Reading, New Media Technology and what they tell us about Social Cognition.

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Abstract. The relationship of the New Digital Media to the human mind has become a fraught question. In this paper we examine some of the frequently made contentions about the possible 'impact' of media technologies on our reading abilities and our wider cognitive processes more generally. We look at a particular case study of how HTML reading has come to be treated with suspicion and cast some doubt on the conclusions that have been drawn from these studies. We cast this fear and loathing against a background understanding of the interaction of culture, technology and brain with special reference to Dehaene's neuronal recycling hypothesis and Michael Anderson's Massive Redeployment hypothesis. Finally we attempt to put these findings into the context of an emerging ecology of reading involving both paper and a variety of electronic texts.

Keywords: Encultured Brains; Cognitive Artifacts, Social-Technical Systems; Neural Recycling; Massive Redeployment; Deep Reading; Cultural/Technological systems.

1 Deep-Reading in Danger?

Sitting in the reading room of the Centro Cultural de Belem in Lisbon in late 2012, it was clear that at least the surface forms of reading have changed dramatically. More than half of the people in the room – in England it would probably be more – are not reading books at all but are immersed in some form of electronically mediated experience. Many of my fellow 'readers' are wearing headphones, most – judging by the frequent interruptions as someone fumbles for a handset - appear to have mobile phones which are either silent or turned to a vibrate setting. Many are reading, but they are writing as well, or periodically tapping some device or other. Most use screens of one sort or another.

Neither reading nor writing are what they were. Reading, in the second decade of the 21st century, is increasingly embedded in or performed upon, a host of digital technologies such as the web-browser, the search engine, the tablet or e-reader. Many claim that our media technologies are going through the most revolutionary period since Guttenberg invented the mobile type printing press. What is the consequence of

this adoption of a new technological substrate for perhaps our most important socio-cognitive technology: the written word.

Arch technophile and net proselytizer: Cory Doctorow has pointed out that as every year goes by, our civilization tend to spend more time reading more off of the screen and less from print books. At some point the curves will cross and our culture will have become a post-print culture. What might the cognitive implications of this be? Is it the same reading in a new guise, or might reading itself have undergone a step change in the process?

Some see these changes as nothing short of disastrous, ushering in the mass adoption of new type of more superficial and disorganized reading. Nicholas Carr in his (2010) book *The Shallows* argues that our use of the internet for reading is changing it not just the way we read, but the way we think and the way our brains work. Moreover, these changes are not for the better. Carr characterizes the brain wrought by the Internet as a 'Juggler´s Brain': a brain which flits distractedly at a surface level between multiple tasks without focusing in detail on any. Carr is a journalist, but he has reported and synthesized what he takes to be the findings of contemporary cognitive science. His writings have been widely reported and appear to chime with a wider societal mood and a series of popular books that sees Internet technologies as threatening our readily and intellectual abilities (Birkerts, 2006; Healy, 2011). Others see a wider set of our cognitive and social abilities under threat (Greenfield, 2009; Lanier, 2010; Turkle, 2011).

Maryanne Wolf, a psychologist and director of the Centre for Reading and Language Research at Tufts, has worried that the new technologies endanger something essential about the way we used to read, that is. This ability has been dubbed: *deep reading*. In one article on *The Importance of Deep Reading* Wolf & Barzillai define deep reading as: "the array of sophisticated processes that propel comprehension and that include inferential and deductive reasoning, analogical skills, critical analysis, reflection, and insight."(Wolf & Barzillai, 2009, p.32; Wolf, Ullman-Shade, & Gottwald, 2012) In a more recent paper, Wolf and her colleagues write that deep reading: "is a slow, immersive process in which a reader requires time and cognitive space to engage in deep thought. Deep reading is characterized by inference, analogical thinking, critical analysis and deliberation, contemplation, and-in its highest forms-insight and epiphany." (Wolf et al., 2012, p.236). Elsewhere, Wolf impies that deep reading is central to the ways in which a reader, in interaction with the work of author on the page, generates the rich generative interpretation of the text, that allows us to imaginatively project into the worlds created by novels.(Wolf, 2007) [1]

Echoing Carr, Wolf & Barzillia (2009) write 'People reading online are characterized by rapid-firing and continuously "partial attention": a demand for immediate information and problem solving; and efficient multi-tasking of diverse sets of information. Wolf and Barzillia worry that the Internet, and new media technologies more

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[1] It appears the term deep reading was in factcoined by Nicholas Carr as recently as recently as his 2008 article *Is Google Making is Stupid* (Carr, 2008), although the article refers to Wolf's work. Even Wolf doesn´t use the term in her book (Wolf, 2007), although she is already thinking that there are particular capacities fostered by reading that the Internet might endanger.

generally, are not good condition to develop or sustain deep reading. A major concern is that as our apparently shallow, browser inflected reading styles come to dominate, that we might lose the inward and projective dimension of reading; and with it many of the cognitive modes which are central to the Guttenberg galaxy.

Wolf & Barzillai are especially concerned the development of young deep readers, theywrite: "The expert reader needs milliseconds to execute these processes; the young brain needs years to develop them. Both of these pivotal dimensions of time are potentially endangered by the digital culture's pervasive emphases on immediacy, information loading, and a media-driven cognitive set that embraces speed and can discourage deliberation in both our reading and our thinking". (Wolf & Barzillai, 2009, p. 32). Others have commented that, with reading, we are in danger of losing the distinctive mode of thought that has allowed us develop our civilization. As Edward Tenner has succinctly put it, "It would be a shame if brilliant technology ended threatening the kind of intellect that produced it"(Tenner, 2006).

But is reading, indeed deep reading, really set to be undermined by the new media? In this article we shall first, in Section 2, look at some of the quite slender empirical evidence for the claim that reading is being undermined by our use of new media technologies. Then, in Section 3, we shall look at the specific claim that the brain circuits underlying deep reading are especially under threat. To get a better grasp on the question, I shall review some ideas about neuronal recycling (Dehaene & Cohen, 2007) and massive redeployment of neural function (Anderson, 2007) which allows us to better understand the claim that a specific type of reading may be under threat. In Section 4 I then widen the context to look at how reading habits have changed over the last fifteen years as people's reading has incorporated more and more screen time. What emerges is a complex set of interactions between the world of paper and the world of the electronic media, as human beings use an ever wider net of technologies to create ever more sophisticated ecologies of reading. Finally in Section 5 we ask again if we should really worry about the decline of the readerly mind.

2 The Case Against New Media Reading

It is of course possible that the new reading indicate a more immersed and active reader or simply one that is more diffuse and less in control of her own attention. Indeed, the empirical study of new reading appears to many, to support the claim that some of the most heavily used technologies of the internet might undermine certain types of reading. I'll argue we have some reasons to doubt the strength of inferences drawn from these studies. One much cited piece of research (Miall & Dobson, 2006), seems to demonstrate that at least reading when reading for narrative (as might typically take place when we are reading a novel) is indeed undermined by hypertext. The research article focuses on the short story by Elizabeth Bowmen *"The Demon Lover"*.

The article is in fact a central plank for Carr's claim that deep reading is being undermined by the new media. Carr reports that "In a 2001 study, two Canadian scholars asked seventy people to read "The Demon Lover, a short story by the modernist writer Elizabeth Bowen. One group read the story in a traditional linear-text format; a

second group read a version with links, as you'd find on a Web page. The hypertext readers took longer to read the story, yet in subsequent interviews they also reported more confusion and uncertainty about what they had read. Three-quarters of them said that had difficulty following the text, while only one in ten of the linear-text readers reported such problems." (Carr, 2010, p.127) He also cites one participant who read the hypertext version of the story as saying: "The story was very jumpy. I don't know if that was caused by hypertext, but I made choices and all of a sudden it wasn't flowing properly, it just kind of jumped to a new idea it didn't really follow." (Miall & Dobson, 2006)

In fact the nature of the task is not quite as Carr reports it. What goes missing in his summary demonstrate problems that dog attempts to evaluate the real cognitive import of the new reading technologies. In fact *both* texts were presented to readers in the study as hypertext on a screen as is shown in the following diagram taken from the original paper.

A shaft of refracted daylight now lay across the hall. She stopped dead and stared at the hall table; on this lay a letter addressed to her.
Next

Figure 1. A short segment from "The Demon Lover" shown in linear form

A shaft of refracted daylight now lay across the hall. She stopped dead and stared at the hall table; on this lay a letter addressed to her.

Figure 2. A short segment from "The Demon Lover" shown in hypertext form

The nature of the hypertextification of "The Demon Lover" was not to make it any sort of enhanced hypertext but merely to add some fairly random links to the next section of text. Each link from the linear version of the text would just link to the next passage of the next in the story with the hyperlink labeled "Next". Each of the links from the hypertext version, e.g., "refracted daylight", "letter" and "her", would link to the very same next section of text from Bowmen's story. In fact the study doesn't really compare a linear text and a hypertext at all but two linear texts. One of these requires the user to click through to the next page after reading each segment in a way which is likely to respect their prior understanding of how hypertext works. A second, which while still being linear, uses the form of hypertext to make it appear that the reader was really reading a branching text. What the study found then was that readers of an essentially quite confusing hypertext presentation of a story were slower at reading it, and comprehended it more poorly, that the same text presented in a less confusing rendering in hypertext.

DeStefano & LeFevre's (2007) meta-analysis of 38 studies is often cited as demonstrating that hypertext reading is inferior to paper reading. In fact it doesn't show this either, although it does identify some domains where hypertext may be inferior. But in any case, many of the studies they review do not really compare like with like in

ways that we have just seen. Often what is compared, as in Miall & Dobson's study, is a linear text with hypermedia version of the same text.

DeStefano & LeFevre put the findings on hypertext into the context of *cognitive load,* i.e., the load that a given cognitive task imposes on working memory. Insofar as the reader of a hypertext document has to continually decide (consciously or unconsciously) whether or not to click on any given link it seems fairly clear that using hypertext must impose a greater cognitive load. Our cognitive powers, being in finite supply at any given moment, are likely to be dissipated by this. We should also remember that a written narrative in the hands of a master, mediated through printed text, can be sublime and well developed use of technology for the controlling and focusing attention. It is unlikely that hypertext applications will generally add much to this at least until they are much matured. In general people take longer to read stories if presented through a web-browser along with evidence that they maintain less information).

It's easier to make sense of these studies against the background of the time when computers were being rapidly introduced to classrooms and many were making great claims for the powers of hypertext to augment many learning situations by, e.g. allowing rich and connected knowledge structures to be developed (Jacobson & Spiro, 1995; Spiro & Jehng, 1990). Such claims were often overblown but this does not mean that reading through hypertext has been shown to be so deficient.

However it is also worth noting that even DeStefano and LeFevre´s study notes that hypertext may indeed have benefits especially where the text treats a subject about which the reader lacks conceptual knowledge. If one doesn´t understand a concept referred to in such a text then a well-chosen hyperlink may indeed prove useful. The picture then is a little more complex and less one-sided that at least Carr presents it and in any case we may increasingly only use hypertext for quite specific purposes which play specific roles in the wider ecology of reading that electronic media supports.

3   Massive Redeployment and the Readerly Mind

The reading brain is one area where the transformation of the brain by our tools is spectacularly apparent. As Maryanne Wolf (2007) elaborates in her book, the sorts of brain rewiring that is required over developmental time in order to transform a child´s non-reading brain into a reading one, requires the development and redeployment of multiple circuits throughout the brain. But the question of how profound the changes are, and exactly what kinds of transformation need to take place for the brain to accommodate reading, is hotly controversial. This is important to our argument because Wolf's claims that deep reading is under threat ultimately turn on her argument that the brains reading circuitry, really its deep reading circuitry is of a particularly fragile kind, such that it might be destabilized or prevented from being developed, because of the environment of the new reading technology.

Brain science is starting to make clear which neural circuits are involved in reading (Castro-Caldas, Petersson, Reis, Stone-Elander, & Ingvar, 1998; Dehaene, Cohen,

Sigman, & Vinckier, 2005). Dehaene emphasizes that, rather being written onto a blank slate, reading reappropriates brain circuits which were already utilized for other tasks. Certain brain areas seem to play an important role across written languages, not least, the left occipito-temporal or 'letterbox' area, that appears to allow the recognition of characters for readers of all languages (Dehaene et al., 2005). The point that Dehaene is keen to make is that the brain circuits in the left occipito-temporal area, originally developed perhaps to recognize animal tracks in different orientation are apt to redeployed to the novel task of interpreting script.

One problem Dehaene has really focused upon is how is it that certain brains circuits appear to be so wonderfully developed to instantiate reading when there has not been enough evolutionary time to build them for that purpose. Dehaene poses this in terms of what he calls the *reading paradox*. This is that, given that our brains can only evolve new structures over millennia, how can it be that we find areas like the letterbox area apparently specialized for reading when there has not been enough evolutionary time for such a circuit to evolve. From the perspective of brain evolution, the fact we can read at all can look slightly miraculous.

Dehaene proposes what he terms the neuronal recycling hypothesis to attempt to dissolve the paradox[2]. He develops this view in contrast to a more general neural plasticity view which sees the cortex if not infinitely, then highly plastic, ready for any kind of learning. The neuronal recycling view by contrast, emphasizes how 'cultural acquisitions must take place within the limited surface and bounded plasticity of the human cortex.', although he continues: "the crucial difference may not lie in the capacity to reconvert brain circuits through learning, but in the very ability to create new uses for evolutionary older circuits." (Dehaene, 2005)

This recycling hypothesis may appear to uphold the idea that we remain brain bound in the sense that our cognitive capacities are constrained and in the final analysis actually blocked by the ability to recycle those circuits. In fact Dehaene holds that culture should be seen as "invading" neural regions. That is to say a brain circuit which was evolved for another purpose, for example recognizing the tracks of animals, is appropriated by culture for computationally similar task, e.g., recognizing written characters.

An alternative framing places the emphasis on just how important social and technical forces are in reappropriating our cognitive hardware. That is, in the profound way in which culture, technology and historical developments of many kinds have played uneliminable roles in producing material system that shape the current structure of the human brain and in particular the way that brain circuits have been repurposed. Part of the way to resolve Dehaene's reading paradox is to notice that skills like reading developed in a social context and appear to require substantial amounts of pedagogical effort to instill in a population. Indeed we have evidence of reading classes as far back as ancient Mesopotamia (Dehaene, 2009,p. 243). But while it may be correct to point out that the brain always acts as a limiting force on what we can learn,

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[2] In fact neuronal recycling is supposed to explain not just our ability to read but a host of other skills where our brains appear to have exquisitely developed mechanisms to deal with a particularly culturally dependent ability. See Dehaene 2009, Chapter 8.

an ever increasing technological substrate also operates as a means of extending what the brain struggles to accommodate.

It is possible to view the development of skills like reading a developmental repurposing of a series of brain circuits which progressively embed brain circuits in ever more complex suites of skilled assemblages. Such reorganization begins in early infancy and continues through the development of each new skill. A related but alternative account of brain evolution is Michael Anderson´s Massive Redeployment Hypothesis. (Anderson 2007) Anderson research has shown that the model of cognitive instantiation in the brain that holds that there is a strict one to one mapping between a given cognitive function and a given brain area turns out to be contradicted by empirical evidence. Indeed many brain circuits, including Dehaene´s favoured letterbox area are in fact implicated in a variety of cognitive operations. What this signals is not that seeking out the brain circuits that underlie a particular function is a misguided task, but rather that brain-circuits are multiply re-used.

One question this raises is whether the re-use of a cognitive circuit may undermine or replace the original function of the circuit. Is neuronal re-use is a sort of zero-sum game. Indeed Dehaene holds open the possibility that certain cognitive competences may indeed be partly compromised by neuronal recycling but this is by no means a necessary corollary of these sorts of models. It is worth noting that if Anderson is correct the massive repurposing of the brain is the norm. It remains an untested empirical question as to whether re-using reading circuits in multiple novel contexts will undermine core abilities. However, we may find that Dehaene's reading circuitry is not just at the centre deep reading, but at the heart of a multiplicity of related reading circuitry, subserving: deep, shallow, literary and technical reading styles. This, in itself, should not unduly worry us. It is only really the hypothesis that brain repurposing is a zero-sum game that pushes the inference that the developing the skills in one form of reading might drive out others. In fact it appears that in the 21st century the reading brain is called upon to subserve an ever greater number of tasks.

4   Text & Screen: Towards Peaceful Co-existence in the Ecologies of Reading

There is little doubt that the written word, with the advent of the electronic transmission and the machinery of the internet behind it, is changing both how we read and what we read. In Liu's (2005) questionnaire based study, particpants were asked to reflect on some of their reading activities over the previous ten year period. Around 80% reported that they spent more time browsing and scanning text, and around the same number that they were performing more non-linear reading; the latter of course only made possible by the development and widespread adoption of hypertext, than in the early 1990s. However 67% of respondents reported that they were reading more than they were 10 years earlier, although increasing amounts of this reading was done from a screen. Many respondents reported they found it harder to read long articles from screens than paper and frequently printed off articles they planned to read "in depth" or in "concentrated" manners. This, points toward an already developing divi-

sion of labour between screens and the printed text in 2005 which seem to have become much more sophisticated and developed since this time.

One reason that readers circa 2005 printed off texts they wanted to read in detail was the need to highlight and annotate texts. Indeed, only 2% of readers did this with electronic texts in 2005 although this likely reflects the fact that E-Readers had scarcely been invented at that time, and more generally digital technology of that period had not significantly developed facilities for convenient text annotation. This highlights one of their major readerly attributes of books as physical objects that invite us to: manipulate them, leaves marks upon and thumb through. Books are not simply transparent objects to conduct us into an imaginative readerly world. Indeed the sort of deep reading about which Wolf rhapsodizes, is really only one sort of concentrated or in depth reading which we perform with the book. Arguably, it is one that contemporary E-Readers such as the Amazon Kindle seem to support rather well. A major problem many readers had with electronic media circa 2005 is precisely that it made it difficult highlight, annotate and otherwise manipulate and find one's way around long-form text. E-Readers are also rapidly developing capacities to aid their users do this.

But might not the new scanning reading be driving out other sorts? As Liu remarks: "it is not difficult to imagine that browsing or scanning is becoming a principal reading pattern in today's information-intensive environment. With an increasing amount of time spent on reading electronic documents, the screen-based reading behavior is emerging. The screen-based reading behavior is characterized by more time on browsing and scanning, keyword spotting, one-time reading, non-linear reading, and more reading selectively; while less time is spent on in-depth reading and concentrated reading, and sustained attention is decreasing." (Liu, 2005, p.705) But it is Pertinent to view the new reading in a broader history of reading evolution in the recent history of Western culture what Liu calls intensive reading: the in depth reading of one book, principally the Bible, has gradually, from about 1750, been replaced with a multitude of reading sources. The trend toward extensive reading: multiple texts read few times or only once, long predates digital culture and the internet. Indeed digital culture may be viewed as partly a response to this long term societal trend although it certainly intensifies it.

In fact the history of reading shows that there have been several major changes in how we read over the millennia. One is the shift from vocal to silent reading. This history needs to be understood alongside the history of writing. Writing as we have it today does not come all of piece but rather through a series of innovations. Early script which was written without spacing among words and could be written right to left, left to right or in alternating fashion, also imposed significantly greater burdens on the reader's brain. Innovations such as punctuation, the standardisation of spelling etc all came much later. The development of writing with spaces between words was probably essential in making possible cognitive innovations like silent reading which appears to be very seldom practiced at least until the late medieval period[3]. The sorts

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[3] We know this precisely because of the surprise or notability of the few occasions when figures from antiquity attest to silent reading as something uncommon and notable. For example

of cognitive (and brain processing) requirements of reading are also likely rather different from that of reading out loud.

We can reflect on how the 'private' reading experience as we know it today is almost certainly a rather late historical invention and probably dependent upon the development of silent reading; a largely invisible reading revolution. This leads to a surprising question and a dilemma. If deep-reading depends on the intensely private experience depicted by Wolf, it is worth asking if anyone were even capable of it before the Renaissance. Were Plato, Aristotle, even Cicero deep readers in Wolf's sense? If they were, then clearly a very different writing technology supports deep patterns of thought and deep reading as such might not be as central as Wolf claims. If they were not, then clearly deep patterns of thought are possible without deep reading.

Looking at the book again in this context it emerges at artifact which is fantastically well developed for allowing a variety of forms of reading among which is Maryanne Wolf's deep reading. However the book also supports a diversity of other types of reading including, but not limited to: underlining and thus the easy relocation of text, marginal note-taking, and the ability to flip through pages and thus take in at a few glances the general drift of a text. (This does not imply that deep reading may not be affected by the new reading, although it does indicate that substantially different reading ecologies can support a variety of sophisticated types of reading).

Since the invention of its ancient form the codex, the book, has supported a multitude of different readily functions. As Liu points out "Reading is not a single activity. It is a complex and variable behavior. It involves different purposes and different skills in handling documents." (Liu, 2005) For the purposes of analyzing what, if any cognitive operations are under threat by reading from screens, Wolf's deep reading might be better decomposed into a number of operations such as imaginative projection, reading for extracting knowledge and so forth. This might help us better understand if any cognitive functions are really being challenged by digital media. Interpreting deep reading as a broader network of activities might help us design electronic media, especially as they mature, to support a variety of reading functions, including more in-depth and concentrated reading.

But to adequately capture what we want to maintain about reading as we move toward a more adequate hybrid electronic and paper reading substrate, Wolf's deep might also be too narrow a category. It is too narrow in that it does not capture all of the types of reading that we use books for or indeed all of those we should value. It is too special purpose in that it obscures some of the most important things we do with books when we engage with them such as re-reading, highlighting and otherwise manipulating text. We might be better served by thinking about how the book really sustains an ecology of different types of reading activities and how these varieties of reading might be sustained or indeed developed.

The question is not whether one can perform deep reading from a screen as no-one denies this can happen. As the owner of a Kindle device, and several other types of E-

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Augustine was so surprised by Anselm's ability to silently read that he wrote in his diary: "his eyes moved but not his tongue". Julius Caeser is also supposed to have been a silent reader.

Reader before it, I can confirm from personal experience that insofar as I have performed deep-reading in the last five years, much of it has been accomplished using an E-Reader device.

The ancient form of the book, the codex was largely adopted over the scroll precisely because it allowed a range of manipulations and particularly the easy location of text that the scroll obscured. Indeed, Manguel (1997) has pointed out how the shift from the scroll to the codex in ancient times was likely driven by the difficulties of annotating and working with scrolls. Similarly, a central advantage of E-Readers over Browsers is their use pagination. The page is a system that makes a useful unit (the page) by which the human mind can find its way around a complex text and affords a variety of more complex forms of reading and re-reading. Recent moves toward the use of E-Reading devices by many millions can be seen as a recapitulation in digital form of the move from scroll to codex as the major support of a variety of types of reading.

The Amazon Kindle E-Reader, to take just example, has only been around since 2007. Since this time the possibility of using E-Readers and other systems to do annotation has significantly increased. It is interesting to perform a comparison with the Amazon Kindle to the standard book, especially with regard to the capacities the former device makes available for track and annotating text. Unlike standard desk-top computers or laptops the E-Reader is designed as a specialized reading device. It paginates like the book, allows highlighting and the annotation of text. Up to a point it allows a host of other book-like features including scanning ahead and of course allows the reader to carry around many books at once. However, scanning around a large text is a yet quite inferior to what a paper book affords. In fact it is fabulous tool for the academic writer or researcher just in so far as one can highlight passages on the kindle and then go to take those portions of text from the computer to be input into say a word-processor. Just like the book then, the E-Reader (at least in the elaborated form of the kindle) supports an ecology of interlinked writing activities[4].

Screen-based reading behavior would clearly be problematic if it implied the ability to engage in deep or concentrated reading itself was being undermined. However, it is far from clear that this has happened and trends since 2005 seem to indicate that concentrated reading, among many other forms of reading, is alive and well. Rather we can see new strategies, and new types of reading developing to cope with what is sometimes called 'information overload'. The variety of types of reading we perform is increasingly supported by a range of technological substrates. As this substrate grows, and as the types of reading we are required to perform to deal with an ever-growing superfluity of text, our reading strategies are growing more various and differentiated.

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[4] All this said, for this user, there are several problems with the institutional framework in which the kindle operates and how this tends to undermine certain aspects of how we traditionally swapped and lent books to one another, and indeed the very idea that we own a book. Problematic though this might be it is all fairly distantly related to the nature of our readerly minds, so we will pass over these questions here.

5   Plasticity of Mind and Human Agency

What the science of reading brain has helped reveal is how human neural hardware and technology are poised in a dialectical relationship. The nature of this relationship has two important aspects for our discussion. First, the plasticity of the brain is constrained such that in the development of any skill complex pre-existing brain systems will need to be repurposed to the task. But second, human beings continue to have agency in how this technology is adapted and appropriated in order to fulfill their collective and individual needs.

A naive view tends to look at brains as being an infinitely plastic surface on which the introduction of new technologies 'impact'; the word constantly re-appears in discussions of new media. In fact the development of new technologies needs to fit into an already existing cognitive and behavioural landscape, not to mention a cultural niche where they make sense. This repurposing of brain circuitry through the adoption of new skills is a process in culture and technology appropriate pre-existing brain structures turning them to new purposes. Such repurposing may be more or less the rule of how Homo sapiens brain allows the construction of human minds. But it is clear this has not stopped and in the early 21st century reading (and writing) are already becoming rather different skills as become habitually used online and thus embedded novel cognitive and technological suites of action. But this is a process of both conservation and innovation.

The earliest writings systems most likely were independently created in China, Sumeria and Egypt perhaps 8000 years ago: the earliest alphabetic systems being developed around 2000BCE. From the very early days there was a need to produce educational centres to make possible to organise the acquisition of this skill even going back to Sumerian times make clear that there was never anything automatic about the acquisition of reading just as there was little autonomous in writing itself that propelled the re-organisation of brains. The creation of readers always required human institutions. This impels us to tell a historical story about how certain developments in the technological basis of writing and associated cognitive developments go hand in hand. Wolf tells one version of just such a story in her *Proust and the Squid* (Wolf, 2007). It is a story where the slow development of the tools to produce a deeply concentrated and inward mind are forged by the technologies of reading only to be imperiled as these technologies are revolutionized in the early 21st century.

Wolf's story emphasizes the fragility of way reading is embedded in the human brain and the particular susceptibility of deep reading to various kinds of perturbation[5]. She fears such capacities may be undermined as our reading becomes increasingly dominated by flitting between web pages. But such a picture of reading opposing the book and the screen may already be becoming out of date, as the ways we read, and the artifacts we use to read become ever more sophisticated and interdependent.

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[5] Wolf, among many interests in reading, is a specialist in the study and treatment of Dyslexia. This perhaps sensitizes her to worries about the acquisition of reading led by technological change.

The future of our media saturated societies is unlikely to be one where we read less. As Liu remarks: "A more complex society will demand increased rather than decreased reading." (2005, p. 702) In this context, it is difficult to argue that there is not more scanning type reading going on but the real question is whether this has implications for our ability to participate more concentrated and immersive forms of reading. As we have seen the evidence that the basic capacities are being undermined is, so far, far from compelling.

But this raises the question of how to think about the development and plasticity of mind in relation to our use of technologies. At least some of the cognitive systems developed in order to process text will be those we share with Sumerians. But the challenges to the contemporary reader are rather different. Reading a long article through a browser offers the ever-present possibility of searching in Google for a concept or name that is unfamiliar and requires from many of us – immured to the possibilities of clicking and searching that the browser affords – considerable exercise of willpower in order to read an article through from beginning to end. But this is one reason people print off articles. Paper-based and electronic reading will continue to co-exist and we will need to develop technological interfaces and readerly strategies to better fit the way we read to whatever type of reading we are attempting to do at any time.

The reading brain becomes core what has been *massively repurposed* throughout history, in part in a conscious way. Of course people would not have seen what they were doing this way as it is only comparatively recently that the brain has been seen as the locus of all mental activity. What they were doing was developing educational programs for students, or else trying to create some pragmatic end. What is important here is that technology is not operating in an autonomous way as an impact, but rather continues to work in order to hold a certain type of formation of mind in place. We need to take a socio-historical perspective to see this.

Rather than a simple impact of technology on the mind what we find is that the brain and technology are tied together in an open-ended duet. Human beings devise technologies like the alphabet, or the E-Reader or instructional systems which in turn make available new cognitive innovations and new re-uses of neural systems. The practical side of this history of development requires an ongoing commitment to making sure that the next generations of children have the means to take advantage of this history, but also the willingness to turn new tools to ends that we care about. In order to maintain the repurposing of brain circuitry and turn them to values we care about, human institutions need to be in place to allow the transmission and restructuring of knowledge. We need to take the renewal of these values seriously in order to make sure reading continues to be all the things we need it to be.

6   Citations

1.   Anderson, M. L. (2007). The massive redeployment hypothesis and the functional topography of the brain. *Philosophical Psychology, 20*(2), 143-174.

2. Birkerts, S. (2006). *The Gutenberg elegies: The fate of reading in an electronic age*: Macmillan.

3. Carr, N. (2008). Is Google making us stupid? *Yearbook of the National Society for the Study of Education, 107*(2), 89-94.

4. Carr, N. (2010). *The Shallows: How the internet is changing the way we think, read and remember*. London: Atlantic Books.

5. Castro-Caldas, A., Petersson, K. M., Reis, A., Stone-Elander, S., & Ingvar, M. (1998). The illiterate brain. Learning to read and write during childhood influences the functional organization of the adult brain. *Brain, 121*(6), 1053-1063.

6. Dehaene, S. (2005). Evolution of human cortical circuits for reading and arithmetic: The neuronal recycling • hypothesis. In S. Dehaene, J. R. Duhamel, M. D. Hauser & G. Rizolatti (Eds.), *From monkey brain to human brain, ed.* (pp. 133-157): Citeseer.

7. Dehaene, S. (2009). *Reading in the brain: The science and evolution of a human invention*: Viking Pr.

8. Dehaene, S., & Cohen, L. (2007). Cultural recycling of cortical maps. *Neuron, 56*(2), 384-398.

9. Dehaene, S., Cohen, L., Sigman, M., & Vinckier, F. (2005). The neural code for written words: a proposal. *Trends in cognitive sciences, 9*(7), 335-341.

10. DeStefano, D., & LeFevre, J. A. (2007). Cognitive load in hypertext reading: A review. *Computers in Human Behavior, 23*(3), 1616-1641.

11. Greenfield, S. (2009, 23 April 2009). How Facebook Addiction is damaging your child's brain: A leading neuroscientist's chilling warning. *The Daily Mail*.

12. Healy, J. M. (2011). *Endangered Minds: Why Children Dont Think And What We Can Do About It*: Simon and Schuster.

13. Jacobson, M. J., & Spiro, R. J. (1995). Hypertext learning environments, cognitive flexibility, and the transfer of complex knowledge: An empirical investigation. *Journal of Educational Computing Research, 12*(4), 301-333.

14. Lanier, J. (2010). *You Are Not a Gadget: A Manifesto*. London, England: Allen Lane.

15. Liu, Z. (2005). Reading behavior in the digital environment: Changes in reading behavior over the past ten years. *Journal of documentation, 61*(6), 700-712.

16. Manguel, A. (1997). *The history of reading*: Penguin.

17. Miall, D. S., & Dobson, T. (2006). Reading hypertext and the experience of literature. *Journal of Digital Information, 2*(1).

18. Spiro, R. J., & Jehng, J.-C. (1990). Cognitive flexibility and hypertext: Theory and technology for the nonlinear and multidimensional traversal of complex subject matter. *Cognition, education, and multimedia: Exploring ideas in high technology, 205*.

19. Tenner, E. (2006). Searching for dummies. *The New York Times*, 12.

20. Turkle, S. (2011). *Alone Together: Why We Expect More From Technology and Less from Each Other*. New York: Basic Books.

21. Wolf, M. (2007). *Proust and the squid: The story and science of the reading brain.* New York: HarperCollins.

22. Wolf, M., & Barzillai, M. (2009). The importance of deep reading. *Educational Leadership, 66*(6), 32–37.

23. Wolf, M., Ullman-Shade, C., & Gottwald, S. (2012). The Emerging, Evolving Reading Brain in a Digital Culture: Implications for New Readers, Children With Reading Difficulties, and Children Without Schools. *Journal of Cognitive Education and Psychology, 11*(3).