Poetics Today 25.1 (2004) 67-90

Print Is Flat, Code Is Deep:
The Importance of Media-Specific Analysis

N. Katherine Hayles
English, UC Los Angeles

Abstract
Lulled into somnolence by five hundred years of print, literary analysis should awaken to the importance of media-specific analysis, a mode of critical attention which recognizes that all texts are instantiated and that the nature of the medium in which they are instantiated matters. Central to repositioning critical inquiry, so it can attend to the specificity of the medium, is a more robust notion of materiality. Materiality is reconceptualized as the interplay between a text's physical characteristics and its signifying strategies, a move that entwines instantiation and signification at the outset. This definition opens the possibility of considering texts as embodied entities while still maintaining a central focus on interpretation. It makes materiality an emergent property, so that it cannot be specified in advance, as if it were a pre-given entity. Rather, materiality is open to debate and interpretation, ensuring that discussions about the text's "meaning" will also take into account its physical specificity as well. **[End Page 67]**

Following the emphasis on media-specific analysis, nine points can be made about the specificities of electronic hypertext: they are dynamic images; they include both analogue resemblance and digital coding; they are generated through fragmentation and recombination; they have depth and operate in three dimensions; they are written in code as well as natural language; they are mutable and transformable; they are spaces to navigate; they are written and read in distributed cognitive environments; and they initiate and demand cyborg reading practices.

Lulled into somnolence by five hundred years of print, literary studies have been slow to wake up to the importance of media-specific analysis. Literary criticism and theory are shot through with unrecognized assumptions specific to print. Only now, as the new medium of electronic textuality vibrantly asserts its presence, are these assumptions clearly coming into view.

Consider, for example, Roland Barthes's influential essay "From Work to Text" (1986). Rereading it, I am struck both by its prescience and by how far we have moved beyond it. As Jay David Bolter (1991) and George Landow (1997) have pointed out, Barthes's description of "text," with its dispersion, multiple authorship, and rhizomatic structure, uncannily anticipates electronic hypertext. "The metaphor of the Text is that of the *network*," Barthes writes (1986: 61). Yet at the same time he can also assert that "the text must not be understood as a computable object," "*computable*" here meaning to be limited, finite, bound, able to be reckoned (ibid.: 57). Written twenty years before the advent of the microcomputer, his essay stands in the ironic position of anticipating what it cannot anticipate. It calls for a movement away from works to texts, a movement so successful that the ubiquitous "text" has all but driven out the media-specific term *book*.

Barthes's vision remains rooted in print culture, however, for he defines "text" through its differences from books, not through its similarities with electronic textuality. In positioning text against work, Barthes was among those who helped initiate semiotic and poststructuralist approaches to discourse, arguably among the most important developments in literary studies in the twentieth century. But this shift has entailed loss as well as gain. Useful as the vocabulary of text was in expanding textuality beyond the printed page, it also had the effect, in treating everything from fashion to fascism as a semiotic system, of eliding differences in media. Perhaps now, after the linguistic turn has yielded so many important insights, it is time to turn again to a careful consideration of what difference the medium makes.[1] **[End Page 68]**

In calling for medium-specific analysis, I do not mean to advocate that media should be considered in

isolation from one another. Quite the contrary. As Jay David Bolter and Richard Grusin have shown in *Remediation* (1999), media constantly engage in a recursive dynamic of imitating each other, incorporating aspects of competing media into themselves while simultaneously flaunting the advantages that their own forms of mediation offer. Voyager's now-defunct line of "Expanded Books," for example, went to the extreme of offering readers the opportunity to dog-ear electronic pages. Another option inserted a paper clip on the screenic page, which itself was programmed to look as much as possible like print. On the other side of the screen, many print texts are now imitating electronic hypertexts. These range from Don DeLillo's *Underworld* (1998) to Bolter and Grusin's *Remediation*, which self-consciously pushes toward hypertext through arrows that serve as visual indications of hypertextual links. Media-specific analysis (MSA) attends both to the specificity of the form—the fact that the Voyager paper clip is an image rather than a piece of bent metal—and to citations and imitations of one medium in another. Attuned not so much to similarity and difference as to simulation and instantiation, MSA moves from the language of "text" to a more precise vocabulary of screen and page, digital program and analogue interface, code and ink, mutable image and durably inscribed mark, texton and scripton, computer and book.

One area where media-specific analysis can pay especially rich dividends is literary hypertext. Some theorists working in the area of electronic literature argue that hypertext ought to be reserved for electronic texts instantiated in digital media. In my view, this is a mistake. When Vannevar Bush, widely credited with the invention of hypertext, imagined a hypertextual system, it was not electronic but mechanical. His pioneering article (1945) testifies that it is possible to implement hypertext in a wide variety of ways, not only through the "go to" commands that comprise the hypertext link in digital computers. If we restrict the term *hypertext* to digital media, we lose the opportunity to understand how a literary genre mutates and transforms when it is instantiated in different media. The power of MSA comes from holding one term constant across media—in this case, the genre of literary hypertext—and then varying the media to explore how medium-specific constraints and possibilities shape texts. Understanding literature as the interplay between form and medium, MSA insists that "texts" must always be embodied to exist in the world. The materiality of those embodiments **[End Page 69]** interacts dynamically with linguistic, rhetorical, and literary practices to create the effects we call literature.[2]

In attending to the materiality of the medium, MSA explicitly refutes the concept of the literary work that emerged from eighteenth-century debates over copyright and that has held considerable sway since then, although not without contestations. As Mark Rose has shown in his important book *Authors and Owners: The Invention of Copyright* (1993), legal theorists such as William Blackstone defined a literary work as consisting solely of its "style and sentiment." "These alone constitute its identity," Blackstone wrote. "The paper and print are merely accidents, which serve as vehicles to convey that style and sentiment to a distance" (quoted in Rose 1993: 89). Subsequent commentators realized it was not practical to copyright "sentiment," for some ideas are so general they cannot be attributed to any single author: that men are mortal, for example. Rather, it was not ideas in themselves but the ways in which ideas were expressed that could be secured as literary property and hence copyrighted.

This judicial history, played out in a contentious environment where conflicting economic, political, and class interests fought for priority, had important consequences for literature that went beyond purely legal considerations: it helped to solidify the literary author as a man (the author's assumed gender in these discourses was invariably male) of original genius who created literary property by mixing his intellectual labor with the materials afforded him by nature, much as John Locke had argued men created private property by mixing their labor with the land.[3] Consistently in these discourses, material and economic considerations, although they had force in the real world, were elided or erased in favor of an emphasis on literary property as an intellectual construction that owed nothing to the medium in which it was embodied. Although this conclusion was repeatedly challenged in court and in such literary movements as futurism and imagism ("No ideas but in things," William Carlos Williams declared), the long reign of print made it easy for literary criticism to ignore the specificities of the codex book when discussing literary texts. With significant exceptions, print literature was widely regarded as not having a body, only a speaking mind.[4] **[End Page 70]**

This split between the physical and verbal has seriously impeded recognition in scholarly communities of the importance of the physical and subverbal qualities of texts, as Jerome McGann (1991, 2001b), Johanna Drucker (1996), and John Cayley (forthcoming) have argued, among others. As electronic textuality becomes more pervasive and important in literary studies, a view that insists that texts are immaterial makes it difficult to understand the significance of importing print texts into electronic environments.[5] It also impedes the development of theoretical frameworks capable of understanding electronic literature as media-specific practices that require new modes of analysis and criticism. The temptation to think of text on screen as essentially identical to text on a printed page, simply because the

words are the same, is all the more seductive because the computer is the most successful simulation machine ever created. It is crucially important, however, to recognize that the computer can simulate so successfully only because it differs profoundly from print in its physical properties and dynamic processes. These differences matter in multiple ways and on many different levels, from the macroscale to the microscale—and they matter more all the time as writers of electronic literature and texts become more adept at exploiting the medium's specificity.

In emphasizing materiality, I do not mean to imply that all aspects of a medium's apparatus will be equally important. Rather, materiality should be understood as existing in complex dynamic interplay with content, coming into focus or fading into the background, depending on what performances the work enacts. I can think of many contemporary electronic works that foreground the interplay between natural language and computer code, from John McDaid's *Uncle Buddy's Phantom Funhouse* (1993) to Talan Memmott's *Lexia to Perplexia* (2000), but I know of no work that foregrounds the computer's power cord. Interpretation cannot be generated by the apparatus alone, independently of how it is used in specific works (this is a lesson film studies learned decades ago when it suffered through the overzealous application of "apparatus theory," a phrase that still makes many film theorists break out in hives). The list of physical qualities is potentially infinite, ranging from the chemical formulas for the polymers used in computer **[End Page 71]** cases to the electronic conductivity of computer chips. Materiality always matters in some sense, but it matters most to humanists and artists when considered in relation to the practices it embodies and enacts.

The crucial move is to reconceptualize materiality as *the interplay between a text's physical characteristics and its signifying strategies*. This definition opens the possibility of considering texts as embodied entities while still maintaining a central focus on interpretation. In this view of materiality, it is not merely an inert collection of physical properties but a dynamic quality that *emerges* from the interplay between the text as a physical artifact, its conceptual content, and the interpretive activities of readers and writers. Materiality thus cannot be specified in advance; rather, it occupies a borderland—or better, performs as connective tissue—joining the physical and mental, the artifact and the user.

To understand these dynamic interactions, media-specific analysis (MSA) is essential. MSA aims to electrify the neocortex of literary criticism into recognizing that strands traditionally emphasizing materiality (such as criticism on the illuminated manuscript, on such writers as William Blake for whom embodiment is everything, on the rich tradition of artists' books[6]) are not exceptions but paradigmatic of the ways in which literary effects emerge from and are entwined with the materiality of texts. Hypertext, understood as a genre that can be implemented in both print and digital media, offers an ideal opportunity to explore the dynamic interaction between the artifactual characteristics and the interpretation that materiality embodies. Like all literature, hypertext has a body (or rather many bodies), and the rich connections between its physical properties and the processes that constitute it as something to be read make up together that elusive object we call a "text"—and that I want now to call instead a codex book or stitched pamphlet or CD-ROM or Web site.

What kind of bodies does hypertext have? To pursue this question, let me suggest a working definition. Following Jane Yellowlees Douglas and others, I propose that hypertext has at a minimum the following characteristics: multiple reading paths; some kind of linking mechanism; and chunked text (that is, text that can be treated as discrete units and linked to one another in various arrangements).[7] In proposing these characteristics, my intent is not to draw a hard-and-fast line that will distinguish between hypertext and everything else. Rather, the boundary is to be regarded as **[End Page 72]** heuristic, operating not as a rigid barrier but as a borderland inviting playful forays that test the limits of the form by modifying, enlarging, or transforming them. From the definition, it will be immediately apparent that hypertext can be instantiated in print as well as electronic media. A print encyclopedia, for example, qualifies as a hypertext because it has multiple reading paths, a system of extensive cross-references that serve as linking mechanisms, and chunked text in entries separated typographically from one another. These hypertextual characteristics of the encyclopedia form the basis for a print literary hypertext in Milorad PaviĆ's brilliant *Dictionary of the Khazars: A Lexicon Novel* (1989). Other examples of print hypertexts include Ursula Le Guin's *Always Coming Home* (1987), where the audio tapes afford multiple ways to access this multimedia text; Philip Zimmerman's artist's book *High Tension* (1993), where a multiplicity of reading paths is created through an unusual physical form that allows the reader to fold over diagonally cut leaves to obtain various juxtapositions of text and image; and Robert Coover's "The Babysitter" (2000 [1969]), a short story that pushes toward hypertext by juxtaposing contradictory and nonsequential events, suggesting many simultaneously existing time lines and narrative unfoldings.

If we grant that hypertext can exist in either print or digital media, what distinguishes hypertext instantiated in a computer from hypertext in book form? To gain purchase on this question in the spirit of

MSA, I propose the following game. Using the characteristics of the digital computer, what is it possible to say about electronic hypertext as a literary medium? The point of this game is to derive these literary qualities from the interaction of the medium's physical characteristics with the signifying strategies of electronic hypertexts to illustrate how the text's materiality provides resources that writers and readers can mobilize in specific ways. Focusing on the text's materiality, how far is it possible to go? This kind of analysis is artificial in that it forbids itself access to the full repertoire of literary reading strategies, but it may nevertheless prove illuminating about what difference the medium makes. To clarify the medium's specificity, I will also offer examples of how these characteristics of digital media can be simulated in print texts. The point here is to explore what Bolter and Grusin call reverse remediation, the simulation of medium-specific effects in another medium, as when Voyager Expanded Books simulated turning down page corners and marking passages with paper clips. My technique, then, amounts to constructing a typology of electronic hypertext by considering both the medium in itself (its instantiation in digital computers) and the extent to which its effects can be simulated in print (the reverse remediation that blurs the boundary between electronic media and print). As I suggested **[End Page 73]** earlier, MSA operates not so much through a simple binarism of similarity and difference as through media-specific considerations of instantiation and simulation.

Following these rules, I am able to score nine points, which are first listed and then discussed in detail.

Point One:	Electronic Hypertexts Are Dynamic Images.
Point Two:	Electronic Hypertexts Include Both Analogue Resemblance and Digital Coding.
Point Three:	Electronic Hypertexts Are Generated through Fragmentation and Recombination.
Point Four:	Electronic Hypertexts Have Depth and Operate in Three Dimensions.
Point Five:	Electronic Hypertexts Are Bilingual, Written in Code as well as Natural Language.
Point Six:	Electronic Hypertexts Are Mutable and Transformable.
Point Seven:	Electronic Hypertexts Are Spaces to Navigate.
Point Eight:	Electronic Hypertexts Are Written and Read in Distributed Cognitive Environments.
Point Nine:	Electronic Hypertexts Initiate and Demand Cyborg Reading Practices.

Point One: Electronic Hypertexts Are Dynamic Images

In the computer, the signifier exists not as a durably inscribed flat mark but as a screenic image produced by layers of code precisely correlated through correspondence rules, from the electronic polarities that correlate with the bit stream to the bits that correlate with binary numbers, to the numbers that correlate with higher-level statements, such as commands, and so on. Even when electronic hypertexts simulate the appearance of durably inscribed marks, they are transitory images that need to be constantly refreshed by the scanning electron beam that forms an image on the screen to give the illusion of stable endurance through time. This aspect of electronic hypertext can be mobilized through such innovations as dynamic typography, where words function as both verbal signifiers and visual images whose kinetic qualities also convey meaning (Hayles 1999b). In David Knobel's poem "Breathe" (2000), done in collaboration with Reiner Strasser, lines appear and disappear as the mouse touches colored rectangles, creating an effect similar to breathing in and out when reading poetry aloud. In Bill Marsh's "6-String Aria" (1999), strings dynamically fold and unfold to form the word *Aria* while an aria plays, creating a fusion **[End Page 74]** of sound, image, and text. Dan Waber's "Strings" (1999) performs a similar fusion through animated lines wriggling into words and shapes that visually and textually evoke an argument beginning and ending, a flirtation, and an embrace. Similar effects are achieved in a different way in Alan Dunning's artist's book *Greenhouse* (1989), which creates a multilayered reading experience by overlaying translucent vellum pages onto opaque pages. Significantly, the five lines of text on the opaque pages are taken from five of Dunning's favorite works of literary criticism, each line set in different typography and written by a different author. As the vellum pages are overlaid onto these, the literary criticism, already interleaved with other critical texts to form a kind of hypertext, is further modified by the visual play set up by the image and Dunning's words printed on the vellum pages.

An important difference between print and electronic hypertext is the accessibility of print pages compared, for example, to the words revealed by the cursor's click in Knobel and Strasser's electronic hypertext. Whereas all the words and images in the print text are immediately accessible to view, the linked words in Knobel's poem become visible to the user only when they appear through the cursor's action. Code always has some layers that remain invisible and inaccessible to most users. From this we arrive at an obvious but nevertheless central maxim: print is flat, code is deep.

Point Two: Electronic Hypertexts Include Both Analogue Resemblance and Digital Coding

The digital computer is not, strictly speaking, entirely digital. At the most basic level of the computer are electronic polarities, which are related to the bit stream through the analogue correspondence of morphological resemblance. Once the bit stream is formed, it operates as digital code. Analogue resemblance typically reappears at the top level of the screenic image, for example, in the desktop icon of a trash barrel. Thus digital computers have an Oreo cookie–like structure with an analogue bottom, a frothy digital middle, and an analogue top.[8] Although we are accustomed to thinking of digital in terms of binary digits, digital has a more general meaning of discrete versus continuous flow of information. Digital computers do not necessarily have to operate with binary code; in the early days of computing, computers were constructed using the base ten codes commonly used in counting.[9] These computers were digital not because they used binary code **[End Page 75]** but because they used discrete bit streams. Analogue computers, in contrast to digital ones, represent numbers as a continuously varying voltage. In analogue computers and analogue technologies in general, morphological resemblance connects one level of code with another. In this sense, iconographic writing is analogue because it bears a morphological resemblance to its referent (albeit in highly conventionalized ways), whereas alphabetic writing is digital, consisting of a few elements that can be combined to make many words, precisely because the relation between mark and referent is arbitrary (Logan 1986 makes this point). By contrast, iconographic writing requires a much larger symbol set because its elements tend to be almost as multiform as the concepts for which they stand; for example, written Chinese has over forty thousand characters.

Print books and digital computers both use digital and analogue modes of representation, but they mobilize the two modes differently. An example of a print book that makes conspicuous use of a digital algorithm is Emmett Williams's *The VoyAge* (1975), in which all the words are three letters long (to accommodate this restriction, Williams often resorts to creative spelling). Williams imposed the further requirement that spacing between the words increases as the page numbers go up. On page one, the three-letter words are separated by one space; on page two, by two spaces, and so on. The book ends when the number of spaces that must intervene before another word can appear is greater than the spaces available on the page. This example makes clear that the difference between print and electronic hypertext consists not in the presence or absence of digital and analogue modalities but rather in the ways these modes are mobilized as resources. In *VoyAge*, the effect of using a digital algorithm is to create visual patterns through the placement of words on the page, so that the words function simultaneously as analogue image and digital code. When the spacing brings all the words into a single column, for example, the narrator remarks: "NOW/WEE/GET/OUR/POE/EMM/ALL/INN/ONE/ROW" (Williams 1975). Typically the computer employs a digital mode at deeper coding levels, whereas in print, analogue continuity and digital coding both operate on the flat surface of the page.

Point Three: Electronic Hypertexts Are Generated through Fragmentation and Recombination

As a result of the frothy digital middle of the computer's structure, fragmentation and recombination are intrinsic to the medium. These textual strategies can also be used in print texts, for example, in Raymond Queneau's *Cent mille milliards de poèmes* (1961), a book in which each page may be cut **[End Page 76]** into several strips corresponding to the lines of a poem. By juxtaposing the cut strip on one page with strips from other pages, large numbers of combinations are possible, as indicated by Queneau's title. Another example is Dick Higgins's book *Buster Keaton Enters into Paradise* (1994). To generate this text, Higgins played thirteen games of Scrabble, each of which started with the words "Buster Keaton" orthogonally arranged. He then used the words that turned up in the Scrabble games to create thirteen skits, each corresponding to one of the games. Here fragmentation was achieved using the Scrabble letters, a technique that emphasizes the digital nature of alphabetic writing; recombination is mobilized through the aleatory combinations that make words and Higgins's subsequent use of these game words in the skits.

With digital texts, the fragmentation is deeper, more pervasive, and more extreme than with the alphanumeric characters of print. Moreover much of the fragmentation takes place on levels inaccessible to most users. This aspect of digital storage and retrieval can be mobilized as an artistic resource, reappearing at the level of the user interface. Stuart Moulthrop's "Reagan Library" (1999), for example, uses an algorithm that places prescripted phrases on the screen in random order. As the user revisits a screen, the text on that screen gradually becomes more coherent, stabilizing into its final order on a fourth

visit, whereupon it does not change further. As if to emphasize that noise is not merely interference but itself a form of information, Moulthrop has designed the piece so that one level of the text moves in the opposite direction from this trajectory. The screens in "Notes," which offer explanatory commentary, actually lose text as the user revisits them, becoming more cryptic and enigmatic the more they are read.

Point Four: Electronic Hypertexts Have Depth and Operate in Three Dimensions

Digital coding and analogue resemblance have specific advantages and are deployed so as to make the most of these advantages. Analogue resemblance allows information to be translated between two differently embodied material instantiations, as when a sound wave is translated into the motion of a vibrating diaphragm of a microphone. Whenever information flows between two differently embodied entities—for example, sound wave and microphone or microphone and recording device—analogue resemblance is likely to come into play because it allows one form of continuously varying information to be translated into a similarly shaped informational pattern in another medium. Once this translation has taken place, digital coding is used to transform the continuity of morphological form into numbers **[End Page 77]** (or other discrete codes). Intrinsic to this process is the transformation of a continuous shape into a series of code elements. In contrast to the continuity of analogue pattern, the discreteness of code enables information to be rapidly manipulated and transmitted.

Human readers, with sensory capabilities evolved through eons of interacting with three-dimensional environments, are much better at perceiving patterns in analogue shapes than performing rapid calculations with code elements.[10] When presented with code, humans tend to push toward perceiving it as analogue pattern. Although most of us learned to read using the digital method of sounding out each letter, for example, we soon began to recognize the shapes of words and phrases, thus modulating the discreteness of alphabetic writing with the analogue continuity of pattern recognition. The interplay between analogue and digital takes place in a different way with screenic text than with print, and these differences turn out to be important for human perception. With present-day screens, reading speed on screen is typically about 28 percent slower than with print (for an analysis of the factors affecting reading speed on screen, see Muter 1996). Although the factors causing this difference are not well understood, they undoubtedly have something to do with the dynamic nature of screen images. Text on screen is produced through complex internal processes that make every word also a dynamic image, every discrete letter a continuous process.

To distinguish between the image the user sees and the bit strings as they exist in the computer, Espen Aarseth (1997) has proposed the terminology *scripton* (the surface image) and *texton* (the underlying code). In a digital computer, texton can refer to voltages, strings of binary code, or programming code, depending on who the "reader" is taken to be. Scriptons always include the screen image but can also include any code visible to a user who is able to access different layers of program. Textons can appear in print as well as electronic media. Stipple engraving, although it is normally perceived by the reader as a continuous image, operates through the binary digital distinction of ink dot/no ink dot; here the scripton is the image and the ink dots are the textons.[11] In electronic media, textons and scriptons operate in a vertical hierarchy rather than through the flat microscale/macroscale play of stipple engraving. With electronic texts there is a clear distinction between scriptons that appear on screen and the textons of **[End Page 78]** underlying code, which normally remain invisible to the casual user. The flat page of print remains visually and kinesthetically accessible to the user, whereas the textons of electronic texts can be brought into view only by using special techniques and software.

In reverse remediation, some books play with this generalization by making print pages inaccessible. David Stairs has created a round artist's book entitled *Boundless* (1983) with spiral binding all around, so that it cannot be opened. A similar strategy is used by Maurizio Nannucci in *Universum* (1969), a book bound on both vertical edges so that it cannot be opened. Ann Tyler also plays with the assumption that pages are visually and kinesthetically accessible to users in *Lubb Dup* (1998), an artist's book in which several pages are double-faced, so that one can see the inside only by peering through a small circle in the middle or prying the two pages apart enough to peek down through the top. These plays on accessibility do not negate the generalization that the flat page is accessible to users, however, for their effect is precisely to make us conscious of the normative rule.

Point Five: Electronic Hypertexts Are Bilingual, Written in Code as Well as Language

Electronic hypertexts, like all electronic texts, consist of multiple layers of text that combine computer code

and natural language. Typically, natural language appears at the top (screenic) level, although it is also frequently found at lower coding levels in comment lines. More subtly, it serves as ground for the syntax and grammar of computer languages, which are specifically permeated, as Rita Raley (2001) has argued, with the linguistic structures and grammar of English. Working in a back-formation from electronic textuality, Jerome McGann has recently argued that print texts are also marked (by analogy with HTML, the hypertext markup language used to format documents for the Web). He argues further that print texts, like electronic documents, are coded and generated through algorithms. It is not difficult to agree that all texts are marked; for example, readers familiar with print conventions recognize an indentation as signaling a paragraph break and parse the text accordingly. Thinking of such textual markings as algorithmic, however, obscures the important distinction between processes enacted by the reader/user and those performed by the computer. An electronic text literally does not exist if it is not generated by the appropriate hardware running the appropriate software. Rigorously speaking, an electronic text is a *process* rather than an object, although objects (like hardware and software) are required to produce it. Moreover, an algorithm is normally considered to be a procedure defined by explicit rules that can be **[End Page 79]** specified precisely.[12] While some rules pertaining to the human understanding of texts can be specified, many literary (and more generally grammatical) practices are notoriously difficult to codify, in contrast to the explicit nature of computer instructions.

The fact that creators of electronic texts always write code as well as natural language has resulted in a significant shift in how writing is understood. Loss Pequeño Glazier (2002) and John Cayley (1998), among others, argue that programming *is* writing. They refuse the distinction between writing that appears on screen as the "real" creative effort, because they deeply understand, through their own creative practices, that screenic text and programming are logically, conceptually, and instrumentally entwined. Increasingly, writers working in electronic media exploit the word/code interplay by crafting a creole, visible on the screen, that comprises English and pseudoprogramming expressions. MEZ (Mary Ann Breeze), for example, has formulated a pidgin she calls "mezangelle," a bilingual practice that breaks the conventional link between phoneme and written mark, forging new connections between code and English.[13] In *Lexia to Perplexia* (2000), Talan Memmott formulates a creole that he uses to articulate a version of cyborg subjectivity in which the machine and the self (which he writes as "cell.f" to suggest its infection by the computational) conjoin in a union that is at once conceptual, linguistic, and technological.

McGann's redescription of print texts by terms normally employed for electronic texts can be understood as a critical (re)enactment of his editorial work with *The D. G. Rossetti Hypermedia Archive* (2001a), in which he has reproduced Dante Gabriel Rossetti's print texts on the Web. While pushing toward envisioning print texts in electronic terms, however, he also deeply understands that simulating print texts in electronic environments involves radically different materialities than the print texts in themselves. Along with many writers working in electronic media, he views the work of literary production as *making* and *doing*, not simply spewing out words seen as immaterial entities. It is no accident that McGann, with a background in bibliographic studies, frequently collaborates with Johanna Drucker, a maker of artists' books as well as a historian and critic of that genre. They share a rich appreciation for the materiality of literature and consequently for reading and writing as material practices. One can certainly arrive at this view without touching a computer, a point made by Loss Glazier (2002) **[End Page 80]** in his discussion of typewriter poetry, that is, poetry visually crafted to highlight the instrumental role of the typewriter in producing the text. It is virtually impossible, however, to create an electronic work *without* grasping the significance of the work as a materialist production. M. D. Coverley (2002) makes this point when she compares a print writer who types a sentence and sits back, satisfied, with a writer in electronic media. The electronic author who types the same sentence then goes on to consider what behaviors and animations should attach to the words, in what font and color they should appear, on what background and over (or under) what layers, to what other texts or structures they should be linked, and so forth. In all these activities, the hardware and software are active partners, facilitating and resisting, enabling and limiting, enacting and subverting. The labor needed to program these effects must be seen as intrinsic to the work of creation. Like the creator of an artist's book who manipulates an Exacto knife to make delicate cutouts in heavy white Italia paper and painstakingly sews the pages together, the writer of an electronic text is intensely aware of the entwining of intellectual, physical, and technological labor that creates the text as a material object.

Point Six: Electronic Hypertexts Are Mutable and Transformable

The multiple coding levels of electronic textons allow small changes at one level of code to be quickly magnified into large changes at another level. The layered coding levels thus act like linguistic levers, giving a single keystroke the power to change the entire appearance of a textual image. An intrinsic component of this leveraging power is the ability of digital code to be fragmented and recombined. Although the text appears as a stable image on screen, it achieves its dynamic power of mutation and

transformation through the very rapid fragmentation and recombination of binary code. In addition, the rapid processing of digital code allows programs to create the illusion of depth in screenic images, for example, in the three-dimensional landscapes of *Myst* or the layered windows of Microsoft Word.[14] In these cases, both scriptons and textons are perceived as having depth, with textons operating digitally through coding levels and scriptons operating analogically through screenic representation of three-dimensional spaces.

Print books can simulate the mutability of electronic texts through a variety of strategies, from semitransparent pages that overlay onto other **[End Page 81]** pages to more elaborate strategies. In Michael Snow's visual narrative *Cover to Cover* (1975), the sequence begins with a realistic image of a door, with the next image showing a man opening the door to go into a rather ordinary room. With each successive image, the previous representation is revealed as a posed photograph, for example by including the photographer in the picture. As one approaches the center of the book, the images begin shifting angles, and at the midpoint, the reader must turn the book upside down to see the remaining images in proper perspective. At the end of the book the images reverse order, so the reader then goes backward through the book to the front, a direction that is then implicitly defined as forward. To facilitate this shift in perspective, the book is bound on both sides, so that either cover can function as "front." Thus such fundamental aspects of the book as forward and backward, up and down, become mutable characteristics that change in the course of reading.

Similar strategies are employed in Karen Chance's *Parallax* (1987), where cutouts and reverse ordering are used to create two narratives, one from the point of view of a straight man who sees gay men as unwanted intrusions in his life, the other from the point of view of a gay man who sees his life threatened by straight people who refuse to acknowledge his existence. A different approach is taken by Tom Phillips in *A Humument: A Treated Victorian Novel* (1997). Phillips took William Mallock's obscure Victorian novel, *A Human Document*, and "treated" each page by creating images that left only a few words on each page untouched. These words are typically connected by pathways or "rivers" of white space, created by surrounding the white spaces between words and lines with colored backgrounds and images. As the rivers meander down the page, they are often arranged in ways that allow multiple reading paths. Other hypertextual effects emerge from the interplay of the words in the pathways, other "treated" text that remains partially visible, and the strikingly diverse images that the treated pages display. Through such manipulations, Mallock's text is made to mutate into an entirely new narrative. Phillips (1997: dustcover) writes: "I took a forgotten Victorian novel found by chance. I plundered, mined, and undermined it to make it yield the ghosts of other possible stories, scenes, poems, erotic incidents and surreal catastrophes which seemed to link with its wall of words." Although this book is not dynamic in the same sense as Java script, the hypertextual effects it achieves through mutation and transformation are complex and dynamically interactive.[15] **[End Page 82]**

Point Seven: Electronic Hypertexts Are Spaces to Navigate

Electronic hypertexts are navigable in at least two senses. They present to the user a visual interface that must be navigated through choices the user makes to progress through the hypertext; and they are encoded on multiple levels that the user can access using the appropriate software, for example, by viewing the source code of a network browser as well as the surface text. As a result of its construction as a navigable space, electronic hypertext is intrinsically more involved with issues of mapping and navigation than are most print texts.

M. D. Coverley's Web novel in progress, *The Book of Going Forth by Day* (in progress), illustrates how navigation becomes a signifying strategy for electronic hypertexts. Modeled after the spatial arrangement of Egyptian hieroglyphs, the interface employs both horizontal and vertical registers. The horizontal panels provide the narrative, while the vertical panels give linguistic, historical, and geographic information about ancient Egypt, modeled after the rubrics that in hieroglyphic texts give information on how to interpret the depicted events. The correspondences between Egyptian hieroglyphs and the interface suggest deep connections between inscription systems, cosmological beliefs, temporal orderings, and geographic assumptions. Ancient hieroglyphic inscriptions were written in all directions, including left to right, right to left, up to down, down to up, edging sideways into margins, or spiraling in a circle, with the order of reading indicated by the direction the figures face. *Going Forth* relates the omnidirectionality of this writing to ancient Egyptian beliefs about the "endless geometry" of the world, in which personages from the past continue over the threshold of death into the present and gods and goddesses manifest themselves in humans alive on the earth. *Going Forth* envisions its own inscription surface as a complex topology, a richly decorated and potentially infinite inscription surface that enables fluid transitions between exposition, narrative, maps, photographs, linguistic information, and historical context. *Going Forth* suggests that there was no clear distinction in ancient Egypt between writing and art.

Art did not so much imitate life as it imitated and was imitated by writing, which is another way to say that worldview and inscription system were intimately related. Transported into an electronic environment, these correlations take the form of complex relations between multimedia components and navigational functionalities in which meaning emerges from their interrelations rather than from the verbal narrative alone.

When navigation becomes an issue in a print text, the effect is usually to transform linear sequence into hypertextual multiplicity. In Susan E. King's **[End Page 83]** *Treading the Maze* (1993), the book is spiral-bound on both lateral edges. The binding on the left side holds pages displaying images on vellum; the binding on the right side holds blue opaque pages of verbal text. Different narrative orders are created by intermixing opaque and translucent pages. The author writes (on a page that most readers will not find until halfway through the book) that the most complete reading is achieved by turning back all the pages on both sides so the back cover is exposed, then interleaving one opaque page with one translucent page until one arrives at the front. In this reading the last two pages are successive translucent images that overlay a labyrinth onto a woman's body, so that the maze the reader has traversed is imaged at once as a human female body, an exploration of the labyrinth as a visual and conceptual form, and the body of the book experienced as a maze through which many paths may be traced.

Point Eight: Electronic Hypertexts Are Written and Read in Distributed Cognitive Environments

Modern-day computers perform cognitively sophisticated acts when they collaborate with human users to create electronic hypertexts. These frequently include acts of interpretation, as when the computer decides how to display text in a browser independent of choices the user makes. It is no longer a question of whether computers are intelligent. Any cognizer that can perform the acts of evaluation, judgment, synthesis, and analysis exhibited by expert systems and autonomous agent software programs should prima facie be considered intelligent. Books also create rich cognitive environments, but they passively embody the cognitions of writer, reader, and book designer rather than actively participate in cognition themselves.

To say that the computer is an active cognizer does not necessarily mean it is superior to the book as a writing technology. Keeping the book as a passive device for external memory storage and retrieval has striking advantages, for it allows the book to possess robustness and reliability beyond the wildest dreams of a software designer. Whereas computers struggle to remain viable for a decade, books maintain backward compatibility for hundreds of years. The issue is not the technological superiority of either medium but rather the specific conditions a medium instantiates and enacts. When we read electronic hypertexts, we do so in environments that include the computer as an active cognizer performing sophisticated acts of interpretation and representation. Thus cognition is distributed not only between writer, reader, and designer (who may or may not be separate people) but also between humans and machines (which may or may not be regarded as separate entities). **[End Page 84]**

Print books can also be structured in ways that create and emphasize distributed cognition. Examples are telegraph codebooks, which matched phrases and words used frequently in telegrams with code groups that were shorter and thus more economical to transmit. The more sophisticated of these codebooks included so-called mutilation tables, which enabled a user to reverse engineer a garbled message to figure out what code element ought to have been there instead of the incorrect element. In this way the distributed nature of the cognition became evident, for part of the cognition resided in the sender, part in the telegraph operator, part in the codebook, part in the mutilation table, and part in the receiver. At any point along this transmission chain, errors could be introduced, making clear that comprehension depended on all the parts working together correctly in this distributed cognitive system.

Point Nine: Electronic Hypertexts Initiate and Demand Cyborg Reading Practices

Because electronic hypertexts are written and read in distributed cognitive environments, the reader necessarily is constructed as a cyborg, spliced into an integrated circuit with one or more intelligent machines. (*Cyborg* is of course a neologism coined from cybernetic organism, part organic being, part machine.) To be positioned as a cyborg is inevitably in some sense to become a cyborg, so electronic hypertexts, regardless of their content, tend toward cyborg subjectivity. This subject position may also be evoked through the content of print texts (for example, William Gibson's *Neuromancer* [1984] and Pat Cadigan's *Synners* [1991]), but electronic hypertexts necessarily enact it through the specificity of the

medium. Of the nine points, this is the most difficult to simulate in book technology, which, for all of its sophistication in content and production, remains remarkably simple to use. Book lovers frequently evoke this quality of print, emphasizing that they enjoy books precisely because books do not interpolate them into the speed, obsolescence, and constant breakdown of electronic culture. This distinction between print and electronic forms is itself undermined, however, with the introduction of electronic books that look like print but have electronic hardware embedded in the spine that enable the pixels of the electronic "page" to be polarized in different patterns, so that one page can be any page. (Researchers at MIT Media Lab, among other developers, are experimenting with developing "electronic ink," in which each small segment comprising a letter form can change from white to black and vice versa when the electronic polarities change, thus allowing a given letter to mutate into a new letter or space. The ink is made of polymers **[End Page 85]** sensitive to electrical charges; because their colors change when the polarities change, the polymers function analogously to LCDs, liquid crystal displays.) Hybrid forms, like the electronic book, show reverse remediation in action: as books become more like computers, computers become more like books.

In the rich medial ecology of contemporary literature, media differentiate as well as converge. Attention to material properties enhances our understanding of how some digital works are evolving along trajectories that increasingly diverge from books as they experiment with the new possibilities opened up by electronic environments. This divergence is strikingly evident in the watershed dividing first-generation hypertexts, such as Michael Joyce's *Afternoon* (1987), from second-generation works, such as Talan Memmott's *Lexia to Perplexia* (2000). *Afternoon*, exemplary of early electronic hypertexts written in Storyspace software, has almost no graphics, and most of the links go from word to word or from paragraph to paragraph. Clicking on a link customarily takes the reader from one screen of text to the next. In retrospect, it is possible to see that the foundational assumption for this kind of linking comes from print books. Although the electronic linking structure differs from turning a page in that it offers multiple reading paths, it reproduces in electronic media the experience of flipping pages. By contrast, second-generation hypertexts mix words with graphics, sounds, images, animation, and a host of other multimedia components. Moreover the links go every which way, from word to navigational apparatus to image to mouseover to animated graphic. In the process, the foundational metaphor of the page as a two-dimensional plane mutates into a very different kind of experience. Instead, the textual space is increasingly represented as a topographic area to explore, with layered strata, hidden openings, crosscutting pathways, links between different world levels, and other spatial and temporal unfoldings that merge the functionality of the artifact—its material and processual properties—with the representations of the imagined world we create when we read.

In retrospect, we can see the view that the text is an immaterial verbal construction as an ideology that inflicts the Cartesian split between mind and body upon the textual corpus, separating into two fictional entities what is in actuality a dynamically interacting whole. Rooted in the Cartesian tradition, this ideology also betrays a class and economic division between the work of creation—the privileged activity of the author as an inspired genius—and the work of producing the book as a physical artifact, an activity relegated to publishers and booksellers. As the means of production moves into the hands of writers and artists for both print and electronic media with desktop publishing, fine letter presses run by artists' **[End Page 86]** collectives, such as the Visual Studies Workshop Press, and electronic publishing on the Web, the traditional split between the work of creation and the work of production no longer obtains. This shift in the economic and material circumstances in which literary works are produced makes all the more urgent the challenge of rethinking critical and theoretical frameworks accordingly. We can no longer afford to pretend that texts are immaterial or that text on screen is the same as text in print. The immateriality of the text has ceased to be a useful or even a viable fiction.

In urging increased attention to materiality, I hope it is clear that I do not mean to argue for the superiority of electronic media. Rather, I have been concerned to delineate characteristics of digital environments that writers and readers can use as resources in creating electronic literature and responding to it in sophisticated, playful ways. I have also shown how in many cases similar—but not identical—effects can be achieved in print books, as well as describing electronic effects difficult or impossible to duplicate in print. Whether in print or on screen, the specificity of the medium comes into play as its characteristics are flaunted, suppressed, subverted, reimagined.

Many critics see the electronic age as heralding the end of books. I think this view is mistaken. Books are far too robust, reliable, long-lived, and versatile to be rendered obsolete by digital media. Rather, digital media have given us an opportunity we have not had for the last several hundred years: the chance to see print with new eyes and, with that chance, the possibility of understanding how deeply literary theory and criticism have been imbued with assumptions specific to print. As we continue to work toward critical practices and theories appropriate for electronic literature, we may come to renewed

appreciation for the specificity of print. In the tangled web of medial ecology, change anywhere in the system stimulates change everywhere in the system. Books are not going the way of the dinosaur but the way of the human, changing as we change, mutating and evolving in ways that will continue, as a book lover said long ago, to teach and delight. **[End Page 87]**

N. Katherine Hayles, Hillis Professor of Literature at the University of California, Los Angeles, teaches and writes on the relations of literature, science, and technology in the twentieth and twenty-first centuries. Her recent book, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics* (1999), was awarded the Rene Wellek Prize for the Best Book in Literary Theory in 1998–1999. Her latest book, *Writing Machines* (2002), won the Susanne Langer Award for Outstanding Scholarship. Her current book project is entitled "Coding the Signifier: Rethinking Semiosis from the Telegraph to the Computer."

References

Aarseth, Espen J.
1997 *Cybertext: Perspectives on Ergodic Literature* (Baltimore, MD: Johns Hopkins University Press).

Barthes, Roland
1986 "From Work to Text," in *The Rustle of Language*, translated by Richard Howard, 56–64 (New York: Hill and Wang).

Berlinski, David
2000 *The Advent of the Algorithm: The Idea That Rules the World* (New York: Harcourt Brace).

Bolter, Jay David
1991 *Writing Space: The Computer, Hypertext, and the History of Writing* (Hillsdale, NJ: Lawrence Erlbaum).

Bolter, Jay David, and Richard Grusin
1999 *Remediation: Understanding New Media* (Cambridge: MIT Press).

Bush, Vannevar
1945 "As We May Think," *Atlantic Monthly*, July, 101–8.

Cadigan, Pat
1991 *Synners* (New York: Spectra).

Cayley, John
1998 "Of Programmatology," *Mute* 11 (fall): 72–75.
forthcoming "Literal Art: Neither Lines nor Pixels but Letters," in *First Person: New Media as Story, Performance, and Game*, edited by Noah Wardrip-Fruin and Pat Harrigan (Cambridge: MIT Press).

Chance, Karen
1987 *Parallax* (Atlanta, GA: Nexus).

Coover, Robert
2000 [1969] "The Babysitter," in *Pricksongs and Descants* (New York: Grove).

Coverley, M. D.
2002 Personal communication with author, July.
in progress *The Book of Going Forth by Day*. Available at califia.hispeed.com/Egypt

DeLillo, Don
1998 *Underworld* (New York: Scribner).

Douglas, Jane Yellowlees
1994 "'How Do I Stop This Thing?': Closure and Indeterminacy in Interactive Narratives," in *Hyper/Text/Theory*, edited by George P. Landow, 159–88 (Baltimore, MD: Johns Hopkins University Press).
2000 *The End of Books—or Books without End? Reading Interactive Narratives* (Ann Arbor: University of Michigan Press).

Drucker, Johanna
1996 *The Visible Word: Experimental Typography and Modern Art, 1909–1923* (Chicago: University of Chicago Press).

Dunning, Alan
1989 *Greenhouse* (Calgary: Alan Dunning).

Friedman, Menahem, and Abraham Kandel
1999 *Introduction to Pattern Recognition: Statistical, Structural, Neural, and Fuzzy Logic Approaches* (London: Imperial College Press).

Gibson, William
1984 *Neuromancer* (New York: Ace).

Glazier, Loss Pequeño
2002 *Dig[iT]al Poet(I)(c)s: The Making of E-Poetries* (Tuscaloosa: University of Alabama Press). **[End Page 88]**

Hayles, N. Katherine
1999a "Simulating Narratives: What Virtual Creatures Can Teach Us," *Critical Inquiry* 26 (1): 1–26.
1999b "Virtual Bodies and Flickering Signifiers," in *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*, 25–49 (Chicago: University of Chicago Press).
2002 *Writing Machines* (Cambridge: MIT Press).

2003 "Translating Media: Why We Should Rethink Textuality," *Yale Journal of Criticism* 16 (263–90).

Higgins, Dick
1994 *Buster Keaton Enters into Paradise* (New York: Left Hand).

Joyce, Michael
1987 *Afternoon: A Story* (Watertown, MA: Eastgate Systems).

King, Susan E.
1993 *Treading the Maze: An Artist's Book of Daze* (Rochester, NY: Visual Studies Workshop).

Knobel, David, with Reiner Strasser
2000 "Breathe." Hypertext poem available online at www.workxspace.de/valentine/val_va.

Landow, George
1997 *Hypertext 2.0: The Convergence of Contemporary Critical Theory and Technology* (Baltimore, MD: Johns Hopkins University Press).

Le Guin, Ursula K.
1987 *Always Coming Home* (New York: Bantam).

Locke, John
1988 [1690] *Two Treatises of Government*, edited by Peter Laslett (Cambridge: Cambridge University Press).

Logan, Robert K.
1986 *The Alphabet Effect* (New York: William Morrow).

Macpherson, C. B.
1962 *Political Theory of Possessive Individualism: Hobbes to Locke* (Oxford, U.K.: Clarendon).

Marsh, Bill
1999 "6-String Aria." Hypertext available online at www.factoryschool.org/btheater/works/6strA/aria.html.

McDaid, John
1993 *Uncle Buddy's Phantom Funhouse* (Watertown, MA: Eastgate Systems).

McGann, Jerome
1991 *The Textual Condition* (Princeton, NJ: Princeton University Press).
2001a *The D. G. Rossetti Hypermedia Archive*, available at www.iath.virginia.edu/rossetti/fullarch.html (accessed July 2002).
2001b *Radiant Textuality: Literature after the World Wide Web* (New York: Palgrave).

McLuhan, Marshall
1994 [1964] *Understanding Media: Extensions of Man* (Cambridge: MIT Press).

Memmott, Talan
2000 *Lexia to Perplexia*. Web media work available at www.uiowa.edu/~iareview/tirweb/hypermedia/talan_memmott/index.html (accessed July 2002).

MEZ [Mary-Anne Breeze]
2001 "The Data][H][Bleeding Texts." Hypertext available at netwurkerz.de/mez/datableed/complete (accessed July 2002).

Moulthrop, Stuart
1999 "Reagan Library," in *Gravitational Intrigue*, CD-ROM, *Little Magazine*. Multimedia hypertext available at iat.ubalt.edu/moulthrop/hypertexts/RL (accessed July 2002).

Muter, Paul
1996 "Interface Design and Optimization of Reading of Continuous Text," in *Cognitive* **[End Page 89]** *Aspects of Electronic Text Publishing*, edited by H. van Oostendorp and S. de Mul (Norwood, NJ: Ablex). Accessed online at www.psych.utoronto.ca/~muter/pmuter1.htm (July 2002).

Nannucci, Maurizio
1969 *Universum* (n.p.: Biancoernero).

Pavic, Milorad
1989 *Dictionary of the Khazars: A Lexicon Novel*, translated by Christina Pribicevic-Zoric (New York: Vintage).

Phillips, Tom
1997 *A Humument: A Treated Victorian Novel*, 2d rev. ed. (London: Thames and Hudson).

Queneau, Raymond
1961 *Cent mille milliards de poèmes* (Paris: Gallimard).

Raley, Rita
2001 "Reveal Codes: Hypertext and Performance," *Postmodern Culture* 12.1. Web-based journal available at www.iath.virginia.edu/pmc/issue.901/12.1raley.html (accessed July 2002).

Rose, Mark
1993 *Authors and Owners: The Invention of Copyright* (Cambridge: Harvard University Press).

Shillingsburg, Peter
1996 *Scholarly Editing in the Computer Age: Theory and Practice*, 3d ed. (Ann Arbor: University of Michigan Press).

Snow, Michael
1975 *Cover to Cover* (Halifax: Press of the Nova Scotia College of Art and Design).

Stairs, David
1983 *Boundless* (n.p.: D. Stairs).

Tyler, Ann
1998 *Lubb Dup* (Chicago: Sara Ranchouse).

Waber, Dan
2000 "Strings," *Vispo*. Electronic hyptertext available online at vispo.com/guests/DanWaber/index.html.

Watanabe, Satoshi
1985 *Pattern Recognition: Human and Mechanical* (New York: Wiley).

Williams, Emmett
1975 *The VoyAge* (Stuttgart: Edition Hansjörg Mayer).

Zimmerman, Philip
1993 *High Tension* (Rochester, NY: Visual Studies Workshop).

Footnotes

Portions of this essay have appeared in the Web-based journal *Postmodern Culture* (January 2000) under the title "Flickering Connectivities in Shelley Jackson's *Patchwork Girl*: The Importance of Media-Specific Analysis." An early version was presented at the Interactive Frictions Conference held at the University of Southern California in June 1999. I am grateful to the following people for granting me access to their impressive collections of artists' books: Jennifer Tobias, reference librarian at the Museum of Modern Art in New York; Joan Lyons, director of the Visual Studies Workshop Press in Rochester, New York; David Platzker at the Printed Matter Bookstore in New York; and Nexus Press in Atlanta, Georgia. I wish to thank Fred and Virginia Brandes of Atlanta, Georgia, for kindly giving me access to their excellent collection of telegraph codebooks and for their generous hospitality during my visit there. Finally, I am indebted to Michael Fadden for his help in preparing the manuscript and to Carol Wald for discussions related to this topic.

1. In many ways this is a return to the agenda set by Marshall McLuhan (1994 [1964]). The recent turn in literary studies of earlier periods toward a consideration of the physical characteristics of books is also related to my arguments here, as Jerome McGann (1991, 2001b) clearly demonstrates. See also Douglas Brooks's essay in part I of this special issue (vol. 24, no. 4) for a critical consideration of the field of book history.

2. For another account of a reading practice that negotiates with materiality while cautioning against the subordination of interpretation to materialism, see James A. Knapp's article in part I of this special issue.

3. Mark Rose (1993: 121) explicitly draws this comparison between liberal economic philosophy and the construction of literary property. Locke's (1988 [1690]) analysis appears in the Second Treatise.

4. Among these exceptions is the long tradition of shaped poetry, including concrete poetry in the twentieth century. Loss Glazier (2002) has an excellent survey of materialist poetics in both print and electronic media.

5. For example, Peter Shillingsburg (1996: 46) argues that "it is possible for the same text to be stored in a set of alphabetic signs, a set of Braille signs, a set of electronic signals on a computer tape, and a set of magnetic impulses on a tape recorder." His conflation of radically diverse media, all qualifying as the "same text," illustrates the problems that a disembodied view of texts engenders. For a fuller version of my argument that texts are embodied, see Hayles 2003.

6. In view of the importance of a book's physicality, particularly artists' books, where the book's material appearance and operation may be crucial, I write only about books that I have had the opportunity to see and handle.

7. I am grateful to Jane Douglas for making her book available to me in manuscript before it was published.

8. For an exploration of what this Oreo structure signifies in the context of virtual narratives, see Hayles 1999a.

9. ENIAC, the first large-scale electronic computer, operated with a code that used base ten.

10. For a discussion of the comparative ease with which computers and humans recognize patterns, see Satoshi Watanabe's (1985) somewhat dated but still useful analysis. For a more recent assessment, see Friedman and Kandel 1999.

11. I am indebted to Robert Essick for this example, proposed in a discussion of William Blake's strong dislike of stipple engraving and his preference (which for Blake amounted to an ethical issue) for printing technologies that were analogue rather than digital.

12. For an extensive discussion on the history and development of the idea of the algorithm, see David Berlinski 2000.

13. See, for example, MEZ 2001, which contains the explanation ".these t.ex][e][ts r _code wurk_ remnants d-voted to the dispersal of writing that has been n.spired and mutated according 2 the dynamics of an active network."

14. To create the illusion of three-dimensional landscapes, the computer takes thin horizontal slices that can be approximated as two-dimensional and stacks them together. This requires massive calculations and would be impossible without the very rapid fragmentation and recombination that contemporary computers utilize.

15. For a fuller discussion of the materiality of *A Humument* and how it serves as a resource for meaning, see Hayles 2002.