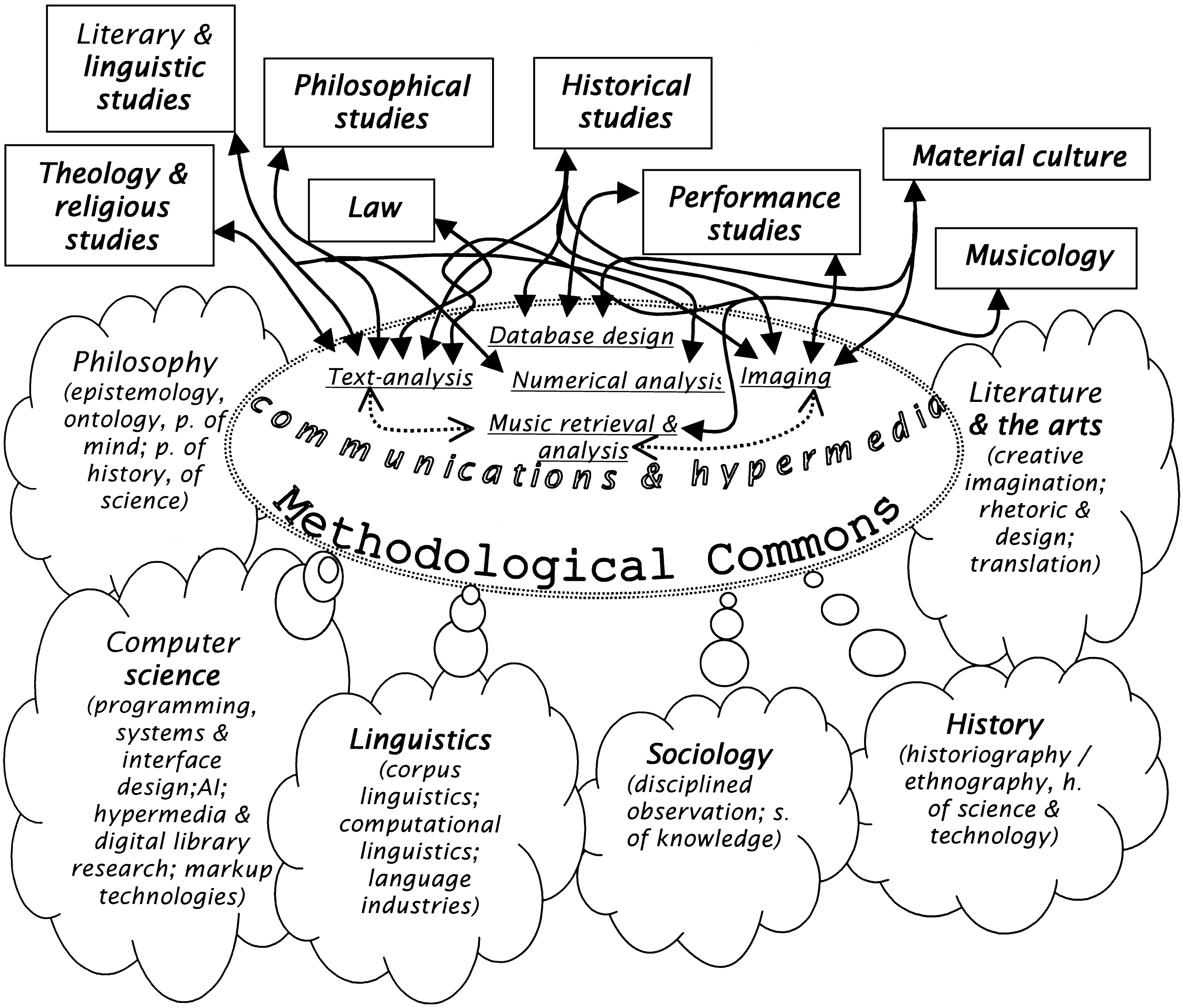

Fig. 1 A rough intellectual map for humanities computing. (Courtesy W. McCarty and H. Short.)

chosen, the result is to historicize inchoate ideas from the practice, which creates a tradition for them and so justifies, if not also illuminates, the work. The goal is what Williams has called a ''reflective equilibrium,'' in which practice defines history, and history clarifies practice.[9]

Making a serious attempt to write such a history for humanities computing constitutes a major research opportunity and is obviously a priority for the field. At this stage, much is to be discovered—indeed, the research begins by setting out to discover what *is* relevant, in as wide a scope as the humanities provide. Critical questions then follow.

The long tradition of actual and imaginary automata, for example, should be richly rewarding: it demonstrates a recurrent effort over the last three millennia to imagine man and nature mechanically—from the autonomous agents in *Iliad* 18, through ''mechanical philosophy'' in the age of Newton, to the German expressionist film *Metropolis* and the American Data in *Star Trek*.[10–12] How do such imaginings illuminate the methodology of humanities computing?

Another rewarding set of historical phenomena comprises commonplace physical devices for manipulating knowledge, e.g., the codex book, a ''machine to think with;''[13] the card-index file, and other forms of alphabetization;[14] and the concordance, whose invention by Dominican monks in the late twelfth or early thirteenth century gave us one of the most powerful tools we have for analysis of language.[15] If these are relevant, as seems undeniable—but in need of further explication—then how do we understand the role of calculating

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machines, which are also symbol-manipulation devices? Perhaps given the application of statistical methods to literary stylistics, for example, we should consider as precedents the ancient counting board or abacus[16] and the well-documented calculating machines of e.g., Schickard (1623), Pascal (1654), Leibnitz (1672), and Babbage (1823), who in *Passages From the Life of a Philosopher* (1864) insists also on the relevance of the Jacquard loom.[17,18]

Abstract formalizations of thought converging on the mechanical likewise come within range, perhaps most obviously the research of Alan Turing (1912–1954), who is recognized by philosophers as one of their own for his work in the modeling of intelligence.[19,20] Norbert Wiener's work in cybernetics, especially because of his interest in the common ground of mechanical and biological systems, is another candidate.[17] But again, and with many others not named here, the historiographical question: If these have the look of precedents, what in humanities computing do they precede? Much of the following may be read as a lengthy reply to this question.

Early Days

(As Mahoney notes, ''firsts'' seem to be ''of consuming interest to computer people'' and ''can be a tricky question because it can come down to a matter of meaning rather than of order in time.''[8] Hence the more or less conventional account given here should be approached with caution.)

Humanities computing is said to begin in Italy in the late 1940s with the Jesuit scholar Roberto Busa's work toward an exhaustive concordance of the writings of St. Thomas Aquinas, the *Index Thomisticus*.[b] Indeed, Busa's project and the insights that followed are widely regarded as foundational, especially to philological, linguistic, and literary computing. Subsequent applications to philological analysis and others to stylistics began to emerge in the late 1950s. Serious efforts by museologists appeared in the early 1960s; by the end of the decade the Museum Computer Network was in operation.[22] In 1966, a year after the last handmade concordance was published (by Ione Dobson, to Byron), the American scholar Joseph Raben founded the first professional journal in the field, *Computers and the Humanities* (*CHum*), whose initial volumes discovered a diverse and enthusiastic flowering of activity already in progress throughout North America and Europe, e.g., in anthropology, archaeology, art history, classics, musicology, history, linguistics, and literary studies. Dedicated research centers began to appear at about this time, e.g., CETEDOC, the Centre de traitement électronique des documents, in Louvain, Belgium. The first international professional body, the Association for Literary and Linguistic Computing (ALLC), was founded in 1972, followed by the Association for Computers and the Humanities (ACH) in 1978, and the Association for History and Computing in 1987. The *ALLC Bulletin* began in 1973, becoming *Literary and Linguistic Computing* (*LLC*) in 1986.

With the emergence of journals, conferences and associations a sense of community seems, in retrospect, suddenly to have emerged. But what is particularly remarkable from the publication record, especially *CHum*, is the intensely introspective questioning of the early years, not only about ''The Next Step,'' as an article in the first issue of *CHum* was entitled,[23] but about the significance of what was already underway. Wild generalizations and unsupportable claims are of course to be found (although these pale in comparison to those that punctuate the history of artificial intelligence research). Characteristic, rather, is this critical questioning, which marks the activity as of the humanities from its very beginning.

Crisis and Change

The early years are also characterized by the closely related attempt to catalog activities, for example, in *CHum*, in an ongoing ''Directory of Scholars Active'' (a list of projects by researcher), surveys, bibliographies, and reports from various centers (e.g., Cambridge, Oslo, Göteborg, Boulder). Entire issues dedicated to work in particular countries (e.g., Italy, Norway) continued into the 1990s, as did a series of bibliographies in *LLC*, from 1986 to 1994. But it would appear that, by then, finding and gathering relevant publications exhaustively had become impractical: too many of them, in too many disciplines, appearing in minor, as well as major places in many languages. The assimilation of computing into the older disciplines meant that, increasingly, much of the relevant work, when mentioned at all, had become subsumed in articles and books whose titles might give no clue.

Another kind of difficulty for the bibliographic project was present from the outset: investment of primary work in constructing nonverbal artifacts in an evolving technology—a problem to which we will return. Although the Web has, in recent years, begun to address the problem of making computational artifacts accessible, the rapid pace of change in the media of computer-based work is deeply problematic for the bibliographic imperative in humanities research.

[b]1974 on paper, 1994 on CD-ROM. See Ref. [21].

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Raben, founding editor of *CHum*, came close to identifying the resulting crisis in his highly critical review of the inaugural *Humanities Computing Yearbook 1988*,[24] which he found wanting in all aspects affected by the factors just named, including significantly its organizational structure (some of these problems were partially addressed in the second and final volume of Ref. [25]).[26] The solidly reliable *Bibliografia di informatica umanistica* of 1994, with 5532 entries, avoided many of the problems Raben indicated by restricting itself to paper publications, listed by author with subordinate indexes.[1] Sabourin's massive series of bibliographies on computing, in 25 volumes, published in the same year, also listed only printed works. Its size and lack of any guide for the humanist scholar also points to the problem that had surfaced by the early 1990s.[27]

This problem is significant because it indicates the failure of the traditional model for scholarship adequately to describe serious intellectual work in humanities computing, whose scope cannot be delimited in the same way and to the same extent as the traditional kind, nor can its genre be confined to stable discursive prose. Like the textual editions described by McGann and the technological artifacts discussed by Mahoney, the crafted objects of humanities computing are themselves primary ''metatheoretical statements''[28] produced by those who ''think in things rather than words.''[8] A new definition of scholarship, demanding new abilities, would seem to follow.

The Internet

The invention of the World Wide Web in 1989, a year after the first *Humanities Computing Yearbook* and the year of the first joint conference of the ALLC and ACH in Toronto, Canada, has, of course, changed nearly everything. The basis for fundamental change in scholarly communications had already been laid in 1969 with the inauguration of ARPANet. In 1987, as a spinoff of an effort to agitate for professional recognition of humanities computing, the electronic discussion group *Humanist* was created in Toronto, quickly grew and shifted its focus from politics to a mixture of critical inquiry and exchange of information in humanities computing.[29] Now in its 15th year, its archives chart, in myriad detail, the history of the field. What has followed in online scholarly publication is beyond the scope of this article,[30] but another early example tells much of the tale: the *Bryn Mawr Classical Review*, which like *Humanist* uses the commonest of online technologies, e-mail, radically to improve scholarly communication.

In his plenary address to the Hypertext'97 conference, the computer scientist John B. Smith exhorted his audience to pay attention to the World Wide Web despite its technical shortcomings: the Web, the Internet, and associated tools, he noted, ''are not just new elements in the computing infrastructure. They *are* the infrastructure.''[31] While that would clearly be an exaggeration in the humanities, we can imagine a time when it would not be, especially in the context of what is called ''the worldwide digital library,'' about which more is below. But even now the question to be asked about scholarly publication online is not *whether* it is appropriate but *when*.

The difficulties facing any comprehensive bibliographic project—and so the basis for an adequate historical grounding in the subject—remain formidable. The best the on-line medium has to offer is a combination of searching, sampling, and conversing. Searching holds some promise, for example through the development of metadata standards and automatic tracking of users' information-seeking behavior, as in *Google* and amazon.com. Sampling would appear to be an inevitable consequence of the explosively growing amounts of informally published but nonetheless serious material. Conversing in groups such as *Humanist*, as well as one-to-one, provides an obvious means for establishing a loose, dynamic sense of the field and the relative importance of contributions to it. Indeed, all of these mechanisms converge on the fuzzy notion of an online community, which they help to define. Winograd and Flores have trenchantly argued that, ''The computer is ultimately a *structured dynamic communication medium*...''[32] Certainly its application to the humanities mediates thought and action no less profoundly than the printed book. But it does so very differently, with consequences for scholarship we can at best help to shape, though not foresee.

Meanwhile, a very old difficulty remains largely untouched: communicating, as well as cataloging work in the field across the various languages *and cultures* in which it is taking place. This difficulty gives new force to Choueka's old question: ''The tools are here. Where are the results?''[c]

Hypermedia and the Digital Library

There are other obvious currents in the history of humanities computing to be taken into account, e.g., Bush's speculations in 1945 on a mechanical workstation-like device for aiding associational habits of mind;[33] the closely related idea of ''hypertext,'' a word coined by Nelson in 1965;[34] and Engelbart's preoccupation with

[c]This question was a session title at the ALLC conference organized by Choueka in Jerusalem, Israel, 1988.

the embodiment of computing,[35] from which came the mouse. Bush's imaginary device brought with it two highly significant implications: that, in the words of his title, the device would perform ''as we may think,'' i.e., by modeling human thought; and, he wrote later, it would do so like ''a stone adze in the hands of a cabinet-maker,''[36] i.e., crudely. I will return to these implications later.

Hypermedia research, principally through the powerfully simple (though technically simplistic) mechanism of hypertext markup language (HTML) and the Web, have provided a basis for our current thoughts about how to refurbish scholarship for a world-wide digital library.[37,38] In part, as a ''shock of the new,'' hypertext and its online instantiation have, McGann notes,[28] brought sharply into focus the mechanisms developed for the codex book and caused us to examine closely the cultural history that the ''electronic book'' inherits.[39] Similarly, the Web has moved us to imagine the kind of ''library'' into which such a ''book'' would fit.

In Teaching

Computer-assisted teaching receives little direct attention here because little of it is specific to the humanities.[40] The shift from proprietary teaching software to Web delivery of common, multipurpose ''resources'' is, however, to the purpose. ''Resource-based teaching,'' as it is called, signifies convergence of pedagogy and research in the ancient model of the research library, where singular and relatively unchanging resources are separated from their manifold and highly changeable uses. Empowering this convergence is the capability of ''smart'' resources (a.k.a. ''adaptive hypermedia'') to be differently selected and contextualized for various target audiences without compromising scholarly or pedagogical integrity.

Institutional and Professional History

The common goal of humanities computing, even across the very different academic cultures within which it has developed, is clear: to move from the periphery to the core of what institutions variously identify as their mandate. Progress toward this goal has, in part, resulted from the continuing argument for the institutional recognition of humanities computing as a distinct field of scholarship. Logically this argument begins with the observation that, as Pelikan has said, older configurations of ''support services'' are no longer valid, if they ever were; in research, ''the formulation and the refinement of the questions themselves'' now often require *collegial* involvement of technical staff.[41] The next step is to identify the scholarly character of such involvement by articulating both a research agenda and a curriculum for a computing that is *of* (intrinsic to), as well as *in* (used by) the humanities. Asking if it is a ''discipline'' is intellectually barren, though a politically potent move, because to do so raises the question of what a discipline is such that accepted departments of learning qualify, and to that is no easy answer. The bibliographic crisis discussed above demonstrates that articulating the field piecemeal, in terms of each established discipline individually, leads to myopia and confusion. Rather, cohesibility must be sought by asking first of all what the humanities as a whole look like from the perspective of an intellectual computing practice that respects their concerns and understands their data.

As noted earlier, attempts to work toward a theoretical foundation for humanities computing surfaced at the outset of scholarly publication in the field and have been in progress ever since—with no consensus in sight.[d] Speculations on a research agenda reveal no overarching theory, nor do serious curricular experiments, begun in the 1960s. But as Culler has argued for English studies,[46] the considerable variety in how humanities computing is evidently conceived is a sign of health rather than decay. Consensus, he notes, is often falsely supposed to characterize the foundational period of a discipline, hence the ''myth of foundationalism'' he is at pains to deconstruct. On the contrary: vigorous disagreement in as wide a conversation as can be engaged is the goal. Only silence is to be feared.

Complicating (and enriching) the picture even further are the transinstitutional, national, and international entities whose contributions to the field are substantial. Some of these conduct research, employ individuals for lengthy periods, and exert strong influence across many disciplines and academies. Some are nonacademic by conventional measure, though they involve and serve academic research, for example, major lexicographical projects such as the *Oxford English Dictionary* and the Collins *Bank of English*. Chief among the transinstitutional projects is the international, multidisciplinary *Text Encoding Initiative* (TEI), founded in 1987—undoubtedly the single most important collaborative project in humanities computing to date. (More about it below.) Other large, ''big humanities'' projects have demonstrably accomplished what the lone scholar could never have done, e.g., among many, the *Thesaurus Linguae Graecae* (1972–), the *British National Corpus* (1991–), the *Prosopography of the Byzantine Empire* (1988–), and the *Perseus Digital Library* (1987–). National academies and

[d]Compare, for example: 1) Ref. [42]; 2) Ref. [43]; 3) Ref. [44]; and Ref. [45].

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other official bodies are also involved: e.g., in the United States, the American Council of Learned Societies took an early and active interest in humanities computing;[47] in the United Kingdom, the Arts and Humanities Data Service, founded in 1995, works ‘‘to collect, preserve and promote the electronic resources which result from research and teaching in the arts and humanities.’’ The *Digital Resources in the Humanities* conference was begun in the United Kingdom in 1996, precisely in response to the boundary crossings of humanities computing.

Achieving institutional recognition is signified by the creation of academic positions, departments, programs, and institutes from the mid-1990s on and by the several awards recently established for achievement in the field: *inter alia* the Roberto Busa Award, in 1998; the Lincoln Prize, in a special category for electronic scholarship, in 2001; the Lyman Award, in 2002; the Scholarly Communication Institute fellowships, to begin in 2003.

All this, however, is good only insofar as it furthers the work. What is that work?

RESEARCH AGENDA

In *Steps to an Ecology of Mind*, Bateson asserts that ‘‘in scientific research you start from *two* beginnings, each of which has its own kind of authority: the observations cannot be denied, and the fundamentals must be fitted. You must achieve a sort of pincers maneuver.’’[48] Here we turn from observations of activity to fundamental questions about the scholarly nature of humanities computing and attempts to answer them. Among these attempts, offered here as a starting point for further discussion, is the following provisional research agenda in three intertwined branches, the ‘‘algorithmic,’’ ‘‘metalinguistic,’’ and ‘‘representational.’’ These are not intended as exclusive categories into which actual research projects in applied computing must fit. Rather they speak to aspects of such projects that themselves are areas of research in humanities computing.

Algorithmic

The algorithmic branch emphasizes the development of software for the analysis of source materials, e.g., to locate permutations of given phrase in a textual corpus, find musical compositions matching a thematic pattern or discover recurrent shapes among visual images. In each of these cases, we must specify *exactly*, algorithmically, when two or more objects (textual, musical, or visual) are to be considered variations on each other or distinct entities. To the extent these algorithms are successful, they importantly identify mechanical elements in the analysis of data, as well as allow large quantities of data to be processed and the specified patterns in them found. For humanities computing, however, the interest lies in the questions raised by such algorithmic thinking, especially by the inevitable mismatch between any algorithm and data of the sort normal to the humanities. This mismatch forces ontological questions that lead back to one or more fundamental problems in the discipline of origin and may at the same time illuminate basic methodological issues relevant beyond it.

Thus, for example, to find compositions with ‘‘the same’’ thematic pattern across all kinds and periods of music would require the musicologist to say what the pattern is, hence to define the atomic units or primitives out of which it is constructed.[49] He or she would need a computationally tractable way of describing this pattern and its similarity to others. The result would be not a description of the sort that musicologists have formerly produced, rather what we might call a ‘‘grammar’’ or phenomenology. On the basis of this grammar a search engine could find instantiations of specified patterns—and, almost inevitably, both produce and miss instances a (human) musicologist would count—because, as Sapir noted for linguistic examples, ‘‘All grammars leak,’’[50] and especially computational ones. These leaks would point the way to further research: to the idea of musical patterns and primitives, to surprising occurrences of them where not expected, perhaps to new ideas in the evolution of music from one’s observations of where the patterns work and break. For humanities computing this research could well lead to insights about pattern recognition exportable to other domains of scholarship, e.g., textual studies.

Another opportunity for algorithmic research emerges from asking what can be done to put the tools to create intelligent tools directly into the individual scholar’s hands and so interiorize the crucial intersection of computing with the humanities. (Interiorizing it is very important for much the same reason that a sculptor holds his or her own chisel: the thinking is most immediately in the act of making, and any other arrangement inevitably slows down if not disables the work.) Training scholars in programming is only part of the answer: the mental discipline is essential, but most scholarly applications are too technically demanding for nonspecialists, and the curriculum is already too crowded. Hence, the research opportunity for humanities computing is to design and build high-level operations or ‘‘scholarly primitives’’ out of which scholars themselves might construct the software their applications require.[e] The idea is hardly new; broadly speaking, it describes the evolution of the human-computer interface and program-

[e]Compare 1) Ref. [51] and 2) Ref. [52].

ming languages.[53] Significant work in this area has in fact been available to textual scholars for decades, e.g., TUSTEP, the Tübingen System of Text-Processing Programs,[54] and the UNIX ''toolbox.'' Component design has become increasingly common, but its central challenge has yet to be answered: creation of a protocol for an open-ended, fully interoperable set of primitives whose development would, as Sperberg-McQueen has remarked, resemble the growth of a coral reef rather than an architectural plan.[55]

Computer science is obviously involved in algorithmic research, but much misunderstanding can easily arise by confusing its focus on the algorithms themselves with the focus in humanities computing on the implications and consequences of applying them. An algorithm trivial for the former can be central to research for the latter and *vice versa*. The drive in some fields of computer science to minimize human involvement is likewise contrary to the goal of humanities computing to shape and improve this involvement, specifically so that scholars may intervene more effectively in the process of interpreting the most complex, imaginative, and fundamentally ambiguous human artifacts we have.

Metalinguistic

The metalinguistic branch of humanities computing is historically itself a response to the inability of computing systems to deal with such artifacts satisfactorily. Its approach is to devise computationally rigorous metalanguages by which computationally elusive entities may be tagged and so reliably processed. (In textual data, examples of such entities range from semiotically consequential details of formatting, such as chapter divisions and italics, to rhetorical and poetic devices, such as references to persons and figures of speech.) To date, the metalinguistic branch has been the most widely successful, principally thanks to the TEI,[f] which has established the intellectual and strategic importance of markup and significantly influenced development of the extensible markup language (XML). From a research perspective, however, the hierarchical design inherited by the TEI from standard generalized markup language (SGML) has proved problematic—and thus fruitful for research. Its assumption that text may be described as a nested series of hierarchical objects runs directly into conflict with the radically non-, pluri- or even antihierarchical texts of the humanities, insistently raising the question of how these are better to be treated.[57]

[f]For current research see the Extreme Markup Languages conference series, http://www.extrememarkup.com/extreme/ (accessed April 2002); the journal in Ref. [56].

The implications of ''deep encoding''—its intensive use for minute analysis and interpretation of literary text—also loom on the problem-horizon. These implications tend not to receive the attention they deserve because examples are few: deep encoding is *very* laborious, and it is precisely the kind of task in which the full range of scholarly abilities are required.[g] It thus demonstrates that encoding can itself be a form of rather than preparation for scholarship.[59] This new form is shaped by the two imperatives of computational tractability, namely total explicitness and absolute consistency. As in the algorithmic branch of the agenda, these brutal imperatives guarantee failure to a significant degree, simply because imaginative artifacts do not work like that and so do not survive the translation well. Again, the point is, however, that if such impossible work is intelligently and persistently attempted, the ways in which the effort fails constitute the most interesting and consequential result possible. More about this below.

Representational

The last of the three provisional branches of research is the representational, which focuses on arranging, formatting, or otherwise transforming the appearance of data. Synthesis of intellectually powerful forms of scholarly expression is the primary goal, whether these have a temporary, heuristic purpose or constitute new genres for scholarship. On the agenda are such problems as: design of tools for heuristic play; visualization, including the representation of nonvisual data, and the development of what Arnheim has called ''visual thinking;''[60] interface design adequate to the potential of the medium, e.g., in realizing its ''full dynamic—and decentering—capabilities;''[61] and those aspects of hypermedia and digital library research concerned with building new scholarly forms and providing the interoperable environment in which they may be indefinitely but intelligently recontextualized.

With the momentary, heuristic kind, primary focus is often, though by no means always, on the efficacy of outcome rather than how it is produced—hence, we speak of a ''black box,'' i.e., an unexamined or obscure process. At minimum, what the scholarly user requires of a black box, as of any mechanical system, is reliability and a rich enough mixture of significance and utility in the results to encourage further work. Research in humanities computing begins, however, when a striking result provides reason to pry into the black box.

[g]For an example of a ''deep encoding'' project, see Ref. [58].

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Two examples. First, in McGann's deformational filtering of images, the algorithmic secrets of the program *Photoshop* seem beside the point. The filtering sequences he finds serendipitously illuminating raise, however, an important research question for humanities computing: whether a systematic correlation may be discovered between patterns in a visual work of art and particular computational transformations of its image.[h] Second, Burrows's applications of statistical software to literary stylistics produce striking representations of the complex relationships between authorial voices.[62,63] The insights these representations offer do not require a statistician's detailed understanding of the process, but the question of why a given test works well—indeed, what the particular successes of statistical procedures tell us about language—hangs in the air.

Scholarly forms, such as the lexicon, commentary, or edition, represent objects of study and what we know about them.[i] Like other representational devices, these forms mediate knowledge and shape thought in ways particular to the historically contingent purposes of their makers—hence, for example, the postmodern intellectual claustrophobia that has been expressed about the traditional commentary. The promise and challenge of the electronic medium is not just in the research imperative to rethink the inherited forms but in the deeper one to rethink what a form is. In the environment of the worldwide digital library, the objects we now call e.g., ''commentary'' and ''edition'' may be what the user dynamically constructs from component parts, such as essays, source texts, explanatory notes, lexicons, secondary literature, and so forth. The challenge is both technical and scholarly: on the one hand, making independently designed components work together (the problem of *interoperability*); on the other, crafting them so that they will make a coherent whole (the problem of *recontextualization*).

EPISTEMOLOGICAL IMAGINATIONS

The question of reinventing our scholarly forms takes us beyond any list of projects to what we might consider the fundamental ''project'' of humanities computing in the philosopher's sense. This is, in simple but far-reaching terms, epistemological: to ask, in the context of computing, what can (and must) be known of our artifacts, how we know what we know about them, and how new knowledge is made. Especially at this historical juncture, it is useful to frame these questions temporally, in terms of coming to know the past, present, and future. To do so is to recast the pragmatic question of a research agenda into more fundamental terms.

Past: Imagining What We Once Knew

The temporal framework is suggested by the current focus on refurbishing inherited artifacts for the electronic medium. This, we might say, is digitization in the broadest sense of remaking an object in a digital form appropriate to its purposes and the opportunities offered by the new medium. Here is a crucial point: to do this in an intellectually responsible way, the original artifact must first be understood as an historical object of its time and place, replete with all ''the potentiality inherent in actuality''[65] and all of the knowledge that at the time went without saying. As we know from the digitization of the *Oxford English Dictionary*, tacit knowledge available only in actual use of the original artifact may be required for successful implementation.[66] More fundamentally, reading the physical evidence provided by the inherited artifact is difficult because it means stepping outside of our historically conditioned selves. Thus, for example, in considering references in a printed commentary, it is profoundly anachronistic to suppose that hypertext would do a better job *tout court* than, say, ''cf. Goldman 1999: 2–4,'' by delivering the full text of the article. Hypertext is without question the central technology for many if not all refurbished scholarly forms, but if we are to learn from inherited exemplars, an historical imagination is required, and that means seeing the past in its own terms, not as a thwarted attempt to realize ours.

Thus, humanities computing runs into the historiographical debate begun in the mid-nineteenth century with von Ranke's declaration that history ''wants to show what actually happened.''[j] The vitality of this debate is perhaps due to the energizing paradox of an impossible but necessary goal. History, Collingwood said less paradoxically, is a reasoned knowledge of the transient and concrete.[67] To gain such knowledge requires the creative faculty that makes present to the mind that which is not present to the senses. We must, that is, be able *to imagine what we once knew* in order to progress with as little loss of knowledge from our inherited artifacts as possible.

[h]See Ref. [61], pp. 84–86.

[i]For concentrated attention on scholarly forms in the electronic age, see Ref. [64].

[j]See Ref. [64], p. 386.

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Present: Imagining What We Know

As the ethnographer Greg Dening brilliantly shows, a present-tense imagination is likewise key to reaching across liminal boundaries in cultural, as well as physical space and making them present to the mind so that we can ‘‘hear the silences.’’[68] In humanities computing, the analogous problem is twofold: 1) intellectually, how the non-computational things of the present may be known computationally and 2) institutionally, how an effective interrelation of humanities computing with the other, very different academic cultures may be imagined.

On the latter question, humanities computing has, from the beginning, operated *de facto* ethnographically in its daily negotiations across disciplinary boundaries, though without a conscious model. A persuasive one is suggested by historian of science Peter Galison’s ‘‘trading zone,’’ an anthropological/linguistic metaphor he uses to describe collaborative arrangements in which specialists from radically different fields develop a local means of trading intellectual goods that normally have quite incompatible meanings in their original contexts.[69] The socioacademic function of humanities computing can be understood as an elaboration of the Galisonian trading zone, which the field establishes as a methodological commons and within it, takes the role of merchant trader among the mutually divergent academic cultures. As I noted earlier, digitization makes this commons possible by rendering the processes and artifacts of scholarship computationally tractable, i.e., both explicit and consistent.

Normally, such a computational rendition will have two closely interrelated functions: as a tool for or as an object of research. As a tool, what matters is its transparent usefulness for the subject of application. Thus, a database of historical records is valued for the comprehensiveness and reliability of the evidence it yields. When, however, application breaks down through significant discrepancy between expectations and results, the rendition itself becomes the object of attention—to use the Heideggerian terms adopted by Winograd and Flores, it emerges from the unnoticed background of ‘‘readiness-to-hand’’ to become ‘‘present-at-hand.’’[k] Through failure, we are able to see it as a tentative, heuristic process or *model of* its original.[64] Its function then is to bring these expectations into question, so that we may ask *how we know what we know*.

Research in humanities computing begins then, in the breakdown, when tools become models. It proceeds in an iterative cycle of constructing, testing, analyzing, and reconstructing these models in order to discover how the thing imitated may better be known. By definition *a model cannot be true*; it is, as Black says, a heuristic fiction.[70] Hence, although better knowledge of the modeled object and of the analytical method results, modeling is essentially a quest for meaningful failure. The best model of something, that is, comes as close as possible to what we think we know about the thing in question yet fails to duplicate perfectly that knowledge. Failure of the model in an engineering sense is its success as an epistemological instrument of research, because skillfully engineered failure shows us where we are ignorant. A computational model, as we saw, does this in a rigorous and particular way by demanding absolute consistency and complete explicitness. It also raises the question in an environment of indefinite flexibility, inviting indefinite heuristic play. We can expect, therefore, that as Bush saw, a model of this kind will be exceedingly crude, as well as powerful—and that the crudity is a matter of principle, not progress.

As just noted, the failures of a model are significant in proportion to the success of its implementation. Contrariwise, its success as an interpretative instrument depends on interesting failures: otherwise from a theoretical perspective, the instrument is trivial. As a collegial service, humanities computing may be valued for the successes, irrespective of interesting failures, but these failures are the key to its scholarship.

Future: Imagining What We Do Not Know

Modeling has another role to play: as a means of discovering or making altogether new knowledge. This face of modeling, as it were, is turned toward the future, in what McGann (quoting Samuels) has happily called ‘‘imagining what we don’t know.’’[71] It figures prominently in Hacking’s epistemology of experimental science,[72] from which humanities computing has much to learn, as will be indicated below.

In representational research, for example, we noted that the use of a black-box process can serendipitously throw new light on old material. Play, apparently without conscious direction, is a recognized factor in scientific discovery.[l] Since the evolution of computing seems increasingly to facilitate interactive play, a place is needed for it in an epistemology of computing: an apparently blind (and therefore black box) ‘‘feeling toward’’ new knowledge rather than a targeting of it, in which what matters most is, as Hacking says, not observation but being observant.

Putting aside the question of the ‘‘two cultures,’’ we nevertheless observe a striking, non-trivial resemblance between humanities computing and experimental sci-

[k]See Ref. [32], pp. 27–36.

[l]See Ref. [29], p. 212.

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ence: both are data-centerd, equipment-orientated activities that centrally involve modeling and tend to be collaborative. This resemblance is significant not because humanities computing requires the honorific title of a ''science,'' rather because, in establishing the field, we need to ask where its kinships lie and what intellectual assistance we may derive from them. Work in the history, philosophy, and sociology of science over the last 20 years or so has decoupled experiment from theory and shown that the former is an epistemological practice of its own, not needing the *imprimatur* of theory to proceed. It has also demonstrated that, as Hacking says, ''[t]here is no one scientific method; the sciences are as disunified in their methods as in their topics.''[73,74] Building on this work, we can infer that humanities computing likewise need not wait on the emergence of a theoretical framework, that its semidirected, semicoherent activities are no discredit, rather the norm for an experimental field. Furthermore, we may find deep kinship in the complex, constructivist idea that, to put the matter crudely, scientific knowledge is both found and made. Particularly useful to us is Hacking's model of experimental science, in which the investigator makes hypothetical entities real by learning how to manipulate them. Hacking's epistemology by intervention and McGann's by imagination would seem to be on a converging course, especially if the simplistic notion of scientific knowledge being ''out there'' and humanistic knowledge ''in here'' is dismantled.

INTELLECTUAL KINSHIPS

The question of intellectual kinships only begins with the humanistic study of the sciences, however. Others are suggested by the rough intellectual map of the field given in Fig. 1. Thus, in philosophy, for example, ontology and the philosophy of mind come to bear on such questions as the nature of text[75] and the relation of form to content, respectively. In addition to historiography, history also contributes the development of technology as a human story, connecting what we do with technological visions and achievements over the millennia. The social sciences contribute the methodology of disciplined observation and the sociology of knowledge;[76] linguistics, models of language, especially from research with corpora;[77–79] computer science[80] as noted above, especially digital library research and work in the language industries;[81] literature and the arts, studies of the creative imagination in verbal[82] and visual forms.[60]

This inchoate list is only the beginning as the field rapidly comes of age. The prospect is daunting. It is realistic, however, to contemplate a working familiarity with the familial disciplines insofar as humanities computing connects to them through the common ground of shared interests. This is a robust challenge to practitioners and to curriculum design but not an impossible one.

CONCLUSION

What is humanities computing? This, for the humanities, is a question not to be answered but continually to be explored and refined. The above is meant to advance the questioning through a rough, provisional map of the field as it now seems to be emerging from discussions and from related scholarly work. The map centers on a large methodological commons of techniques derived largely from and applicable across the other disciplines. These techniques depend for their application chiefly on the kind of data in question (e.g., discursive or tabular text, numbers, images, and sound) rather than subject matter. In the extended Galisonian model, the humanities computing specialist acts as merchant trader of these intellectual goods, seizing opportunities for importing and exporting them as the occasion warrants. From his or her perspective, the various disciplines serve as laboratories in which these goods are exercised, probed, and improved upon. Research questions for humanities computing arise from his or her involvement and so a research agenda and all that goes with it. In addition, however, the methodological commons is deeply informed by impinging on areas of intellectual concern in these disciplines. Hence, the specialist must not only be able to get along in various disciplinary cultures but also to partake at some level in their most basic conversations.

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REFERENCES

1. Adamo, G. *Bibliografia di informatica umanistica*; Informatica e discipline umanistiche, Bulzoni Editore: Roma, 1994; Vol. 5, pp. 349–357.
2. McCarty, W.; Kirschenbaum, M. Institutional models for

humanities computing. Lit. Linguist. Comput. **2003**, *in press*. http://www.allc.org/archive/hcim/ (accessed April 2002).
3. Cherry, C. The Telephone System: Creator of Mobility and Social Change. In *The Social Impact of the Telephone*; de Sola Pool, I., Ed.; MIT Press: Cambridge, MA, 1977; 112–126.
4. Raben, J. Humanities computing 25 years later. Comput. Humanit. **1991**, *25*, 341–350.
5. Fraser, M. *A Hypertextual History of Humanities Computing*; Computers in Teaching Initiative: Oxford, 1996. http://info.ox.ac.uk/ctitext/history/ (accessed April 2002).
6. Adamo, G. Informatica umanistica. In *Enciclopedia italiana di scienze, lettere ed arti*; Appendice 2000, Istituto della Enciclopedia italiana: Roma, 2000; 917–919.
7. Fowler, D. Criticism as Commentary and Commentary as Criticism in the Age of Electronic Media. In *Commentaries–Kommentare*; Most, G.W., Ed.; Vandenhoeck und Ruprecht: Göttingen, 1999; 442.
8. Mahoney, M.S. Issues in the History of Computing. In *History of Programming Languages II*; Bergin, T.J., Gibson, R.G., Eds.; ACM Press: New York, 1996; 772–781.
9. Williams, M. *Problems of Knowledge: A Critical Introduction to Epistemology*; Oxford University Press: Oxford, 2001; 14.
10. de Solla Price, D.J. Automata and the origins of mechanism and mechanistic philosophy. Technol. Culture **1964**, *5* (1), 9–23.
11. Bedini, S.A. The role of automata in the history of technology. Technol. Culture **1964**, *5* (1), 24–42.
12. Freudenthal, G. *Atom and Individual in the Age of Reason: On the Genesis of the Mechanistic World View*; McLaughlin, P., translator; Boston Studies in the Philosophy of Science, D. Reidel: Dordrecht, 1986; Vol. 88.
13. Richards, I.A. *Principles of Literary Criticism,* 2nd Ed.; Routledge & Kegan Paul: London, 1926; 1.
14. Daly, L.W. *Contributions to a History of Alphebetization in Antiquity and the Middle Ages*; Revue d'Ètudes Latines, Latomus: Bruxelles, 1967.
15. Rouse, R.H. The verbal concordance to the scriptures. Arch. Frat. Praedic. **1974**, *44*, 5–30.
16. Menninger, K. *Number Words and Number Symbols: A Cultural History of Numbers*; Broneer, P., translator; 1969; 297–388; Boston MA: MIT Press.
17. Mahoney, M.S. Cybernetics and Information Technology. In *Companion to the History of Modern Science*; Olby, R.C., Cantor, G.N., Christie, J.R.R., Hodge, M.J.S., Eds.; Routledge: London, 1990; 537–553.
18. Babbage, C.S. *Passages from the Life of a Philosopher*; Longman Green and Company: London, 1864; 112–141.
19. Turing, A. Computing machinery and intelligence. Mind **1950**, *59*, 433–460.
20. Machines and Thought. In *The Legacy of Alan Turing*; Millican, P., Clark, A., Eds.; Mind Association Occasional Series, Clarendon Press: Oxford, 1996; Vol. 1.
21. Busa, R. The annals of humanities computing: The Index Thomisticus. Comput. Humanit. **1980**, *14*, 83–90.
22. *The Wired Museum*; Jones-Garmil, K., Ed.; American Association of Museums: Washington, DC, 1997.
23. Milic, L. The next step. Comput. Humanit. **1966**, *1*, 3–6.
24. Lancashire, I.; McCarty, W. *Humanities Computing Yearbook 1988*; Clarendon Press: Oxford, 1988.
25. Lancashire, I. *Humanities Computing Yearbook 1989–90*; Clarendon Press: Oxford, 1991.
26. Raben, J. The humanities computing yearbook—1988. Comput. Humanit. **1990**, *24*, 111–113.
27. Sabourin, C.F. *Infolingua Bibliographical Series in Linguistics—Informatics—Communications*; Infolingua: Montréal, Québec, 1994.
28. McGann, J. The Rationale of Hypertext. In *Electronic Text: Investigations in Method and Theory*; Sutherland, K., Ed.; Clarendon Press: Oxford, 1997; 19–46. http://www.iath.virginia.edu/public/jjm2f/rationale.html (accessed April 2002).
29. McCarty, W. HUMANIST: Lessons from a global electronic seminar. Chum **1992**, *26*, 205–222.
30. Bailey, C.W., Jr. *Scholarly Electronic Publishing Bibliography*; http://info.lib.uh.edu/sepb/sepb.html (accessed April 2002).
31. Smith, J.B. The King is Dead; Long Live the King. In *Hypertext '97*, Proceedings of the Eighth ACM Conference on Hypertext and Hypermedia, Southampton, U.K., Association for Computing Machinery, 1997; 240. ACM Digital Library, http://www.acm.org/ (accessed April 2002).
32. Winograd, T.; Flores, F. *Understanding Computers and Cognition: A New Foundation for Design*; Addison-Wesley: New York, 1987; p. 176.
33. Bush, V. As we may think. Atl. Mon. **1945**, *176* (1), 101–108.
34. Nelson, T.H. In *A File Structure for the Complex, the Changing, and the Indeterminate,* ACM 20th National Conference; 1965. http://www.cs.berkeley.edu/~wilensky/CS294/readings.html (accessed April 2002).
35. Bardin, T. *Bootstrapping: Douglas Engelbart, Coevolution, and the Origins of Personal Computing*; Writing Science, Stanford University Press: Stanford, 2000.
36. Bush, V. Memex Revisited. In *Science is Not Enough*; William Morrow and Co.: New York, 1965; 92.
37. Deegan, M.; Tanner, S. *Digital Futures: Strategies for the Information Age*; Library Association Publishing: London, 2002.
38. McCarty, W. (compiler of this work) Digital Libraries, Working Environments and Collaborative Work. In *A Serious Beginner's Guide to Hypertext Research*; http://ilex.cc.kcl.ac.uk/wlm/essays/diy/hyperbib.html (accessed April 2002).
39. *The Future of the Book*; Nunberg, G., Ed.; University of California Press: Berkeley CA, 1996.
40. Chambers, E. Computers in humanities teaching and research: Dispatches from the disciplines. Computers and the Humanities **2000**, *34* (3).
41. Pelikan, J. *The Idea of the University: A Re-examination*; Yale Univ. Press: New Haven, **1992**, ; 62.
42. Aarseth, E. *The Field of Humanistic Informatics and its Relation to the Humanities*; http://www.hf.uib.no/hi/espen/HI.html (accessed April 2002).
43. Gardin, J.-C. On the Way We Think and Write in the Humanities: A Computational Perspective. In *Research in*

Humanities Computing 1; Lancashire, I., Ed.; Selected Papers from the ALLC/ACH Conference, Toronto, June 1989, Clarendon Press: Oxford, **1991**, ; 337–345.
44. *Interpretation in the Humanities: Perspectives from Artificial Intelligence*; Ennals, R., Gardin, J.-C., Eds.; Library and Information Research Report, British Library Publications: Boston Spa, Yorkshire UK, **1990**; Vol. 71.
45. Orlandi, T. Ideas for a Theoretical Foundation of Humanities Computing. In *Humanities Computing: Formal Methods, Experimental Practice*; Seminar in Humanities Computing, King's College London, **2000.** http://rmcisadu.let. uniroma1.it/˜orlandi/saggiomio.pdf (accessed April 2002).
46. Culler, J. *Framing the Sign: Criticism and its Institutions*; Basil Blackwell: Oxford, **1988**, ; 44, 45.
47. Lieb, I.C. The ACLS program for computer studies in the humanities: Notes on computers and the humanities. Comput. Humanit. **1966**, *1*, 7–11.
48. Bateson, G. *Steps to an Ecology of Mind,* Rev. Ed.; University of Chicago Press: Chicago, 2000; xxviii.
49. Rolland, P.-Y.; Cambouropoulos, E.; Wiggins, G.A. Pattern processing in music analysis and creation. Computers and the Humanities **2001**, *35*.
50. Sapir, E. *Language: An Introduction to the Study of Speech*; Harcourt Brace: New York, 1921; 38.
51. Unsworth, J. Scholarly Primitives: What Methods do Humanities Researchers have in Common, and How Might Our Tools Reflect This? In *Humanities Computing: Formal Methods, Experimental Practice*; Seminar on Humanities Computing, King's College London, 2000; http://jefferson.village.virginia.edu/~jmu2m/Kings.5-00/primitives.html (accessed April 2002).
52. McCarty, W. Humanities computing: Essential problems, experimental practice. Lit. Linguist. Comput. **2002**, *17*, 103–125.
53. Winograd, T. Beyond programming languages. Commun. ACM **1979**, *22* (7), 391–401. ACM Digital Library, http://www.acm.org/ (accessed April 2002).
54. Ott, W. Strategies and tools for textual scholarship: The Tübingen System of Text Processing Programs (TUSTEP). Lit. Linguist. Comput. **2000**, *15*, 93–108.
55. Sperberg-McQueen, C.M. *Text Analysis Software Planning Meeting, Princeton, 17–19 May 1996: Trip Report*; http://tigger.uic.edu/~cmsmcq/trips/ceth9505.html (accessed June 2002).
56. *Markup Languages: Theory and Practice*; MIT Press: Boston, 1999–2001.
57. Caton, P. Markup's current imbalance. Markup Lang.: Theory Pract. **2001**, *3* (1), 1–13.
58. McCarty, W. *An Analytical Onomasticon to the Metamorphoses of Ovid: On-line Sampler*; http://www.kcl. ac.uk/cch/wlm/onomasticon-sampler/ (accessed April 2002).
59. Sperberg-McQueen, C.M. Text in the electronic age: Textual study and text encoding, with examples from medieval texts. Lit. Linguist. Comput. **1991**, *6*, 34–46.
60. Arnheim, R. *Visual Thinking*; University of California Press: Berkeley, CA, 1969.
61. McGann, J. *Radiant Textuality: Literature After the World Wide Web*; Palgrave: New York, 2001, p. 74.
62. Burrows, J.; Craig, H. Lucy Hutchinson and the authorship of two seventeenth-century poems: A computational approach. Seventeenth Century **2001**, *16*, 259–282.
63. Burrows, J. Computers and the Study of Literature. In *Computers and Written Texts*; Butler, C.S., Ed.; Blackwell: Oxford, 1992; 167–204.
64. McCarty, W. A Network with a Thousand Entrances: Commentary in an Electronic Age? In *The Classical Commentary: Histories, Practices, Theory*; Gibson, R.K., Kraus, C.S., Eds.; Mnemosyne Supplement, Brill: Leiden, 2002; pp. 359–402.
65. Lukacs, J. *At the End of an Age*; Yale University Press: New Haven, CT, 2002; 58.
66. Raymond, D.R.; Tompa, F.W. Hypertext and the Oxford English dictionary. Commun. ACM **1988**, *31*, 871–879.
67. Collingwood, R.G. *The Idea of History,* Rev. Ed.; Oxford University Press: Oxford, 1994; 234.
68. Dening, G. *Readings/Writings*; University of Melbourne Press: Melbourne, 1998; 213.
69. Galison, P. *Image and Logic: A Material Culture of Microphysics*; University of Chicago Press: Chicago, 1997; chapter 9 esp., but also chapter 1 and sections 3.11, 6.7, 6.11, 8.1, 8.5, 8.7.
70. Black, M. *Models and Metaphors: Studies in Language and Philosophy*; Cornell University Press: Ithaca, NY, 1962; 219–262.
71. McGann, J. *Imagining What You Don't Know: The Theoretical Goals of the Rosetti Archive, 1997*; http://jefferson.village.virginia.edu/~jjm2f/chum.html (accessed April 2002).
72. Hacking, I. *Representing and Intervening: Introductory Topics in the Philosophy of Natural Science*; Cambridge University Press: Cambridge, 1983.
73. Hacking, I. *The Social Construction of What?* Harvard University Press: Cambridge, MA, 1999; 198.
74. Feyerabend, P. *Against Method,* 3rd Ed.; Verso: London, 1988.
75. Renear, A. Out of Praxis: Three (Meta)Theories of Textuality. In *Electronic Text: Investigations in Method and Theory*; Sutherland, K., Ed.; Clarendon Press: Oxford, 1997; 107–126.
76. Winch, P. *The Idea of a Social Science and Its Relation to Philosophy,* 2nd Ed.; Routledge: London, 1990.
77. McEnery, A.M.; Wilson, A. *Corpus Linguistics,* 2nd Ed.; Edinburgh University Press: Edinburgh, 2001.
78. Biber, D. *Variation Across Speech and Writing*; Cambridge University Press: Cambridge, 1988.
79. Sinclair, J. *Corpus Concordance Collocation*; Describing English Language, Oxford University Press: Oxford, 1991.
80. *Constructions of the Mind: Artificial Intelligence and the Humanities*; Franchi, S., Güzeldere, G., Eds.; Stanford Humanities Review, 1995; Vol. 4 (2). http://www.stanford.edu/group/SHR/4-2/text/toc.html (accessed April 2002).
81. Zampolli, A. Introduction. In *Survey of the State of the Art in Human Language Technology*; Varile, G., Zampolli, A., Eds.; Linguistica Computazionale, Giardini Editori: Pisa, 1997; Vol. XII–XIII.
82. Donoghue, D. *The Sovereign Ghost: Studies in Imagination*; Ecco Press: New York, 1976.

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