Digital libraries, the Semantic Web and the New Scholasticism: Comparing revolutions of document structure and cognition in the twelfth and twenty-first centuries

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Usability studies have been an integral part of digital library research, but they have tended to focus on particular interfaces and document collections.[1] Because digital libraries have only seen significant development since the mid-1990s (Fox & Urs, 2002), there has been little longitudinal research examining their use, and the implications of their use, from a broader social and cultural perspective (Fox & Urs, 2002).

That's not to say that observers haven't made optimistic or cautionary pronouncements about the impact of electronic information on society as a whole. There are those such as the founders of the Perseus Digital Library, who herald the potential of networked and richly layered information to open new possibilities for intellectual inquiry (Crane, Fuchs, Smith & Wulfman, 2000). Similarly, World Wide Web creator Tim Berners-Lee touts the potential of the Semantic Web as a kind of ultimate digital library, which would unite information and Web-based services in a vast, uniform network (Berners-Lee, 2000).

Others warn of the potential for subtle losses of comprehension as an increasing amount of information is delivered electronically through the medium of hypertext. David Levy (1997) suggests that hypertext mitigates against deep and sustained reading, while Sven Birkerts (1994) goes further to suggest that broad cultural changes are impending because of the increasing pervasiveness of electronic media. "We are living in the midst of a momentous paradigm shift," says Birkerts (p. 18), who suggests that individuals are gaining from electronic media "an expanded neural capacity, an ability to accommodate a broad range of stimuli simultaneously," but suffering "a reduced attention span and a general impatience with sustained inquiry" (p. 27).

It bears saying that digital libraries as a means of knowledge transmission in an electronic medium represent a significant paradigm shift from information to be gained from paper books in physical libraries. Jacob (2002) notes that traditional libraries present one with both the idea of a universe of knowledge and the physicality of books, requiring an individual path of exploration to construct one's own concept of an information totality. A digital library, on the other hand, presents information in a digital, networked form with the goals of open access and nearly instantaneous delivery (Fox & Urs, 2002).

And one might characterize the emergence of Extensible Markup Language (XML) in the last few years as a miniature revolution nested within the larger revolution of digital information. From an integration of content and form in traditional hypertext-coded Web pages, knowledge representation on the Web is rapidly adopting a formal separation of document structure and manifestation. Philosophically, the separation of information content from the medium of transmission has no previous analogue in the history of written

[1] For examples, see Das Neves & Fox, 2000, and Bishop, Neumann, Star, Merkel, Ignacio & Sandusky, 2000.

communication. And historically, scholars have suggested that changes in the presentation and structure of language, documents, and document collections have accompanied gradual, but profound changes in cognition.

In her study of the intellectual status of reading during the medieval Scholastic period, Jacqueline Hamesse (1999) notes one such cognitive shift that occurred in the Middle Ages. She suggests that a rising availability of manuscripts and a growing emphasis on summarization led to a change in reading style. Hamesse's comment echoes those of Levy and Birkerts, as she suggests that from the twelfth century on, "an uninterrupted reading … was gradually replaced by a more fragmented, piecemeal reading style that had the advantage of providing a quick grasp of the selections but no longer encouraged any deep contact with the text…. Utility had outstripped knowledge" (p. 107).

It's too early to say what cognitive and cultural impacts digital libraries and robust networked information will have on society as a whole. But I would argue that there are fruitful comparisons to be drawn from the changes to manuscript conventions and reading practices as they occurred between the sixth and fourteenth centuries – and particularly during the Scholastic period – and current theorizing about the social and cultural impact of hypertext and the potential of the Semantic Web. I suggest that contemporary advances in document structure through metadata markup and visualization techniques have direct parallels in the introduction of manuscript word spacing, elaborate section markers, and indexes.

Scholars have argued that the rise of silent reading and advanced mnemonic techniques in the Middle Ages contributed to an increasing sense of personal autonomy and self-expression (Amtower, 2000; Saenger, 1997). I would argue that one may extrapolate a contrary cultural trend of increasing externalization and collectivity through examining the concept of a digital library and the expressed structure and purpose of the Semantic Web. Berners-Lee's own dream of the Semantic Web is to leverage "ever-larger, more interconnected groups of people acting as if they shared a larger intuitive brain" (2000, p. 202). Examining elements of the nexus of changes in cognition, language representation, and document structure in the Middle Ages suggests that Berners-Lee's dream of societal transformation is not beyond the realm of possibility.

I shall compare what I consider to be three sets of analogous developments in information organization that took place during the Middle Ages and that are taking place currently through digital library development. I believe the introduction of manuscript word spacing, indexes, and other structural conventions during the Middle Ages finds parallels in the development of contemporary hypertext, document metadata, and techniques of information visualization. Both sets of innovations contribute to cognitive outcomes: spaces between words and structural conventions in manuscripts facilitated the internalization of knowledge – namely silent reading and elaborate mnemonic techniques. In contrast, hypertext and the extensibility of information represented by the World Wide Web contribute to a sense of knowledge that is externalized and collaborative in form.

Scholars who have studied relationships between representations of language and cognition have noted the danger of reductionism in attributing particular modes of thought to particular graphic conventions, and that danger should be noted here. Quoting the medieval historian Brian Stock, Elena Llamas Pombo (2002) notes that historians should resist the temptation to attribute changes in mentality to changes in the form of communication.

In examining the medieval milieu, it's clear that cultural trends valuing contemplation, interiority, and memorization are as much a product of the spread of Christianity, the growing availability of manuscripts, and the monastic traditions in which those manuscripts were transcribed and stored, as the development of word spacing and tables of contents. Still, a number of scholars suggest there are valid connections to be made between changes in scribal practices and changes in ways of thinking.

The first structural development I shall address is the introduction of spaces between words in Latin manuscripts by Irish monks during the sixth and seventh centuries. Before that, manuscripts were largely transcribed in a continuous flow of writing known as *scriptura continua* (Pombo, 2002). In his paleographic study of the emergence of word spacing, Paul Saenger (1997) notes that the practice of continuous writing went hand-in-hand with a view of language as a transcription of oral speech, meant to be read and memorized as a whole. "Because those who read relished the mellifluous metrical and accentual patterns of pronounced text and were not interested in the swift intrusive consultation of books, the absence of interword space in Greek and Latin was not perceived to be an impediment to effective reading as it would be to the modern reader who strives to read swiftly" (p. 11).

Pombo (2002) suggests the development of word spacing was a pragmatic one: since Irish monks did not speak a Latin-derived Romance language, the division of words was an aid to reading and understanding the Latin texts. M.B. Parkes (1999) contends that the monks adapted the practice of dividing Latin texts into parts of speech and grammatical units, based on their study of ancient grammatical treatises. Although silent reading did not begin with this development (Cavallo & Chartier, 1999), the practice was made easier by word spacing. Notes Pombo, "Separation of the words ... freed the intellectual faculties of the reader, thus encouraging silent reading and, in this way, faster reading..." (p. 33).

The advent of word spacing is comparable to the invention of hypertext. Both developments pave the way for a radical shift in apprehension. Word spacing, which became consistent by the twelfth century (Parkes, 1999), allowed an intellectual dissociation of the text from the physicality of the book (Pombo, 2002). The practice as it contributed to silent reading also facilitated a sense of language as an embodiment of concepts, not merely an imitation of vocalized speech (Parkes, 1999). This had revolutionary consequences. Freeing the eyes from having to resolve graphic ambiguity on the page, allowed easier viewing and memorization of groups of words, thereby increasing comprehension (Saenger, 1997). The difficulty of reading was thus made easier, contributing to the spread of literate culture. "Even readers of modest

intellectual capacity could read more swiftly," notes Saenger, "and they could understand an increasing number of inherently more difficult texts," (1997, p. 13).

In the way that word spacing freed the intellect to conceptualize and abstract ideas from written words, hypertext facilitates the freely associative nature of human thought. As a concept first proposed by Vannevar Bush in 1945 (Berners-Lee, 2000), hypertext was meant to allow random linking of microfiche texts, through a device called a "memex," releasing one from the constraints of a traditional index (Bush, 1945). Hypertext allows a shift in apprehension – text may be composed and read in an associative, rather than strictly linear, context. As implemented in the World Wide Web by Berners-Lee through hypertext transfer protocol (http) and hypertext markup language (html), the concept of hypertext formed the basis of the Web's accretive structure: "New webs could be made to bind different computers together, and all new systems would be able to break out and reference others" (Berners-Lee, 2000, p. 16).

Other developments during the period of rapid knowledge dissemination in the twelfth century also prefigure contemporary concerns with document structure and visualization. Both sets of innovations reflect a similar need to improve the efficiency of information recall and retrieval.

The twelfth century coincided with the formalization of Scholasticism and its emphasis on rationality and knowledge absorption (Carruthers, 1990). Scholasticism began several centuries earlier with the spread of Christianity through barbarian tribes, and represented "an unprecedented process of learning" in which "the very prosaic labour and 'schoolwork' of organizing, sorting, and classifying materials inevitably acquired an unprecedented importance" (Pieper, n.d.).

Thus arose the importance of document structuring. Hamesse (1999) and Carruthers (1990) note scholarship pointing to the pioneering efforts of Cistercian and Dominican monks in dividing and organizing the text. Paragraph markings, chapter titles, concordances, and alphabetical indexes emerged over the twelfth and thirteen centuries (Hamesse, 1999). Parkes (1991) notes that twelfth-century page designs incorporating authority texts and commentaries upon those works were supplemented with additional components such as running titles, marginal numbers, and analytical tables of contents by the thirteenth century. The purpose of these manuscript conventions, notes Hamesse (1999), was to give a reader a greater facility to abstract a book's content from its form, through the creation of excerpts, glosses, and summaries: "Teaching and the fastest possible acquisition of culture replaced a deep knowledge of works" (p. 118).

Scholars have also argued that memorization was an integral part of textual study during the period, and indexes and other structural forms helped serve that end. Carruthers (1990) suggests that various indexing schemes introduced in the twelfth and thirteen centuries were meant to be as much for the purpose of memorizing a work as for navigating a text. In her monograph, *The Book of Memory*, Carruthers discusses the prominence of memory work in schooling and its highly valued status in medieval society, and refers to a number of specific techniques – many adapted from Greek and Roman times – that were popular during the period. These included alphabetic and numerical formulas for creating a mental grid of an entire book and

locating particular passages by memory precisely within a text. To Carruthers, "indexing systems derived in the monasteries and, later, the universities seem all to have served the dual function of being both tools for finding texts initially and also for noting them in the memory, as mnemonic 'hooks'" (p. 100).

Similarly, Carruthers (1990) argues that the decorative conventions of manuscripts of the time, such as illuminated capitals and section headings, were not merely added for aesthetic purposes, but to aid comprehension and memorization of the work. In a later paper, Carruthers (2002) recalls a particular mnemonic scheme related to manuscript reading of the 12th century theologian and teacher Hugh St. Victor; In "De Tribus Maximis Circumstantiis Gestorum," Hugh advises memorizing a work by superimposing short passages of text upon an imaginary numbered grid. To aid recall, one was advised to memorize the words exactly as they appear: "The images of written text are impressed as they appear in the particular codex from which they were first memorized, including their location on the page (recto, verso, top, middle, bottom), the shapes and colours of the letters themselves, and the appearance of each page, including marginalia and illuminations, to make a clear visual image" (p.21).

Current research on information visualization bears at times a striking resemblance to the medieval goal of improved memory and cognition through visual clues. Visualization research has emerged as a significant field in the last decade as a means to counteract the effects of information overload by rendering information structures visually (Card, Mackinlay, & Schneiderman, 1999). Using the high-bandwidth processing ability of human vision, information visualization seeks to reduce searching time, enhance pattern recognition, and expand working memory by representing information in quickly understandable visual forms (Card, Mackinlay, & Schneiderman, 1999).

Two-dimensional and three-dimensional visualizations of digital library collections, Website directories and other forms of information have also been created to attempt to leverage spatial memory when working with information (see Modjeska, 2000). One such project developed at the MIT Media Lab, a three-dimensional virtual reality model of a personal newspaper, City of News, is founded partially on classical and Renaissance mnemonic theory. The project, which places news stories on the sides of skyscrapers in a virtual, navigable city, refers to the ancient, location-based mnemonic techniques of associating texts with imaginary building interiors. "We have endowed the City of News with salient images which act as architectural landmarks and memory cues in the different districts," (Sparacino, Davenport & Pentland, 2000, ¶ 17).

Indeed, the proliferating research in visualization (see Börner, Chen & Boyack, 2002) suggests an increasing intimacy, even interdependency, of text and image in contexts of information searching, retrieval, and summarization. Recent trends in visualization research – such as the information visualizer tools developed at Xerox PARC (Rao, Pedersen, Hearst, Mackinlay, Card Masinter, et al., 1995) – suggest a wedding of language and visual form not unlike that which characterized illuminated manuscripts. Parkes (1991) suggests that Irish scribes who first introduced visually elaborate punctuation and capitals did so for

practical ends: "In Irish manuscripts punctuation and decoration became inextricably linked. The scribes saw them as two aspects of the same thing, the presentation of a text which facilitates its use, and as one developed so did the other" (p. 9). Interestingly, Bolter has suggested that notions of literacy in the World Wide Web environment are returning to a primarily visual, rather than purely textual, sense: "literacy in electronic environments may have more to do with the production and consumption of images than the reading and writing of either hypertext or linear prose" (as cited in Sutherland-Smith, 2002, p. 667).

As the medieval book became an increasingly sophisticated means of knowledge transmission during the twelfth and thirteenth centuries, structural tools such as the index were adopted with unprecedented speed (Carruthers, 1990). Arguably, one might remark on the rapid dissemination of XML and XML Schema as a comparable revolution in the structuring of digital documents. XML derives from Standard Generalized Markup Language and was expressly created to be a simpler, more widely disseminated means of "capturing, distributing, and processing knowledge" (Connolly, Khare & Rifkin, 1997, p. 122). XML permits users to define the syntax of documents independently of their appearance using arbitrary identifiers. The identifiers, or metatags, are interpretable by humans because they are simple terms in ordinary text and also readable by machines because they are linked to a logical data definition or document schema (Berners-Lee, Hendler, and Lassila, 2001; Bosak & Bray, 1999). Here, unlike the overt visual structures on the manuscript page, XML metadata is – usually – hidden in the source code and not viewable on a Web page. But the purpose of XML is similar to the paragraph markings and running titles of a medieval book: to provide pointers to, and identifiers of, portions of a text.

Indeed, if the organization and codification of knowledge was seen as one of the highest goals of the Scholastic period, one can see direct parallels in contemporary concerns with the interoperability and standardization of knowledge ontologies associated with development of the Semantic Web. Here, however, the parallels between the increasing structural and semantic efficiency of the medieval text and the current state of digital libraries, hypertext, and the World Wide Web begin to diverge.

Where indexes and other book conventions have developed as navigational aids to a physical text, XML structure has become hidden to offload portions of information searching and retrieval from humans to machines. In effect, XML assigns computers the task of reading indexes and doing the memory work. Berners-Lee, Hendler, and Lassila (2001) note that the purpose of XML is to invest the components of a document with human- and machine-readable semantic meanings. XML also forms the basis of the Resource Description Framework (RDF), which uses XML to express meaning in triples – simple sentence constructions with subject, verb, and object – that unite individual terms in larger networks of meaning called ontologies (Berners-Lee et al., 2001). The purpose of these RDF-encoded ontologies, stored on the Web and referenced through Universal Resource Identifiers (URIs) is to create a universal network of meaning, called the Semantic Web (Berners-Lee et al., 2001).

The idea of the Semantic Web, in turn, is to be machine-searchable by software agents, which would locate information resources and services and also interact with each other to exchange information (Berners-Lee et al., 2001). To date, work has begun in creating standards for agent development and interoperability (McGuinness, Fikes, Hendler & Stein, 2002; Sycara, Paulucci, van Velsen & Giampapa, 2001).

Berners-Lee, who created the World Wide Web and is pushing to have it evolve into the Semantic Web, unabashedly trumpets the Semantic Web's potential to further the growth of human cognition:

> The Semantic Web, in naming every concept simply by a URI, lets anyone express new concepts that they invent with minimal effort. Its unifying logical language will enable these concepts to be progressively linked into a universal Web. This structure will open up the knowledge and workings of humankind to meaningful analysis by software agents, providing a new class of tools by which we can live, work and learn together" (Berners-Lee et al., 2001, ¶ 44).

In a noteworthy parallel, the attainment of universal knowledge – or knowledge of "the whole of reality and existence" (Pieper, n.d.) – was also the highest goal of Scholasticism. In her works on memory in the Middle Ages, Carruthers argues that the goal was predicated on mnemonic skill. In "The Art of Memory and the Art of Page Layout in the Middle Ages" (2002) Carruthers discusses Hugh St. Victor's numerical ordering technique for memorization and notes that word-by-word memorization of entire texts was a prominent goal of education. Quoting St. Victor, Carruthers says "the crucial task for recollection is the construction of the orderly grid of numbers which one can see in the memory. This enables one 'when asked, without hesitation [to] answer either in forward order, or by skipping one or several, or in reverse order and recited backwards' whatever is in the memorized text as a whole. And it also enables one to construct mentally a concordance of the text, thus 'compounding with the interest the authority of some one psalm' by citations from a multitude of other, related texts" (p. 22). In essence, Carruthers describes the process of turning human memory into the image of a computer's random access memory, by assigning bits of text to specific memory addresses.

During the Scholastic period, *Summae*, or philosophical treatises attempting a "comprehensive view of all that exists" (Pieper, n.d.) were considered the greatest intellectual achievement of the period. Carruthers suggests in *The Book of Memory* that the culture of the time promoted mnemonic skills and encouraged individuals to cultivate holistic knowledge by practicing the flexible recall of prominent texts. She presents anecdotal evidence that one of the greatest thinkers of the period, Thomas Aquinas, completed his best-known work, the *Summa theologica*, largely by such a process of remembering and extemporizing. "The contemporary sources suggest strongly that the entire *Summa theologica* was composed mentally and dictated from memory, with the aid at most of a few written notes, and there is no reason to disbelieve them" (1990, p. 5).

Perhaps one might call Thomas Aquinas the Tim Berners-Lee of his time, except he contained the era's equivalent of the World Wide Web in his own memory.

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As the textual innovations of the Scholastic period responded to a need by scholars to absorb information at a faster rate, so have digital information structures evolved to handle a vast proliferation of data. One might characterize the Scholastic period as an information age that required bibliographic innovations to codify knowledge. Similarly, developing strategies to select, classify, and codify information has been one of the more prominent aspects of recent times. This is especially apparent with the rise of the field of knowledge management in the past several years. The imperative to overcome information overload and "know what we know" has become a broad societal priority, stretching from corporate governance to anti-terrorism efforts (see Lichtblau & Piller, 2002).

Digital libraries and the World Wide Web have been in widespread use for less than a decade (Berners-Lee, 2000; Fox & Urs, 2002), and the long-term cultural implications of their use are difficult to gauge. But a comparison of the role of the library as it existed in the Middle Ages and the role of the digital library as it is currently evolving helps resolve a possible image of the digital library's future. The differences may be broadly grouped around notions of information conveyed through the physical form of books or through an electronic network, and ideas of information centred on a subjective or a collective orientation.

The medieval library acts as a physical embodiment – however circumscribed – of the idea of a collective, universal knowledge. The library historian Christian Jacob notes that it is the materiality of books present in a physical library that contributes to a sense of scholarly exploration and heroic endeavour. "Through this all-inclusive social memory [the library], which may sometimes be restrictive and imposed, individual memories plot their own paths" (Jacob, 2002, p. 41). Physical libraries also imply a sense of active connection-making among the books on the shelves: "Using a library cannot be reduced to reading the books it contains; it also implies reading them in relation to each other, whether in terms of comparison, supplementation, criticism, explanation or investigation, of exploring an area of knowledge in detail or on the contrary taking an overview of it" (Jacob, 2002, p. 43).

With this conception of libraries in mind, it is worth noting that a sense of scholarly engagement and a rising sense of individualism and interpretive freedom are common themes of histories of reading during the Middle Ages. Saenger (1997) suggests the rise of silent reading contributed to greater intellectual freedom, privacy, and personal expression. Amtower (2000) also argues that reading contributed to increasing evidence of self-expression during the fourteenth and fifteenth centuries: "Reading … requires that one grapple with the essential difference of the otherness of the text, and that one acknowledge the very possibility of otherness to oneself" (p. 3). Saenger closes his book 1997, *Spaces Between Words*, by suggesting that the introduction of word spacing in the seventh century began a continuum of private spiritual study and a growing resistance to church orthodoxy that culminated in the Protestant revolution of the fifteenth century. One might also speculate that the spiritual roots of Humanism and the birth of the Renaissance may also be situated, at least in part, in the rich intellectual atmosphere fostered by the private study of books.

Digital libraries do not affect one's ability to read silently or pursue a self-directed path of learning. But, as Birkerts (1994) has written, digital libraries do change the conditions by which one acquires knowledge. His book, *The Gutenberg Elegies*, contains a number of dire predictions about the death of literature hastened by electronic text, but also many cogent observations about how digital libraries and hypertext may affect cognition.

In a chapter discussing an earlier, CD-ROM version of the Perseus Digital Library, Birkerts at once praises it as a "powerful grazing tool" (p. 137) that facilitates cross-referentiality, and warns of its potential to denature historical context and create "a kind of Disneyland of information" (p. 139). Steering clear of Birkerts' more alarmist and reactionary statements, one may glimpse the parameters of social and cultural change brought on by new modalities of information in electronic form. Speaking of the Perseus Digital Library, Birkerts suggests, "the field of knowledge is rendered as a lateral and synchronic enterprise susceptible to collage, not as a depth phenomenon. And if our media restructure our perceptions, as McLuhan and others have argued, then we may start producing generations who know a great deal of 'information' about the past but who have no purchase on pastness itself" (1994, p. 137).

Birkerts values traditional books as a means of connection with a continuous narrative and a palpable sense of history. He laments the instantaneousness of electronic information, which may be too easily accessible to make an impact on one's intellectual development. Birkerts also views hypertext as an erosion of the physicality of language on a printed page to something more ephemeral – words generated by an electronic circuit. Such a destabilizing of the authority of the printed word, Birkerts argues, leads to an erosion of language itself: "The words that appear and disappear on the screen are naturally perceived less as isolated counters and more as the constituent elements of some larger, more fluid process" (1994, p. 156).

Here one might suggest that the rising prevalence of XML as a means of adding coded structure to documents offers an intriguing enlargement of – and crucial difference from – Birkerts' characterization of electronic text. In the notion of structuring electronic documents with XML is a magnification of Birkerts' idea of content separated from form. The extensibility of XML documents, with their suggestion of reusability in a variety of settings such as Web pages, print products, and PowerPoint slides, suggest a further sense of information as something extractable from its physical embodiment. But the concept of XML also mitigates against Birkerts' notion of electronic text as an unstable, unrooted medium. The idea of XML creates the notion of an information archetype – the XML-encoded document parsed through the XML schema – which may be manifested in a variety of different ways.

Birkerts' arguments are at times conservative, reactionary, and intellectually elitist, but he does offer compelling observations about the potential social impact of changing information modalities. As a virtual space, a digital library embodies the idea of a universe of knowledge to a far greater degree than a medieval library could, but a digital library also removes much of the intellectual labour in making connections. Birkerts suggests that intellectual effort is crucial to the forming of a personal world view.

Birkerts' views of the cultural impact of electronic information are highly subjective, but there is evidence that hypertext and the connection-rich environment of the World Wide Web are contributing to changes in students' learning patterns. In a study of Grade 6 students in an Australian classroom, Sutherland-Smith (2002) notes that the students rarely read linearly or sequentially on the World Wide Web and often feel rushed to gather information as quickly as possible. The author promotes the practice as a "snatch and grab" researching technique, in which students are encouraged to gather as much material they can as quickly as possible to be sorted through later: "The aim is that students read only superficially, with limited comprehension of the complete text, and compile a grab-bag of references. Teachers must reinforce that students need to read the compilation of texts in a more detailed manner and that references should be culled after a closer scanning of texts. We found this technique is effective in the limited computer laboratory time many classes are allowed" (Sutherland-Smith, 2002, p. 666). Interestingly, the author notes that the rushed feeling many students experience while surfing the Web is not discouraged, partly because of limited computer resources in a school setting. The suggestion here is of a fundamental change in the act of research itself, which is no longer a solitary, belaboured, contemplative activity but a frantic gathering of links in one's allotted time on the network.

Amtower (2002) and Saenger (1997) suggest that the reading of books in the Middle Ages contributed to a rising sense of individuality. But to Birkerts, the idea of a networked information space leads to a loss of self; engagement ceases to be an act of personal discovery and becomes "intrinsically public, taking place within a circuit of larger connectedness" (1994, p. 122). He adds his belief that electronic networks are contributing to an elimination of the self as a singular entity: "We may even now be in the first stages of a process of social collectivization that will over time all but vanquish the ideal of the isolated individual" (1994, p. 130). The statement, like many in Birkerts' book, edges toward incredibleness, but its kernel – a glimpse of the societal impact of networked knowledge and collaboration – bears consideration. Both concepts of shared resources and cooperation are powerful tenets of digital libraries and the Semantic Web.

For example, one digital library project in development at the University of California at Santa Barbara, the Alexandria Digital Earth Prototype, is expressly designed to link personal collections in an interoperable, georeferenced framework (Smith, Janée, Frew & Coleman, 2001). More broadly, the vision of the National Digital Library Program of the Library of Congress is to facilitate nearly universal access to resources: "From the user's point of view, the digital library has the potential, in ways not yet realized and not possible with traditional library resources, to be an extension to every desktop, classroom, and personal library" (Library of Congress, n.d.).

The concepts of resource sharing and collaborative information find their fullest expression in the Semantic Web. As noted above, Berners-Lee (2001) believes the Semantic Web will unleash unprecedented opportunities for data mining and knowledge discovery through the linking of ontologies into a common web

of meaning. Staab (2003) notes recent developments toward combining ontologies in the biological sciences to facilitate new forms of collaborative research in protein discovery and gene sequencing.

Cautiously, one may begin to glimpse a potential revolution in understanding through the power of networked information. Birkerts objects to the destabilization of language and the blurred relationship between author and reader suggested by electronic text (1994). But there is a corollary – the potential for new and unprecedented levels of information synthesis through networked resources. The Scholastic period created an era of unprecedented information summarization as individuals possessing sophisticated memory skills memorized a personal canon of structurally advanced books. Similarly, the era of the digital library, and by extension the Semantic Web, promises a similar revolution of efficiency. Metaphorically, one might describe the shift from physical books and libraries to digital information as a shift from exploration to command and control.

With the rise of hypertext and digital libraries Birkerts sees the demise of an individual's sustained encounter with narrative. On the other hand – and which Berkerts fails to value – is a society's encounter with information as a nearly inexhaustible plenitude. Ongoing research suggests that digital libraries are rapidly evolving toward multimedia information spaces that will offer a variety of interfaces tailored to user needs (Fox & Urs, 2002). These interfaces may be text-based; they may incorporate information visualization functions similar to expert systems; or they may offer a fully immersive three-dimensional virtual reality environment for information seeking (Fox & Urs, 2002). In their usability study of one such virtual-reality model of a digital library, Das Neves and Fox (2000) suggest that "there is little chance of finding an ideal interface for all users and uses of a digital library; rather, different interfaces will coexist as they are adopted by different sets of users" (p. 103). Networked information implies collectivization, but Birkerts' notion of erased individuality does not take into account new levels of customization implied by a proliferation of interfaces. Digital libraries suggest a pull toward universal access and collaborative use, but also a maximizing of information use and efficiency for individuals.

The modality of digital library use will remain fundamentally different from the use of physical books and libraries in the Middle Ages – including the library's relationship to human memory. Where access to books was limited and books themselves were highly valued, Carruthers (1990) suggests that memorization was a vital skill. The function of a digital library, however, is to be as accessible as memory itself – even a replacement for it. Berners-Lee (2000) conceives the Semantic Web as an ultimate digital library containing a vast nexus of meaning, one that will allow new cognitive achievements that humans could not achieve alone. His suggestion, noted above, is that the Semantic Web would magnify the capabilities of the human brain, and even act as a kind of prosthetic storage and computational device. If the Scholastic period yielded an unprecedented synthesis of knowledge and an expansion of human consciousness, the current period of networked information suggests an unprecedented blending of person and machine.

And the Semantic Web also offers an intriguing coda to the subject of word spacing, which Pombo (2002) and Saenger (1997) suggest contributed to the cognitive achievements of the Scholastic period. If the Semantic Web heralds a new age of intellectual triumphs, they will be accomplished not through the applying of pen to parchment, but through the functioning of machine-readable ontology languages, which will process the logical and semantic relationships among Web-based taxonomies and thesauri (Berners-Lee et al., 2001). In these languages, terms are expressed without spaces – in a new kind of *scriptura continua* – as "PropertyValue" and "subClassOf" (McGuinness, Fikes, Hendler & Stein, 2002).

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