Electronic Environments for Reading: An Annotated Bibliography of Pertinent Hardware and Software (2011)

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Abstract
In the development of new research environments, hardware has often been neglected. E-readers have (reasonably) successfully been developed for leisurely reading, but reading with the goal of writing demands a different approach. This bibliography has been written to inform the INKE research group on physical aspects of digital scholarly reading. It consists of two parts: a hardware section, including a description of commercial e-readers as well as an overview of academically developed digital reading devices and a software section, also including commercially available packages next to academically developed reading environments which allow for flexible manipulation of text and other modalities; as well as reflections on digital scholarly reading. Combined, the two sections inform an integrated approach in the development of new research environments.

Keywords
Reading environments; Knowledge environments; Social reading; Social media; Digital reading; E-reading; E-readers; Hardware; Software; INKE

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The INKE Research Group comprises over 35 researchers (and their research assistants and postdoctoral fellows) at more than 20 universities in Canada, England, the United States, and Ireland, and across 20 partners in the public and private sectors. INKE is a large-scale, long-term, interdisciplinary project to study the future of books and reading, supported by the Social Sciences and Humanities Research Council of Canada as well as contributions from participating universities and partners, and bringing together activities associated with book history and textual scholarship; user experience studies; interface design; and prototyping of digital reading environments.

Introduction

In researching and implementing new research environments, hardware is an important feature that up until recently was not a central concern: it was implied that a researcher's hardware was simply a personal computer. Larger devices (such as tabletop settings) as well as smaller digital devices (such as a PDA) have existed for quite some time, but recent hardware especially, such as dedicated e-reading devices (the Kindle, 2007), smartphones (the iPhone, 2007), and tablet computers (the iPad, 2010) have widened access to information, by extending reader control of digital texts. These devices have resolved long-standing issues in digital reading, such as portability and eyestrain. People seem willing to read on an LCD-screen, as long as the device has an aesthetically pleasing design and is portable. This has implications for the development of digital information environments. Support for the complicated and flexible practices of flipping back and forth within and between documents, and remembering the location of information (which are practices so familiar to the reader when using printed hard copies), is still necessary. In designing new hardware however, much current research is informed by turn-of-the-century projects such as EBONI (Electronic Books ON-screen Interface), which advocate the transferal of paper affordances to the digital environment. The physical affordances of the digital medium seem to have attained a little less attention in this field of research and there is thus still much to be gained.

Additionally, although software for leisurely reading and personal social reading environments has started to emerge, professional reading does not yet have this degree of neat packaging to support it. The complex nature of this type of reading – reading with the aim of building knowledge – means that many levels of handling information need to be supported: not just the act of continuous reading, but also flexible document organization, multi-document and text navigation, information triage, annotation, and possibly, the inclusion of a writing space. There is an impressive body of research on all of these aspects of active reading and (personal) digital library organization, but there are few comprehensive approaches. Moreover, the Internet and the popularity of social media have opened up a wider perspective: online, synchronous, and asynchronous collaboration within the academic community, but also outside of it; this challenges the hard-to-deconstruct notion of the (academic) author as an island. Environments in this area are tentatively researched, but again, no holistic approaches as yet have arisen.

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This bibliography gives an overview of the recent history in reading hardware and software (until mid-2011) that includes all of the above-mentioned eclectic approaches, in order to inform the Implementing New Knowledge Environments (INKE) research group in developing such a comprehensive approach.[1]

Hardware

Commercial e-reading devices

Sony Reader

The first "modern" dedicated e-reader platform was the Sony Reader, released through Borders booksellers in the United States in September 2006. It featured a greyscale screen similar to that of the first- and second-generation iPod and iPod Mini, and was a surprisingly multi-functioned device, able to play MP3 audio and natively display PDF, ePub, Mobipocket, and MS Office document formats. Of these, PDF support was handicapped by the device's low refresh rate, which made horizontal scrolling of documents that did not conform to the screen width very inconvenient. Sony also introduced its own proprietary e-book format, called BBeB ("Broadband eBook"), though it was not very successful, probably due to an inability to purchase content on-the-go without using a PC as an intermediary. The device no longer has a meaningful market presence.

Amazon Kindle

In November 2007, twelve years after it sold its first physical book over the Internet, Amazon.com gave the e-book a gargantuan, consumer-grade push, in the form of their Kindle. The device was only on sale in the United States until late 2009, when it was gradually introduced into hundreds of other markets worldwide. The Kindle's loudest boast was a screen made from the revolutionary Vizplex, brainchild of Cambridge, MA start-up E-Ink. Without a backlight, Vizplex is easier on the eyes, and with the help of a technique called electrophoresis, Vizplex displays can freeze, without any power consumption, until a user presses the "next page" button. Now, a revision of Vizplex is used in every major commercial e-reader, and is arguably the single greatest advantage of using a dedicated device.

The Kindle's other greatest innovation, and almost certainly its financial triumph, is the ease with which it allows users to download and purchase content on-the-fly without the use of a tethered PC. Amazon's Kindle is still the only device to provide free wireless 3G access to all users for this purpose, and the only device not to support the open ePub document format, in a relatively transparent effort to push its own DRM-secured (digital rights management), proprietary eBooks. Despite this, Amazon has been successful in part because their content library is undisputedly the largest, and with their considerable resources will likely remain so. The Kindle is also one of few dedicated e-reader devices to include a full physical keyboard, which some users may prefer for text entry when searching or annotating content.

Because the Kindle was for a good while the market leader, it was Amazon who addressed many of the growing pains of e-readers, and in some cases – such as the provision of page and line numbers for scholarly use of texts, as would be present in

physical editions – it still provides the best solution. In early 2011, Amazon released an Application Development Kit (ADK) for third-party developers to build software specifically for its dedicated Kindle device.

Barnes & Noble Nook

Barnes & Noble booksellers' Nook, released in November 2009, runs on a variant of Google's Android smartphone platform, thus alleviating the need for a proprietary Application Development Kit. Unlike the Amazon Kindle, it supports ePub content and does not have a full keyboard. There is also a version of the Nook with a colour display (named, appropriately, the Nook Color), which is unique among dedicated e-readers and may be ideal for heavily illustrated content. Beyond this, though, newer iterations of the device have made it very similar, both ergonomically and feature-wise, to the Kindle, with Barnes & Noble's selection of available content impressive in its own right.

Kobo

The Kobo, developed by an independent Toronto-based firm in 2010 and marketed primarily through the US Borders bookstore chain and Chapters in Canada (until the former's recent bankruptcy), was initially much less expensive than its competition (at $149 CAD), and served as a budget alternative to the Nook and Kindle, until it effectively drove down the cost of all three devices. It, too, has become strikingly similar to its brethren on modern revisions, offering a near-identical feature set to the Nook (including ePub) and a notably better selection of Canadian content.

Apple iPad and other mobile devices

Apple's iPad is, of course, a multifunction device, and not a true dedicated e-reader, insofar as it does not use Vizplex display technology (as it would be inappropriate for other content displayed on an iPad). It has, however, garnered an extraordinary amount of developer interest for its novel form factor, and in fact all of the manufacturers of dedicated e-reader hardware now provide an iPad app,[2] which provides most or all of the functionality of a dedicated device.

In the current software market, supplemental reading tools such as annotation are typically handled by third-party application developers,[3] and may not necessarily be compatible with the more straightforward reading environments of the Kindle, Nook, and Kobo apps. For example, the Kobo iPad app has been criticized for deleting all stored annotations whenever the software is updated and the user's library is refreshed, making it apparent that so-called "active reading" has not been a priority for the application's developers. There has been a clear focus on the provision of reading statistics and other metrics.

Google's Android smartphones have generally received comparable development attention, and benefit from Google's comparatively relaxed stance on allowing unlicensed content, which need not originate from a trusted source. However, still more novel e-book applications, which would not be possible on dedicated hardware, are for the most part being developed only for the iPad, notably an interactive

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Alice in Wonderland Storybook (http://itunes.apple.com/us/app/alice-for-the-ipad/id354537426) and the *LiquidText* reading environment (http://liquidtext.net/), which is discussed at length in the software part of this bibliography.

Below, a number of lesser-known e-reading devices are discussed, both dedicated and general. After the initial success of the Amazon Kindle, besides a large number of imitations, there have been some efforts to improve on its design, for instance in the incorporation of two screens. Although more versatile than single-screen dedicated devices, such devices have as yet not been very successful and probably will not become so. This proves the consumer need for simple, ergonomically *and* aesthetically pleasing, affordable devices.

Google's iriver Story HD e-reader

The first cooperation between Google and a hardware manufacturer, the iriver Story HD e-reader, is a bit disappointing. It looks very similar to the Kindle, with an integrated keyboard and a sleek design. The device has actually been designed to play on a reader's emotional attachment to the codex: the rim colour and rounded edges are meant to remind the reader of the codex, or as iriver puts it: "to inspire the familiar nostalgia of your favorite book," as is claimed on the device's website (http://www.iriverinc.com/product/productOverView.asp?pn=storyhd).[4] With iriver, Google has tried to improve on existing models, instead of trying something new: the device is light and thin, its E Ink display is more crisp, and it offers compatibility with more file formats. The unique aspect of this device is of course the direct access it offers to the Google bookstore through Wifi, but Google is asking other manufacturers to seek co-operation (http://googleblog.blogspot.ca/2011/07/first-google-ebooks-integrated-e-reader.html), and thus the device does not impose an exclusive relationship with iriver on its users. There are no indications that the device allows for flexible annotation – there seems to be no other input device than the keyboard, which is strange considering the large proportion of academic content on the Google Book Platform.

Dual screens: Alex and EntourageEdge

Besides LCD screen tablets and E Ink reading devices, there are also some devices available that combine both screens. Examples include the Alex (http://www.springdesign.com/index.html) and the recently failed EntourageEdge and Pocket Edge. The latter two have been discontinued from May 21, 2011 but are still for sale through other vendors (http://www.entourageedge.eu/).[5] The EntourageEdge has a is a heavy device which does not have a sleek enough design overall. Moreover, the hinge that connects both screens seems fragile. The Pocket edition is better, but is still an inert machine. For the Alex, pricing is probably the reason wide-spread adoption is not at hand: it costs about as much as a tablet, while it basically is no more than an e-reader with a little LCD screen attached underneath.

Figure 1: The Alex, dual screen reader on the Consumer Electronics Show (CES) 2010. Copyright: Nan Palmero, 2010.

Asus Eee Pad Slider, and MeMo 3D

Asus announced its first tablet in the summer of 2011, the Asus Eee Pad Slider, with a physical keyboard attached, making it more similar in design to a netbook. The tablet runs on Google Android 3.1. Another tablet, the MeMo 3D was announced that would offer 3D image without the need for 3D glasses, but it was never brought onto the market. See http://www.engadget.com/2011/01/06/asus-tablet-lineup-preview-slider-transformer-memo-and-slate for more images and videos.

The Asus Eee Pad Slider. Copyright: Pierre Lecourt, 2010

Lenovo IdeaPad U1 Hybrid Notebook

Another device that has combined a tablet and keyboard is the Lenovo IdeaPad U1 Hybrid Notebook, presented at Consumer Electrics Show 2011 held in Las Vegas. It can function as a netbook, but when the screen is detached from the shell, it functions as a touch screen tablet. It combines a Windows-running laptop with an Android 2.2-running LePad tablet. This will probably not be the solution to the limitations of the tablet computer, as the Asus Eee Slider is more compact, cheaper, and user-friendly,

but it is noteworthy as an example of how companies try to solve this issue. Note: this particular notebook appears not to have been released, but other companies such as Dell and Toshiba now offer 'ultrabooks', of which the screens are detachable and usable as a tablet.

Griffey, J. (2010a). Chapter 2: Electronic book readers. (Gadgets and gizmos: Personal electronics and the library). *Library Technology Reports*, *46*(3), 7.

Griffey, J. (2010b). Chapter 3: Personal multimedia devices for capturing and consuming. (Gadgets and gizmos: Personal electronics and the library). *Library Technology Reports*, *46*(3), 20.

Although already a bit dated, "Chapter 2" gives a brief overview of some dedicated e-reading devices from the CES 2010 (held in Las Vegas) and practical software platforms. "Chapter 3" provides an interesting overview of devices that can capture and share audio, video, and other media, amongst which are the iPod Touch and iPad, as well as the LiveScribe Pen. These chapters are written from the viewpoint of the library.

Herther, N. (2011). The sizzling e-book marketplace: Part one. E-Reader Devices. *Searcher*, *19*(3), 14–18, 42–43,46–47.

This is a fairly comprehensive and compact overview of the current dedicated e-reading device market, including 2010 and 2011 e-reader hardware (based on CES 2010 and 2011), software platforms, different e-book formats, and suggestions for future hardware, including a short discussion of the possible threat tablet PCs pose for e-reading devices.

Purcell, K. (2011). *E-reader ownership doubles in six months*. Washington, DC: Pew Research Center's Internet & American Life Project. URL: http://pewinternet.org/Reports/2011/E-readers-and-tablets.aspx .

This is a compact report from the Pew Research Center reporting some interesting finds on e-reader ownership in the United States based on telephone interviews. The overview states for instance:

> The percent of U.S. adults with an e-book reader doubled from 6% to 12% between November 2010 and May 2011. Hispanic adults, adults younger than age 65, college graduates and those living in households with incomes of at least $75,000 are most likely to own e-book readers. Parents are also more likely than non-parents to own these devices. (Purcell, 2011)

Other findings in this report: at the time this report was published, the tablet computers market had not grown as fast as the e-reader device market, and there was a notable overlap between e-reader ownership and tablet ownership.

User experience (UX) and usability

In the last couple of years, many trials have been conducted, especially among North American students, to assess the usefulness and usability of dedicated e-reading devices for academic purposes. The influential EBONI-project conducted extensive research from 2000–2003 and produced comprehensive guidelines for making e-books and dedicated e-reading devices (see http://ebooks.strath.ac.uk/eboni). Experiments with first-generation e-reading devices report on physical restrictions, such as weight and eye strain (Gibb & Gibson, 2010). Second-generation devices have solved these issues – sacrificing benefits as colour, but other problems remain and come to the surface (Gibbs & Gibson, 2010). In the most recent studies, the Kindle is often the device under scrutiny; Amazon has also sponsored a trial in collaboration with seven universities. The choice of choosing to study the Kindle is undoubtedly informed by its popularity in North America, but it is a curious one, as its restrictive format policy makes the device perhaps less suited for relevant trials than others. The findings of the trials with second-generation e-reading devices all paint a similar picture: the devices are fine for sequential, linear reading but not for active reading, which is the basis of academic research or education. The studies report a number of issues relating to: note-taking (annotation and highlighting, see for instance Aaltonen et al. 2011); inaccessibility due to DRM (Aaltonen et al. 2011); the representation of charts and figures, especially ones that use colour; and spatial location of information (Thayer et al., 2011). These are all affordances of paper that cannot or can hardly be mimicked by (current?) digital devices. Benefits that are reported are portability, storage capacity, and search functionality – all digital affordances. Most of the studies report a brighter future with the advent of tablet computers (see for instance Patterson et al., 2010) and trials will be forthcoming. The question remains how and whether – or to what extent – these tablets will be better suited to find a solution for the absence of certain paper affordances.

Aaltonen, M., Mannonen, P., Nieminen, S., & Nieminen, M. (2011). Usability and compatibility of e-book readers in an academic environment: A collaborative study. Journal *of the International Federation of Library Associations and Institutions*, *37*(1), 16–27.

This article describes a trial that combined the study of e-readers and electronic library material at the Aalto University School of Science and Technology, and that took place from the autumn of 2009 until the summer of 2010. E-reading devices are discussed from the viewpoint of the library collection: is it possible to read academic journal articles on an e-reading device? The answer is "barely." Due to DRM restrictions and restrictions relating to file format (such as PDF, which cannot be read on Kindles), it proved to be a cumbersome process to transfer articles to the e-readers tested. In addition, the usefulness and usability of the e-readers was tested by a small group of students. They report several problems for academic work, for instance, "students and researchers ... use multiple resources and need the ability to jump from one document to another, making use of links and cross references. This is not yet possible on most e-reader devices" (Aaltonen et al., 2011, p. 25)

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Gibb, F. & Gibson, C. (2011). An evaluation of second-generation ebook readers. *The Electronic Library*, *29*(3), 303–319.

This article gives an overview of e-reader research and employs its own user survey among master students, based on EBONI questionnaires. The readers tested were the Sony PRS 505 Reader, Cybook Gen3, the Iliad, and an Eee PC 105HA netbook. The netbook was considered to be the most functional overall – the authors suggest that familiarity might be the reason – and the Cybook the least functional. One significant benefit mentioned in relation to the netbook as compared to the other devices was its zooming function. Overall, the researchers conclude that several issues in e-readers were solved from the first to the second generation, such as size, weight, and screen glare (because of E Ink), but zooming and page turning are still problematic in many of the devices.

Lam, S. L., Lam, P., Lam, J., & McNaught, C. (2009). Usability and usefulness of ebooks on PPCs: How students' opinions vary over time. *Australasian Journal of Educational Technology*, *25*(1), 30–44.

This is an often-cited article describing a study in which the authors used pocket personal computers (PPCs) instead of dedicated e-reading devices. Students were excited at the start, but encountered numerous problems: synchronizing content with their PCs, limited battery power, the difficulty of downloading books through the device, 24-hour periods of loan, a small selection of e-books, backlighting, etc. Even if students succeeded in transfering books to the device, the screen was too small to read effectively. The subtitle of the article refers to the fact that although the students who were encountering the device recently were satisfied, the test users who needed to work with the device for a longer period of time were decidedly less happy.

Patterson, S., Nahachewsky, J., Stokes-Bennett, D., & Siemens, R. (2010). Enacting change: A study of the implementation of e-Readers and an online library in two Canadian high school classrooms. *Liber Quarterly: The Journal of European Research Libraries*, *20*(1), 66–79.

This study differs from others, in that it integrated an online library environment with the implementation of e-readers (Sony Reader) in a classroom setting. The study shows that tablets like the iPad might offer a solution to the cumbersome process of integrating the two central functions in teaching through text: a social library environment and a reading platform.

Siegenthaler, E., Wurtz, P., & Groner, R. (2010). Improving the usability of e-book readers. *Journal of Usability Studies*, *6*(1), 25–38.

This study on dedicated e-reading devices differs from the others in this section, in that it does not only rely on qualitative user assessments, but also on eye-tracking measures. Participants had to perform several small reading tasks while their eye movements were tracked, resulting in interesting outcomes: reading on an e-reading device is actually a better reading experience than on paper, as users can change the font size. Also, a discrepancy in eye-tracking and user reports showed that although a user might find it easier to read on the e-reading device, users still report problems due to the

lack of proper usability. Devices tested were IRex Iliad, Sony PRS-505, BeBook, Ectaco jetBook®, and Bookeen Cybook Gen. Thus, qualitative data on its own is not enough in determining e-reader usefulness and usability is even more important than readability for user preference.

Thayer, A., Lee, C. P., Hwang, L. H., Sales, H., Sen, P., & Dalal, N. (2011). The imposition and superimposition of digital reading technology: The academic potential of e-readers. *Proceedings of the 2011 annual conference on human factors in computing systems* (pp. 2917–2926). Vancouver, BC: ACM.

This is a sound report on a Kindle DX study conducted at the University of Washington, which can be useful for informed hardware design. The authors of this article are quite critical of the Kindle DX, noting that the degree to which students expect to be able to skim physical textbooks is totally unlike their expectations of speed-reading PDFs, which are usually read on screen: the Kindle is not up to this task. In addition, the Kindle was found to be poorly suited to both horizontal scrolling and annotation (both of which have been addressed in later revisions of the hardware).

A great benefit of this study is that it identifies the reasons for the relevant failures and points to crucial aspects that need to be supported by e-reading devices in order for students to reach their goals. Four hindered tasks in academic reading were identified: marking up texts, using references, using illustrations, and creating cognitive maps. The discussion sections offer the most interesting information (see "Discussion and implications for design"). For instance, some observations include 1) the spatial memory students build up while reading a text may be a crucial factor in the success of an e-reader, i.e. whether the e-reader whether it is capable of supporting an alternative mode of or for spatial memory building; 2) seamless switching between reading techniques needs to be supported: from skimming to responsive reading and back again; 3) navigational issues – an extremely complex factor – are also discussed. The researchers conclude somewhat unequivocally that this incarnation of the Kindle is not nearly as well-suited to multimodal academic reading as its success with consumers might suggest.

Weisberg, M. (2011). Student attitudes and behaviors towards digital textbooks. *Publishing Research Quarterly*, *27*(2), 188–196.

This article describes a two-year trial (from fall 2009) with students of a Boston business school. The e-readers tested were the Amazon Kindle, Sony eReader Touch, Apple iPad, and a PC, the enTourage eDGe, or a laptop combined with the e-textbook platform CourseSmart. To each of these five digital devices, a group of students was assigned. A sixth group used the paper textbook. Five groups of students were assigned to each of these readers and one group used the paper textbook. E-reader testers had a paper book at their disposal in case the e-reader did not work. Conclusions were that 1) students' attitudes towards the devices improved over time (the devices were improved, too, during that time, for instance, highlighting was included in later versions); 2) 26–29% of the students would use an e-textbook on an e-reader or tablet as a primary device, but most of the students would use the electronic version as a secondary device to the paper textbook, to refer to them as needed; and 3) the devices neither improved

or impaired the students' results. The greatest benefit mentioned by the students was efficiency: the introduction of the use of e-readers meant that less effort and time was required when carrying out class work.

Wilson, R. & Landoni, M. (2003). Evaluating the usability of portable electronic books. *Proceedings of the 2003 ACM symposium on applied computing* (pp. 564–568). Melbourne, FL: ACM.

This is one of the EBONI project papers, which discusses first generation e-reading devices. Problematic issues often still remain in current dedicated devices, except for issues concerning the hardware in general (i.e., poor battery life and weight have largely been addressed). The authors provide recommendations, including a list of paper book-like features that need to be kept in the design of new hardware, for example: "opening an electronic book at the correct page should be as quick and easy as opening a paper book" (Wilson & Landoni, 2003, p. 566).

Reading theory and interface design

The user studies in the former section were focused on the usability and usefulness of existing hardware for e-reading in an academic setting. In this section, studies we have assembled studies that can inform the construction of future (dedicated) devices, some more theoretical than others. As the interface of the "text" and the device are closely related, not all of these articles focus exclusively on hardware.

Adler, A., Gujar, A., Harrison, B., O'Hara, K., & Sellen, A. (1998). A diary study of work-related reading: Design implications for digital reading devices, *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 241–248). Los Angeles, CA: ACM. This is an influential article by the Xerox Palo Alto Research Center, which reports on a diary study of 15 professionals. These professionals kept a diary on their reading practices (including screen reading) for five consecutive days. Based on these diaries, a taxonomy is presented. One type of professional mentioned in this study, which relates most to academic research, is the cross-referencer – a person who reads multiple documents to extract information, possibly for writing purposes. For this type of reading/writing, the authors suggest 'two functionally interlinked screens' (Adler et al., 1998, p. 247) This article has informed many studies on e-reading and devices in an academic context, although no academic researchers were participants in this study.

Hillesund, T. (2010). Digital reading spaces: How expert readers handle books, the Web and electronic paper. *First Monday*, *15*(4). URL: http://firstmonday .org/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/2762 .

This article could be listed both in the software and hardware bibliography, as it includes both. The author points to the fact that most research on digital reading has focused on cognitive aspects, even though the body itself is just as important in the reading act. Based on research by Anne Mangen (2008) and Sellen and Harper (2002), Hillesund conducted qualitative interviews with a group of humanist and social science scholars in 2009.[6] After establishing a conceptual model for reading modes – introducing the term "sustained reflective reading" for academic research –

the author discusses the results. Although still focusing mainly on cognitive aspects, there are some interesting findings in the context of handling hardware and software. 1) The desktop computer is seen by the author and the participants as ill-suited for sustained reading: it offers access to multiple applications, reminding the users of other obligations such as email, and using a browser for reading introduces distractions such as advertisements. To remain undistracted for longer periods of reading time, the participants sought physical spaces away from the computer; 2) The participants use a pen or highlighter not only for actual annotations, but also as a tracker or a means of focusing. To sum up, this article provides a number of interesting clues in the cognitive and physical aspects of academic reading. The author concludes by stating that we need solutions for 1) continuous reading – which he sees as provided for in current dedicated e-reading devices; and 2) sustained reflective reading – which he sees as a greater challenge that can only be solved by modular design. This is where software takes a greater place in his recommendation, for instance 1) Web browsers should offer possibilities of switching between reading and study modes; and 2) portions of texts for handheld devices need to be offered.

Jacob, R., Girouard, A., Hirshfield, L., Horn, M., Shaer, O., Solovey, E., & Zigelbaum, J. (2008). Reality-based interaction: A framework for post-WIMP interfaces. *CHI '08: Proceeding of the 26th annual SIGCHI conference on human factors in computing systems* (pp. 201–210). Florence, Italy: ACM.

The authors propose a simple but powerful framework for the analysis of new user interfaces, called Reality-Based Interaction (RBI), a framework that includes a large range of interfaces, including tangible user interfaces (TUI). The authors call RBI's "emerging interaction styles" and state that these have important commonalities. Four themes of reality are discerned, of which these interfaces (can) make use (made insightful through the figure that accompanies the article), including 1) Naïve Physics: Common sense about the physical world; 2) Body Awareness & Skills: Awareness and use of one's body; 3) Environment Awareness & Skills; and 4) Social Awareness & Skills: Awareness of others in one's environment. These themes are described and four case studies show how the framework can be employed. A strong point made by the authors is that the trade-offs of the interfaces are also incorporated in the framework, although this part could be developed further. The incorporation of the unique affordances of both real-world interfacing and computing power makes the framework a useful tool to weigh the affordances of new hardware and software.

Kirschenbaum, M. G. (2004). "So the colors cover the wires": Interface, aesthetics, and usability. In S. Schreibman, R. Siemens, & J. Unsworth (Eds.), *A companion to digital humanities*. Oxford, UK: Blackwell. URL: http://www.digitalhumanities.org/companion/ [October 31, 2011].

This is a theoretical exploration of interface and usability design. Perhaps not practically applicable, but the author does cover a scale of properties concerning interfacing, tacitly including the hardware we use. By discussing the background of computer interfacing – including the choice for bitmaps over vectors for image rendering – he gives insight into the paradigms we use. The author also notes the practical but impairing distinction between application and interface, where the latter

is generally pushed back in development projects. The author argues for aesthetic interface design, using two examples, and discusses the issues in design in the Blake Project. In the final paragraph, he envisions a digital set-up completely different from the "typewriter and television setup" that our computing environments now often still resemble:

> I think of it as a magic carpet: a rectangle of thin, flexible, waterproof plastic, perhaps 3x4 feet, which I carry about rolled up under my arm (or folded in a bag). I can lay it out on any tabletop or flat surface, or else unfold only a corner of it, like newspaper readers on a train. The plastic sheet is actually an LCD screen, with an embedded wireless uplink to the Web. Applications, both local and remote, appear on its surface like the tiles of a mosaic. I move them about physically, dragging, shrinking, or enlarging them with my hands, pushing and pulling them through the information space. Text entry is primarily by voice recognition. The keyboard, when needed, is a holographic projection coupled to a motion tracker. Data are stored on a solid state memory stick I keep on my keychain, or else uploaded directly to secure network servers. (Kirschenbaum, 2004)

In 2004, this idea might have sounded like science fiction; in 2012 we are coming close, as can be seen by the descriptions of experiments in the next section of this bibliography.

Kostick, A. (2011). The digital reading experience: Learning from interaction design and UX-Usability experts. *Publishing Research Quarterly*, *27*(2), 135–140.

This is not an article on hardware but it does offer some leads. The author argues the need for publishers to look into initiatives in the technology sector for informed e-book and e-reader design. She interviews some usability experts, thereby briefly discussing some issues related to e-readers and their contents, and offers a couple of initiatives for better informed e-book and e-reader design. One example of the initiatives she mentions is described in the following blog post:

> ***Core77.* (2009, November 2). *Announcing the winners! 1 Hour design challenge: The future of digital reading.* URL:** http://www.core77.com/blog/featured_items/announcing_the_winners_1_hour_design_challenge_the_future_of_digital_reading_15084.asp .
> This blog post documents the results of a challenge on the future of digital reading, where contestants developed several hardware set-ups for a new fashion of reading. Some of the designs have notable features, like flipping over the device to change page, which has actually been incorporated in an academic test setting (see the next section).

Kratky, A. (2011). Re-thinking reading in the context of a new wave of electronic reading devices. In F. Cipolla Ficarra, C. de Castro Lozano, E. Nicol, M. Cipolla-Ficarra, & A. Kratky (Eds.), *Human-Computer Interaction, Tourism and Cultural Heritage*, Lecture Notes in Computer Science (Vol. 6529, pp. 1–11). Berlin/ Heidelberg, Germany: Springer.

This is a theoretical analysis of the current e-book/e-reader environment for literary reading from a cultural media perspective. Not surprisingly, the changes in the book industry are compared with those of the music and film industries, but from the perspective of the interconnection of available hardware and software and the *perceptual format* of the media experience, as in how the content is taken in. The author argues that the perceptual format of music and video were not significantly altered by digital medium, making screen size the most important feature to test, whereas the perceptual format of books was so altered, because of the introduction of hypertext. Technological refinement will not solve current difficulties, according to the author, who referred to the unique haptic experience of reading a paper book; thus interfacing is the solution. The author disapproves of the use of metaphors for a device emulating "historic media formats," in this case, the codex. He uses Espen Aarseth's theory of ergodic literature to argue the need for forms that support the *content* of the text instead: allegorical interfaces. Although not particularly useful for the design of hardware, the idea of "postponing" the imposition of a restrictive interface can be useful for the inclusion of content that is more dynamic than only document-based e-content (which of course can also be seen in the design of the iPad, which the author fails to mention).

Landoni, M. A. (2008). The active reading task: E-books and their readers. *Proceeding of the 2008 ACM workshop on research advances in large digital book repositories* (pp. 33–36). Napa Valley, CA: ACM.

This paper is an attempt to engage researchers in the Active Reading Task, part of the INEX Book Search Track (now: INEX 2013 Social Book Search Track, see https://inex.mmci.uni-saarland.de/tracks/books/). INEX'sgoal is to build a base of research by supplying a database and a framework, which participants can use to test e-books and e-reading devices according to scenarios of use in selected communities. The studies should focus, of course, on usability and analyze how people interact with documents in certain scenarios. Combining the studies should provide a framework for the design of better e-books and e-readers. Although not seemingly successful so far (see for instance http://www.sigir.org/forum/2010J/2010j-sigirforum-beckers.pdf,, para. 3.3.3), Active Reading was still a part of the Track in 2012. Participants in the 2011 Track had access to data sets, among which a corpus of 50,000 out-of-copyright books.A social data collection and a corpus of 1,000 books are available for other parts of the Track.

Mangen, A. (2008). Hypertext fiction reading: Haptics and immersion. *Journal of Research in Reading, 31*(4), 404–419.

The author stresses the importance of sensorimotor affordances in the act of reading fiction. By providing a predominantly phenomenological framework, through which she analyzes hypertext fiction, she argues that the computer does not lend

itself to phenomenological immersion like a book does (her choice of wording). The main strengths of this article are 1) its argument for conducting empirical research concerning haptics and different sensorimotor affordances in handling codices and digital devices – most paper-emulating prototyping as can be found in the next section of this bibliography is based on cognitive research; and 2) the framework it provides for analyzing such affordances. Mangen's article can serve as a base for empirical research; see for instance Hillesund (2010) in this bibliography.

Marshall, C. (2003). Reading and interactivity in the digital library: Creating an experience that transcends paper. ***Proceedings of the CLIR/Kanazawa Institute of Technology Roundtable*** **(pp. 1–20). URL: http://csdl.tamu.edu/~marshall/KIT-CLIR-revised.pdf .**

This paper provides a clear overview of what reading entails, what paper affordances need to be taken into account in designing digital reading devices, and how these can be transcended. Properties discussed are (local) mobility; materiality; interactivity – by which she means gathering, clipping, annotating, and sharing. She expands on all of these concepts. For instance, the author points to findings on annotations, such as, they are 80% non-semantic (underlines, highlights, and circles); are generally idealized (when returned to, annotations are often less useful than expected); and they are written for private use. The author then relates the affordances of digital reading, by discussing the notion of the portable personal digital library and some situation-specific capabilities, such as shared annotation. To conclude, she stresses the importance of transcending paper in innovation and the necessity of recognizing that people need more than one platform for reading and critical thinking.

Catherine Marshall has done much more research on paper and digital affordances, including on navigation. Her description of "lightweight" navigation in paper is influential in much e-reading research, as can be seen in the next section of this bibliography.[7]

Morris, M. R., Bernheim Brush, A. J., & Meyers, B. R. (2007). Reading revisited: Evaluating the usability of digital display surfaces for active reading tasks. *Second Annual IEEE International Workshop on Horizontal Interactive Human-Computer Systems* **(Vol. 0, pp. 79–86) Washington, DC: IEEE Computer Society.**

This is another research paper by Microsoft engineers; Microsoft is an important researcher/funder in this sector. This article is interesting as it researches different display conditions: horizontal and vertical. It describes a user test for active reading (reading-to-summarize task) in four conditions, using: paper, a traditional computer with vertical displays, a stylus-enabled horizontal surface, and multiple tablet computers. The authors found that the users preferred different set-ups for different tasks. Reading is preferred from paper and tablets for instance, while the vertical condition was preferred for the writing task. Annotation was seen as sufficient in all the horizontal surfaces. The tablets showed strong performance for reading and annotation (but not for writing). Other findings: bi-manual use was seen in all but the vertical condition, interleaving navigation for instance was done using a touch strip on the bezel of the (horizontal) Cintiq display – although users expected other results

from their actions in using this (see section 3.3, Morris et al., 2007); the participants often tilt the horizontal screens off the surface of the desk; big screens were seen as a disadvantage by several participants. Most notably, none of the single computing set-ups was sufficient for the participants. This leads to five recommendations for workplace set-ups: 1) include both horizontal and vertical displays; 2) be configurable (i.e. support tilting); 3) support multiple input devices; 4) allow bi-manual input and focus; and 5) improve software support for window navigation and management.

Pearson, J., Buchanan, G., & Thimbleby, H. (2010). HCI design principles for ereaders. *Proceedings of the 3rd workshop on research advances in large digital book repositories and complementary media* (pp. 15–24). Toronto, ON: ACM.

This is a paper presented at the BooksOnline Workshop 2010 in Toronto, Canada, which focused on digital libraries, the media employed to use them, and social reading/annotation.[8] This paper evaluates three dedicated e-reading devices (Sony Pocket PRS-300, Sony Touch PRS-600, and Amazon Kindle 2), using human-computer interaction (HCI) principles instead of user studies. The issues discussed are metaphor, lightweight, ergonomics, consistency, completeness, and reading functions. This method does not provide groundbreaking new conclusions, but does specify some issues that are related to only in a general sense in user studies. For instance, the paper discusses 1) the placement of buttons for navigation, which is said to be illogical in the Sony devices; 2) page numbering, which remains an issue: does one keep the page numbers of the original paper book (like the Sony Readers aim to do) or make a more flexible system (like the Kindle does); and 3) consistency in zooming: menu items cannot be zoomed in any of the devices, making it difficult for the visually impaired to use these. The paper could have been improved if the researchers had compared three completely different e-readers, instead of two by the same manufacturer. Moreover, the HCI principles still seem to be applied by using the researchers' common sense, which is "uncheckable" to say the least. It leads to a contradiction for instance between this research and Wightman et al. (2010) on the usability of the side navigation buttons on the Kindle.

Tashman, C. S. & Edwards, W. K. (2011). Active reading and its discontents: The situations, problems and ideas of readers. *Proceedings of the 2011 annual conference on human factors in computing systems* (pp. 2927–2936). Vancouver, BC: ACM.

This research goes beyond most individual-oriented studies that discuss active reading (AR) using paper and digital devices, and unlike many other studies, it does not aim to emulate paper affordances, but rather, tries and develop a new paradigm of systems to support digital active reading – although the authors emulate paper perhaps somewhat more than they would like to admit. This article is an exploration of AR based on user studies: using diary studies, group brainstorms, and a participatory design workshop (which resulted in tablet PC software called LiquidText, see the e-reading software section of this bibliography). This formative study discusses general AR-related issues, such as a need for organizing content and comparison, thus in-document and multi-document manipulation. Six recommendations for/issues in AR-supported software

and hardware design are given: support collaboration; support flexible annotation; support memory; offer adequate visualization; people use multiple work spaces; and offer directness (hybrid pen-plus-touch input model).

Gradmann, S. & Meister, J. (2008). Digital document and interpretation: Re-thinking "text" and scholarship in electronic settings. *Poiesis & Praxis*, *5*(2), 139–153.

This relatively recent article, ostensibly about changing modes of interpreting electronic documents, in fact deals much more directly with publishing workflows than its title suggests. The authors note that while electronic document publishing has greatly simplified the indexing and delivery process, the relatively linear scholarly workflow of previous years remains unchanged, except for the fact that we are now producing PDFs rather than printed journals. A truly new paradigm – which the authors appear to assume will somehow involve XML – will instead allow for branching paths, with inline annotations and version identifiers providing new ways of interacting with documents. Here, the authors clearly anticipate the "Beyond the PDF" movement, which arose more recently, and deals generally with the perceived inability of scholarly communication to move beyond workflows that are still technically reducible to print journals. This is particularly remarkable for the simple reason that "Beyond the PDF" has still not much taken hold in the social sciences or humanities, and has so far proven more interesting to scientists who are concerned with structured data more than the scholarly process broadly. The authors go on to theorize about the problems of "born digital" workflows for the humanities – namely, that the idea of reducing the world to measurable chunks is almost directly opposite to the traditional goal of humanists – and conclude with reasonable apprehension that "the core issue [of digital adaptation] seems to be discreteness" (Gradmann & Meister, 2008, p. 144).

Ophir, E., Nass, C., & Wagner, A. D. (2009). Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences*, *106*(37), 15583–7.

This straightforward study of the cognitive habits of heavy "multitaskers" is perhaps more trustworthy simply for the reason that it predates the current media frenzy surrounding the subject, and makes no attempt to speak directly to teenaged multitaskers or academic multitaskers. Instead, it provides some general evidence, which may inform the context in which we design digital reading environments. According to the researchers, heavy media multitaskers (abbreviated here and elsewhere as HMMs) do indeed have correspondingly heavy filtering issues; "[their] breadth-biased media consumption behavior is indeed mirrored by breadth-biased cognitive control" (Ophir, et al., 2009, p. 15583). The authors suggest that the difference between HMMs and infrequent or low multitaskers "may be a difference in orientation rather than a deficit" (Ophir, et al., 2009, p. 15585), with the latter tending toward a more top-down model of information processing. Research into digital reading specifically has historically drawn similar conclusions about "field-dependent" individuals for whom information context is everything, and "field-independent" individuals who are better able to isolate details at the risk of missing the forest for the trees. A dynamic reading environment should of course support both.

Cull, B. W. (2011). Reading revolutions: Online digital text and implications for reading in academe. *First Monday*, *16*(6). URL: http://firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/3340/2985

This article, written from the perspective of an academic librarian, surveys many recent developments in social and cognitive reading behaviour with respect to the technological circumstances that enabled them. Given the review-like nature of this piece, surprisingly many of the key points are the author's own, not least his refutation of the pronouncement that "Google is making is stupid" in light of the evolution of reading ("not a natural act" – Cull, 2011) over the centuries. Although the author makes no effort to diminish his perspective as a librarian at a Canadian university, this hardly hinders his arguments, and allows him to soften current public judgments on "the reading elites" (Cull, 2011) (i.e., the perceived small portion of the public who still habitually read physical books) and their reverence for the written word, or lack thereof. The author also adheres to the stance that "online multitasking and lack of cognitive focus is not an effective way to learn" (Cull, 2011), based on a carefully constructed and rarely encountered argument, which considers research into electronic and physical text reading speed alongside factors affecting the *availability* and use of electronic and physical texts. Cull even takes to task the parallel "Google is changing our brains" argument with the only counter-argument endorsed by neuroscientists: *everything* is changing our brains, and will keep doing so for as long as we have them. When he reaches his eventual conclusion, he speaks only to his fellow librarians, with a level-headed and unobjectionable message: reading will change, and any librarian that does not change with it can only be called unhelpful.

MacFadyen, H. (2011). The reader's devices: The affordances of ebook readers. *Dalhousie Journal of Interdisciplinary Management*, *7*, 1–15.

This article, a polite lamentation of sorts on what it is we are gaining and losing by migrating away from paper and toward digital documents, begins with a telling anecdote: a search of the Google Books corpus revealed that prior to 1990, there were relatively few published references on the wonderful smell of books, after which mounting concerns about the disappearance of this smell made the published references more and more prevalent. The author reviews the mostly-failed (and variously worrying, for still-relevant reasons ranging from deprecated libraries to privacy concerns) attempts at popularizing e-books prior to Amazon's Kindle, which is "as much a device used to buy books as it is a device used to read books" (MacFadyen, 2011, p. 5). She believes, however, that the somewhat collapsed physical extension of e-books – a "brown paper wrapper" (MacFadyen, 2011, p. 7) on the bus, containing entire libraries – will eventually speed the intellectual work of readers working across multiple texts and wanting to copy and paste at will, though she seems to believe unequivocally that we are not there just yet.

Marshall, C. C. (2010). *Reading and writing the electronic book*. Synthesis lectures on information concepts, retrieval, and services (Vol. 9). Morgan & Claypool Publishers.

This book is an exhaustive review of research over the past two decades, on interacting with electronic documents. The introduction is a retrospective approach to how reading has changed with the advent of hypermedia. There is a review of the long relationship between typography and reading behaviour, and entire chapters devoted to annotation and social reading. After a brief discussion on how reading is best understood and studied, the book's second half focuses largely on metadata, text markup, and other issues concerning file formats. Although the book's relatively recent publication date makes the absence of any discussion about modern platforms such as the iPad or about file formats such as ePub disappointing, and there are some subjects (such as DRM) that the author is unable and perhaps justifiably unwilling to give full recognition to in the limited space, this is likely the most comprehensive review of electronic reading, as a process and a history, that is currently available.

Physicality, tangibility, and hardware design

Apart from studies in existing commercial hardware, within academia, a range of exciting and interesting devices have been and are being developed, based on the (user) studies as outlined in the sections above, or on own research. Most prototypes are reported in conferences such as the Computer-Human Interaction (CHI) conference. Simple dedicated devices such as the Kindle can hardly be found here, instead one finds various types of input (pen, motion, finger touch) employed in hardware as varied as tabletop desks, dual screen tablets, and flexible sheets.

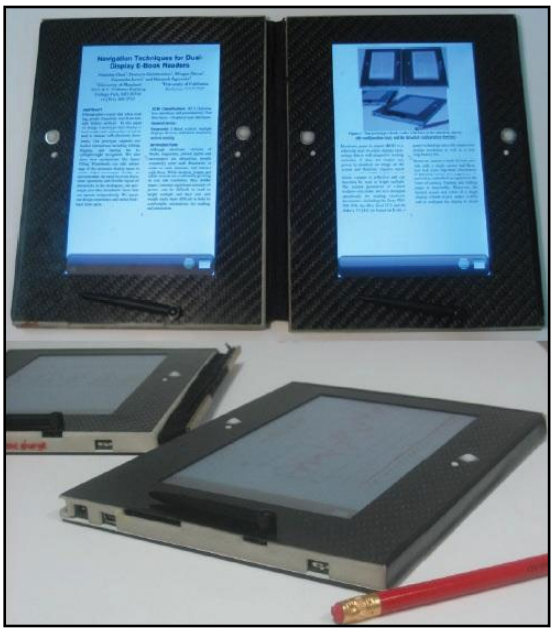
The metaphor of the single person doing research and reading a book is still a very compelling one. Collaborative work is mentioned in only a few articles (i.e., the ones concerning dual screen displays). The hardware described often tries to emulate certain affordances of paper sheets and/or the paper codex, such as page flipping. Embodied interaction (through tangible user interfaces) makes this more feasible and is thus more and more often employed, making the strike of a certain balance between intuitive action and digital affordances imperative.

Chen, N., Guimbretiere, F., Dixon, M., Lewis, C., & Agrawala, M. (2008). Navigation techniques for dual-display e-book readers. *Proceeding of the 26th annual SIGCHI conference on human factors in computing systems* (pp. 1779–1788). Florence, Italy: ACM.

This paper discusses prototype development and testing of a dual display device that allows for navigation using an embodied interface and flexible display configurations. LCD displays were used, but the authors state a preference for bi-stable displays (i.e., E Ink) and have designed for such an implementation at a later date. The displays can be detached, which offers different functionality: multiple documents can be read. Flipping the screen over will turn a page. Sensors detect the relative positions of the displays, for instance, allowing for the flipping of pages by a fanning gesture: "closing" the attached screens, bringing the left and right ends close to each other. Clickable trackballs on the sides of the displays offer an alternative when needed. Space Filling

Koolen, Corina, Alex Garnett, and Ray Siemens. (2012). Electronic Environments for Reading: An Annotated Bibliography of Pertinent Hardware and Software (2011). *Scholarly and Research Communication, 3*(4): 040154, 62 pp.

Thumbnails (SFT) are used for navigation, as opposed to, for instance, scrolling. Test users preferred the device to a laptop for reading. Downsides reported by test users included that the behaviour of the combined displays can be hard to predict (especially as the sensor did not always work well); the dual displays make handling of the device more complicated; and the second display adds weight, making portability another issue. Hinckley et al. (2009) have improved on this design.



The dual display reader with screens attached side-by-side (top) and detached (bottom) Photo credit: Chen et al. 2008

Deininghaus, S., Möllers, M., Wittenhagen, M., & Borchers, J. (2010). Hybrid documents ease text corpus analysis for literary scholars. *ACM international conference on interactive tabletops and surfaces* (pp. 177–186). Saarbrücken, Germany: ACM.

This article discusses a tabletop document augmentation prototype and hybrid document model for literary scholars. It also gives a good, compact overview of research in the area of paper and digital active reading overall (i.e., not only relating to tabletop settings). The task the authors focused on was the gathering of information for textual analysis, which is a non-collaborative activity undertaken by readers. In their set-up, multiple document management through spatial layout is supported in an environment that integrates screen and desk. It is a rather complicated but interesting set-up that uses video recognition of paper documents in order to show supporting information digitally, such as notes, expanding from and attached to the paper document. Despite some limitations, the close integration of paper and digital makes this article interesting reading matter. The researchers plan to integrate the system with digital pens in order to allow for digital annotation.

The tabletop setting in Deininghaus et al. (2010), the black arrow points to the attached file.

Fishkin, K. P., Gujar, A., Harrison, B. L., Moran, T. P., & Want, R. (2000). Embodied user interfaces for really direct manipulation. *Communications of the ACM*, *43*(9), 74–80.

Although somewhat dated, this article provides a nice initial exploration of the possibilities in reading hardware using embodied interaction, building on their earlier work (Harrison et al., 1998). The authors implement and test three touch features in hardware to aid reading. These features are not in general use nowadays, but might be an interesting addition to hardware. One example is a touch sensor in the shell of the device that recognizes the author's intention to annotate, thereby automatically enlarging the margin of the document on the screen on one side.

Harrison, B. L., Fishkin, K. P., Gujar, A., Mochon, C., & Want, R. (1998). Squeeze me, hold me, tilt me! An exploration of manipulative user interfaces. *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 17–24). Los Angeles, CA: ACM Press/Addison-Wesley Publishing Co.

This is a highly cited article, also from the Xerox Palo Alto Research Center, on manipulating content on devices using sensor input to detect physical manipulation. Two popular handheld devices that allowed pen-based input were used and enhanced. The inclusion of a sensor – as opposed to the addition of one – was a novelty in research on the topic. The tasks researched were navigation within a book or document, navigation through long sequential lists, and document annotation. The authors discuss interaction design (including detecting handedness in annotation) and implementation. Navigation by chunks – multiple pages at the same time – proved difficult, revealing the trade-off between intuitive and learned mappings.

Hinckley, K., Yatani, K., Pahud, M., Coddington, N., Rodenhouse, J., Wilson, A., Benko, H. & Buxton, B. (2010).

Pen + touch = new tools. *Proceedings of the 23rd annual ACM symposium on user interface software and technology* (pp. 27–36). New York, NY: ACM.

This paper documents another Microsoft Research project, using pen *and* touch to employ direct manipulation on a touchscreen, whereas usually these two tools are separated.[9] A Microsoft Surface screen is used, combined with an infrared LED pen. The problem of the accidental resting of the palm on the touchscreen remains, but the

Koolen, Corina, Alex Garnett, and Ray Siemens. (2012). Electronic Environments for Reading: An Annotated Bibliography of Pertinent Hardware and Software (2011). *Scholarly and Research Communication, 3*(4): 040154, 62 pp.

possibilities in the manipulation of digital objects are impressive, especially when it concerns pictures – for instance in making a "carbon-copy" (see Hinckley et al., 2010, p. 32). The project also incorporates many of features that mimic paper affordances, such as holding of pages and flipping, and which are discussed in other articles in this section.

Hinckley, K., Dixon, M., Sarin, R., Guimbretiere, F., & Balakrishnan, R. (2009). Codex: A dual screen tablet computer. ***Proceedings of the 27th international conference on human factors in computing systems*** **(pp. 1933–1942). Boston, MA: ACM.**

This paper describes a dual screen tablet computer prototype, which has a couple of advantages over other prototypes, being the addition of implicit background sensing through sensors as well as collaboration support. The sensors detected a number of different positions (see Hinckley et al., 2009, p. 1935) and act accordingly. The screens are not used as a dual page metaphor as in the codex (but still called "page," interestingly enough), but as split pages. The software is based on note-taking software InkSeine, which is included in the list on e-reading software. The codex allows for wireless connection to a desktop computer, so it can be used as a scrapbook for instance. A user study showed positive response. The possibility to detach the screens was seen as vital. All-in-all, an interesting prototype and experiment.

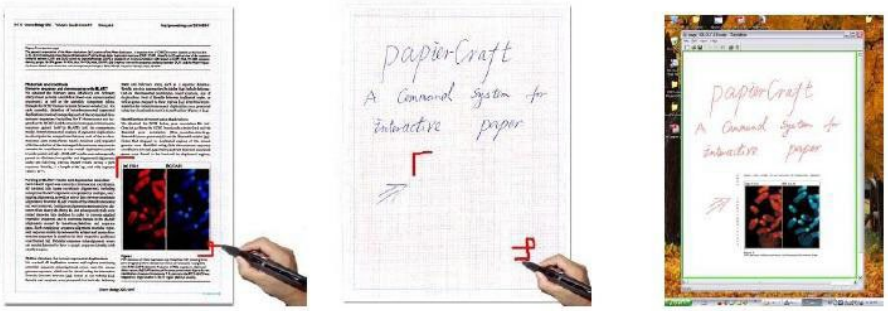
Hwang, J., Jung, J., & Kim, G. J. (2006). Hand-held virtual reality: A feasibility study. ***Proceedings of the ACM symposium on virtual reality software and technology*** **(pp. 356–363). Limassol, Cyprus: ACM.**

This paper offers a promising perspective in navigating digital libraries as related to hardware. Much research on Virtual Reality (VR) asserts the benefit of large displays.[10] However, this article suggests that combining motion-based interaction and a handheld display can improve the user's perceived field of view as compared to an only-visual large display. The study compares three interfaces, being motion-based (handheld with two hands); button-based (handheld with two hands); and three keyboard and mouse interfaces with different screen sizes, from small to large screens (non-handhelds). The outcome of this research of course does not necessarily mean that locating or manipulating information in such a combined space is better, but it opens up possibilities; the combination of motion and display for 3D navigation in digital library environments could be an interesting one to pursue.[11]

Liao, C., Guimbretière, F., Hinckley, K., & Hollan, J. (2008). Papiercraft: A gesture-based command system for interactive paper. ***ACM Transactions on Computer-Human Interaction*****,** ***14*****(4), 1–27.**

This paper is funded by Microsoft Research, and describes PapierCraft, "a gesture-based command system that allows users to manipulate digital documents using paper printouts as proxies" (Liao et al., 2008, p. 1). An Anoto digital pen (still in production: http://www.anoto.com/?id=19146) is used for making the annotations. Synchronization allows for search and navigation. Users print a document on specially patterned paper, make annotations with the digital pen, synchronize these with a digital version of the document and, if necessary, are able to print these annotated documents again. Real-

time interaction is also possible through Bluetooth. The article describes several features of the system, including linking, copying, and pasting. A feature that test users felt was missing was real-time feedback. The system was implemented in field biology research.[12]



Copy-and-pasting in Papiercraft: first on the printed document and eventually transformed into a digital document. Photo credit: Liao et al. 2008

Ruecker, S., & Uszkalo, K. C. (2007). Binding the electronic book: Design features for bibliophiles. *Visible language: The triannual concerned with all that is involved in our being literate*, *41*(1), 50–69.

This article represents a thought experiment which mimics the codex to a much further extent than other experiments which have tried to emulate the experience of print codices. The authors asked bibliophiles what they would like to see in an e-book and perhaps not surprisingly, the answer was something pretty close to a codex. A conceptual model of the e-book was developed, the Bi Sheng (named after the inventor of movable type). A machine (a customized printer) produces a number of digital pages depending on the document requested, binds the pages, and thus produces the most codex-like e-book ever described in literature, with the exception of the digital affordances incorporated in the e-book.

Scott, J., Izadi, S., Rezai, L. S., Ruszkowski, D., Bi, X., & Balakrishnan, R. (2010). RearType: Text entry using keys on the back of a device. *Proceedings of the 12th international conference on human computer interaction with mobile devices and services* (pp. 171–180). Lisbon, Portugal: ACM.

Whereas this bibliography focuses mostly on reading devices, allowing input (whether typed or written) is of course an important feature of devices that support active reading. Much research has been done on the topic – see the "Related work" section in this article – but this article deserves a mention, as it documents an interesting solution to the general problem of lack of space and the impracticality of using a keyboard on a touchscreen. The device described in this article uses the back of the device (which is often left unused) for typing, splitting the keyboard in half, and positioning it on two sides of the device. Within the experiment, expert QWERTY users could obtain speeds comparable with a touchscreen keyboard in one hour. Although keybord cannot be taken into production due to several issues – see the "Conclusion and further work" section – it is nonetheless an interesting experiment, and the article also provides a brief overview of related experiments, such as LucidTouch, where semi-transparency allows the user to type on the back of the device using a touchscreen keyboard.

Koolen, Corina, Alex Garnett, and Ray Siemens. (2012). Electronic Environments for Reading: An Annotated Bibliography of Pertinent Hardware and Software (2011). *Scholarly and Research Communication, 3*(4): 040154, 62 pp.

Tajika, T., Yonezawa, T., & Mitsunaga, N. (2008). Intuitive page-turning interface of e-books on flexible e-paper based on user studies. *Proceeding of the 16th ACM international conference on multimedia* (pp. 793–796). Vancouver, BC: ACM.

This article is included not for its direct applicability, but to attest to the range of experiments that have been conducted. This technology has not yet materialized in usable form.[13] The article describes a prototype for an e-reader, which is basically no more than an e-paper, that is to say, a flexible digital sheet. It mimics paper sheet affordances, the lack of which users often lament in operating digital devices; the prototype "handlings" allow for turning, flipping through, and leafing through digital text.

Wightman, D., Ginn, T., & Vertegaal, R. (2010). TouchMark: Flexible document navigation and bookmarking techniques for e-book readers. *Proceedings of Graphics Interface 2010* (pp. 241–244). Ottawa, ON: Canadian Information Processing Society.

This paper describes another application for reading which tries to emulate codex affordances, in this case page thumbing and bookmarking. Sensors at each side of the reading device allow for these manipulations, more precisely: "The left tab provides access to the previous page when touched from above and to the previous bookmark when touched from below. The right tab mirrors this behavior for forward navigation" (Wightman et al., 2010, p. 241) Earlier tests included more tabs, but users found this to be too complex. It is the intention of the authors to employ TouchMark on future flexible E Ink screens.

Yoon, D., Cho, Y., Yeom, K., & Park, J.H. (2011). Touch-bookmark: A lightweight navigation and bookmarking technique for e-books. *Proceedings of the 2011 annual conference extended abstracts on human factors in computing systems* (pp. 1189–1194). Vancouver, BC: ACM.

This paper was presented at the Computer-Human Interaction conference 2011 (CHI 2011). It presents a prototype that, again, mimics behaviour in codex use: finger bookmarking. We have seen this in other research, but the difference here is that the prototype uses the touchscreen instead of (as yet non-existent) e-paper affordances. By holding a touch point on a touch screen, a reader can "remember" a page, like keeping a finger in a book. The reader can then continue to other pages. Flicking the touch will return the reader to the touch point page. A couple of test users enjoyed the similarity to paper affordances.

A user "finger bookmarking" a page, while flicking inwards to the next page. Photo credit: Yoon et al., 2011

Pearson, J., Buchanan, G., & Thimbleby, H. (2011). The reading desk: Applying physical interactions to digital documents. *Proceedings of the 2011 annual conference on human factors in computing systems* (pp. 3199–3202). Vancouver, BC: ACM.

Although the design of virtually all digital reading environments has been directly informed by their physical counterparts, the authors' *Reading Desk* software prototype is unique for how closely it approximates an actual reading desk. The authors describe how, in their efforts to streamline the use of the system, they eliminated every extraneous tool that could not be expressed by a metaphor of a post-it note, which can be colour-coded, dragged, and dropped to different positions in a document being read. A single post-it note is a bookmark; two of the same colour are, effectively, a link. Notes can be annotated and automatically grow or shrink in size according to needs for legibility – a clever flourish in a system that goes out of its way to appear as near to its physical equivalent as possible). Although the authors do not mention it as a concern, it seems probable that some of the low ratings they received from the user study have to do with the very physical-looking desktop system's relative lack of kinaesthetic interaction potential; future prototypes would likely be better suited to the range of interactions afforded by touchscreen devices.

Koolen, Corina, Alex Garnett, and Ray Siemens. (2012). Electronic Environments for Reading: An Annotated Bibliography of Pertinent Hardware and Software (2011). *Scholarly and Research Communication, 3*(4): 040154, 62 pp.

Software

E-reading software packages

The applications in this section are all available to the public. Most facilitate continuous, long-form reading of texts that were originally intended for print. Many allow some form of annotation such as bookmarking and sticky notes, some allow for flexible making and even sharing of annotations (iAnnotate, Copia, Diigo) or references (Zotero). There are many packages that have been built and eventually failed, the ones in this overview are either very popular at the moment, much discussed, or seem to have survived for a relatively long period of time (that is to say, several years).

Adobe Acrobat Reader
http://www.adobe.com/nl/products/reader.html [14]

This program is probably the most important e-reading software in academia. Articles are most often published online in a PDF-format (digital journals aside), and this leaves digital reading with a big paper legacy that will continue to cause difficulties for screen reading. Adobe has improved the software over the years – allowing a document to open within a browser, and with Adobe Reader X offering highlighting, annotation, and sharing possibilities – but it remains a static publication platform, with no possibilities for reflowing of text and images for instance. Neither does the Reader offer a library of any kind. The Adobe Reader for mobile devices forces the reader to zoom and scroll to read the pages (see Loizides & Buchanan, 2010).

Internet Archive BookReader
http://openlibrary.org/dev/docs/bookreader

This is an online reading application, which does not require any logins or downloads – it thus has a different access logic than other online reading applications: the library is the base, not the e-reader itself. To access the application, the user goes to the Open Library website, searches for a book – Open Library contains an enormous amount of scanned out-of-copyright books – and then clicks on the "Read online" button in the left pane of the page. The application is not without faults (try reading Austen's Emma from Project Gutenberg on a PC – page turning can be rather slow and it does not offer a clickable table of contents with every book), but provides a clean and well-designed interface for reading digitized books. Full text search is an option for a number of the books offered. Sharing is possible, but limited: the application offers the reader the URL to the webpage in question, which a user can then copy and paste. A description of the reader can be found at http://blog.openlibrary.org/2010/12/09/new-bookreader .

Blio
http://www.blio.com; http://www.blioreader.com

The launch of Blio was surrounded by great buzz. It was introduced at the Consumer Electronics Show 2010 and was immediately applauded, perhaps partially due to its famous inventor, Ray Kurzweil (through K-NFB Reading Technology Inc.). After its introduction, the attention faded, as it did not live up to its promise to be a versatile, device-independent platform for e-reading: Windows was the only supported operating

system for a long time – the iPhone and Android support, promised in September 2010, only materialized in July 2011 – and supported formats are limited to ePub and XPS. Moreover, only ePubs bought through Blio's own Baker & Taylor bookstore and DRM-free ePubs can be used. This makes Blio only a little less constrained than any of the other platforms that now arise. Blio contains some interesting features though, such as Dragon Naturally Speaking dictation software and integration with popular social platform GoodReads (http://www.goodreads.com). A demonstration at Book Expo America 2011 showed off its primary assets: the read-aloud function and full-colour display of pages: (see http://www.youtube.com/watch?v=LpBvbQnGBRY). It is notable also that within this e-reading software, books most closely resemble the original print book: it reproduces colour, layout, and original fonts.

Calibre
http://calibre-ebook.com/

This is a popular software package that, unlike the others in this section, is not focused on the reading activity, but on the organization of the library. Even the reading mode it offers is called "View" – it is not actually intended for sustained reading. However, we found the software to be too versatile and interesting not to be included. It is intended only for desktop use and offers synchronization of e-books to nearly all e-reading devices. Formats can be converted, metadata can be downloaded automatically, magazines can be downloaded and are converted for use on a reading device, and books can be bought through several stores, which makes this one of the few store-independent "reading" applications – it will even offer price comparison.

Copia
http://www.thecopia.com

This is the only e-reading application that uses social media as its base in a promising fashion. It resembles Social Book, which IF:Book's Bob Stein discussed at the Unbound Book conference (Amsterdam/The Hague 2011). Copia was announced at CES 2010 like Blio, and received just as much attention. Initially the company wanted to release a $99 e-reader as well, but abandoned that plan and instead focused on the reading platform, which was showcased at CES 2011.

The social website, where you can form reading groups, recommend books etc., is strangely enough not integrated with the reading software, which needs to be downloaded to your desktop (Mac/PC), iPad, or Windows 7 touch device. In the downloaded application, readers can annotate books and then decide whether their notes should be private, shared with friends, or made public. The application's downside is that the sharing function only works with books bought through Copia, which also have DRM (thus the Copia account needs to be linked to an Adobe account).

The interface is attractive. A pane on the right side of the screen, next to the text, allows the user to see their own or other people's comments. The application also provides a sort of tag cloud, which shows thumbnails of book covers, the largest covers being the

Koolen, Corina, Alex Garnett, and Ray Siemens. (2012). Electronic Environments for Reading: An Annotated Bibliography of Pertinent Hardware and Software (2011). *Scholarly and Research Communication, 3*(4): 040154, 62 pp.

ones with the most comments. In a film made at CES 2011, a company representative tells the viewer that the textbook market is a next step for the company (see http://www.youtube.com/watch?v=UY4Hw1p3x-Y&feature=related).

Diigo
http://www.diigo.com

Diigo is a system designed to support active Web document reading, and is one of the most versatile and flexible tools available for Web tracking and annotation. It allows a reader to save, organize, tag, and annotate Web materials, including separate storage of images. The annotations can be kept private or shared with other Diigo users. The tools can be accessed through a toolbar installed in a browser and the information stored is accessible from any other device through the cloud. A big downside of Diigo is that it does not allow PDF-annotation however, not even when the PDF is opened in the browser itself.

FBReader
http://www.fbreader.org/

This is a reader that is built for Windows and UNIX. This is probably the reason that it supports more formats than other e-readers (although not PDF): epub, html, chm, plucker, palmdoc, oeb, rtf, and fb2. It also supports direct reading from tar, zip, gzip, and bzip2 archives. The design is not as slick as any of the other readers, but does offer support for Russian and Chinese texts. It does not allow annotation or highlighting and does not have any social features. Font size and colour can be adjusted.

iAnnotate
http://www.ajidev.com/iannotate/

iAnnotate for the iPad is an e-reading application that focuses on active reading instead of leisure reading – and is the only application in this list that is not available for free. The highlighting and annotation tools include the "standard" options but also include stamps, voice recording, and image annotation. These can be performed on PDF documents only, but the application can convert Powerpoint, Word-documents, and websites to PDF. Other useful features are tabbed browsing and library full-text search, neither of which Adobe Reader allows. The annotations can be shared, but this needs to be done through an export, they cannot be instantly synchronized as in the Copia software. Due to the nature of the files, the pages can only be zoomed and panned; text is not reflowed.

Kindle Reading Apps
http://www.amazon.com/gp/kindle/kcp

Amazon has of course tightly integrated their reader with the Amazon Kindle bookstore, but realized that with the popularity of tablet PCs, they needed to extend their options. The Kindle Reader software is now available for nearly any platform (see http://www.amazon.com/gp/feature.html/ref=kcp_ipad_mkt_lnd?docId=1000493771) and it allows Kindle Bookstore buying and reading without owning a Kindle, which

is of course the app's main purpose. As a result, the reading software is very simple. Amazon also released Kindle Cloud Reader (https://read.amazon.com/about) on August 20, 2011, which of course, offers reading in the cloud, for Chrome and Safari browsers.

Zotero
http://www.zotero.org

This is an open source tool that facilitates the management of references, see also Cohen (2008). The Firefox browser add-on facilitates easy import and generating of references in different formats and thus allows for simple and flexible bibliography management. Recently, the tool was expanded with the introduction of an online community that facilitates collaboration, including sharing of bibliographies, publicly or within groups.

Interfacing digital reading

This section does not focus on specific software but instead offers an overview of usability research of interface elements. Many of the applications discussed in the final section make use of strategies to display information, and the articles in this section discuss research on the effectiveness of these techniques or focus on screen real estate.

Cockburn, A., Karlson, A., & Bederson, B. B. (2009). A review of overview+detail, zooming, and focus+context interfaces. *ACM Computing Surveys*, *41*(1), 1–31.

An elaborate overview of four types of interface (the fourth interface, cue-based systems, is not mentioned in the title), which allow a user to view part of a screen in more detail, based on either graphical or semantic properties. Examples include experimental systems, as well as familiar interface elements, such as the Mac OS X Dock icon-panel.[15] Empirical research on the four types of interface is also discussed, distinguishing between the usefulness for "low-level aspects of interaction such as target acquisition, or high-level user aspects such as the ability to comprehend the information space" (Cockburn et al., 2009, p.17). Different types of applications are discussed, such as navigating though documents and texts (see section 7.2.4 in the text) or computer program navigation (see section 7.2.5 in the text). The authors' conclusion is that although empirical research indicates that none of the systems is ideal, the benefits eventually often outweigh the costs. A combination of focused and contextual views outweighs constrained single-view. The *goal* of the interaction is crucial in finding the right combination however. An example can be found in Hornbæk et al. (2002) where comprehension is better aided by overview+ detail (thus deep reading) but reading is faster with fisheye (thus search).[16]

Koolen, Corina, Alex Garnett, and Ray Siemens. (2012). Electronic Environments for Reading: An Annotated Bibliography of Pertinent Hardware and Software (2011). *Scholarly and Research Communication, 3*(4): 040154, 62 pp.

Hillesund, T. (2010). Digital reading spaces: How expert readers handle books, the Web and electronic paper. *First Monday*, *15*(4). URL: http://firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/2762 .

This theoretical essay explores various currently practised modes of "expert reading" (variously also called "active reading") in-depth, and discusses how well each is supported by up-and-coming electronic reading interfaces. The author briefly reviews the history of casual reading, and the history of hypertext, noting that from the start, "the art of printing was primarily a culmination of [the] development of the navigable book" (Hillesund, 2010). He further observes, citing an essay about distinguishing between one's "warm" (active) and "cold" (inactive) documents, that some such paradigms extended into a digital environment perfectly well (in this case, with the advent of window management schemes for multitasking), if not particularly much better than in the physical realm. For the author, "expert" reading implies discontinuousness, while "immersive" reading does not. One can debate whether this conceptual distinction completely captures the subtleties of digital and print active reading, but the author does not equal either to a specific medium.

Jakobsen, M. R., & Hornbæk, K. (2007). Transient visualizations. *Proceedings of the 19th Australasian conference on Computer-Human Interaction: Entertaining User Interfaces* (pp. 69–76). Adelaide, Australia: ACM.

As reported in Cockburn et al. (2009), the use of certain visualization types for enlarging parts of a screen depend heavily on the user's goal. And a user might have several different goals in using the same interface, which is especially true in active reading. In this article, the authors present a base for transient visualizations – visualizations that are temporary and appear near the focus of the user's attention (i.e., the cursor). A user study reported a number of difficulties, but less sensory-motor efforts of the user were needed.

Jakobsen, M. R., & Hornbæk, K. (2010). Piles, tabs and overlaps in navigation among documents. *Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries* (pp. 246–255). Reykjavik, Iceland: ACM.

Many of the interfaces discussed in the final section of this bibliography use piles and overlapping to give readers an overview of and search structure for their documents related to a single task. In this article, the authors have researched the usability of these 2D-organizing principles, and that of tabbing, for document navigation. They have focused on piling, providing an overview of research in that particular area. In an experiment, four interfaces (overlapping, tabbed, and piling with a fixed and flexible order) for Web browsing were compared. The set-up was highly artificial: 11 participants in a laboratory setting who were asked to perform specific tasks ("find a document with a this word in the title") on documents unknown to them; and the authors seem a bit disappointed with the results, amongst which was the fact that tabbing and overlapping interfaces were faster in navigation through documents than piling. Piling was mainly useful when visual features were important in search, for instance when looking for a title with a specific word in it. What the authors do not

note is that perhaps familiarity is also important in the speed of locating information through tabbing and overlapping: piling is not a well-supported interface element in current desktop interfaces and browsers.

Loizides, F. & Buchanan, G. R. (2010). Performing document triage on small screen devices. Part 1: Structured documents. *Proceeding of the 3rd symposium on information interaction in context* (pp. 341–346). New Brunswick, NJ: ACM.

Document triage has been researched abundantly, most often in desktop settings. In this article, the authors have used a Dell Axim X51 palmtop with Adobe Acrobat Reader installed to investigate how users perform document triage on a small screen. However, instead of focusing on the specific difficulties of the use of the small screen, the authors focus on the elements in the text the readers use, which, not surprisingly, are quite similar to readers who perform the same task on a desktop (main title and abstract are the most important, the main text is not used often). The participants did report problems on using Acrobat Reader: it forces left-to-right scrolling, which makes the triage process cumbersome; one 29-page journal article was reported to be harder to assess than the shorter conference papers; the first page of the document remains the most important, and its reading thus does not depend on screen size, readers merely scroll more to read it. As long as the PDF file continues to be the most important format for displaying academic articles, the small screen will cause difficulties and this needs to be addressed.

Vogel, D. & Balakrishnan, R. (2010). Occlusion-aware interfaces. *Proceedings of the 28th international conference on human factors in computing systems* (pp. 263–272). Atlanta, GA: ACM.

When using a tablet device, one always occludes areas with arms and hands. This sometimes makes for awkward positioning of the hands. The authors have developed an interface that provides temporary pop-outs for important occluded information, which is based on the previously developed Shift technique for occlusion.[17] A number of issues arose during testing, making this strategy not immediately feasible, but as the portion of the screen that is occluded by the hand and arm while using a pen or touch screen can be substantial, this is an important issue to consider during software design. An explanatory video is available through http://www.youtube/4sOmlhEJ2ac .

van der Weel, A. (2010). New mediums: New perspectives on knowledge production. In W. T. van Peursen, E. Thoutenhoofd, & A. van der Weel (Eds.), *Text comparison and digital creativity* (pp. 253–268). Leiden: Brill. URL: http://www.let.leidenuniv.nl/wgbw/research/Weel_Articles/15_KNAW_Weel_rev_Aug09.pdf .

This article provides a conceptual perspective on knowledge production. The author stresses the problematic aspect of using not only familiar technological features, but also traditional *concepts* in the production of new digital environments, as we have seen often in this and the hardware part of this bibliography. He analyzes the history of medium transition and the specific socio-technical nature of the digital medium to prove his point. This article is useful in that it gives a meta-perspective on the transition

of knowledge from the paper to the digital medium. Four models show what the affordances of the computer as a "Universal Machine" are, leading up from markup to a collaborative model – and provide a basis for a more profound use of the digital medium.

Graham, J. (1999). The reader's helper: A personalized document reading environment. *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 481–488). Pittsburgh, PA: ACM.

Hornbæk, K. & Fr¢kjær, E. (2001). Reading of electronic documents: The usability of linear, fisheye, and overview+detail interfaces. *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 293–300). Seattle, WA: ACM.

These two relatively early studies of electronic reading environments have an interesting commonality: they are both designed to help the reader get some information out of the way. Whereas Graham's (1999) Reader's Helper allows users to browse thumbnail selections of other documents related to the one they are currently viewing, Hornbæk and Frokjær's prototype allows users to minimize selections of the active text, performing a sort of reverse-highlighting that they call a fisheye view. Modern readers should take note that concerns about information overload have stood in opposition to our striving for intextuality for at least a decade hence. A review of these and other approaches can be found in Cockburn et al. (2009).

Dyson, M. C. & Haselgrove, M. (2001). The influence of reading speed and line length on the effectiveness of reading from screen. *International Journal of Human-Computer Studies*, *54*(4), 585–612.

This landmark article from a decade ago contains one of the most comprehensive treatments of how digital document layouts affect reading speed for a varied audience. The authors begin by reviewing reading research from the 1950s through the 1970s, which assessed the tradeoff in reading speed versus comprehension, and note that a range of 55 to 70 characters per line was and remains something of a sweet spot for monospace and variable-width fonts alike. Curiously, longer line lengths of up to 100 characters seem to be better for the express purpose of skimming, and, of course, the idea that there can be more than one optimal document layout strongly reinforces the advantages of "reflowable" text. In 2001, this finding stood in opposition to their participants' apparent preference for paginated, rather than scrolling documents, as the de facto paginated document, PDF, only supported a fixed document layout. Now, new formats such as ePub appear to combine the best of both worlds.

Baumer, E., Sueyoshi, M., & Tomlinson, B. (2008). Exploring the role of the reader in the activity of blogging. *Proceeding of the 26th annual SIGCHI conference on human factors in computing systems* (pp. 1111–1120). Florence, Italy: ACM.

This article, while not about a reading tool or tools *per se*, provides an excellent thinking-through of the affordances of reader discourse in electronic documents. The authors begin by noting that the shift in literary theory of the 1960s and 1970s toward

analyzing the reader's response to literature has not quite been carried through to our study of digital media. In order to understand the behaviour and expectations of blog readers, they conducted an ethnographic study of 15 participants, which revealed that blog reading is a deeply habitual process – simultaneously productive and time-wasting – and that blogs unsurprisingly command a great degree of authenticity relative to other written media. The study also suggests that the "non-chronicity" of blogs was somehow special, in that posts have a clearly defined *sequence* of following one after another: this is the full extent to which blogs have any relevant temporality. The authors believe that these factors should be taken into account in the design of new and novel reading tools.

Buchanan, G. & Owen, T. (2008). Improving navigation interaction in digital documents. *Proceedings of the 8th ACM/IEEE-CS joint conference on digital libraries* (pp. 389–392). Pittsburgh, PA, ACM.

This conference paper contains some helpful reminders for the use of within-document navigational aids, which are especially relevant for highly self-contained documents such as PDF. The authors conducted a user study using a prototype system with two different linking conditions in a scholarly article – traditional anchor text links (e.g., to the article bibliography), and thumbnail images (of both figures within the article and the article itself). Although the thumbnail condition unsurprisingly received much poorer subjective judgments due to difficulties in automatically rendering subsections of mostly-text documents that would be not only legible but identifiable, the hyperlink condition was generally well-liked. The only exception was when hyperlinks spanned fewer than two pages within the document, and users found them disorienting (expecting, perhaps, that they'd have been transported farther through the document than was actually the case), preferring to scroll. Hyperlinks were rated especially *helpful* when they were two-way (i.e., able to be reversed, as with the "back" button in a browser), though this required simply creating an additional link in the opposite direction, as no PDF reader supports a backward navigational step as such.

Loizides, F. & Buchanan, G. R. (2008). The myth of find: User behaviour and attitudes towards the basic search feature. *Proceedings of the 8th ACM/IEEE-CS joint conference on digital libraries* (pp. 48–51). Pittsburgh, PA: ACM.

This article discusses one of the most powerful and most often taken for granted features in any electronic document reader: the Control+F search shortcut. Although the authors write extensively on the results of a user study, the essential conclusion is this: many people do not use Ctrl+F, and those that do are typically disinclined to use a more sophisticated search system (e.g., with features such as spelling correction) because it is not as lightweight as Ctrl+F.

Olive, T., Rouet, J.-F., François, E., & Zampa, V. (2008). Summarizing digital documents: Effects of alternate or simultaneous window display. *Applied Cognitive Psychology*, *22*(4), 541–558.

This paper is unlike the majority of reading environment design studies in that it rejects the notion that an optimal reading environment is likely to be "designed" at all. Rather, it supports the notion of reading environments being assembled post-hoc by the user – grouping various tools, in various different applications, wherever happens to be most convenient – and in so doing, reinforces the advantages of narrow, single-column document layouts that can be made to accommodate as much marginalia as possible. Interestingly enough, since the publication of this paper, new dedicated devices have gone the opposite direction and begun to wrest back away users' ability to multitask as they see fit, though it is worth noting that most e-reader applications (along with many Oxford journal reading environments) have opted for smaller-than-A4 page layouts.

Qayyum, M. A. (2008). Capturing the online academic reading process. *Information Processing & Management*, *44*(2), 581–595.

This article, an extension of the author's dissertation work, reports on the electronic document reading, sharing, and interaction habits of graduate students. He found that the vast majority of annotations fall into just two categories – underlined or highlighted text, and anchor points for some marginalia. Either selection of text (in the first case, the original author's; in the second, the reader's) could be indexed by a sufficiently powerful reading environment and presented to the reader or readers as a table of contents of notes. One finding from this study that subverts a key assumption of open online annotation systems is that many individuals do *not* want to inherit an already-annotated document, even less so if the prior annotator is anonymous. While we can learn much from the wisdom of crowds, we seldom sit out to read a self-contained document with these crowds in mind, as doing so can be confusing or overwhelming. It is thus a sensible assumption that the annotation layer should be secondary to the original text in a well-designed reading environment – and worth considering when this assumption may *not* hold true.

Vandendorpe, C. (2008). Reading on screen: The new Media sphere. In S. Schreibman & R. Siemens (Eds.), *A Companion to Digital Literary Studies*. Oxford, UK: Blackwell. URL: http://www.digitalhumanities.org/companionDLS/ .

This chapter from the Oxford *Companion to Digital Literary Studies* shows its humanist hand almost immediately. Vandendorpe explains in his introduction that "the most important milestone in the history of the book was the adoption of the *codex* format … and the subsequent demise of the *volumen* or scroll" (Vandendorpe, 2008). This format supported what we now call "active reading" not only because codices were far less cumbersome to physically handle, but because pagination provides us with much more reliable reference points within a text. With some exceptions, of course, hypertext is largely non-paginated, and hypertexts that most closely approximate the printed page have encountered some well-publicized and well-researched growing pains in trying to

achieve the best of both worlds. Vandendorpe reflects on the developments in digital reading, recognizing for instance that breaking with the past is not necessary or useful, although this does not mean that all now-existing products are ideal.

Kamil, M. L., Pearson, P. D., Birr Moje, E., & Afflerbach, P. P. (Eds.). (2011). *Handbook of reading research*. New York, NY: Routledge.

This lengthy volume, while not about electronic reading per se, is a comprehensive single source for much of what we currently know about the reading process from the perspective of education. The book's short first chapter deals with how controlled reading studies are best conductive, in both an ethnographic and computational context. After this, the book turns to focus entirely on the reading process itself: in the second chapter, through the life cycle; in the third, at various levels of linguistic depth; and in the fourth, in the teaching and learning of reading. The fifth and final chapter, also the most diverse, deals with many sociocultural facets of reading, such as how popular culture has altered our approach to language and literacy, how second languages are learned, and how literacy can thrive in informal contexts. The lattermost is perhaps of particular note for reading specifically non-academic content on the Web.

Campbell, D. G. (2002). The use of the Dublin Core in Web annotation programs. *Proceedings of the 2002 international conference on Dublin core and metadata applications: Metadata for e-communities* (pp. 105–110). Florence, Italy: Dublin Core Metadata Initiative.

This short and straightforward article examines the extent to which the popular Dublin Core metadata schema is or can be supported by popular document annotation layers. Though originally intended as a contribution to a meeting, which was organized specifically around the Dublin Core, this piece now seems to anticipate current efforts to adapt data packaging schema (such as RDFa, which stands for Resource Description Framework in Attributes) to annotation. Although the author elaborately describes annotation types, enthusiasm for which has decreased considerably in the intervening decade, there is a standing need for attribution and versioning of annotations such as he describes, and the Dublin Core could serve that purpose then and now still.

Milne, D. & Witten, I. H. (2008). Learning to link with Wikipedia. *Proceeding of the 17th ACM conference on information and knowledge management* (pp. 509–518). Napa Valley, CA: ACM.

This paper reports on an ongoing project in automatically parsing and embedding noun-phrase links in webpages, using Wikipedia as a reference. Linking with Wikipedia – or, as the authors say, "wikifying" pages – has so far succeeded where similar projects have failed, thanks to Wikipedia's breadth and (supposed) impartiality. For example, where similar lookup engines might require a great deal of editorial effort to create a functional "dictionary" and attempt to use the long-standing WordNet lexical database for disambiguating word meanings, Wikification is based on statistical relevance judgments, using one of the largest such databases in existence (dwarfing

Koolen, Corina, Alex Garnett, and Ray Siemens. (2012). Electronic Environments for Reading: An Annotated Bibliography of Pertinent Hardware and Software (2011). *Scholarly and Research Communication, 3*(4): 040154, 62 pp.

WordNet's coverage of noun phrases). In this paper, the authors explain in detail their method for making these relevance judgments, noting that the overall machine-derived statistical relevance for their results is somehow identical to that of the aggregate relevance judgment of their user study participants: 79%.

Personal e-reading software and interface design

An abundance of interfaces and software has been designed in academia to support single-author active reading, for handheld devices but mostly for desktop interfaces. In this section, we provide sources for a selection of concepts, interfaces, and complete packages to support specific types of annotation on single (which is most frequent) or multiple documents (text, images, video); document triage and navigation; and organization of personal libraries.

Alexander, J., Cockburn, A., Fitchett, S., Gutwin, C., & Greenberg, S. (2009). Revisiting read wear: Analysis, design, and evaluation of a footprints scrollbar. *Proceedings of the 27th international conference on human factors in computing systems* (pp. 1665–1674). Boston, MA: ACM.

This paper describes a visually attractive system to aid readers in navigating through multiple-page documents. Although the scrollbar is perhaps not the best element of current interface designs, the principle of *intuitive* (or "lightweight") read wear can be applied in other reading software as well. The benefit of this system is that it is based on user studies: a previous version was completely revised after user testing, resulting in this footprints scrollbar. This background is described in the article, and a video of a demonstration of the reading environment is also available through http://doi.acm.org/10.1145/1518701.1518957 .

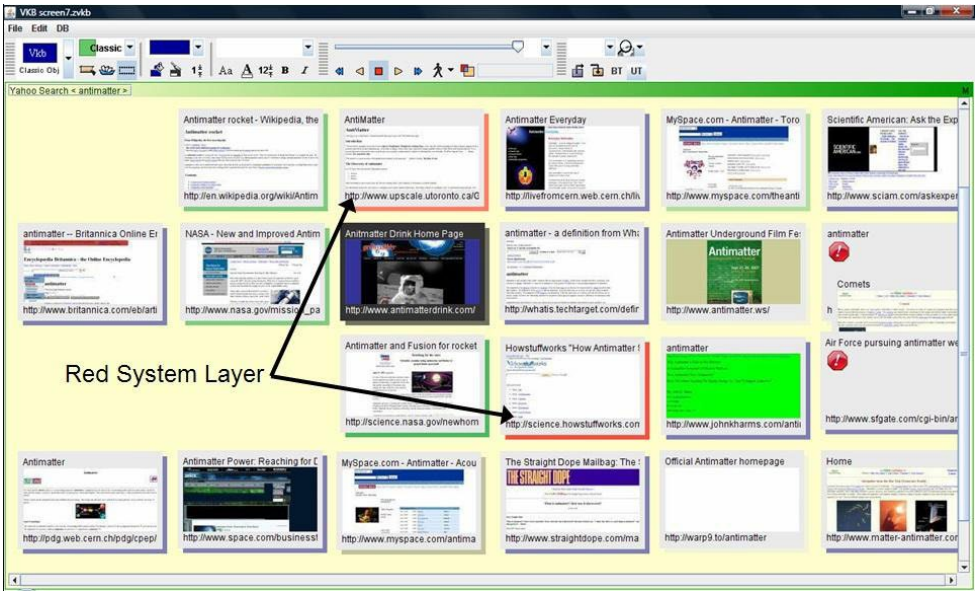
Anuradha, K. T. & Usha, H. S. (2006). E-books access models: An analytical comparative study. *The Electronic Library*, *24*(5), 662–679.

In this article some online and offline e-book "access models" are compared: Microsoft Reader, Mobipocket Reader and Adobe Reader; ebrary (http://www.ebrary.com), Kluwer (http://www.kluwer.com) and Engineering village (http://www.engineeringvillage2.org). Features of each of the models are described, singling out those that are unique to each model. Although this is not a very exciting article, it does give an overview of features of relatively old systems.

Bae, S., Kim, D., Meintanis, K., Moore, J. M., Zacchi, A., Shipman, F., Hsieh, H. & Marshall, C. (2010). Supporting document triage via annotation-based multi-application visualizations. *Proceedings of the 10th annual joint conference on digital libraries* (pp. 177–186). Gold Coast, Australia: ACM.

In this research by Microsoft, a mix of applications is used to support (desktop) document triage, that is, "rapid assessment of documents based on their potential" (Bae et al., 2010, p. 177). This research is noteworthy for several reasons. It offers a set of tools, as opposed to a single tool, to aid the professional reader in asserting document interest. User interests are automatically inferred from document usage and user annotation. And most importantly, it supports document reading *and* organization. It

uses Visual Knowledge Builder (VKB, version 3 in this article, based on the older tool VIKI) for searching and organizing HTML-documents and WebAnnotate as a proof-of-concept reading application, an add-on for Mozilla Firefox. Records of user activity in both are stored in an Interest Profile Manager (IPM), which generates visualizations on possible interesting paragraphs in Web documents that look different from the user's own annotations. Lab tests indicate that the visualizations help users to focus: there is less frequent switching between the reading and the search environment.



A VKB screenshot. The Interest Profile Manager (IPM) generates coloured layers to indicate similarity with user colour-annotated documents. The intensity of the colour indicates certainty. Photo credit: Bae et al., 2010

Beel, J., Gipp, B., Langer, S., & Genzmehr, M. (2011). Docear: An academic literature suite for searching, organizing and creating academic literature. *Proceeding of the 11th annual international ACM/IEEE joint conference on digital libraries* (pp. 465–466). Ottawa, ON: ACM.

This paper attempts to integrate several research functions in an open source software suite for academics. Its functionality is demonstrated through a film, which can be found on http://www.docear.org, and includes mind-mapping tools, a reference manager and annotation.

Bier, E., Good, L., Popat, K., & Newberger, A. (2004). A document corpus browser for in-depth reading. *Proceedings of the 4th ACM/IEEE-CS joint conference on digital libraries* (pp. 87–96). Tuscon, AZ: ACM.

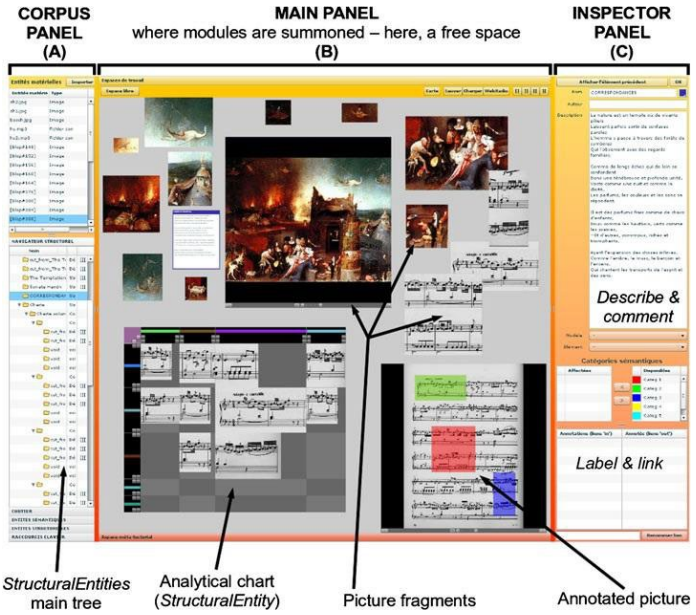
The system outlined in this paper is one of the few approaches that tries to integrate document finding/reference search, storing, and reading. The paper describes five still-important desiderata on which the system is based, for example, "[v]isualizations of a bookplex should reveal information at several levels of granularity, from individual documents to all documents in the bookplex" (Bier et al., 2004, p. 90). A bookplex

Koolen, Corina, Alex Garnett, and Ray Siemens. (2012). Electronic Environments for Reading: An Annotated Bibliography of Pertinent Hardware and Software (2011). *Scholarly and Research Communication, 3*(4): 040154, 62 pp.

is the environment in which documents are stored and retrieved. Three tools were implemented, a reference extraction tool, a document finding tool, and a corpus browser (with a Zoomable User Interface, or ZUI). The tools offer a combination of automated extraction and search, and user input. The corpus browser allows for a smooth transition between document browsing and document reading, although the latter was not yet developed fully at the time of publication; there were no annotation possibilities for instance. Although this approach is solely aimed at *personal* library building, and the actual reading of the document is not facilitated in any way, expanding on this design could allow for a versatile and time-saving reading environment.

Bottini, T., Morizet-Mahoudeaux, P., & Bachimont, B. (2011). A model and environment for improving multimedia scholarly reading practices. *Journal of Intelligent Information Systems*, *37*(1), 39–63.

The authors present a document model and experimental software tool for academic analysis of multi-medial "documents," such as audio recordings of lectures, and sheet music, with the intention of leading up to some form of publication. In other systems in this bibliography multi-medial content is rarely included, and if so, it is not possible to make annotations within the multi-medial document itself. The model described in this paper does allow for within-document spatial and/or temporal annotation of several types of non-text documents. It also allows for linking between parts of the documents (see figure below). The model is described comprehensively, including a visualization through a Unified Modelling Language (UML) graph. The authors have also implemented the model by making a generic module (see figure below) and two software tools implemented for specific groups: an audio recording annotation tool and a musicological annotation tool. The former was used as an educational tool where students could build a structure for and annotate an audio recording of a lecture. By giving the teacher access to the tool, the analysis process leading up to a presentation students were required to make (the construction of which was also facilitated by the tool) could be judged. Although it does not seem feasible to design a tool that can be applied to many types of non-text documents, the generic tool offers an interesting mix of detailed and overview presentation of information, annotation, and linking of information, which could possibly also be applied to a combination of textual and non-textual documents. The users of the interface did find it too crowded however.



A generic tool based on the model in Bottini et al. (2011). It gives a comprehensive overview but did not work for smaller screens.

Chen, J., Xiao, J., Fan, J., & O'Brien-Strain, E. (2011). PageSpark: An e-magazine reader with enhanced reading experiences on handheld devices. *Proceedings of the 3rd ACM SIGCHI symposium on engineering interactive computing systems* (pp. 149–152). Pisa, Italy: ACM.

This paper describes PageSpark, a tool that segments and enhances static PDF magazines to provide a better reading experience on the iPad. The tool focuses on page layout reorganization, page elements interaction (for instance multi-page image browsing and single column scrolling), and page transition. User tests showed greater engagement with PageSpark than other magazine applications. In the long run, this tool is perhaps not necessary, but with the majority of online academic articles now being in PDF format, this could be a very practical tool to aid screen reading of PDF files.

Dourish, P., Edwards, W. K., LaMarca, A., & Salisbury, M. (1999). Presto: An experimental architecture for fluid interactive document spaces. *ACM Transactions on Computer-Human Interaction*, *6*(2), 133–161.

The article describes Presto, a prototype for document organization software in a desktop environment. The software is not very recent but is nonetheless interesting software, because of the more holistic approach underlying it. It is part of Placeless Documents, a document space organization project confronting the traditional hierarchical structure of document storing and retrieval. The Presto system provides tagging for documents. Tagging is created by the user as well as automatically generated, relying on attributes instead of naming to locate documents. It does not provide special features for single document handling. The whole Placeless Documents architecture is described in the article "Extending document management systems with user-specific active properties" (Dourish et al., 2000).

Koolen, Corina, Alex Garnett, and Ray Siemens. (2012). Electronic Environments for Reading: An Annotated Bibliography of Pertinent Hardware and Software (2011). *Scholarly and Research Communication, 3*(4): 040154, 62 pp.

Hinckley, K., Zhao, S., Sarin, R., Baudisch, P., Cutrell, E., Shilman, M., & Tan, D. (2007). InkSeine: *In Situ* search for active note taking. *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 251–260). San Jose, CA: ACM.

This paper describes a Microsoft software tool implemented on the dual screen hardware Codex (see the hardware part of this bibliography) but available for all Windows-run tablet PCs. It offers a specific strategy for active reading through search, based on pen-based input. Like Microsoft's XLibris, it offers search through free-form digital ink input, in a personal library and online. See http://www.youtube.com/watch?v=DW1PGq4_7eI for an idea of the possibilities. The paper and the video do not show how a user can keep track of their work spaces (other than by numbering); it is of course solely based on Microsoft software and tooling – the capturing is limited to text and images, but it is still an interesting application to have a look at. It can be downloaded at http://research.microsoft.com/en-us/um/redmond/projects/inkseine.

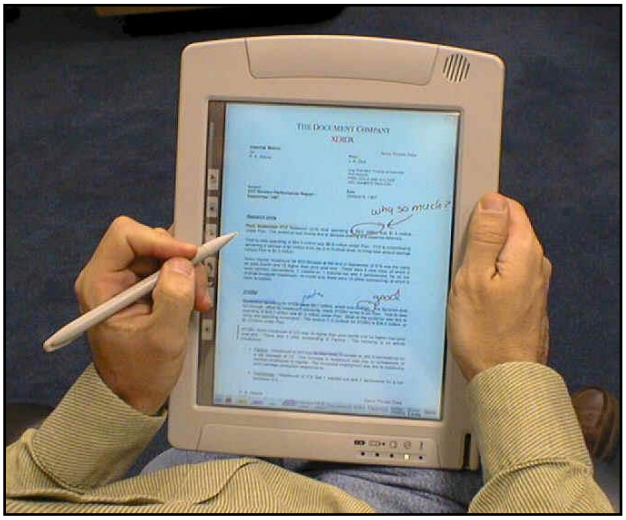
Ramos, G., & Balakrishnan, R. (2003). Fluid interaction techniques for the control and annotation of digital video. *Proceedings of the 16th annual ACM symposium on user interface software and technology* (pp. 105–114). Vancouver, BC: ACM.

This paper describes LEAN, a software tool for annotating digital video on a tablet PC using pressure-sensitive pen input. Although the software is not that recent, it seems to be one of the most intuitive and fluid video annotation tools constructed in the last decade in academia. Perhaps it was never realized, as tablet PCs then were not fast enough to allow for this kind of manipulation (Ramos & Balakrishnan, 2003, p. 107). LEAN allows for flexible annotation and selection of (a series of) frames in a video, while working in a workspace that contains the original video, one or multiple separate timeline bars, and extracted frames, all of which can be placed and manipulated anywhere in the workspace. When selecting an annotation, all of the connections to frames and other notes are represented visually by a semi-transparent beam. This layout makes it less rigid than other visual interfaces, which often use thumbnails. A unique feature is the Twist Lens slider, which allows the user to focus on one frame through fish-eye zooming in a line-up of frames without obstructing adjacent frames, by creating an s-shaped timeline. The downsides of the system are that there are no multi-document annotation or sharing opportunities. A film showing its features can be found at http://dx.doi.org/10.1145/964696.964708 .

Schilit, B. N., Golovchinsky, G., & Price, M. N. (1998). Beyond paper: Supporting active reading with free form digital ink annotations. *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 249–256). Los Angeles, CA: ACM Press/Addison-Wesley Publishing Co.

"Old" is not useless by definition. Although never widely adopted, the XLibris Active Reading machine by Microsoft is referred to by many academics in recent research on e-readers. There are good reasons for this lingering popularity, as it was developed for research in the first place, unlike more recent software for devices; it departed from the WIMP interface at an early stage; and incorporates certain features that

are still compelling. It uses some affordances of paper documents and adds digital affordances. The interface mimics a single sheet of paper, whereas current dedicated e-readers (understandably) often split up a page in several sections because of smaller screen size; it contains active reading support, by the implementation of flexible and searchable highlighting and annotation, long before popular dedicated devices started to penetrate the market – and even then only incorporated those features in later versions; and most interestingly, it generates automated recommendations for further reading that pop up in the margins while annotating, using the markings as queries. This allows for (often lamented) serendipitous finds in the digital realm. For more images see http://www.fxpal.com/?p=xlibris. The hardware the program runs on however, was too heavy to ever gain widespread use. A different and newer version of the software is called InkSeine, which is also included in this bibliography. (Hinckley et al., 2007). For a more detailed description of XLibris' search engine, see the paper "Linking by inking: trailblazing in a paper-like hypertext" (Price et al., 1998).



XLibris running on a Fujitsu Point 510. Photo credit: Schilit et al., 1998

Secord, A., Winnemoeller, H., Li, W., & Dontcheva, M. (2010). Creating collections with automatic suggestions and example-based refinement. *Proceedings of the 23rd annual ACM symposium on user interface software and technology* (pp. 249–258). New York, NY: ACM.

In this article, two tools meant for semi-automated personal media library manipulation are discussed. These tools could possibly be applied to other domains. The design of the tools is based on the *actual* iterative process of selecting a sub-collection of music or images, bypassing the still dominant hierarchical structure of storing files. A good example can be found in the implementation of the following simple yet crucial observation: "Adding an item to a collection can be just as much about the item's fit in the collection as the item's individual quality" (Secord et al., 2010, p. 251). Semantic search and recommendation are the basis of the creation of a collection, after which the user can iteratively work through a suggested selection and manually edit it. It is impressive how the tools, SongSelect and PhotoSelect, make use of imprecise parameters (including search quantifiers such as "some") and relations to select appropriate items. A downside of the system is that it relies heavily on pre-

defined metadata, which can make it wonky when applied to bigger collections that make use of automatically generated metadata; thus it relies on the user to supply quality. The reason why this approach is perhaps not completely applicable to academic research is that searches within a personal library are often targeted to a specific item (and not a "good enough" one) – although this type of navigation might help. It may be useful in searching a public library for personal collecting purposes, but there a problem concerning the quality of the metadata at hand. However, the tool is still very impressive and it employs interesting features. The features can be seen in the video available at http://dx.doi.org.ezproxy.library.uvic.ca/10.1145/1866029.1866069 .

Siemens, R., Leitch, C., Blake, A., Armstrong, K., & Willinsky, J. (2009). It may change my understanding of the field: Understanding reading tools for scholars and professional readers. *Digital Humanities Quarterly, 3*(4). URL: http://digitalhumanities.org/dhq/vol/3/4/000075/000075.html .

This is a report on a user opinion study in which digital humanists and graduate students participated and gave feedback on using the scholarly article reading tools embedded within the Public Knowledge Project's Open Journal Systems. The authors embedded the actual research process in the study, and did not focus on single document reading, but on how readers position texts in a field and the wider context. Participants were provided with an article and a set of reading tools in a bar to the right of the document. The tools offer aids in situating the article being read, by providing access to a thesaurus, an author's related work, or government databases for instance, which were deemed particularly useful for students not yet as familiar as domain experts in a given field. According to the authors, the single most interesting finding from this research was that the reading tools were overwhelmingly found to be better at locating articles within their respective scholarly context than actually assisting with individual readings. The most likely reason volunteered for this is that there are simply not many productive ways that software can intervene in readers' variously idiosyncratic means of interacting with isolated documents (with the exception of annotation, which was not well-supported by Open Journal Systems at the time of the study). Indeed, their think-aloud protocol evinced almost as many descriptions of individual reading processes than commentary on the tools themselves. Among the tools that did work well was an engine for discovering authors' related work, assisting in readers' credibility judgments of authors whom they had not previously been introduced to (and all the more so in the context of Open Access). Among the features that did not work well for many readers were broader-scale "find more like this" options, usually because the article metadata, which was mined for search terms, was insufficient to compete with the relatively trivial alternative of readers formulating their own Google Scholar search. The results are organized in several themes that can be used to inform the design of new interfaces, which are concerned not only with usability and speed of navigation, but also with the quality of the information that is accessed – a primary concern for academics.

Sun, Y., Harper, D. J., & Watt, S. N. K. (2004). Design of an e-book user interface and visualizations to support reading for comprehension. *Proceedings of the 27th annual international ACM SIGIR conference on research and development in information retrieval* (pp. 510–511). Sheffield, UK: ACM.

This is an interesting article mainly for its ideas, which seem not to have been realized. ProfileSkim is a within-document retrieval tool that authors had developed in earlier research. In this article, the authors' idea was to use ProlifeSkim to aid comprehension in reading a narrative text by automatically generating a thematic overview and lists of characters based on information retrieval. Although perhaps not very practical, the idea that automatically generated within-document and contextual information could aid in reading (complex) *narratives* is an interesting one, not only for educational purposes.

Tashman, C. S., & Edwards, W. K. (2011). LiquidText: A flexible, multitouch environment to support active reading. *Proceedings of the 2011 annual conference on human factors in computing systems* (pp. 3285–3294). Vancouver, BC: ACM.

LiquidText is prototype tablet software that offers various within-document manipulations for active reading that are not found in software on touchscreen devices today. It was presented at the 2011 Association for Computing Machinery (ACM) CHI conference in anticipation of the software's release later in the year. LiquidText is based on the assumption that paper affordances are not necessary and trying to copy them can even impair the reading experience – although the metaphor could not completely be avoided. The authors detail a user study, which was designed with the express purpose of determining which components of active reading (annotation being the long-standing example) are still better-supported by pen and paper than they are in electronic reading environments. Their findings, on which their system design is predicated, are summarized as follows: the least organized and most valuable insights are usually located in a cross-document context, not in a single PDF or Word file but in the margins of Powerpoints and email threads. As such, LiquidText is being built to preserve the context of text snippets once they have been dragged and dropped (or, as per the tablet paradigm, pinched or pulled) out of their original context, while still allowing them to be dynamically re-formed elsewhere, and highlighted or bookmarked accordingly. LiquidText is said to be meant for use on a tablet device, but this makes many of the manipulations provided complicated, as they require the use of both hands – which can be seen in a screenshot below. This means that the tablet needs to be propped up or laid down. An outcome of the formative study, namely the need for multiple document manipulation, was not yet implemented in this system; the authors intend to do so in future studies. For a description of the formative study, see Tashman et al. (2011) in the hardware part of this bibliography. A video on LiquidText's workings is available on YouTube: http://youtu.be/gpA_bGUm3Wo .

Terrenghi, L., Serralheiro, K., Lang, T., & Richartz, M. (2010). Cloudroom: A conceptual model for managing data in space and time. ***Proceedings of the 28th of the international conference extended abstracts on human factors in computing systems*** **(pp. 3277–3282). Atlanta, GA: ACM.**

This paper describes Cloudroom, an example of a (concept for a) 3D interface for information storage and retrieval by the research & development department of Vodafone. The interface is an interesting one in that 1) it is based on storing information in the cloud; 2) it is conceptualized to be used on a small screen device in combination with use on larger screens; 3) its three dimensions are used to support recall of information based on *time* parameters, with long-term storage for older files and short-term storage for current projects, each on their own axis; 4) work can be organized in sessions, which can be shared with others; and 5) the authors try to lift the distinction between application and data by allowing manipulation in the interface at all times. Of course, this all sounds great in a concept, but absent of implementation, the question is whether the conceived features can actually all come together and work properly. A problem that needs to be mentioned for this approach, is one discussed in Jakobsen and Hornbæk (2010):

> Users may identify a document by a thumbnail view from among visually distinct documents (e.g., pages from different web sites). However, if documents are visually similar (e.g., source code files or pages from digital library), a thumbnail view contains no salient features for identifying the document. (p. 248)

The Cloudroom authors looked to timeline-based Liquifile (http://www.liquifile.info) and 3D environment BumpTop for inspiration.[18]

The Cloudroom interface. Photo credit: Terrenghi et al., 2010

Social e-reading software and collaboration tools

Collaboration in the scholarly environment is a well-studied topic in the fields of Computer Supported Collaborative Work (CSCW) and Computer Supported Collaborative Learning (CSCL). The new environments developed on the Internet, in the form of Social Media, are not often considered in these fields however and need to be sought elsewhere. In this section, we bring together a selection of examples of Online Social Media tools for academic purposes, supplemented by a theoretical base in (scholarly) online collaboration.

Cohen, D. J. (2008). Creating scholarly tools and resources for the digital ecosystem: Building connections in the Zotero Project. *First Monday*, *13*(8). URL: http://firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/2233/2017 [March 18, 2013].

This article discusses the Zotero Project developed by the Center for History and New Media (CHNM) at George Mason University. The author describes the goal of the project as being to combine the benefits of stand-alone applications with those of Web applications in order to facilitate the academic research workflow. The author then discusses the benefits of Zotero and its development into the tool it currently is. He states that Zotero is built on the principles of academic research in general, integrative and part of a network of thought. The author stresses the underlying principles of Zotero – open source and open to external connections and intervention – as a facilitator of its success.

Fitzpatrick, K. (2007). CommentPress: New (social) structures for new (networked) texts. *Journal of Electronic Publishing*, *10*(3). URL: http://quod.lib.umich.edu/j/jep/3336451.0010.305?rgn=main;view=fulltext [March 18, 2013].

The author discusses a different model for digital publishing. The argument is built up from the perspective that experiments have relied too often on the metaphor of the codex and the incorrect notion of the single, isolated academic author and reader. Instead, the author states the metaphor of the network, allowing for dialogue, is more efficient, and notes that the blog is a good starting point. This has materialized in the form of CommentPress, an open source Wordpress theme and plugin. The author then describes several experiments with the model, conducted with the Institute for the Future of the Book, one of which is G4M3R 7TH30RY, the Web version of the book Gamer Theory by McKenzie Wark (http://www.futureofthebook.org/gamertheory/), which was the basis for CommentPress. The author then discusses the possibilities for academic publishing, noting that the use of CommentPress can be a labour-intense process for the author, for instance in keeping track of the comments.

The MediaCommons version of the article (see http://mediacommons.futureofthebook.org/mcpress/cpfinal) has not solicited many comments, perhaps because first-time commentators were moderated before being published; the comments are interesting however to scan. Some are content-related, others involve for instance practical problems in installing CommentPress. CommentPress has now evolved into Digress.it (http://www.digress.it).

Koolen, Corina, Alex Garnett, and Ray Siemens. (2012). Electronic Environments for Reading: An Annotated Bibliography of Pertinent Hardware and Software (2011). *Scholarly and Research Communication, 3*(4): 040154, 62 pp.

de la Flor, G., Jirotka, M., Luff, P., Pybus, J., & Kirkham, R. (2010). Transforming scholarly practice: Embedding technological interventions to support the collaborative analysis of ancient texts. *Computer Supported Cooperative Work (CSCW)*, *19*(3), 309–334.

This is a thorough research project, involving a different type of "humanities reading" than the other texts in this corpus. The authors studied the natural collaborative practice of researchers in a Classics department, who were trying to decipher text from (images of) an ancient tablet. Subsequently, a Virtual Research Environment (VRE) was developed for supporting this analysis, based on the features the researchers would want. This VRE included a desktop setting and an overhead projection. There were a number of interesting findings. An important aspect was the ability to annotate the image, and to organize and search these annotations, but in a more complex manner than the authors originally envisioned. Another finding was the fact that the researchers needed to be able to gesture over the image to make a point for the others, to demonstrate the shape and form of letters. The authors state that rather than supporting intricate automated digital processes, the focus should be on facilitating interpretative practices and discussion among researchers. The fashion in which this elaborate research was conducted is just as interesting as the outcome and the discussion of the VRE.

Hoadley, C. M., & Kilner, P. G. (2005). Using technology to transform communities of practice into knowledge-building communities. *SIGGROUP Bulletin*, *25*(1), 31–40.

This paper brings together the perspectives of learning, knowledge building, communities of practice, and online communities; it presents two theoretical frameworks to support the design of online communities for knowledge building, one on learning in communities of practice (CoPs) called C4P (content, conversation, connections, (information) context, and purpose) and one on learning through technology, Design for Distributed Cognition (DDC). Together these frameworks provide a general base for online knowledge community building, which the authors demonstrate with two examples. For more research on scholarly online collaboration and a converged perspective see Leitch (2009).

Kam, M., Wang, J., Iles, A., Tse, E., Chiu, J., Glaser, D., Tarshish, O., et al. (2005). Livenotes: a system for cooperative and augmented note-taking in lectures. *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 531–540). Portland, Oregon: ACM.

Although not ubiquitous in active reading research, collaboration is of course an important part of academic work. Asynchronous collaboration for professionals is gaining in interest, but educational settings are another aspect of professional academic life that should not be overlooked. Moreover, collaboration of this type could also be carried into other settings. This study uses a practical approach to collaboration in the classroom, by using handheld digital devices. LiveNotes is designed as a learning practice and technology and in this paper, a user study with the fourth iteration of the software is described. Computer Science students used handheld devices to take

notes on a whiteboard interface, which included the lecturer's presentation slides. The interface allowed them to see each others' annotations as well and to interact with one another through them. Possible pitfalls are obvious, but in this controlled settings the students gained from the collaboration, although there were some limitations such as problems in keeping up because of the interaction taking more time than private note-taking. Despite the limitations of the approach (i.e., allowing for Powerpoint slides only), the collaborative whiteboard metaphor appears to be a good basis for collaboration on handheld devices.

Marlow, C., Naaman, M., Boyd, D., & Davis, M. (2006). HT06, tagging paper, taxonomy, Flickr, academic article, to read. *Proceedings of the seventeenth conference on Hypertext and hypermedia* (pp. 31–40). Odense, Denmark: ACM.

This article presents a framework for tagging systems. A conceptual model integrates resources, users and tags, laying a base for a holistic approach to social tagging. Two organizational taxonomies for social tagging systems are then presented that describe "system design and attributes" and "user incentives," which the authors believe to have a substantial effect on the tags and the users. These are then applied to Flickr, a social image annotation website and Del.icio.us. (now delicious), a URL tagging website. Although one should note that Yahoo! Research Berkeley employees have conducted this research, the framework provides a decent basis to consider when building a tagging system. It shows how the design model of the tagging system has great influence on the shape of the output. For a broader base in research on scholarly online collaboration and a converged perspective see Leitch (2009).

McDonald, D. W. (2003). Recommending collaboration with social networks: a comparative evaluation. *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 593–600). Ft. Lauderdale, FL: ACM.

This article identifies user issues in recommending experts using social networks, which are important to consider before integrating social networks into groupware. A study was performed at a middle-sized company called Medical Software Company (MSC). The authors used quantitative and qualitative methods to extract two social networks: a work context structure and a more personal social structure, which, not surprisingly, have a reasonable overlap. This information is used to build and test the Expertise Recommender system, that recommends experts in less familiar parts of the company, based on either of the two networks, or a "no matching" principle, where the networks are not used and only expertise is considered. Users were asked to compare results based on either of the networks and the "no matching" principle. No quantitative differences were found, but the recommendations based on the social network resulted in the most polarized opinions. The authors summarize the outcome in a useful list of recommendations for designers, which include for instance the need for user control and perceived trade-off. For a broader base in research on scholarly online collaboration and a converged perspective see Leitch (2009).

Leitch, C. (2009). Social networking tools for professional readers in the humanities. Electronic Textual Cultures Lab Whitepaper, University of Victoria, Canada.

The author identifies three key strategies for Social Media use in the humanities: evaluating (concerning identity), communicating, and managing. An overview of social networking sites and tools is provided, and a bibliography of articles in the area of collaboration is presented, concerning the background of Social Media and collaboration. Also discussed are approaches to collaboration through social networks, including a number of expert(ise) retrieval methods (see McDonald, 2003; Marlow et al., 2006; Hoadley & Kilner, 2005), as well as issues of identity, privacy, and trust.

Priem, J., & Light Costello, K. (2010). How and why scholars cite on Twitter. *Proceedings of the ASIS&T annual meeting*. Pittsburgh, PA. URL: http://www.asis.org/asist2010/proceedings/proceedings/ASIST_AM10/submissions/201_Final_Submission.pdf [July 8, 2011].

The authors conduct bibliometric analysis of Twitter feeds by a sample of 28 academics (faculty, postdocs, or doctoral students) from the humanities, social sciences, and sciences, selected through snowball sampling. The authors worked with a sample of Tweets (numbering 2,322) that contained direct or indirect links to a peer-reviewed scholarly article online, and both authors isolated and analyzed the Tweets using open coding. The direct citations are called first-order, the citations that linked to an intermediary webpage are second-order citations. The authors also conducted qualitative research by conducting interviews. Reasons given for not citing directly were workflow and the existence of a paywall, which was supported by the quantitative data. Citing in Tweets was reported to be seen as part of an ongoing conversation. The participants favoured the speed with which articles spread (also supported by the quantitative data). Moreover, the platform aided their daily academic process: Twitter functions as a filter and helps direct attention to interesting articles. The authors concluded by stating that Twitter citations could be a valuable part of bibliometrics to supplement traditional citation analysis.

Ribière, M., Picault, J., & Squedin, S. (2010). The sBook: Towards social and personalized learning experiences. *Proceedings of the 3rd workshop on research advances in large digital book repositories and complementary media* (pp. 3–8). Toronto, ON: ACM.

This is a position paper on the need for e-books to become more social, especially in relation to students' learning needs. The authors first explain their suggested model: within-textbook annotation, with the book itself being the social community, as opposed to asking readers to sign into one (this should give rise to some privacy questions). To find annotations that are of use to a reader, the authors propose several features, for instance 1) an enhanced heat map, where the user can define either a set of criteria to set a scope: geography, language (culture), and social relationships or define a reading goal and an area of interest and 2) social tagging for paragraphs. The interesting aspect of this paper however, is that it also suggests using learning paths, steps that readers take to learn something (i.e., the books they read), thus also not only

treating reading as social, but also widening the idea of the book itself as a standalone item. Finally, the authors want to include video annotations and SMS alerting. The suggestions are being addressed in a collaborative research project (until 2013), in which Alcatel-Lucent, Abilene Christian University, and Cambridge University Press are involved.

Sawant, N., Li, J., & Wang, J. (2011). Automatic image semantic interpretation using social action and tagging data. *Multimedia Tools and Applications*, *51*(1), 213–246.

This is an impressive report on semantic image tagging: the authors reviewed about two hundred papers in the field to build a comprehensive model of social image tagging, automated techniques and possible applications for a combination of these methods, based on an analysis of two fields, being 1) collaborative image labelling games and 2) tagging in media sharing social networks. The sheer volume of the article base results in a somewhat eclectic approach to the discussion of the body of research, but it provides a good classification, a nice integration in the epilogue, and it is useful as a reference work to locate materials on the subject.

Siemens, R., Elkink, M., McColl, A., Armstrong, K., Dixon, J., Saby, A., Hirsch, B. D. & Leitch, C. (2010). Underpinnings of the social edition? A narrative, 2004–9, for the Renaissance English Knowledgebase (REKn) and Professional Reading Environment (PReE). In J. McGann (Ed.), *Online humanities scholarship: The shape of things to come* (pp. 401–460). Houston, TX: Rice Unversity Press. URL: http://shapeofthings.org/papers/RSiemens/RSiemens.doc . [August 25, 2011].

In developing an electronic scholarly edition, a group of researchers, including Implementing New Knowledge Environments (INKE) and the Public Knowledge Project (PKP), has built a proof-of-concept Professional Reading Environment (PReE) to facilitate a more flexible use of the Renaissance English Knowledgebase (REKn). The publication discusses the challenges, successes, and consecutive considerations for future implementations in detail, which entails moving from desktop to a Web application, and from a personal environment to one enriched with social media.

Yang, S. J. A., Zhang, J., Su, A. Y. S., & Tsai, J. J. P. (2011). A collaborative multimedia annotation tool for enhancing knowledge sharing in CSCL. *Interactive Learning Environments*, *19*(1), 45–62.

This article describes a Social Media tool that has been built in academia (within the discipline of Computer Supported Collaborative Learning) to support collaborative learning, PAMS 2.0. An overview of earlier research in and outside CSCL is first given, including several approaches to collaborative and cooperative learning. Then, PAMS 2.0 is described. PAMS 1.0 was not Web-based whereas the later version is. Some features of PAMS 2.0 include: it makes use of the Web Services Resource Framework technology (WSRF), which is XML-based; readers can annotate on document files and webpages – although the latter have to be imported; it allows for role assignment; and it provides synchronous discussion possibilities next to the read/annotation space. The authors then described an experiment. Two groups of student volunteers – one using

Koolen, Corina, Alex Garnett, and Ray Siemens. (2012). Electronic Environments for Reading: An Annotated Bibliography of Pertinent Hardware and Software (2011). *Scholarly and Research Communication, 3*(4): 040154, 62 pp.

PAMS, the other not – read, annotated, and discussed materials during a semester, which they were tested on in five iterations. The students using PAMS performed equally to the other group at the beginning of the trial, but performed better at the end. The authors hope to implement the system on the Web. This article not only shows the possible benefits of this system, but also provides an indication of the possible benefit of using (semi) commercial applications in educational settings, for instance Diigo. Not much research has been done on such platforms.

Cadiz, J. J., Gupta, A., & Grudin, J. (2000). Using Web annotations for asynchronous collaboration around documents. *Proceedings of the 2000 ACM conference on computer supported cooperative work* (pp. 309–318). Philadelphia, PA, USA: ACM.

This is among the earliest comprehensive work on asynchronous Web document annotation, reporting on the inter-office use of a Microsoft Word 2000 plugin, and the majority of its points still hold up well today. It is curious, however, to note that the authors claim "virtually all commercial document-processing packages (e.g., Microsoft Word, Lotus Notes) support some form of annotations" (Cadiz et al., 2000, p. 310). While this has indeed been true of word processing software for the decade-plus claimed by the authors, this only serves to make more obvious the degree to which PDF and Web annotation have lagged behind. We have, however, hardly lacked for advancements in eleven years. In a time before ubiquitous cloud server architecture, the annotation environment described by the authors more closely resembles an asynchronous chat log containing symbolic links to a particular document than the "living" documents that have been theorized since. What this may tell us, however, is that simple online chats are officially of the "want to happen" persuasion and any way that we can sustain them is nevertheless useful. Indeed, the frequency with which users annotated documents appeared to follow a common power law, as with many other collaboration systems.

Erickson, T. (2008). "Social" systems: Designing digital systems that support social intelligence. *AI and Society*, *23*(2), 147–166.

This article is a cogent and intelligent summary of best practices for designing social electronic collaboration spaces, which are sufficiently transparent to their users. In some respects it is an update of Erickson and collaborator Wendy Kellogg's earlier work on a theory they dubbed "social translucence," which they had intended to apply primarily to the visualization of social systems, as a means of ensuring that no social cues would be missed from real-world interactions (Erickson & Kellogg, 2000). Here, Erickson pulls back the scope of his research to focus on how we silently and effectively communicate the rules of engagement for any particular scenario, and revisits some prototypes that he has created over the past decade for helping to guide the rules of *online* interactions, without under- or over-communicating. One of the systems he demonstrates, intended for chat-type logs (in a "lecture" scenario, when one node is given primacy over the others, and a "conference" scenario, when each of the nodes are organized around a circle), might easily be extended to the social space around a single

document. In closing, he lists six points for effective social representation, each of which builds on the idea of making each participant's action visible to everyone in the same manner, but leaving the interpretation of this action to the user.

Noël, S., & Robert, J. M. (2003). How the Web is used to support collaborative writing. *Behaviour & Information Technology, 22*(4), 245–262.

The authors, writing in a time that narrowly predates Google Docs and AJAX (Asynchronous JavaScript and XML), review past efforts in creating collaborative writing systems for the Web. They begin by discussing prior research into groupware systems supporting what they call distributed cognition (including some of the foundational work from the 1990's on co-located note-taking and social proxies). The described systems focus not so much on writing-specific tools as on architectures that resemble Version Control Systems (as in collaborative software development). Nevertheless, commenting, coordinating actions, versioning, supporting multiple roles, and setting different permissions on different parts of the text are all included.

Eklundh, K. S., & Rodriguez, H. (2004). Coherence and interactivity in text-based group discussions around Web documents. *Proceedings of the 37th annual Hawaii international conference on system sciences* (Vol. 4). Washington, DC: IEEE Computer Society.

This paper begins with a discussion of linguistic turn-taking to present a novel system prototype intended to aid with contextualizing multi-threaded electronic discussions across time and space. The authors discuss some of the lacking aspects of traditional email and give particular attention to supporting informal "citations," being simple hyperlinks in part of a larger discussion. The defining feature of the system interface they present is the ability (i.e., the requirement) for each new discussion entry to refer to one or more of several others, with corresponding timestamps and navigational aids. They note that this system appeared to encourage the use of implicit reference by deictic terms such as "you," which is not traditionally common in electronic discussion. However, perhaps more interesting than the system itself are the visualizations, which the authors present in the paper's final pages; they provide a substantially more intricate network graph than ordinary threaded discussion trace data, which is, of course, still being actively mined today.

Marshall, C. C., & Bernheim Brush, A. J. (2004). Exploring the relationship between personal and public annotations. *Proceedings of the 4th ACM/IEEE-CS joint conference on digital libraries* (pp. 34–357). Tuscon, AZ: ACM.

This study, equal parts annotation and collaboration, looks at the way that personal annotations are transformed for public sharing and discussion. Although public annotation is still an interesting unsolved problem 3 (look, for example, to PLoS' efforts to sustain a public annotation system for an example of this), relatively little research has looked specifically at the relationship between private and public annotation, and fewer still from the perspective of beginning with the private annotation, as Marshall and Brush do here. Chief among their findings is the fact that annotators seem be very conscientious about what it is they share: relatively little private annotation material is

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eventually shared online (25%) or used as the basis of online discussion (8%), and when it is, it is usually transformed with no small effort to be made intelligible to a broader audience. The implications of this are manifold, not least of which is the idea that it need not be too easy for an annotator to move from the assumption of not sharing the content to the eventual entry into a larger dialogue; rather than automatically uploading the entirety of some private annotation corpus to see whether it might be useful to a broader audience, the time spent in transferring annotations from a private to a public space (occasionally cross-media, most commonly from page to screen) may afford a productive opportunity for reflection and revision. Also important is that the annotations, which most commonly formed the basis of a future discussion, were simple marginal notes with anchors in the text – not, in other words, hyperlinks, which can be better supported in born-digital public annotation spaces.

Xia, S., Sun, D., Sun, C., Chen, D., & Shen, H. (2004). Leveraging single-user applications for multi-user collaboration: The CoWord approach. *Proceedings of the 2004 ACM conference on computer supported cooperative work* (pp. 162–171). Chicago, IL: ACM.

Of all the document collaboration research that anticipates Google Docs, probably none does so as obviously and directly as this study of the CoWord application. CoWord is, put simply, an adaptation of Microsoft Word for simultaneous collaborative document editing. This paper provides a relatively technical perspective on the means by which it functions, called *Operation Transformation.* The final pages of the paper are more general, discussing the need for communicating *intent* in such systems. CoWord only reflects changes as they are made to the document in real-time; Google Docs, some years later, also shows other users' cursor positions in the document editor. There are of course benefits and drawbacks to either approach. On a very basic level, sometimes we want to be able to work without distraction while not necessarily being alone, and at other times we want to have the additional information channel for communicating where other users are reading, or plan to edit – each of which requires a different kind of system.

Skaf-Molli, H., Ignat, C., Rahhal, C., & Molli, P. (2007). New work modes for collaborative writing. In N. S. K. Bobby Granville (Ed.), *International conference on enterprise information systems and Web technologies* (pp. 176–182). ISRST. URL: http://hal.inria.fr/inria-00129222/en/ .

This conference paper employs the popular (although declining) Computer-Supported Cooperative Work (CSCW) matrix to categorize and describe new techniques for collaborative writing and editing. In using Google Docs as a reference, the authors explain that while it supports both synchronous and asynchronous modes of writing (as you can use Google Docs perfectly well when working alone), unlike CoWord reviewed above, it does not allow you to work in a bubble, as collaborators are always represented in the system interface. The authors also draw distinctions between when collaboration systems *send* and *receive* data; in the Google Docs model, this is system-initiated, and thus effectively automatic (and unhelpful for version control), whereas in a Wiki or traditional version control system (VCS), it is user-initiated. The authors rate several systems according to their performance on what they call the SRI, or *send-*

retrieve-initiate model, and note that Google Docs performs relatively poorly in this model, sacrificing control in favour of perceived ease of use. However, training non-developers to use a traditional VCS is not easy.

Notes

1. Interestingly, in 2013, although hard- and software has developed further, no major changes have taken place in the digital reading market since the time of writing in 2011. Moreover, the general issues in scholarly digital reading, such as the impracticality of collaborative annotation, are still current today, leaving this bibliography to remain a valuable compilation of sources. Information on availability of hardware etc. has been updated to the current-day situation.

2. Along with, it is worth noting, applications for the iPhone, Android, and Windows/Mac OSX desktop platforms.

3. The apparent winners for annotation functionality as of Summer 2011 are iAnnotate on iPhone or iPad (see the software part of this bibliography), and RepliGo on Android or Blackberry. RepliGo deserves further praise for its ability to reformat PDF documents into a single screen view for easier browsing on a mobile device – a powerful and rare feature.

4. All the hyperlinks mentioned in the hardware section of the bibliography were last visited in July 2011.

5. It is interesting to note that dual screen devices have been developed in academic settings as well and considered promising, see the final section of the hardware part of this bibliography.

6. See Sellen & Harper (2002).

7. The notion of "lightweight navigation" is introduced in Marshall & Bly (2005).

8. For an overview of all presentations, see Kazai & Brusilovsky (2011).

9. Another manuscript research project explores the combination of touch and motion —see Hinckley & Song (2011).

10. See for instance Tao et al. (2006).

11. For instance by combining text with 3D displays, see Jankowski et al. (2010).

12. See Yeh (2006).

13. Other examples of applications using bendable screens are PaperPhone (Lahey, 2011) and Bookisheet (Watanabe, et al., 2008).

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14. All the URLs mentioned in this second part of the bibliography have been accessed on August 22, 2011, unless otherwise specified.

15. Which, later in the article, is reported to be only useful for its aesthetic qualities: users do not mind "to trade-off efficiency for fashion and design luster" (Cockburn et al., 2009, p. 26).

16. See Hornbæk et al. (2002).

17. See Vogel & Baudisch (2007).

18. See Agarawala & Balakrishnan (2006).

Websites

Adobe Acrobat Reader. http://www.adobe.com/nl/products/reader.html

Amazon.com: Free Kindle Reading Apps. http://www.amazon.com/gp/feature.html/ref=kcp_ipad_mkt_lnd?docId=1000493771

Anoto – The digital pen. http://www.anoto.com/?id=19146

Alice in Wonderland Storybook. http://itunes.apple.com/us/app/alice-for-the-ipad/id354537426

ASUS tablet lineup preview: Slider, Transformer, MeMO, and Slate EP121 go wild (with video!). http://www.engadget.com/2011/01/06/asus-tablet-lineup-preview-slider-transformer-memo-and-slate

Blio. http://www.blio.com/

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Calibre – E-book management. http://calibre-ebook.com/

CommentPress | MediaCommons Press. http://mediacommons.futureofthebook.org/mcpress/cpfinal

Copia. http://www.thecopia.com

Copia Social Reading showcased at CES 2011. http://www.youtube.com/watch?v=UY4Hw1p3x-Y&feature=related

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