Machine Enhanced (Re)minding: the Development of Storyspace

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Abstract

This article traces the history of Storyspace, the world's first program for creating, editing and reading hypertext fiction. Storyspace is crucial to the history of hypertext as well as the history of interactive fiction. It argues that Storyspace was built around a topographic metaphor and that it attempts to model human associative memory. The article is based on interviews with key hypertext pioneers as well as documents created at the time.

Note: This article is an extract from Belinda's forthcoming book, *Memory Machines: The Evolution of Hypertext* (Anthem Press, UK (2013)). The book is largely based on interviews with the original hypertext pioneers. Copies can be pre-ordered from the publisher.

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> Re:minding. And yet. But still. (*Mais encore*) Still flowing. (Michael Joyce, *unpublished manuscript*, [Joyce 2011a, 3])

Michael Joyce has kept a journal for many years. Before he begins to write, he inscribes the first page with an epigram: "Still flowing". As anyone who has read Joyce's fictions or critical writing will attest, his work is replete with multiple voices and narrative trajectories, a babbling stream of textual overflow interrupted at regular intervals by playful, descriptive whorls and eddies. If there is a common thread to be drawn between his hyperfictions, his academic writing and his novels, then it is this *polyglot dialogue*, as Robert Coover terms it — a lyrical stream of consciousness. Joyce can tell a story. And he has told many stories: four books, forty scholarly essays, and at last count (my count), a dozen fictions.[1] What courses through this work is a gentle concern, or even fixation, with how stories are told, with "how we make meaning, as if a caress" [Joyce 2004, 45]. The metaphor of water is an appropriate one. Like Ted Nelson, who had his first epiphany about the nature of ideas and the connections between them as he trailed his hand in the water under his grandfather's boat, Joyce has long been concerned with how to represent a multiplicity of ideas and their swirling interrelationships, with how stories change over time. In the essay "What I Really Wanted to Do I Thought", about the early development of Storyspace, Joyce writes:

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> What I really wanted to do, I discovered, was not merely to move a paragraph from page 265 to page 7 but to do so almost endlessly. I wanted, quite simply, to write a novel that would change in successive readings and to make those changing versions according to the connections that I had for some time naturally discovered in the process of writing and that I wanted my readers to share. [Joyce 1998, 31]

That novel, of course, would become *afternoon* , the world's first hypertext fiction [Joyce 1987]. The development of Storyspace is, at least in part, the story of Joyce's quest to find a structure for what did not yet exist, or as he wrote in a lengthy document created at the time called the Markle Report (see note on sources[2]), to find "a structure editor...for creating 'multiple fictions'" [Bolter and Joyce 1986, 12].

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As I have argued elsewhere,[3] the early hypertext systems were built to embody particular visions about how the human mind and memory work, to represent the "complex interconnections" that hold between ideas. Each system (re)presented a different model of these interconnections and of the perceived complexity underlying a mass of information. As Jay David Bolter put it in 1991, "electronic symbols...seem to be an extension of a network of ideas in the mind itself" [Bolter 1991, 207] (also cited by [Joyce 1998, 23]). Storyspace is no exception; Joyce intuitively felt that stories disclose themselves in their "connectiveness," and that "we are associative creatures. That's what we do" [Joyce 2011b]. Unlike the hypertext pioneers van Dam, Engelbart, Nelson or Bush, however, Joyce is first and foremost a writer – and Storyspace was designed for writers. The image of potentiality that guided Joyce was consequently a literary one; it started with an idea for a novel.

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In every interview Joyce has given about *afternoon* or the development of *Storyspace*, the leitmotif of a "story that changes each time you read it" returns like a Wagnerian melody. Joyce's writing is filled with such recurrences, with images and phrases that return again and again; "recurrence is the sounding of memory in air," he writes in *Othermindedness* [Joyce 2004, 97]. As Stuart Moulthrop observed in response to this article, the name "Joyce" is also an echo, "an echo he won't acknowledge for fear of trading on homonymity" [Moulthrop 2011]. Joyce, keen as always to create a self-reflexive eddy in the text, has a response to that response)[4]. This particular image, the image of a multiple fiction, is important enough that it appears verbatim or near verbatim in many of his essays on hypertext (e.g., [Joyce 1998, 31] [Bolter 1991, 247] [Joyce 2004, 123] as a "multiple" story).

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Although he is quick to point out that "it wasn't a matter of just bringing a set of ideals and aspirations to Bolter," and then building a system to do that [Joyce 2011b], the idea of a novel that changes with each reading was obviously important to him, based on its longevity in his own work. In our interview, he actually corrected my phrasing: "forgive this, this is like an English teacher, it's not *every* reading in the sense of every different reader, but I said *each* reading, and I had in mind readers who would go back to a text again and again" [Joyce 2011b]. If Storyspace has an origin legend, then it begins with this multiple fiction; in Vassar College's version of the tale, Joyce "looked at his little Apple II in the early 80s and said I'll bet you could do a story that would change every [sic] time you read it. He called around, looking for such software, and it didn't exist" [Vassar College 1992]. Apocryphal stories aside, what is clear is that as a novelist, Joyce was thinking about the process of writing, and even more importantly, about the internal connections that exist in stories - connections that might, with the aid of a computer, be shaped by potential readers.

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In the early 80s, as a classics professor working at the University of North Carolina, Chapel Hill, Jay David Bolter was also thinking about the computer as a writing space, and about the connections that hold between ideas. His department had been pioneering research into the computerization of classical scholarship since 1975, led by David Packard (son of billionaire computing pioneer David Packard, Sr., the co-founder of Hewlett Packard). Unlike his contemporaries, and crucially for the future of humanities computing, Bolter had a background in computer engineering. He completed a Masters in Computer Science in 1978 as well as a PhD in Classics in 1977, both from UNC, and he was a member of the Committee for Computer Applications (APA) beginning in 1981[5].

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As a classics student at UNC in the late 70s, he remembers in our interview, he was the "only student in the class who had a computer science background" [Bolter 2011]. He became Packard's assistant for a couple of years and worked on his pioneering mini-computer system IBYCUS.

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IBYCUS was the first computer to allow the editing, search, and retrieval of classical texts in a fully integrated desktop package[6]. When Packard left UNC, he left his computer there and Bolter was responsible for running IBYCUS for a few more years.

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> This was really my first important humanities application and it was at that time that I started thinking about the impact of the computer as a technology, which led to my book *Turing's Man* [Bolter 2011].

Consequently, when he started working with Joyce in 1983, Bolter had already been thinking about the relationship between computing and classical scholarship for a few years[7]. Joyce remembers he "felt drawn to Jay's vision because he was concerned with questions of how the epic narrator, how the Homeric narrator, adjusted stories so they changed" [Joyce 2011b].

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Computing science was engaged in a love affair with AI in the 70s and 80s; it was particularly intent on modeling the perceived structure of the human mind and memory, imitating nature and improving on it (a topic that Bolter critiques in the first edition of *Writing Space* [Bolter 1991, 171175], unfortunately removed from the second edition published in 2001). Both Joyce and Bolter spent a year as Visiting Fellows at the Yale AI Project, Bolter from 1982 to 1983 and Joyce from 1984 to 1985. Bolter recalls there was "a general paradigm of representation that AI was following at the time, which was the concept of basically linked structures, interlinked structures, nets of ideas" [Bolter 2011], a concept that was also central to Storyspace. "Crucially," he recalls, "the AI community didn't see this as writing, they saw it as thinking, in other words they thought they were [actually] modeling the mind" [Joyce 2011b].[8]

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From 1980 to 1987, there was a second "boom" in this area and large amounts of money were available for research[9]. It was a glamorous field, and both Bolter and Joyce felt the gravitational pull of it. In the Markle Report they note that their "collaboration stems from, and has been energized by, work in artificial intelligence" [Bolter and Joyce 1986, 12]. It might be worth reflecting at this point that, whereas the project of hypertext has been all too successful with the proliferation of the web, AI remains arguably fictional[10]. In the 1980s however, there was a brief resurgence of hope as the new technology of "expert systems" and artificial neural networks picked up steam.

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Given the prominence they ascribe to this research, I will briefly explore some of the work produced at Yale here. Joyce in particular was influenced by the ideas of the indomitable Roger Schank, Director of the Yale AI Project and author of a seminal book in AI called *Dynamic Memory*, first published in 1982. (It has subsequently been revised. The 1999 edition is the one I will be referring to here.) Joyce picked up the term *remindings* from Schank's work, probably from this book, noting in *Of Two Minds* that Schank is "nearly alone in artificial intelligence researchers in using the computer as a test bed for expressing representations of thought" [Joyce 1998, 165].

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He also spent a couple of years corresponding with Natalie Dehn, a researcher at Schank's lab, who used the term extensively in her work on story-generation programs[11]. When Joyce first began corresponding with Dehn in 1983, she was working on a story generation program called TALE-SPIN that attempted to simulate an author's mind as she makes up a story [Dehn 1981]. The ideal structure editor, write Bolter and Joyce in the Markle Report, would facilitate "machine enhanced reminding" [Bolter and Joyce 1986, 40].

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For Dehn, the process of writing is deeply influenced by the author's own memory: "This memory needs to contain not only facts about the storyworld thus far constructed, but also prior knowledge of memorable episodes, characters, etc., in the author's life" [Dehn 1981]. TALE-SPIN was an "AI attempt at story generation" by making up Aesop-fable-like stories that were the consequence of a particular storyworld. It was a world simulator, and this world included the characters that lived in it and their goals and motivations. TALE-SPIN behaved, in effect, like an author's memory. It had to keep track of these characters and their specific environment, access the material, and reformulate the narrative based on these items. To explain and describe this process of reformulation and retrieval she also borrowed the term *reminding* from Schank.

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For Roger Schank, *reminding* describes the association of episodes in human memory, and the *remodeling* that takes place upon recall (hence the title of his book, *Dynamic Memory*). A library does not have a dynamic

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memory; it changes with great difficulty. Human memory, on the other hand, is constantly rewriting the connections between episodes and changing the categorizations and associative trails of information. It does not recall information so much as reconstruct it (hence, re-mindings, not just bringing episodes to mind again and again, but building them afresh each time).

In the early 80s, there were specific research questions that concerned Schank at the Yale AI lab:

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> When we process events as they happen, we need to find particular events in memory that are closely related to the current input we are processing. But how do we define relatedness? What does it mean for one experience to be like another? Under what labels, using what indices, do we look for related episodes? [Schank 1999, 21].

These are questions about the relationship between ideas, and how the mind snaps instantly from one item to another, to paraphrase Bush. They were also questions, Joyce recalls, that made sense to him during his fellowship. He would sit with Dehn and members of Schank's group and "once they got over the initial hump of my being the story generation person, there was this wonderful sense that they were concerned with questions that I could recognize as a writer" [Joyce 2011b].

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From early on in the piece, due to the high profile of this field and their involvement with it, Bolter and Joyce evidently felt the need to stress that Storyspace was not AI: "We hasten to note," they wrote in 1986, "that STORYSPACE in [no] way embodies what could legitimately be called AI" [Bolter and Joyce 1986, 33]. Such an observation would be entirely unnecessary for a hypertext system now, but in 1986, by contrast, most "computer people" who were tinkering with networks were doing AI[12], as they go on to note with no small sense of irony; "we may be among a very small number of current software developers who do not claim to be doing AI" [Bolter and Joyce 1986, 34].

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Bolter published a book shortly after his fellowship at Yale that would become a classic in computing studies *Turing's Man: Western Culture in the Computer Age* (1984). In *Turing's Man*, he sets out to "foster a process of cross-fertilization" between computing science and the humanities and to explore the cultural impact of computing [Bolter 1984, xii][13]. He also introduces some ideas around "spatial" writing that would recur and grow in importance in his later work; in particular, the relationship between early Greek systems of place-memory loci (the art of memory) and electronic writing.

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The seeds behind Bolter's oft-cited and influential observation from *Writing Space* (1991) that hypertext "is not the writing of a place, but rather a writing with places, spatially realized topics" [Bolter 1991, 25] germinated here, in the early 80s, in his reflections on computers and the classical arts. The classical art of memory represented information by attributing to it spatial characteristics, and similarly, "the computer makes a geometer out of anyone with a computational problem to solve" [Ayer 1984, 99]. In the chapter on "Electronic Memory", Bolter writes:

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> The computer…offers us a "new dimension" in the representation of information. In building such structures, computer memory is associative rather than linear. It allows us to follow networks of association in our data, as indeed human memory does. This fact was particularly appreciated in the oral culture of Greece and Rome [Bolter 1984, 163].

Bolter's ideas around "topographic writing" were nascent when he started collaborating with Joyce in September 1983 [Bolter and Joyce 1986, 10]. They would later have a profound influence over hypertext theory and criticism, and also the Storyspace system; from the outset, the nodes in Storyspace were called "writing spaces," and it worked explicitly with topographic metaphors, incorporating a graphic "map view" of the link data structure from the first version, along with a tree and an outline view (which are also visual representations of the data). "The tree," Bolter tells us in *Turing's Man*, "is a remarkably useful way of representing logical relations in spatial terms" [Bolter 1984, 86]. Also in line with the topographic metaphor, writing spaces in Storyspace acted (and still act) as containers for other writing spaces; an author literally "builds" the space as she traverses it, zooming in and out to view details of the work, the map making the territory. This is an important point. "The whole thing about Storyspace was – the big thing about Storyspace [was] – you could write hypertext hyper-textually" as Adrian Miles put it in an interview with the author [Bolter 2011].

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In his 1991 book *Writing Space*, Bolter uses the term *topography* to incorporate both its original use as a description of a place and its later use as the act of "mapping or charting" [Bolter 1991] Topographic writing is "both a visual and a verbal description," and the design of Storyspace reflected this; as "the line, the tree and the network all become visible structures at the writer's and reader's disposal" [Bolter 1991, 114].

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Many of the early pre-web hypertext fictions were written in Storyspace. Some were not – including Judy Malloy's beautiful "narrabase" programs that generated stories that *changed each time you read them*, by randomizing retrieval from a database (the most famous of these is *Uncle Roger*, 1986, available on the web[14]). We might also include here John McDaid's *Uncle Buddy's Phantom Funhouse,* which was produced in Hypercard (1992). This also makes use of a navigational "map" and topographic metaphor. Both Malloy's and McDaid's work remarkably prefigure the movement in contemporary e-literature toward what Victoria Vesna, following Lev Manovich, calls "database aesthetics" [Vesna 2007] (Thanks to Michael Joyce for this reference).

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Those hypertexts that were written in Storyspace had a strange "preoccupation with the 'topography' of hypertext" [Ciccoricco 2007, 197]. The metaphor also seemed to stick in hypertext theory for many years; Joyce (1998), Moulthrop (1995), Dickey (1995), Landow (1992), Nunes (1999), Tolva and Johnson-Eilola (1993), to name but a few of the "first wave" theorists, explicitly conjure images of exploration and map-making to describe the aesthetics of hypertext, due in no small part to Storyspace and to Bolter's book, *Writing Space* (we will be discussing Interactive Fiction later in this piece). "Our current obsession with the creation of interactive, virtual spaces is a sign of the revival of certain features of the art of memory," observes Darren in *Memory Trade* [Tofts 1998]. Some ideas, as Howard Rheingold wrote in *Tools For Thought* over twenty years ago, are like viruses: "if they are released at the right moment, they can infect an entire culture" [Rheingold 1985, 128].

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At the time he started working with Bolter, Joyce had ambitions of his own; he wanted to write a book that changed with each reading, as we have seen. According to the Markle Report, which was written entirely by Joyce even though Bolter appears as an author (see note on sources), he was also "insistent on the non-hierarchical and associative working habits" of writers [Bolter and Joyce 1986, 24]. After they were introduced by Natalie

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Dehn in 1983, they quickly began "a deeply engaged discussion about storytelling and what kind of associative thinking we each understood" [Joyce 2011b]. They didn't have a formal model at the time, "not like a formal AI-like model or psychological model," just some concepts that were working through in their own writing. Joyce recalls that they would talk every day on the telephone, "this was well before we were habituaries of email," and that these discussions were thrilling for both of them; "it was the most profound intellectual period of my life" [Joyce 2011b]. In the manner of all great partnerships, the collaboration would change the arc of their creative vectors far into the future; Joyce would later have "trouble distinguishing where Bolter's thought leaves off and mine begins" [Joyce 1998, acknowledgements].

It is interesting to note that Joyce is still playing with the idea of memory and "re:mindings" in his work, "in the same way that narrative reforms our understandings of our world and ourselves"; his unpublished manuscript is called *Re: minding, Essays After-net* [Joyce 2011a]. Bolter, of course, would go on to write *Remediation: Understanding New Media* with his colleague Richard Grusin (2000), which developed a model for reminding in the digital era: in this book, Grusin and Bolter argue that visual media achieve their cultural significance by remodeling or reworking earlier media (hence *re*mediation). There is a double logic to remediation; contradictory impulse towards both immediacy and hypermediacy. "Our culture wants both to multiply its media and to erase all traces of mediation: ideally it wants to erase its media in the very process of multiplying them" [Bolter and Gruskin 2000, 5]. To put it crudely, we would like to have the most all-encompassing, rich sensory experience possible, while "forgetting" that this experience has been shaped in advance by the media that enable it.

When I put it to Bolter that the concept of remindings may have been influential for him personally, he replied that he would "put that back on Michael":

> I think that Michael was always very interested in the notion of memory and its relationship to storytelling. And I think he always [had this] vision of a technological medium that would somehow capture or do justice to the complex process of memory and reminding. [Bolter 2011]

We might call this a tool for machine-enhanced reminding, or the "Mind as a Writing Space", to paraphrase one of Bolter's chapter titles from *Writing Space* (1991, removed from the second edition, 2001). Bolter wanted to emphasize in our interview that he never believed hypertext to be any more than a metaphor for how human mind or memory works [Bolter 2011].

The thing about technological visions is that they change. In particular, they change as they are being built into artifacts. Computer languages and hardware have their own limits and capacities, and these impact on the direction of development projects. Andrew Pickering calls this dance, this mutually constitutive dance between vision and artifact, the "mangle of practice". When Bolter and Joyce first started tinkering with an early software experiment for the IBM PC to "try out" some of these ideas, this was precisely what happened; their ideas evolved in tandem with the software experiments.

In the Markle Report, Joyce refers to an early program Bolter brought to their discussions called TEXT [Bolter and Joyce 1986, 12]. According to Joyce, this "was a kind of offering," something to "try out the ideas we were having about what we understood narrative and thinking to be" [Joyce 2011b]. Bolter believes this program was called GLOSSA – "TEXT or GLOSSA, the names were changing rather casually at that point"[15] [Bolter 2011] – but either way the name is not important. Joyce was primarily using an Apple II at this stage; he soon acquired a Macintosh ("not, however, before he purchased an Apple Lisa [using grant money] for something like $11,000, or $9.8 billion in today's money," adds Stuart Moulthrop in the margin of this article[16]). GLOSSA was written for the IBM PC in Pascal, one of the high-level development languages in use at the time[17]. The precursors of Storyspace, TALETELLER, TALETELLER 2, and also the original Storyspace, were all written in Pascal - and by 1985, when both Joyce and Bolter were using Macs, Apple had its own Mac Pascal[18]. Once converted to Mac, Bolter and Joyce were committed – "once we went to the Mac, we never went back" [Bolter 2011].

One of the most basic and enduring tools in Pascal is linked lists, which is a simple way to store and present "elements" using pointers to indicate the next element (or "node") in a list. In our interview Bolter pointed out that he had taken a lot of computer science courses, and "linked lists obviously are the key to thinking about hypertext, if you want to implement it in the most obvious way" [Bolter 2011]. GLOSSA was a basic implementation in this sense, based on Bolter's experience with classical texts. "You'd tab a text and then you'd be able to associate notes with any particular word or phrase in the text. . .an automated version of classical texts with notes" [Bolter 2011]. It wasn't clickable because the IBM PC wasn't clickable at the time; the user would move the cursor over the word and select it. This linked data structure formed the basis for their future experiments "but only in the sense that it had this quality of one text leading to another" [Bolter 2011].

In his well-researched chapter on *afternoon*, Matthew Kirschenbaum suggests that Storyspace has "significant grounding in a hierarchical data model" [Kirschenbaum 2008, 173] that has its origins in the tree structures of "interactive fictions of the Adventure-type" [Kirschenbaum 2008, 175]. This is an interesting observation, and Joyce mentions Adventure-type fictions as an influence in the Markle Report ([Bolter and Joyce 1986, 19], although he also mentions numerous cultural and literary influences including the novels of Sterne and Joyce, Cortazar's *Hopscotch,* even jazz music). Neither Bolter nor Joyce believe, however, that they were influenced by Adventure-type games, except in the sense that they were "a kind of zeitgeist at the time" [Bolter 2011]. Joyce is especially adamant that they were trying to avoid hierarchical structures [Joyce 2011a]. Human memory is fallible though, particularly concerning the past - and data models are very hard to trace at any rate (they always reflect something else, popping up everywhere like the grin of the Cheshire cat, as [McAleese 1999] points out).

For my part, I'd like to suggest that if there is a technical "origin" to the tree-like data structure in Storyspace, it is more likely to have come from the functions at hand in the computer language Bolter was using than Adventure-type games, namely linked lists. In other words, the tree-like structures were just part of the forest of software design[19]. In my investigations into hypertext history, one surprising find is that this very basic programming function has been quite influential (the reader will have to look at my new book to discover just how deep they go). This is a far more pedestrian explanation, almost trivially true, but sometimes programming is about implementing the most obvious sequence of instructions.

The first product of Joyce's and Bolter's conversation around the original program, GLOSSA, was called TALETELLER, a name that stuck until 1985 (as Matthew Kirschenbaum observes [Kirschenbaum 2008, 174]). Bolter had GLOSSA in hand when they first started collaborating, but its successor, TALETELLER, was a product of tinkering together. As Joyce recalls, "We would have these conversations, we'd talk about things, and [Bolter]

would say 'let, let me try this in code,' and then shoot back something and say, 'Well, is this going to work?'" [Joyce 2011b].

TALETELLER was an attempt to hack together, and without any visual structure, the kind of associative program that would work for what we wanted to do [Joyce 2011b].

Around this time, Joyce started preparing what he called "pseudocode," a delightful mash of poetic handwritten text, symbols and logical notations, to explain his ideas. Given the lyrical, polyglot style of his fictions and critical work, we would expect no less in his technical projects; Joyce has always written to his own loony tune music, to paraphrase him in *Of Two Minds* [Joyce 1998, 181].

In his book *Mechanisms*, Kirschenbaum explains how this pseudocode was eventually used to plan and write Joyce's fiction *afternoon* [Kirschenbaum 2008, 182–183]. Joyce generally uses an arrow → "to indicate a link, and symbols for various operators," e.g. an ampersand to indicate an AND condition [Kirschenbaum 2008, 182]. Joyce thinks the process may have been a little more complicated than this, however, and that the pseudocode was more like a lyrical "mnemonic" than a draft or plan. The trope of memory returns;

There exist only scraps of notes from writing [*afternoon*] in the Harry Ransom Centre archive and they are (and were) mnemonics for some fairly complex sequences of the fiction, which otherwise I wrote totally "in" the system of Storyspace, reading and re-reading sequences, and experiencing guard field permutations, from the first. Indeed this was why, in your wonderful phrase [in the next paragraph], I was "hyperconscious" of where the narrative has already been [Joyce 2011b].

Joyce's "urge toward a novel that changes each time it is read" [Joyce 1998, 181] inspired the most distinctive feature of Storyspace: guard fields.

As we have seen, one of Joyce's key rhetorical strategies is recurrence (the "sounding of memory in air"), phrases that appear again and again as the writing progresses, relying heavily on the reader's own memory of previous instances of the same phrase or node to alter their present experience. He is hyperconscious of where the narrative has already been. Guard fields control a reader's experience of the text based on where they have been. This is done by placing conditions on the activation of links, "preventing a link from being followed unless a specific node has been visited" [Ryan 1999, 138]. The reader's experience is thus literally as well as metaphorically shaped by the path already taken, enabling Joyce to repeat terms and nodes throughout the work and have them reappear in new contexts. Conversely, they enable Joyce to ensure that readers don't access key nodes until they have seen or visited others; although the narrative seems to be following a path that may have been followed before, it changes slightly at the next turn.

The most famous example of the use of guard fields is the "white afternoon" node in *afternoon*, the node that reveals that Peter may have inadvertently killed his own son. Hypertext critic Jane Yellowlees-Douglas (Joyce's favourite reader, whose dissertation was on *afternoon*) argues this node "completes" the work for her, but it is accessible only after the reader has seen a certain sequence of other nodes; "a succession of guard fields ensures that it is reached only after a lengthy visitation of fifty-seven narrative places" [Yellowlees-Douglas 2004, 106]. Guard fields are a powerful device, and one that Joyce deploys to full effect in *afternoon*. According to the Markle Report, Joyce "agitated" for them to be included in the design of Storyspace from the outset, and Bolter quickly obliged in their fledgling program:

It was just a matter of putting a field into the link data structure that would contain the guard, and then just checking that field...against what the user did before they were allowed to follow the link...
It was [that] idea you know and it was Michael's. [Bolter 2011]

Guard fields, along with the topographic "spatial" writing style, have remained integral to the Storyspace program for 30 years hence.

In 1985 Bolter became involved with an interdisciplinary research group at UNC directed by a colleague from computer science, John B. Smith. Smith formed this research group when he returned to UNC as a faculty member in 1984 [Smith 2011]. Bolter and Joyce have always credited Smith as a coauthor of Storyspace, but Smith wanted to clarify in our interview that he wasn't involved in the development of either TALETELLER or Storyspace — he feels he made more of an intellectual contribution insofar as "there was a sort of cloud of ideas that we were all drawing on in the discussions we'd have in this research entity at UNC, Textlab" [Smith 2011].

Textlab was comprised of three people from computer science including Smith, a cognitive scientist called Marcy Lansman, and Bolter from classics. The group would have weekly meetings at Chapel Hill, "and we would debate and discuss'" problems and issues around hypermedia, data structures and the visual representation of writing and thinking [Smith 2011]. Textlab was a very productive group, and they developed a number of hypertext systems between 1984 and 1989. Primary among them was the Writing Environment (WE), the system with which Smith was most closely associated. This expository writing system was contemporaneous with Storyspace.

The development of the Writing Environment was central to these discussions; it was the major project concerning Textlab. WE was a hypertext system built for the PC explicitly designed in accord with a "cognitive model of the writing process" [Smith et al. 1986]. Unlike Bolter and Joyce, Smith and the rest of the WE team were "not interested in prose, in fiction". Designed to produce paper documents for professionals, users employed the system to represent their ideas as nodes, move them into "spatial" clusters, and link them into an associative network. Crucially, this network was not intended to be read at a screen like Storyspace fictions are. WE would assemble the nodes in sequence and print a linear document. If the user edited this tree structure, then the structure of the corresponding printed document would change. The model was derived from a review of the literature in cognitive psychology, composition theory, and the nascent field of Human Computer studies (this would become HCI). Bolter coauthored a seminal paper on WE in 1986 with Smith, Lansman, Stephen Weiss, David Beard and Gordon Ferguson, and contributed to its development.

From the outset in the discussions this group were having, however, according to Smith, it became apparent that:

Jay was more interested in the Macintosh hardware, and he was also interested in applying these ideas to literature and a literary context. So Jay at some point said "Ok, I think I'm going to set off and do an alternate system," probably incorporating a lot of the ideas that were floating around in this group, and also, of course, creating new ideas of his own [Smith 2011].

The Markle Report refers to a system that "strongly influenced Storyspace" at this time called PROSE, credited to John B. Smith [Bolter and Joyce 1986, 13]. Smith does not recall making a system called PROSE, however, and believes it is referring to an early version of WE (2011)[20]. Although there was actually a program around at the time called PROSE (Prompted Revision of Student Essays, built by Nancy Kaplan, Stuart Davis and Joe Martin[21]), both Joyce and Bolter believe that WE was far more influential[22]. Either way, the discussions that this interdisciplinary research entity were having, and the "cloud of ideas" surrounding the development of what would become WE in Textlab, influenced the development of Storyspace[23].

Joyce and Bolter's next implementation, again in Pascal, was called TALETELLER 2. They both emphasized the influence of the Macintosh user interface on their thinking at this time, particularly the idea of representing the working space as a series of nested levels or spaces inspired by the "idea of containing documents inside folders" [Bolter 2011]. The way the Mac did this was too cumbersome and hierarchical, however; on a Mac the user retrieved a piece of text only by "going into the document folder to open the document" [Bolter 2011]. This file structure was not designed to be redrawn at will, and the assumption was that users were concerned with editing documents, not their *connections* to other documents. Bolter and Joyce wanted it to be more "fluid, so basically documents and folders are the same thing, you can open any particular cell and it can be either a document or it can be a container [for another document]" [Bolter 2011]. Again, the metaphor Joyce and Bolter had in mind was the writer as cartographer — not the writer as Apple filing clerk.

The Markle Report refers to a meeting at this time with Dr. Kristine Hooper from the Apple Educational Division, who explained the Aspen Movie Project at MIT, an early hypermedia system that allowed the user to take a virtual tour of surrogate travel through the city of Aspen, Colorado. (Joyce now believes it wasn't a meeting but a conference; "If I wrote that in the Markle Report, it is incorrect. We didn't have a meeting with Hooper but rather I attended a conference where I heard her speak about, and demo, the *Aspen Movie Project*" [Joyce 2011b]). This system had a navigation map overlaid above the horizon that allowed the user to jump to a two-dimensional city map.

This reinforced a decision, prompted by both Bolter's initial working paper and the limitations of the Macintosh screen, to present users with a small (but enlargeable) depiction of the hierarchical tree which would largely serve as a mapping space and for manipulation of large-scale structures, i.e. deleting and moving sub-trees [Bolter and Joyce 1986, 20].

As noted earlier in this chapter, the topographic metaphor has always been integral to this hypertext system — both in the interface design and in the development of technical functionalities. "From the beginning," remembers Joyce, "we tried to find the consonant, physical, visual structures that would suit associative [writing]" [Joyce 2011a]. In 1985, the team dubbed the program Storyspace, a name chosen to reflect this metaphor. Also in 1985, they received a grant from the Markle Foundation "to study methods for creating and presenting interactive compositions…by developing a microcomputer-based 'structure editor'" [Bolter and Joyce 1986]. Aside from providing a much-needed injection of funds at the time, this resulted in the Markle Report, which has proved most useful historically.

Although this report covers dozens of influences and design decisions over almost 60 pages, there is no reference to Joyce's fiction *afternoon*, only to his "ambitious but somewhat unformed" desire to create a multiple fiction [Bolter and Joyce 1986, 12]. Joyce did, however, have a copy of *afternoon* to present and distribute one year later at the Hypertext '87 conference at UNC Chapel Hill, November 13-15. If hypertext had a coming-out party, then it was this first ACM hypertext conference.

Many of the early hypertext systems were presented at Hypertext '87, and many of the personalities behind them were walking the halls. It was an exciting time, recalls John Smith; it was the first large international conference devoted to hypertext and "the hypertext community discovered that it was bigger than anyone realised" [Smith 2011]. Smith was there with his Textlab colleagues presenting the Writing Environment WE (Smith actually co-chaired the conference with Frank Halasz). Joyce and Bolter were there, at their "famous, but not mythological rickety table, where we sat outside the plenary sessions" [Joyce 2011a]. Andy van Dam gave a legendary keynote presentation.

Apple presented HyperCard with much pomp and ceremony, but it was met with an undertone of disdain; the feeling was "we all knew systems that had a good deal more functionality, like FRESS, and we sort of resented being told, 'here's hypertext'" [Joyce 2011b]. Ted Nelson also presented a paper on Xanadu ("All for One and One for All") and Janet Walker presented a paper on the Document Examiner. "It was fabulous," recalls Joyce, "the whole hypertext world discovered one another" [Joyce 2011b].

The demos at Hypertext '87 were literally at the center of the conference. One big room, lots of big systems, systems we'd been reading about for years but that you'd never actually seen before. There in one room: Ted Nelson's Xanadu, Engelbart's NLS/Augment, Walker's Symbolics Document Explorer, Joyce and Bolter with Storyspace, [Bernstein's] Hypergate, Meyrowitz and Landow and Yankelovich and van Dam with Intermedia. [Bernstein 2008]

In the midst of this party, Joyce and Bolter presented their paper on Storyspace [Bolter and Joyce 1987]. There is a brief note towards the end of that paper, enclosed in parentheses, that a copy of *afternoon* is "available to interested readers" [Bolter and Joyce 1987, 49]. Joyce recalls that he worked hard to get the first version of *afternoon* done by that meeting so he could distribute it on diskette as an example of what could be done in Storyspace: "[a]bsolutely. It was written for that meeting, I mean not written about that meeting, but distributed as an example" [Joyce 2011b]. This is a modest estimation of the work, however (Joyce is characteristically modest); *afternoon* was no mere footnote to hypertext history, a little "example" of the kind of thing you could do in Storyspace.

Along with Stuart Moulthrop's *Victory Garden*, *afternoon* is arguably the most important hypertext fiction in the history of computing. Citations of it are too numerous to include here because "it appears in virtually every scholarly publication on literary hypertext," as Astrid Ensslin puts it [Ensslin 2007, 71]. If there is a hypertext "canon," then *afternoon* belongs there: it appears in "every hypertext seminar in the Western hemisphere" [Ensslin

2007, 71].

It also continues to influence Storyspace: Bernstein, who has maintained the code for the last twenty years, pointed out in our interview that his design goal is fairly simple; "[it] has to always be able to run *afternoon* and *Victory Garden* and *Patchwork Girl*…the agenda related to the writing process is less prominent in my mind than perhaps it used to be in Michael's" [Bernstein 2011]. That said, more has been written about *afternoon* than any other work of digital literature; as Bernstein put it, "if you don't know *afternoon*, you don't know hypertext" [Bernstein 2011].

The closest reader of Joyce's fictions has always been Jane Yellowlees Douglas (particularly in her book, "The End of Books, or Books Without End?" 2000), and several new interpretations of *afternoon* have been published in recent years by young scholars, most notably literary critic Alice Bell (2010) and Bangor University's Astrid Ensslin (2007).

For this reason, I will not take the reader through yet another interpretation of *afternoon*; this has already been done, elsewhere and brilliantly. I will simply note that the fiction Joyce distributed on diskette at Hypertext '87 did more than just demonstrate Storyspace; it demonstrated what network literature could be, and arguably opened a space for that genre to evolve. *[A]fternoon* was also the realization of Joyce's long-held dream. It is a book that changes with each reading.

As Matthew Kirschenbaum observes in his own chapter on *afternoon*, there is a journal entry in the Joyce Archives dated June 4, 1988, that notes:

> What is not recorded here, but exists in a series of papers, letters and what-have-you is the experience of succeeding at what I set out to do before Jay and I first contacted each other: "to write a novel that changes each time you read it" came to be the story, *afternoon*, which will likely be the centerpiece of S[tuart] Moulthrop's first disk magazine. (Journal, 1987-89, also cited by [Kirschenbaum 2008]).

In 1988, Joyce, Bolter and Smith formed a startup they called Riverrun Ltd., a return to Joyce's favourite metaphor (and an evocation of the famous first word of James Joyce's *Finnegans Wake*). The official letterhead from 1990 has running water as its logo[24]. Together they approached Brøderbund Software, Inc, an American software and game manufacturer best known for the *Carmen Sandiego* and *Galactic Empire* games. According to Matthew Kirschenbaum, who went through the correspondence between Joyce and Brøderbund, it was eventually dropped in 1989 because of "what was perceived to be a weakening in the software market, as well as lingering confusion over what the tool did and who its potential audience was" [Kirschenbaum 2008, 176]. After Broderbund, Joyce entered into conversation with Mark Bernstein, the founder of Eastgate Systems. Eastgate signed a contract licensing Storyspace in December 1990 and has distributed it since that time.

Pieces of editing software, particularly hypertext systems, are not known for their shelf life. None of the first-generation hypertext systems from the 60's and 70's have survived into the modern era. Even what is called the "second generation" of hypertext systems from the late 70' and early 80's, the contemporaries of Storyspace – FRESS, Intermedia, Smith's WE, Apple's Hypercard – are no longer in use. Storyspace, however, has survived for almost thirty years; content is still being written for it, it still being bought and sold, and it is still being used in pedagogic environments, although the user base is probably fairly small (a couple of hundred users). This is virtually unheard of in the history of computing software; systems just don't last that long. The reason Storyspace has survived is fairly simple: Eastgate Systems has been maintaining it.

It would be remiss to write a history of hypertext without devoting time to Eastgate and to its founder, Mark Bernstein. In addition to the development of early hypertext systems, "the history of hypertext was also driven by efforts to create hypertext content for the wider public" [Kitzmann 2006]. Eastgate Systems has been the major publisher of hypertext fiction for over twenty years, and published the majority of what is now considered "serious literary hypertext" (this is also Eastgate's tagline), including Joyce's *afternoon*, Stuart Moulthrop's *Victory Garden* and Shelley Jackson's *Patchwork Girl*. In addition, Bernstein has maintained and extended the Storyspace code since 1990 (it has been entirely rewritten in C, and doesn't share a single line of code with the original Pascal version, which presents its own conundrum: where is the Storyspace in Storyspace?). He has also made significant contributions to hypertext as a critical discourse[25]. As John Vinder puts it on his blog,

> Who has made a more substantial contribution to the field of electronic literature than Mark Bernstein? This makes for a fun parlor game if you know anything about the field. You could name individual authors whose works helped to legitimize the field of born-digital literature. If you go with this approach, you may suggest Michael Joyce, Shelley Jackson, or Stuart Moulthrop, yet all these authors were published on Bernstein's Eastgate Systems. [Vinder 2010]

Eastgate pioneered hypertext publishing in the late 80's and arguably legitimised hypertext as a creative endeavor. As Australian hypertext theorist and author Adrian Miles remembers it,

> They were shrink wrapping stuff and putting it in envelopes and mailing it out [before the Web]. You've got a physical thing with a cover and a floppy disk or a CD, originally [they were] floppy disks, that you load onto your computer. So from the get go it was sort of stamping itself as this is a literary enterprise, it's not experimental, and it's not here are some hypertext experiments. [Miles 2011].

Eastgate has also been criticized for the dominance of its titles in the hypertext canon, and the fact that the company sells these titles for a profit[26]. It is not universally celebrated in the historical literature. Most notably, Matthew Kirschenbaum managed to write an otherwise brilliantly researched chapter on the evolution of *afternoon* and *Storyspace* while devoting but a sentence to Eastgate's role in this story ("a small company specializing in hypertext systems research," [Ensslin 2007, 177]) and to Bernstein's role personally (he "maintains the code" [Kirschenbaum 2008, 162]). Admittedly Kirschenbaum and Bernstein have their own history, and it is best for readers to interpret this themselves rather than have me recount it[27]. It must be said, however, that it was Eastgate's business model that garnered a profile for its authors in the United States and internationally before the web, a direct "result of their marketing and distribution by Eastgate systems" [Ciccoricco 2007, 2].

If we have now come to the point where we might talk about a hypertext "canon," and indeed Astrid Ensslin has just published a book arguing we should do that, this is due in no small part to the publishing and marketing of titles by Eastgate. From early on, Bernstein sought to find and publish hypertexts because he felt the literary world needed some real examples; it was all hypertext theory, no "serious hypertext". As Stuart Moulthrop observed, in 1990, Bernstein stood before the European Conference on Hypertext and uttered the famous first words, "Where are the hypertexts?" – a question that is arguably still just as urgent. Eastgate was set up to provide an answer to that question.

Bernstein also developed his own hypertext system, which was operational by 1988 – Hypergate. Hypergate is noteworthy because it introduced the concept of *breadcrumbs* – showing whether a link takes you back to a place you've already seen. This concept was invented by Bernstein, and eventually made its way into the Mosaic browser (Eastgate never implemented breadcrumbs in Storyspace). Possibly for this reason, Bernstein was initially more interested in signing Joyce's hypertext fiction, *afternoon,* than he was in Storyspace. As Joyce recalls it, "*afternoon* was my bargaining chip in many ways. That's how I remember things. I made the publishing of *afternoon* contingent on [Eastgate signing Storyspace]" [Joyce 2011b]. Bernstein thought this was overstating the situation. He remembered approaching Joyce about *afternoon*, because it seemed a natural fit, but he "didn't expect Storyspace to be on offer. I might have seemed more reluctant than I was" [Bernstein 2011].

Beginning in 1989, these discussions went on for some time:

> At Hypertext '89, I had discussions with Michael Joyce where we basically agreed that we were going to do this, and Broderbund had returned the right to Storyspace to Michael and Jay. So from that time for the next several months we proceeded under the assumption that it would be. [Bernstein 2011]

The contract with Eastgate licensing the development and maintenance of Storyspace is dated December 17, 1990. Over the next five years, a number of hypertext fictions were written in Storyspace and marketed by Eastgate that have since attained (or should attain, according to Ensslin's book *Canonizing Hypertext* 2007) "canonical" status. These include Moulthrop's *Victory Garden* (1991), Carolyn Guyer's *Quibbling* (1993), Jane Yellowlees Douglas *I Have Said Nothing* (1994) and Shelley Jackson's *Patchwork Girl* (1995).

So important was Storyspace (and Eastgate) to the early development of the field, argues Katherine Hayles, that works created within Storyspace have come to be known as the Storyspace School [Hayles 2008, 6]. Alice Bell's recent book on hypertext fiction similarly argues for the creation of a hypertext canon, and analyzes four hypertext fictions that were created in Storyspace, providing "a critical theory for the analysis of Storyspace fictions" [Bell 2010, 7].

For my own part, I find it strange that recent theorists are arguing for a formal canon – it is almost as though we have forgotten the lessons of poststructuralism. What, exactly, is wrong with margins and interstices? Isn't that where all the interesting stuff happens? Why canonize it? Stuart Moulthrop wrote an interesting response to Alice Bell's book on Storyspace fiction in the *Electronic Book Review*:

> For Dr. Bell, the adjectival *niche* is a term of suspicion. I disagree, having learned to think of literary or cultural niches not as traps, but as necessary predicaments or premises. As I see it, if dwellers in these dens need to escape anything, it is the niche distinction itself, the overriding concern with separation of specialist and popular markets. [Moulthrop 2011a]

This is the legacy of Storyspace. Whichever side you fall in this debate, the fact is that Storyspace fictions predominate in what arguably already is (or should be) a hypertext canon. The arrival of the Web and HTML changed the landscape for hypertext and for Storyspace. Storyspace was originally built (as were all the early hypertext systems) as a standalone system – in this case running under the Macintosh OS. It was not intended to create networked hypermedia like the texts found on the Web. Arguably, it still belongs to the pre-Web era (and by including it in this story, I have contributed to that perception).

Bernstein extended the program in 1995 to enable users to export HTML templates, but as Katherine Hayles points out, " the limitations of Storyspace as a web authoring program are significant. For example, it has a very limited palette of colors and cannot handle sound files that will play on the web"[28] [Hayles 2008, 6]. Guard fields are also very difficult to implement on the web, and the HTML link model simply cannot support some of the more complicated link models of the earlier hypertext systems.

> The relationship between Storyspace and the web has never been entirely easy, in part because the Storyspace link model is richer than the web's and it turns out that for the sorts of things people want to do in Storyspace the richness matters a lot… Guard fields are invaluable for large scale narrative and we have not come up with an alternative [on the web] [Bernstein 2011].

Authors also started turning to Flash and to some extent Javascript around the turn of the century. We now have a generation of writers who are willing to script within Application Programming Interfaces (APIs) – or as Stuart Moulthrop puts it, "a wave of Jay Bolters"[29]. For these reasons, although Storyspace continues to be used to produce stand-alone works, "it has been eclipsed as the primary web authoring tool for electronic literature" [Hayles 2008, 6]. Like all the first generation hypertext systems, the web presented a completely different model for building hypertexts. Storyspace was never about engaging a crowd, and it has never really entered the web era.

Bolter has a rather pessimistic view of the impact of the web on networked literature, and on the legacy of Storyspace. "The web compromised on the vision of hypertext," he observes. It compromised on the "literary, political, social vision of the original hypertext movement" [Bolter 2011], and it allowed work to be commercialized quickly and easily. This has its benefits, of course. The web provides a massive new audience and a quick (and free) way of distributing products to that audience – but the web obliterated Bernstein's original business model. The whole concept of selling hypertext is made immensely more difficult when everywhere literature is given away for free. As Bolter pointed out, the literary community "often revolted against this, because it was so easily commercialised" [Bolter 2011].

The most famous example of this rebellion against the web is Robert Coover's "Literary Hypertext: The Passing of the Golden Age" (1999). In this keynote address to the second Digital Arts and Culture (DAC) Conference,

Coover lamented the passing of a specific body of digital literature – what we would now classify as the Storyspace School – and the rise of the "noisy, restless, opportunistic, superficial, e-commerce driven" web texts, that "are about as appealing as a scatter of old magazines on a table in the dentist's lounge" [Coover 1999]. The Golden Age of hypertext has passed, the visual usurping the verbal (the margins, in fact, used to be the site for revolutions: perhaps this is why Moulthrop is reluctant to leave them).

Looking back on its history, one of the most interesting aspects of Storyspace is the fact that it bridged the gap between humanities and computing science so early, and that it was taken seriously by both fields. This was largely due to the fact that Bolter "had a seat in both worlds," as Joyce points out, collaborating with his engineering colleagues from the outset [Joyce 2011b]. Unlike Nelson and Engelbart, Bolter and Joyce were not ridiculed; on the contrary, they both felt embraced by computing science. This set a precedent for future work in the area. In fact, according to Joyce, "what has gone unremarked is Storyspace's contribution to a dialogue, if not across the two cultures then at least across the engineering and literary communities" [Joyce 2011a].

Notes

[1]Though in many cases the "critical" works are also fiction, and the "books" are also critical works.

[2]Historians attach great importance to "primary evidence" — source material and documents that were created at the time under study. Matthew Kirschenbaum notes in his recent book, *Mechanisms* (2008), "The single indespensible source for the early history of Storyspace is Joyce and Bolter's report to the Markle Foundation, which funded Storyspace for a crucial development year in 1985" [Kirschenbaum 2008, 172]. The copy I will be using here is held at the Michael Joyce Archives at the Harry Ransom Research Centre, dated 1986 (hereafter "the Markle Report"). The Markle Report was written during the first development cycle for Storyspace, and describes both the research process behind the program and the tool itself as it was used at the time over 60 typed pages; for this reason, I will be relying heavily on it. That said, human memory is fallible, but so are documents. The Markle Report was written mainly by Joyce, and in the manner of any document assembled in haste and addressed to a funding body, it presents a particular view of the task at hand (and sometimes gets the minor details mixed up).

As Joyce put it when I queried his use of some terms in the report, "I feel like I'm hoisting my own petard, but obviously I wrote the whole Markle Report; my imprecisions of language are coming back to haunt me" [Joyce 2011b]. To get a more detailed picture I will be supplementing this source with oral histories obtained in 2011 – most particularly the recollections of Michael Joyce, Jay David Bolter, John B Smith and also Mark Bernstein, who has maintained the code for the last twenty years. Stuart Moulthrop and Nancy Kaplan have kindly helped with some of the minor details, and Michael Joyce provided me with a copy of his unpublished manuscript, *Re:mindings* (he was reluctant to part with this, but it is used by permission). I also rely heavily on Joyce and Bolter's critical work because this theory influenced the development of the system.

[3][Barnet 2013]

[4] Eco writes "Joyce (the living one) is here to prove that Joyce (the dead and everlasting one) gave us with *Finnegans Wake* a good example of hypertextual experience... A textual hypertext is finite and limited, even though open to innumerable and original inquiries. Then there is the possibility outlined by Michael Joyce, hypertexts which are unlimited and infinite, a sort of jazz-like unending story" [Eco 1994], reprinted, without the living/dead Joyce reference as the "Afterword" in *The Future of the Book*.

[5]I've gleaned this information largely from Bolter's CV: http://www.jdbolter.net/bio-and-cv.html

[6]http://www.tlg.uci.edu/about/titlestory.php

[7]He had also done some work on interactive text, and gave Joyce a copy of his article "The Idea of Literature and the Electronic Medium" in 1983. This was later published in *TOPIC* in 1985 (Joyce refers to it in the Markle report as "some thoughts on literature in an electronic medium," [Bolter and Joyce 1986, 12].

[8]The research led by Brooks at UNC, however, was really more in line with Engelbart's way of thinking — the computer as intelligence amplification rather than artificial intelligence.

[9]In the 1980s a form of AI program called "expert systems" was adopted by corporations around the world and knowledge became the focus of mainstream AI research. Traditional AI took a back seat to research in this area and in neural networks. In those same years, the Japanese government aggressively funded AI with its fifth generation computer project. Another encouraging event in the early 1980s was the revival of connectionism in the work of John Hopfield and David Rumelhart. Once again, AI had achieved success.

[10]Stuart Moulthrop, personal communication 2011.

[11]Matt Kirschenbaum details this correspondence well in his chapter on afternoon and Storyspace; I will not cover it again here.

[12]Indeed, as Stuart Moulthrop observes in response to this chapter, hypertext turns AI inside out.

[13] Again, the influence of AI is clear in this book; The New York Times went so far as to call it "the most illuminating book that has yet come [our] way on the topic of artificial intelligence" [Ayer 1984].

[14] http://www.well.com/user/jmalloy/uncleroger/unclerog.html

[15] "...I think I probably did call it TEXT at one point but that was such a boring name compared to GLOSSA" [Bolter 2011]."

[16] Stuart Moulthrop, personal communication.

[17] Along with FORTRAN and BASIC. Pascal is obviously still in use, but is no longer the primary development language for Apple machines.

[18] When we called it TALETELLER 2, we were already working on Mac by that time [Bolter 2011].

[19] Stuart Moulthrop, comment in the margin of this article.

[20] Interview, 2011. This suspicion was later confirmed by both Joyce and Bolter.

[21] Developed 1985-87 with funding from Cornell University and Apple.

[22] Joyce wrote in an email: "the 'strongly influenced' makes me think I mixed up the names of Nancy's program, which I knew about but hadn't used and John's, which Jay indeed felt we had to acknowledge given his work with John's group".

[23] We do not have space to go into more detail about WE here, but it was an important system in the history of expository or "professional" writing systems; it was presented at Hypertext '87 alongside FRESS, HyperCard, Storyspace and NLS.

[24] Letter to Barton Thurber from Riverrun, February 2 1990, Joyce Archives.

[25] Bernstein's paper, "Patterns of Hypertext" (1998) is widely cited in the field.

[26] For example, Ensslin seeks to redefine "producer-defined, commercially ideologised" terminology that has come into widespread us as a result of "specified hypertext software, mostly traded by Eastgate Systems" [Ensslin 2007, 7].

[27] Here is a link to Bernstein's post: http://www.markbernstein.org/ELO.html and here is a link to Kirschenbaum's response: http://otal.umd.edu/~mgk/blog/archives/000087.html

[28] Though Hayles doesn't seem to realize these limitations also apply to HTML.

[29] Comment to the author.

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