TOWARDS A NEW DIGITAL TEXT

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The design of computer interfaces for reading

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After the technologists come the theoreticians.
— Friedrich A. Kittler, chosen by George Landow as the epigraph for his seminal *Hyper/Text/Theory*

He told me his book was called the Book of Sand, because neither the book nor the sand has any beginning or end.
— Jorge L. Borges, *The Book of Sand*
In an age when media-rich digital distractions abound, users are still turning to computing devices—e-readers, computers & laptops, tablets, and smartphones—to read long-form text. But many interfaces for reading digital text are holdovers from a time when screen-based text layout was constrained by primitive display technology. The design of new paradigms for reading on computers requires not just a creative approach to interface design, but an understanding of how the digitization of reading affects comprehension and how readers have historically adapted to new technologies. Armed with these insights, I aim to propose a new methodology to improve the user experience of reading on today’s digital, interactive, connected, and often mobile screens. Hopefully this thesis will spur user interface innovations for future computing devices, and underscore the importance of drawing on multi-disciplinary research and historical precedent for design inspiration.
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INTRODUCTION
INTRODUCTION

1.1 THE PLOIGHT OF THE INTERFACE DESIGNER

Are you looking for a heated debate about the future of technology, the nature of learning, and the fate of mankind? Visit a local book club and casually mention that you have read an article about digital text recently. Every reader, in fact, seems to have strong feelings about the encounter between the literary and the digital. There are those who proclaim with gleeful abandon (or dejected resignation) that print is dead, slain by the digital document, the e-reader, or the internet; others who maintain their stance as neo-Luddites and bibliophiles, stubbornly printing out every email they receive; and still more who worry about their diminishing attention spans as they put down The New York Times to skim an online feed of abridged content, flying across the computer screen in real-time. The spectrum of reactions is understandable given the highly personal nature of a habit like reading, but it should give pause and beg the question: what is so upsetting about text on a computer screen? The designer of computer interfaces for digital reading should take away two things from the uproar surrounding text on screens: first, that his job is a weighty one bound to incite heated opinions from all sides, and second, that the normal methods of design feedback—surveys, comparison tests, online polls, and formal analysis—can hardly capture the breadth and complexity of reader responses. A new methodology is required to make sense of the medium of digital text.

The proliferation of digital text may be a jarring event for today’s readers, but the shock of this new medium is hardly a unique phenomenon. Plato tells us that in Classical Greece, Athens’ smartest men grappled with similar questions about the consequences of written text as a medium. In his dialog with Phaedrus, Socrates recalls the tale of Thamus, king of Egypt, and Theuth, so-called inventor of writing:

...When they came to letters, This, said Theuth, will make the Egyptians wiser and give them better memories; it is a specific both for the memory and for the wit. Thamus replied: O most ingenious Theuth, the parent or inventor of an art is not always the best judge of the utility or inutility of his own inventions to the users of them. And in this instance, you who are the father of letters, from a paternal love of your own children have been led to attribute to them a quality which they cannot have; for this discov-
Thamus’ words echo those of many readers today; the same maladies—forgetfulness, shallowness, ephemerality, and more—have been attributed to digital reading. Socrates and Phaedrus may not have reached a conclusion about the veracity of Thamus’ claims, but history tells us that the careful attention paid to writing and its effects on memory and learning by early scribes, thinkers, readers, and eventually bookmakers resulted in an expressive, informative, and long-lasting medium which stimulated millennia of intellectual advancement and coexists to this day with the oral tradition. The important takeaway from this historical example is that although Thamus’ fears were put to rest, the success of the book was in no way inevitable. All media, digital text included, are malleable information carriers whose effects on content, cognition, and interpretation are constantly modulated by authors, editors, designers, and makers. Dialog, such as that between Socrates and Phaedrus, is essential for understanding the potential of a medium and deciding its future. Now, however, the medium with the undecided future is electronic text. The goal at hand is to ignite more nuanced dialog about written content in the digital realm among those who author, produce, and present it, dialog that is informed by history and media theory as much as empirical science.

Digital text will change how people read, and “architects” of the digital realm can profoundly affect the direction of that change depending on how they design the way we read on screens. That the creators of content in any given medium have the ability and responsibility to fundamentally alter the medium’s character should come as no surprise. In medieval times, to highlight just one example, increased attention to rhetoric and epistemology necessitated the creation of meta-textual works containing analysis and commentary. Books of the era began to be segmented and expanded with headings and subheadings to provide easier reference points in complex arguments. In such a manner, page design and reading style evolved hand-in-hand, allowing the medium to support new ways of thinking about text and engaging with authors. More specifically, the formal elements of the book (headings and subheadings, for example) were derived from how the book was meant to be used. In one fell swoop, the nature of academic discourse was changed forever by book design.
The intentionality of crafting specific reading experiences should be an integral part of digital text design too.

The metaphor of the designer as “architect” is useful because it allows us to leverage an important architectural term to explore a particular methodology in greater depth: that of the “program”. An architectural program is the set of activities which are supported by the formal structures of a building. What this simple definition hides is a powerful perspective that places the inhabitant of a building at the center of the design process. The program is as much a description of how a building will be used as it is a sketch of the building as a performance space, enabling certain activities, and dissuading from others. In a more general sense (and one that is directly applicable to digital text), the program of any object describes the author or creator’s ideal vision for how the object will be interacted with and used. As a prescriptive process, therefore, the development of a program is useful for framing a discussion of what digital text should look like. I posit that deciding how to design digital text so as to effect better readers is equivalent to determining the ideal program of digital text.

The vast majority of digital text designed today is presented on screen-based interfaces preoccupied with flashy visuals and poorly-defined measures of “utility” The dialog between interface designers (to the extent that it exists at all) assumes that the ideal digital text interface is simply one which combines all possible technologies in a legible manner: the text itself along with dynamic media, real-time content updates, a commenting system providing instantaneous annotations from readers around the world, dense hyperlinks, animations, and interactivity. But as the research of the following section shows clearly, the nuances related to how humans decipher, analyze, understand, and learn textual information complicate such a straightforward interpretation of good design. Ultimately, these user interface designers are creating a digital medium on which text is simply not pleasant to read (even if it may look pretty). If we continue to let the technological imperative and the trends du jour of the internet dictate the design direction of digital text interfaces on computers, we will be left with a fundamentally non-literary medium.

The way forward is a two-part process. First, the informed interface designer must understand empirically how readers read and how digital interface elements affect human reading abilities. In this thesis, this empirical evidence comes in the form of a scientific literature review detailing the effects of digital text on reading ability. The science behind how people read on computers is prerequisite knowledge for the rest of the design process. Second, the critical interface designer must create a program for digital text, or a prescriptive proposal for the activities to be supported by reading on digital devices. I posit that the development of such a program for digital text, should be informed by history and media theory. Ultimately, we must under-
stand what assumptions we can make about digital text based on our knowledge of print text, and what phenomena are entirely new to the digital medium. The goal is to begin with readable text, and to enter a brave new world where computer technology enhances reading and digital literature evolves into a mature, purposeful, and unique medium.
Part II

EMPIRICAL RESEARCH
The goal of the following section is to examine the digital reading process by reviewing empirical research. Equipped with greater knowledge about how readers read text on screens, the interface designer gains a better idea of how an interface should support that process. To put it another way, this research is mostly descriptive and rarely prescriptive, but it is incredibly useful for informing design decisions and later suggesting a program of activities for digital text.

There is a significant body of scientific literature investigating the effect of digital text on reading and comprehension. The subject has been the focus of attention from many disciplines including: psychology, cognitive science, neuroscience, human-computer interaction, and user interface design. The following survey will attempt to highlight studies and identify trends which reveal important disparities between print and digital text or hint at aspects of digital text which can be changed to improve reading performance and comprehension.

2.1 THE PROBLEMS OF DIGITAL TEXT

Research on screen-based reading began in earnest in the mid-1980s. Kerr wrote an agenda in 1984 urging researchers to understand electronic text by focusing on three aspects of the medium: typography, graphics, and “interpanel navigation”. He presciently concluded, “Understanding the use of electronic text needs closer ties between human factors and learning research” [Kerr, 1984]. The following year, the first major study of screen-based reading and comprehension was conducted. Belmore [1985] found that reading time was longer and comprehension less accurate when subjects read texts on an Apple II computer monitor versus white bond paper. She concluded that the evidence collected over multiple trials raised “the possibility that the processes involved in reading video text may not be comparable to traditional reading, especially without extensive practice on a given task” [Belmore, 1985]. Other research of the time contributed to a general consensus that print text was a better format for reading in terms of comprehension and difficulty. Said one researcher with finality (channeling Gertrude Stein): “but a book is a book is a book. A reassuring, feel-the-weight, take-your-own-time kind of thing...” [cited in Waller, 1986, p. 261]. In retrospect, much of the pessimism for digital text was a product of the technology available for displaying it at the time. The computer monitors that were the subject of studies in the earliest years of digital text were notorious for their low resolution,
flickering scanlines, fluctuating luminance, and poor color fidelity. Some studies involved white text displayed in capital letters over a neon-blue background—such were the limitations of the era. Nevertheless, the scientific and technical communities were both confident that display technology would inevitably improve [Dillon, 1992]. In the words of Ted Nelson, who coined the term hypertext: “The question is not can we do everything on screens, but when will we, how will we and how can we make it great? This is an article of faith—its simple obviousness defies argument” [Nelson, 1987].

By the early 1990s, there was enough literature to provide the basis for an initial survey of the differences between paper and screen-based reading. By this point, however, the research conclusions were more nuanced. Dillon [1992] attempted to highlight findings in specific categories of comparison, including speed, comprehension, and eye movement (as a measure of reading efficiency). He noted that the most common experimental conclusion was that “silent reading from screen is significantly slower than reading from paper [Kak, 1981; Muter et al., 1982; Wright and Lickorish, 1983; Gould and Grischkowsky, 1984; Smedshammar et al., 1989]” [Dillon, 1992]. Other differences between paper and screens were not as clear. Comprehension of text after reading, for example, seemed to be about the same across media, at least in some studies. But Dillon strongly qualified this statement by noting the difficulty of developing sound, accurate qualitative measures of comprehension across subjects. Experiments tracking eye movement, on the other hand, proved conclusively that there were noticeable differences in the way subjects physically scanned their eyes across text between paper and screen. Since numerous researchers have shown that eye movements (or saccades) during reading correspond to difficulty, discriminability and comprehensibility of text [Mills and Weldon, 1987; Tinker, 1958], Dillon argues that these movement patterns might also suggest means of improving screen-based reading. While his analysis of 82 studies provided ambiguous conclusions in some areas, Dillon found one point agreed upon with near unanimity: “Invariably it is the quality of the image presented to the reader which is [most] crucial.” At the time, display quality was the bottleneck which prevented readers from assimilating to the medium and researchers from studying more subtle differences between print and text.

2.1.1 Screen Quality

In the two decades since Dillon’s survey, the facet of digital text that has improved the most has been screen quality. Cathode Ray Tube (CRT) monitors have been replaced by Liquid Crystal Display (LCD), plasma display, and Organic Light-Emitting Diode (OLED) monitors. The newer displays provide higher resolution, higher con-
contrast (brighter whites and deeper, darker blacks), wider color gamuts, and less intense backlights (not to mention non-visual improvements like lower power consumption). Furthermore, displays for digital text have expanded beyond the computer screen. Mobile devices and smartphones promise pixel densities high enough that the human eye is unable to discern individual pixels, and e-readers (or e-book readers) display text on screens designed to mimic the appearance of ink on paper. By all accounts, the current landscape of devices provide a visual reading experience that is leaps and bounds better than the technology of the ’80s and ’90s. Moreover, the rapid advancement of screens thus far suggests that their readability will only increase. It is prudent and pragmatic to imagine a near-future hardware landscape where screens are not only indistinguishable from paper, but provide better text fidelity than the mass-market paperback book, for example.

The proliferation of screens and different devices for reading text has at least one negative side effect, however. The range of sizes and shapes of screens is vast, and a single digital text document is usually expected to be displayed on all of them. This expected digital ubiquity is a sharp contrast to the world of print text, in which the publisher of a document has exact control over the form that the reader sees. In practice, displaying text on a variety of different screens usually means losing control over certain aspects of page layout. Layouts which change dynamically according to screen size currently fit text onto large and small screens alike by altering certain parameters automatically: the size of the text, the width of individual lines, the number of columns of text, or the length of the page. Often, these parameters are forced outside their recommended set of values. Thus even when empirical research determines optimal aspects for page layouts, it is often difficult or impossible to generalize the results to a layout which adjusts flexibly to the myriad screens available on the market today.

Save the inherent dilemma of increased screen variety, recent studies suggest that better display quality has had only a positive impact on reading on the computer. But improving display quality is low-hanging fruit. Substantial visual improvement of computer text has revealed that the way text looks to the reader is only one of many factors in how easy it is to read and understand. Modern survey studies show that the cognitive differences between reading print and digital text are more systemic than previously expected. Noyes and Garland [2003] performed a study of digital and print text comprehension and found that with better screens, reading speed and basic comprehension were very similar between media. But they also found that the manner in which learned information was recalled showed significant difference. Textual knowledge was more readily retrieved when presented in paper format. The difference was remarkable enough
that the authors cautioned: “there may be occasions, e.g., in safety-critical systems, when vital information that needs to be assimilated quickly should not be presented via a computer screen.” Noyes and Garland’s study shows that more research is needed to understand cognitive differences at a deeper level.

2.1.2 Cognitive Load

The key to understanding how cognitive processes differ between print and text may come from a better understanding of mental workload. Cognitive scientists postulate that individuals have a limited amount of mental bandwidth that can be used for information processing; when the demands of a cognitive task exceed the capacity for attention, the individual’s ability to complete the task will be impaired. Indeed, Mayes et al. [2001] found that comprehension difficulties in digital text were only noticeable when individuals attended to a secondary task (keeping track of a word list) while reading. This result suggests that compared to print text, digital text may carry an increased cognitive load as baggage, the effects of which are subtle enough that they are recognized only when mental workload exceeds a certain threshold. Other researchers have noticed this mental overhead and postulated as to its origin. Wastlund found that page layout and navigation methods could contribute to a high cognitive load. Designs better adapted for content and context, accompanied by intuitive controls, may eventually reduce the cognitive overhead of digital text. Unfortunately, the underlying complexity of the process of reading means that it is very difficult to design experimental studies which reveal exactly how the brain comprehends text.

2.1.2.1 Ergonomics

Other differences between books and screens seem similarly intractable. The ergonomics of the physical book are difficult to mimic with a two dimensional screen. In The Myth of the Paperless Office, Abigail Sellen and Harper highlights the tangible differences between media, noting, “The implicit feel of where you are in a physical book turns out to be more important than we realized” [Sellen and Harper, 2003]. The feel of the book isn’t just an aesthetic preference, though. Manipulating a physical book is a necessary element of most reading tasks. To read literally requires dexterity: the reader turns pages sequentially (usually), marks locations with a finger, earmarks important pages, riffles the edge of the text to move to different sections, and compares passages by bending one page to reveal another. In a study of magazine readers, Marshall and Bly [2005] cataloged a list of reading actions which also included folding the entire magazine to narrow focus on particular text passages, or opening it fully to consider an entire spread of text as a whole. They remarked, “Much of
the reader’s field of view is devoted to orientation cues such as running headers, page numbers, section titles, and—importantly—the stack of page edges on either side of the reading position” [Marshall and Bly, 2005]. Research even shows that readers’ awareness of their position in a document and the documents overall length is a subliminal process that doesn’t require purposeful monitoring [Crestani and Ntioudis, 2001]. The physical book also provides other cues to the reader which are unfortunately lost in the migration to digital. Hill et al. [1992] and Chu et al. [2004] note that the wear of a book provides valuable information about how old it is and what pages are read often. Although screens are rapidly increasing in resolution and quality, it will be a relatively long time before they break out of their flat, two-dimensional, rigid form factor. It appears that we are nearing the ability to recreate the look of ink on paper (on a screen) much faster than the ability to mimic the texture, flexibility, thinness, and weight of paper (on the same screen). For this reason, the tactile differences between paper and screens require careful analysis—we will be stuck with them for a while.

2.2 INTERFACE SOLUTIONS

The scientific literature generally supports the notion that print text, and in particular, the book, still have a number of advantages over digital text. Although researchers are not in complete consensus on the issue, it is clear that when considering comprehension and ease of use, digital text is at best equal to print text as a general reading medium, and at worst deficient in numerous aspects. Studies suggest that cognitive load is higher when reading from a computer screen, and researchers are unanimous in concluding that current input and navigation devices pale with regards to ergonomics in comparison to the book. The ideal digital text interface “will not only capture the affordances of paper, but also transcend paper’s limitations” [Marshall and Bly, 2005].

Current limitations aside, digital text already promises a brave new world of information conveyance and retrieval. Hyperlink connections and full-text search alone allow for learning opportunities and research tools unlike anything found in even the most complete print encyclopedias. The onus of the interface designer, therefore, is to use empirical knowledge of digital text’s deficiencies to create interfaces which minimize or eliminate them. The prospect of well-designed digital text is exciting, but poor implementation of interfaces will cripple the medium and the reader.

Capturing the affordances of paper in a digital text interface means finding a way to translate certain elements of the physical print experience to the digital realm. This translation process is not always straightforward; it involves abstracting a three dimensional object
(the book) into the two dimensional plane, and replacing dexterous physical movements (a page turn, for example) with analogous interactions through limited means of input (a mouse movement or keystroke) in such a way that the cognitive process of reading is disturbed as little as possible for the reader. Fortunately, empirical evidence can help the designer by shedding light on what types of interface elements and interactions have been successful in the past. We will draw on this evidence to inform a number of different aspects of the interface: layout, spatial cues, navigation, focus, and representational style.

The role of the interface designer, and the designer in general is also that of an artist. Although the practice is a pragmatic one, it is highly subjective and governed by a unique set of aesthetics, principles of craft, and wisdom passed down from previous practitioners. The function of empirical data in design discourse is not to replace artistic license, but to ground broader design discussions with evidence about how design affects users (in this case, readers). In other words, the purpose of interface design studies is not to justify the minutia of every design decision. Scientific studies about how users react to certain interface elements serve a parallel purpose: reminding the designer that the design object (the interface) is a means to an end (serving the reader and conveying information successfully, efficiently, and aesthetically), not an end in itself.

2.2.1 Typography & Page Layout

With that disclaimer aside, we turn our attention to the typography of digital text. A preliminary question of importance is determining the role of print-based research in designing digital text. In the early 1980s, when some of the formative research on digital text design was first conducted for computer screens, the consensus was that page size (or screen size) was the fundamental variable which determined every other typographic parameter. The size and orientation of the medium affects decisions about columns, line length, letting, spacing, choice of typeface, and positioning. At the time, the vast majority of electronic displays shared a “landscape” orientation (i.e. they were wider than they were tall). Moreover, the amount of text which could comfortable fit on an early, low-quality computer monitor was much less than the equivalent amount of text on the average printed page. And it wasn’t just layout which was constrained by early computer systems, but typography itself. Monospaced fonts were the default for most commercial computers until the Apple Lisa introduced proportional fonts to the masses in 1984 [Wright, 1998]. Deficiencies in screen quality, poor digital typography, and ubiquity in monitor shape and size therefore dictated that digital text design deviate from print text design. In a 1987 article on designing digital
text, James Hartley notes: “I am often asked what relevance my research on the design of printed text has for the design of electronic text. My cautious reply usually suggests that certain features of print-based text research do apply to electronic text, but that there are many features that do not. Electronic text is limited in some ways compared with printed text” [Hartley, 1987]. If we view Hartley’s statement as a causal relationship, then the converse is equally true today: since the display of electronic text is no longer limited in the same ways compared with print text, then many features of print text research which did not apply to electronic text in the 1980s now apply today. Put another way, now that digital text typography has the same range and repertoire as print text typography, digital designers can use all of the print-based research at their disposal to inform issues of legibility and layout on the computer-screen page.

2.2.1.1 Print-based Typography

A survey of print-based research on typography, page layout, and book design is outside the scope of this thesis, but it is worth mentioning some of the notable scholars who have contributed to the field. The majority of research on legibility in print design occurred between the ‘20s and the ‘60s; publications from this period include Pyke [1926], North and Jenkins [1951], Tinker and Paterson [1939]; Tinker [1945, 1948, 1963], Zachrisson [1965], Poulton [1965] and Hartley [1987]. The seminal work is Tinker’s Legibility of Print, published in 1963. Unfortunately, perhaps due to the specificity of its title, Legibility of Print has had little impact on the field of interface design, and in particular digital text design. Far from being an out-dated relic of an earlier era, Tinker’s work is a timeless standard for design, as applicable today for digital text as it was on mid-century print typography. To put it differently, the way humans decode, read, and understand typography has evolved much more slowly than the mediums through which text is transferred. Empirical experiments concerning legibility and typographic design details are in some sense timeless too. The designer of today misses out on some of the best and most pertinent research by consulting only those studies which were designed specifically for digital text.

2.2.1.2 Digital Typography

The literature on digital typography and page layout is much more nascent. Few studies accurately isolate individual parameters to test their effect on reading legibility and comprehension. The focus of those studies which do elucidate specific design considerations tends to be the organization of text into blocks and columns. The matter of column width was explored by Dyson and Kipping in 1997. They found that the preference of readers for wide columns or narrow
columns of text was affected by the method by which they changed pages (either scrolling or paging). In a follow-up study, Dyson and Haselgrove [2001] added a specific suggestion of ideal column width: 55 characters per line. This medium line length supported comprehension and effective reading with both normal and fast readers. It is worth noting that this conclusion agrees with the print typesetting tradition where the recommended line length is anywhere between 40-60 characters. Dyson and Kipping [1997] also investigated whether one large column of text was more legible than three narrower columns of text. Readers rated the three-column format as easiest to read. Closely related to column layout is the arrangement of multiple windows of text alongside each other, where interface windows are distinguished from columns by their ability to display distinct pages from one or more documents in separate browsing environments. Multi-window interfaces are seen by some as an attempt to replicate digitally the ability to compare two print documents side by side. Tombaugh et al. [1987] found some evidence that multi-window interfaces could be useful to advanced computer users who were already familiar with the modal paradigm; however, the average reader was slowed down by having to navigate separately in multiple different windows. Given the suggested column width of about 55 characters and the very wide screens of many monitors, the question of how to center the column is not always obvious. By studying eye movements during reading in a variety of trial participants, Vitu et al. [2004] noticed strong biases towards the central region of the screen, specifically a spot slightly left of center. The findings suggest that the ideal location for a block of text is directly to the left of the midway point of the screen. It is important to note that the conclusions of page layout research on legible text are merely evidence of good practices. Like books, digital text documents should be designed with careful attention to content, context, and audience. The ideal column width or line length will inevitably vary with the document at hand; the research merely provides a good starting point in the form of general guidelines for layout.

2.2.2 Navigation

While the typography and page layout of digital text should draw heavily on that of print text, paradigms for navigating digital text have no direct analogue. The most natural counterpart for turning a page in a book is paging through digital text by keyboard key or button. Formally, paging is the navigation device in which a binary trigger (left/right or up/down) replaces the current “page”, all the text displayed on the screen, with the previous or following “page”. The length of a page is determined solely by the available screen space, and differs from monitor to monitor, program to program. Scrolling,
on the other hand, is the more ubiquitous, but less intuitive navigation device. Defined as sliding a text document across a display screen, vertically or horizontally, scrolling makes for fluid navigation, but disrupts the fixity of print. As early as 1987, Mills and Weldon discovered that non-scrolled text was read more efficiently than scrolled text. Users also preferred paging to vertical scrolling. It is important to note that Mills and Weldon used test subjects who were inexperienced computer users. Hansen and Haas [1988] identified other disadvantages of scrolling in the loss of cues to the location of information. Because a scrolled document constantly advances vertically, there is no permanence to where particular words are read, and thus spatial relationships are weakened. As Hansen and Haas put it colloquially, readers had a better “sense of text” with paging rather than scrolling. In a landmark study, Piolat et al. [1997] measured the difference between paging and scrolling through six parameters of reading performance:

A. Level of participants’ involvement in the task
B. Level of mental representation of the spatial layout
C. Level of processing saliently located information (i.e. information at the top or bottom of a page)
D. Level of locating information in the text
E. Level of text comprehension
F. Level of detail processing

They concluded that reading performance in each of the six categories was better when paging through text versus scrolling. Despite the clear results of early research, the debate between scrolling and paging continued as researchers struggled to distinguish between familiarity with a format (scrolling is by far the most ubiquitous document navigation paradigm) versus inherent efficiency Liesaputra and Witten [2012]. Dyson and Kipping [1997] tested more experienced computer users and found that paging was consistently faster for reading long documents than scrolling (with a similar level of comprehension among subjects). Parsons [2001] found that many readers continued to be actively dissatisfied with the scroll format. The evidence suggests that paging is ultimately a more efficient and comfortable navigation strategy than scrolling, but that any transition away from scrolling must mitigate users’ ingrained familiarity.

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1 Results in some categories were observed directly, while results in the others were known to be dependent on the observed categories.
2.2.2.1 Implementation of Paging

The implementation of paging on a computer screen is a matter which must be treated with finesse. Most digital documents implement paging as a discrete act in which the current screen of text is immediately blanked and replaced with a new segment of text [Benest, 1990]. Unfortunately, immediate text replacement can be a jarring, unnatural effect which disrupts the flow of reading. In order to maintain continuity and evoke the feeling of physically turning a page, Liesaputra and Witten [2012] recommend a subtle animation when the previous or next button is triggered. The key here is the subtlety of the animation. Since McCusker [1998] notes that 3D page animations are seen as ineffective and inefficient, the best animation is one which conveys motion without resorting to photorealism or introducing a noticeable delay between pages. Slight horizontal movement as a new page of text is introduced is enough to maintain continuity within the document, and indicate to the reader the direction of their travel [Liesaputra and Witten, 2012].

2.2.2.2 Hypertext Navigation

When designing hypertext documents, navigation is not just constrained to forward and backward linear traversal. The hyperlink itself introduces a new mode of navigation. Specifically, clicking a hyperlinked word or phrase will take the reader to a different text segment or document. Choosing how to navigate a hypertext turns reading into an open-ended process. Research supports the notion that novice readers can have difficulty recognizing important relationships between different parts of hypertext [Mcnamara and Shapiro, 2005]. The reading interface, therefore, must provide visual aids to make navigation cohesive and clear. Building off the work of van Oostendorp and Juvina [2007], Ignacio Madrid et al. [2009] showed that highlighting particularly pertinent hyperlinks in a given hypertext segment increased the coherence of the reading process and reduced cognitive load. Adding “link suggestions” to a hypertext document doesn’t reduce the number of possible ways for a reader to peruse the text, but it is a means of providing fewer suggested paths. In other words, the author is able to reassert some influence over reading order, and in doing so guide the reader through a reasonable traversal of the open-ended document.

2.2.2.3 Lightweight Navigation

The implicit aim of navigation devices and aids is to make the reader’s traversal through a document direct and clear. In digital text, traversal is often discontinuous; that is, navigating from one section of a document to another gives little indication of what lies between the starting and end positions. Deciding to read an article in the middle of a digital magazine, for example, is often translated into a single
“jump” from the table of contents to the beginning of the chosen article. Ideally, we would like to add an element of serendipity to the navigation of a paginated or hypertext document. In a study aimed at understanding how subscribers read *The New Yorker* magazine, Marshall and Bly [2005] noted that one of the key features of the print magazine was that they provided for “serendipitous encounters of new unsought information.” When first opening a magazine, readers tended to flip through it quickly gaging the overall content of issue and seeing what images and titles caught their eye. In many instances, this casual, haphazard perusal led test subjects to read articles they wouldn’t have discovered from the table of contents. Marshall and Bly realized that skimming the magazine contents as a whole was just one of several reading behaviors that resulted in serendipitous finds. They dubbed these behaviors (which are often subconscious to the reader), “lightweight navigation.” Instances of this phenomenon included: viewing page elements outside of normal text flow, skipping ahead to anticipate future text, and rereading past text for context or better understanding. Furthermore, Marshall and Bly noted that lightweight navigation was much rarer among readers of digital text. Their conclusion was that the navigation devices of ebook readers were unable to capture the casual, happenstance nature of lightweight navigation. Given the prevalence of lightweight navigation in reading print text of all kinds, it is imperative that digital text navigation is simple enough to become subconscious, expressive enough to encompass lightweight navigation, and indirect enough to enable serendipitous discovery.

### 2.2.3 Spatial Representations of Textual Information

Reading is a bi-directional process. It involves not just the decoding of text from the page, but the encoding of spatial information in a mental representation of the document. As Piolat et al. [1997] confirm, positional information about words, sentences, and text segments is stored while reading. It has been demonstrated that readers can even identify the location on a page where a block of text was first read, after they finish perusing the document [Rothkopf, 1971; Christie and Just, 1976]. This supports the notion that spatial encoding of information happens in a two-dimensional plane Piolat et al. [1997]. Furthermore, there is evidence that “the ‘where’ may serve to recall the ‘what’” [Baccino and Pynte, 1994]. Some researchers have posited that spatial encoding of textual information exploits human spatial capabilities from the physical world to speed recall [Tavanti and Lind, 2001]. Piolat et al. are quick to add that not all textual information is stored spatially, nor is the frame of reference for the spatial encoding understood. While the mechanisms surrounding the linking of spatial and textual information have not yet been elucidated, it is clear
that the page itself and the location of the page in relation to others in a document or book play a fundamental role in giving structure to the reader’s mental representation of the content of the work.

The page, as a fixed unit of text and a foreground for situating text spatially, is entirely capable of being reproduced on the screen. More difficult from the perspective of the interface designer is the task of recreating spatial cues to situate each individual page in the context of the entire digital document. Many implementations of paginated digital text include a horizontal navigation bar to show the relative position of the current page in the entire document. Navigation bars are often composed of a “trough,” or track representing the entire document, and a “thumb,” or highlighted segment of the trough representing the proportionate length and relative position of currently displayed text. In order to provide more information than just relative position, McCrickard and Catrambone [1999] propose an alternative to the navigation bar dubbed the “mural” bar. This interface element adds abstract graphical elements to the trough to indicate characteristics of the text document. Section headings, chapter markers, and other text structures are represented by elements such as colored lines or shapes, giving the reader a sense not just of how far through the document they have traversed, but where they are located relative to other segments of the text. Li et al. [2013] propose another method of embedding visual cues in a spatial representation of the document. Instead of a navigation bar, Li et al. introduce an interface below each page of text which uses icons arranged horizontally to indicate where pictures, bookmarks, and text comments appear throughout the document. A pictorial representation of the document as a physical book highlights the current chapter in red. Li et al. rely on ordered icons rather than abstract proportional elements to give shape to their cognitive map. Trial studies found that the visual cue map improved navigation performance, but had no significant effect on comprehension scores. Li et al. postulated that in certain cases, the map may have distracted the readers, and in turn affected their comprehension. This result is consistent with earlier efforts to study visual cue maps [Hofman and Van Oostendorp, 1999]. As is the case with most interface elements, it seems that subtlety is the key to conveying spatial information without distracting readers.

2.2.4 Realistic Book Interfaces

A number of researchers have explored reading interfaces which replicate three-dimensional books realistically. One of the driving principles for this research is the argument that realistic books rendered on a computer screen in three dimensions convey valuable spatial information to the reader. Separate from the impact of photorealism on spatial awareness, the question is emblematic of a larger concern.
At what level of abstraction should reading interfaces (or other interfaces for that matter) be designed? The research is somewhat divided. In a landmark study of realistic electronic books, Liesaputra and Witten [2012] summarize the literature related to realism and abstraction in interfaces. Early proposals for three-dimensional book environments (Webook and 3Book [Card et al., 2004]) proposed book models but did not test their effectiveness empirically. Later studies by Cockburn and McKenzie [2001, 2002] reveal that users often find three-dimensional interfaces cluttered and inefficient for reading and studying texts. In studies, researchers found that the affordances a three-dimensional book interface yielded in terms of navigation ability and spatial awareness were diminished by confusion about how to use the interface and an inability to quickly retrieve information. Nielsen [1998] suggests that some of the confusion and inefficiencies of three-dimensional interfaces may stem from the fact that current input devices only allow two-dimensional manipulation. The mouse, the keyboard, and the touchscreen are difficult to wrangle in three-dimensional space. Fortunately, the studies of Cockburn and McKenzie [2001, 2002] also reveal a potential solution to the problem of realistic representation. Cockburn and McKenzie found that a two-dimensional interface that simulated the appearance of being three dimensional (by using graphical projection and slight perspective) allowed readers to perform better on a multitude of tests. These so-called two-and-a-half-dimensional interfaces may be able to capture some spatial cues about the relationship of page to document without bringing the clutter and confusion of a true photorealistic interface.

Clearly, the body of literature related to empirical studies of readers using computer interfaces is vast. Although it can be difficult to glean overarching, general conclusions about the state of digital reading—or even find consensus between different researchers on more specific issues, there is much to be learned from a careful study of the scientific evidence related to human-computer interaction. Furthermore, there are ample results which can be applied directly to modern reading interfaces. A short survey of the most popular interfaces for digital text, including websites with written content, shows that although research regarding best practices for reading on screens exists, there is little discourse between prominent interface designers and the scientific and academic communities.
Part III

MEDIA THEORY
3.1 THE FUTURE OF THE BOOK

Digital text seems innocuous enough as a concept. Any reader with technological savvy is familiar with the idea of text appearing on a computer screen. After all, text was the first content that the earliest computers were capable of displaying, and for decades, the only interface by which users were able to interact with their devices. But the seemingly simple marriage of text to screen is actually a pairing of two very different media that raises many difficult questions. Our primary inquiry—what digital text on a screen should look like to a computer user—can only be answered after considering the consequences of digital text as a new medium.

What characterizes digital text exactly? The label is ambiguous in part because it has different meanings in different contexts, and in part because of the nebulous definition of text. To computer scientists, affixing “digital” as an adjective to any object of study is a bit of an oxymoron. A programmer or interface designer might interpret digital text to mean simply any words on a computer, that is everything from a single-word label on an operating system menu to the content of a newspaper article appearing in a web browser. Most scholars of literary theory, however, use the term “digital text” to refer to literature, fiction or nonfiction, that appears on a computer (as opposed to “print text”). This is the definition that best conveys the subject of this paper.

There is a further semantic distinction that is useful to confront early in our analysis of digital text as a medium. The term hypertext is often used alongside digital text, but has a slightly more specific definition. George Landow has formalized the definition of hypertext as “an information technology consisting of individual blocks of text, or lexias, and the electronic links that join them” [Landow, 1994]. In this sense, hypertext is the subset of digital text that contains electronic links, or hyperlinks.

Hypertext exemplifies a key structural difference between print text and digital text. The vast majority of print text is intended to be read

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1 At first glance, it seems that “digital literature”, would be a more appropriate term and less likely to be misinterpreted by readers of different backgrounds. Unfortunately, I feel that literature connotes not just a definition of a type of text, but the entire canon of work which falls under the definition as well. I hesitate to use “digital literature”, therefore, because I am interested in literature on a computer in general, not any specific works of content. “Digital text” clarifies this distinction by referring to written works in the abstract sense.
from beginning to end in a sequential and continuous manner. Much digital text is linear in nature too. But hypertext, whose continuity and sequence depends on how the reader navigates links between lexias, has the potential to be circular, recursive, forking, meandering, even infinite. Jorge Luis Borges’ “The Garden of Forking Paths”, a story published in 1941 well before the introduction of the computer, is often cited as inspiration for the conception of hypertext. Borges was captivated by the idea of a text which could contain simultaneously multiple narrative arcs.

The implications of hypertext (and of Borges’ vision) are great. Hypertext overturns conventional assumptions about the nature of authors and readers. Since it is the reader who chooses how to navigate between hypertext’s different lexias connected by hyperlinks, the role of the author in guiding how the reader reads his work is somewhat diminished. With infinite or indefinite ways to navigate through a hypertext, there is no guarantee that two readers of the same work will have even read precisely the same thing. Umberto Eco navigates this uncertainty by referring to hypertext as a system rather than a canonical document. Give the same properly-hyperlinked dictionary to Shakespeare and to Dan Quayle, he jokes, “and they have the same odds of producing Romeo and Juliet” [Eco, 1996] (Shakespeare by writing it intentionally and Dan Quayle by happening to click the links between words in the right order).

Armed with a working definition of digital text which encompasses both hypertext and linear text designed to be read sequentially, we can begin a more careful analysis of the medium under the guise of media theory. The first distinction to make is that between digital text itself and the experience of reading digital text on any particular device. In other words, although we have defined digital text to be literature that appears on a computer, it is important to note that it can appear on any computer (mobile phone, e-reader, and future devices included). As Landow puts it, digital text’s key characteristic is “its intrinsic separation of text from the physical object by means of which it is read” [Landow, 1994, pg. 3–4]. This division of text from physical object is not necessarily new to digital text; the Mexican-Dutch artist Ulises Carrión writes in 1975, “A writer, contrary to the popular opinion does not write books. A writer writes texts” [Ludovico, 2012, pg. 163]. But the fixity of print makes any practical separation beyond the conceptual, impossible. Landow points out that the distinction between text and device in the digital domain crucially undermines the two most common reservations about digital text: that “you can’t read an electronic book in the bathtub” and that reading on a computer screen can’t compete with “the experience of reading a leather-bound volume” [Landow, 1994, pg. 4]. While today’s technology may make for unpleasant or even impossible reading experiences, digital text is particularly exciting because the experience of reading it has
the capacity to change and improve as new display and presentation technology is invented.

Through this lens, it is interesting to consider the French artist Ville-mard’s 1910 vision of Paris in the year 2000. He depicts a teacher grinding up books in a machine which distills information into audio signals to be heard by a class of students through headphones. While a mystery machine that grinds print text into audio signals is still as fanciful today as it was in 1910, it is certainly plausible to imagine a computer program that synthesizes an audio lesson from digital text. The medium of digital text is intrinsically transmutable and flexible.

Of course, assuming that media (digital or not) are somehow interchangeable flies in the face of at least 50 years of cultural theory summed up in the oft-quoted Marshall McLuhan expression “the medium is the message” [McLuhan and Fiore, 1967]. As McLuhan later elaborated, “all the new media are art forms which have the power of imposing, like poetry, their own assumptions” [Ludovico, 2012, pg. 87]. This observation is the crux of any analysis of digital text as a new, distinct medium. Although digital text has existed for at least 50 years, its timeline pales in comparison to print text and the history of the written word before Gutenberg. Despite the feverish pace at which technology has evolved and digital text with it, we are still grappling with theoretical frameworks to explain and study digital innovations that happened decades ago. Digital media theory and digital literary criticism are newer areas of study yet. This continual evolution of technology means that it is difficult to establish any sense of finality for even the introduction of digital text. Is today’s technology for reading concrete and advanced enough that we may herald the adolescence of digital text? Or are we still exploring the landscape of the medium, determining where to lay the foundations for future development? The fact that we will never be able to answer these questions with any degree of certainty shouldn’t hinder a critical assessment of the medium in the present. And more importantly, it is prudent to anticipate future advancements related to digital text by acknowledging that certain things are imminent; at some point in the near future computers will be arbitrarily fast, screens arbitrarily high fidelity, and storage arbitrarily vast. Embarking in 1970 on a two-year study about the future of libraries, Licklider ensured a degree of timelessness in his assessment by ignoring contemporary limitations of technology and anticipating future paradigms of computing. As he put it, “Our thinking and our planning need not be, and indeed should not be, limited by literal interpretation of the existing technology” [Licklider and Clapp, 1965, pg. 19].

Digital text is also new in the sense that its full artistic and practical possibilities are still being explored. Many digital texts today are ebooks that are published in tandem with print texts. These publications are carried into the digital realm with little effort to adapt
the work to a new environment. Other works, such as articles for online publications, may be written and conceived entirely as digital texts, but have yet to explore the full capabilities of hypertext. Landow notes that a similar phenomenon existed after the invention of moveable type: “In the first decades of the Gutenberg revolution, printing presses, as McLuhan long ago pointed out, poured forth a flood of manuscripts in print form. In a similar manner, one can expect that in the first stages of hypertext publishing, printed books will provide both its raw material and much of its sylistics” [Ludovico, 2012, pg. 93]. It’s likely that authors will eventually discover new forms and conventions for written works that are more native to the digital environment. A healthy digital text ecosystem will hopefully harbor many different types and forms of written text. But for now, it’s difficult to assess the full potential of a medium which hasn’t yet developed a cohesive or distinctive identity.

The arrival and proliferation of digital text promises to affect the very nature of reading and writing in the 21st century. But digital text is far from the only new medium effecting change in an increasingly digital society. The computer, of course, also facilitates mass consumption and transmission of images, videos, music, and games. In fact, even prior to the computer, with the exception of written text, the printing press, and the telegraph, the evolution of media has been largely iconic. Levinson, drawing on the writings of McLuhan notes that “painting, photography, telephone, the phonograph, motion pictures, radio, and television [as opposed to textual media] have with each in their own ways brought us more of the world as we see and hear it with our eyes and ears” [Levinson, 2003, pg. 53]. Given the unquestionably vast amount of human knowledge archived in textual form and the undeniable importance of literacy in human intellectual history, it seems almost blasphemous to ask: how permanent is text as a medium for human communication? Or, to address the cause for concern, why have recent evolutions of media been iconic in nature? The answer, fortunately, is that text has needed little evolution at all because it is so efficient as a means of communication. Lest we worry about a cyberspace sans alphabet, Levinson elaborates: “the alphabet conveys abstraction so effectively that we lack the impetus to improve upon it in other media. Print, of course, is but the alphabet writ large; as is the telegraph, in another sense... Given this uniquely high degree of abstraction of the alphabet, together with the centrality of abstraction to human thought and life, a reasonable prediction based on a Darwinian evolution of media towards increasing consonance with human communication would be that the alphabet’s place as the conductor of... cyberspace [too] is quite secure” [Levinson, 2003, pg. 54].

Text may be around forever, but not all text is created equal. It is worth noting that the dawn of digital text has also prompted much
debate about the future of the book. Nostradamuses of the digital era have been declaring that print is dead since the earliest decades of the computer. In fact, as early as 1931, Bob Brown, in his manifesto titled *The Readies* declared that “the written word hasn’t kept up with the age” [Brown, 1931]. Umberto Eco likens this modern fervor to Frollo’s quote in Hugo’s *Hunchback of Notre Dame*: “Ceci tuera cela,” (this, the book, will kill that, the cathedral of knowledge), noting that “the idea that something will kill something else is a very ancient one” [Eco, 1996]. In this case, the worry is that “ceci”, digital text, “tuera cela”, printed text. And there is also another element of concern implicit in the digital/print debate. Will hypertext, with all its potential for new patterns of narration and new paradigms for navigation, kill linear text, the normal, sequential way for an author to tell a story or delineate an argument? Eco allays both fears by reminding us that “the problem is in saying that we have replaced an old thing with another one; we have both, thank God” [Eco, 1996]. Print text, linear digital text, and hypertext are all here to stay.

Perhaps most importantly, each textual medium (print, linear digital, and hyper) will encourage evolution and creative change in the others. The same effect was apparent in the visual arts after the invention of photography. Eco observes: “After the invention of Daguerre painters no longer felt obliged to serve as mere craftsmen charged with reproducing reality as we believe we see it. But this does not mean that Daguerre’s invention only encouraged abstract painting. There is a whole tradition in modern painting that could not exist without the photographic model: I am not thinking only of hyperrealism, but also (let me say) of Hopper. Reality is seen by the painter’s eye through the photographic eye” [Eco, 1996]. Similarly, the introduction of new paradigms of writing and reading has had a profound effect on existing paradigms, often encouraging experimental exploration, creative advancement, and boundary pushing. In *Post-Digital Print*, Alessandro Ludovico explores some of these effects on print text: from Rob Matthews’ *Wikipedia*, a 5,000-page book collecting articles featured on Wikipedia to ‘Thoughts on Dreams’, an experimental art book by Maria Fischer in which keywords and passages across the book are connected by threads as a physical imitation of the hyperlink. And not all textual experimentation has to be artistic in nature. One of the most exciting areas of development in digital text today is using hyperlinks to add extra-textual asides to linear digital text. This authorial device is much more integrated and easy to read than the print equivalent, footnotes. In other words, the hyperlink can be used not to create a twisting, circuitous user-defined narrative, but to embellish a linear digital text with an extra layer of analysis: editorial comments, additional research, ancillary figures, further reading, translations, citations, and links to external resources. This practice is not necessarily new in the digital realm, but recent technological
developments have made it easier than ever to add an element of interactivity to this extra-textural layer. The consequences, merits, and implementation of this type of annotated linear text will be developed in future sections.

In sum, print text and linear digital text are not only safe from digital text and hypertext, respectively, but are ripe for innovation and advancement as respective, unique media. Moreover, the study of digital text as a medium is important in and of itself because it is a “machin[e] that provoke[s] further thoughts” [Eco, 1996]. In big, bold, flashy text, McLuhan writes in his graphic manifesto *The Medium is the Massage*, “Societies have always been shaped more by the nature of the media by which men communicate than by the content of the communication” McLuhan and Fiore [1967]. And not only is the medium deserving of attention for its societal and culture effects. The reader, he for whom all text is ultimately written, deserves to read through the best possible medium.
Part IV

APPENDIX
A N E X A M P L E I N T E R F A C E

The following experiment aims to provide an example of the methodology described in the body of my thesis. In describing an example interface, I ground my design decisions in a meditated program encompassing the activities of a reader reading an art reference book.

A.1 RETHINKING THE SIDENOTE

The canvas of the web presents an enormous opportunity to enrich online text with ancillary images, figures, references, marginalia, links, and other interactive elements. This freedom, however, must be met with caution; readability and reader focus can be interrupted by an oversaturation of extraneous content. This experiment aims to explore such a balance by rethinking the interactive sidenote in the context of an online art essay. I will also touch on a few related issues: interactive aesthetic, and guessing user intention. Please follow along with the example here:

http://seththompson.org/sidenote-experiment/
The inspiration for this project came about as I was reviewing notes from a survey course on Modern Art. I wanted an interactive version of my notes, in which quotes, artists, and pieces of artwork could somehow be expanded to reveal extra information. Edward Tufte’s extensive use of sidenotes was a print precedent for this kind of extratextual elaboration. Thus, I set out to rethink the sidenote in an online context. As source text, I used an excerpt from a critical art essay because it was rich with references and figures.

A.1.1 References

It never made sense to me that references in online content were pushed to the bottom of the page. Interacting with a reference in the middle of reading usually requires a click to jump to the bottom of the page to view the target, and then a second click to return to where you left off. The advent of the mobile web seems to have triggered a rethinking of references on at least some websites. The mobile version of Wikipedia, for example, displays content in a hovering text bubble at the site of the inline citation. Given that I also wanted to display images (artwork, in this case) in the margin of the source content, it felt natural to display the content of references in the margin to—just as Tufte does. However, in a piece as rich with references and figures as the example art essay, there was simply no room in the margin to display everything. Even if all ancillary information fit in the margin, a crowded margin would have distracted from the importance of the main text.

A.1.2 Hover

I decided on hover as a natural action to reveal the contents of an inline citation for references and figures. Unfortunately, hover effects can be extremely distracting if triggered unintentionally. This is problematic if the hover triggers are inline citations, since many users track their reading progress with their mouse.

Therefore, I added a timeout to the hover event which ensures that the effect is triggered only after 500ms—a span of time both long enough to be reasonably sure that the mouse position is intentional and short enough so as not to appear laggy. Moreover all content in the margin fades in and out when appropriate so as not to be jarring.

A.1.3 User Intention

The second problem with hover only becomes apparent once an element of interactivity is added to the content revealed by the trigger. There is simply no way to move the mouse to the revealed content.
As soon as the mouse leaves the inline citation that triggered the reveal, the sidenote is hidden again. Conceptually, the solution to the problem lies in determining the users intention when the mouse leaves the hover trigger. If the user intends to explore the revealed content (that is, by moving their mouse in the direction of the content), then content should remain visible. If, however, the user continues reading (by moving their mouse anywhere but towards the revealed content), then it should fade out like normal. The mechanics of implementing such actions are, unfortunately, somewhat complex. My solution involves continually calculating the angle between two vectors: the first vector is one that represents the direction of mouse movement (that is, the vector between two locations of the mouse over time, and the second vector is simply the vector pointing from the hover trigger to the center of the revealed content. Deciding whether the user is moving towards or away the revealed content is therefore a matter of continually checking if the calculated angle is under a certain threshold.

A.1.4 Interactive Aesthetic

The purpose of allowing the user to explore the revealed content was, in this case, to allow them to zoom in on the artwork. The traditional method to allow such interaction is to use a Lightbox script. I’ll be frank: I’m not a big fan of Lightbox. For one, opening and closing each Lightbox requires two separate clicks in different corners of the screen—in the middle of reading an essay. Perhaps more importantly, I don’t think the interaction design fits aesthetically with this particular use case. What do I mean by interactive aesthetic? Much as visual designs aim to have a unified aesthetic which grounds them in a certain style and form, interaction designs too harbor similar styles. A topical example is the interactive aesthetic of iOS 7 which aims to convey a sense of depth and spatiality through the physics of transitions and the layering of screens over each other. In the case of the art essay at hand, however, I felt that the interactive aesthetic should be almost the opposite. Rather than creating a separate Lightbox layer over the top of the article which would create a sense of 3D space and introduce the concept of modal windows, I wanted to emphasize the fact that this essay was originally just a 2D print article. I chose therefore, to allow art zooming by way of a natural scaling motion which didn’t introduce any extraneous modal windows, and pushed aside the main article rather than overlapping it (again, I wanted to emphasize the 2D nature of this webpage). In keeping with the minimalism of the page design, I added a subtle opacity reduction in the article as the user scaled up the artwork. Moreover, I tied the scaling action to the horizontal position of the user’s mouse over the image. Doing so allowed me to reduce the number of clicks necessary to zoom in
on the artwork (it requires no clicks, in fact), and added a naturalness and ease to the flow of movement necessary to highlight a figure and explore it.


Andy Cockburn and Bruce McKenzie. 3D or not 3D? evaluating the effect of the third dimension in a document management system. 2001.


COLOPHON

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