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## The Affect of E-books on Reading

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Abstract:  
(E-books, Reading, Books)

This thesis is concerned with the possible effects of e-books on reading from a socio-historical perspective and a neurological perspective. It looks at how reading habits change due to e-books and what that means for society. It also looks at what experts are currently saying about how e-books might affect human brains and the validity of these concerns. In addition, conclusions of areas of research to focus on are suggested. A survey about the reading habits of FSU students was taken. These results were incorporated to track FSU trends compared to national averages.

# The Affect of E-books on Reading

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COLLEGE OF ARTS & SCIENCES

THE AFFECT OF E-BOOKS ON READING

By

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The television stand in my room in Tallahassee doubles as a bookcase. Its two shelves are crammed three layers deep with books and every inch of the top that is unoccupied by the TV is filled with more books. The total is somewhere over one hundred and under one hundred fifty books. I have that plus a little more back home. The books in my actual bookcase are double stacked; more are shoved into my desk, and tucked away in decorative baskets around the house (placed there by my mother after the last time I left to go back to school). I own forty-something more books on my kindle. To say the least, I am a voracious reader. As I began the transition from print books to e-books, it seemed like I was being inundated with opinions about e-books and the fate of the publishing industry. Certainly the world of publishing is undergoing a technological transition unlike anything since the Gutenberg Printing Press Revolution. With so much attention being placed on e-books, much of it reactionary, I began to wonder how e-books actually affect the way we read. This is a broad question with two main components— how e-books affect reading from a social perspective and how e-books affect readers from a neurological perspective.

I will explore this question primarily through the analysis of secondary sources. However, I have also conducted a survey of eighty random Florida State University students. The purpose of the survey was to determine the students' reading habits particularly in regards to e-books and uncover any trends. I then compared the acquired data to what others said was happening with e-books. The survey gives an immediate look into the mindset of a demographic to which new technology is often advertised and adopted quickly by. The review of secondary sources indicates overall thoughts about e-books from researchers and media, giving a broader view of the issue.

An e-book in its most basic form is simply an electronic book. However, the term e-book has evolved past this simple definition. It is easiest to define an e-book by what it is not. The definition of an e-book does not stretch to include blogs, websites, or text mounted on microfilm, text based flash programs. In general, an e-book is an electronic edition of text that would traditionally be printed and considered literature. For example, novels, nonfiction books, short stories, poetry, long form journalism, magazines, and news papers can all fall under the domain of e-books. And yet, some more experimental works are being produced to include video and hyperlinks within the text. These are still e-books. The line between what is an e-book and what is simply electronic text can be blurry. However, the two most basic requirements for e-books are that all are electronic and are distributed online.

## **Digital Society**

### **Increase in E-book Adoption**

Changes in reading technology have profoundly affected society. The advent of punctuation, the codex, and Gutenberg's printing press all revolutionized society and social behavior in regards to books. E-books are the most recent major mainstream technological change in reading. E-books have only started to become mainstream products within the last decade, yet of the FSU students surveyed, 25% reported primarily reading e-books with another 20% reading an even mix of e-books and printed books. In a study in part by the Bill & Melinda Gates Foundation, the Pew Research Center found that 21% of American adults had read an e-book in the last year (the number expands to 43% when the age range is reduced to 16 and over and the definition of an e-book expands to include content outside of a book in electronic form) (Rainie et al). This number is increasing with time. The PEW Research Center reported that there



are four times more people reading e-books on any given day this year than there were two years ago (Rainie et al). The FSU survey indicates a much higher rate of e-book adoption with at least 45% of participants read an e-book in the last year (all participants reported reading in general on a regular basis). Additionally, it is possible at least some of the remaining 55% of participants reporting to primarily read print books could have also engaged in e-book reading. The study found that 29% of American adults “own at least one specialized device for e-book reading – either a tablet or an e-book reader” with many more engaging in e-book consumption via non-dedicated devices like cell phones and computers (Rainie et al). Granted, this does leave the majority of participants (55%) and the majority of adult Americans primarily reading print books but these results still display a rate of technological adoption of significance. In the past, major technological changes in book technology and practice produced social changes. Because the use of e-books is on the rise, there is every indication that this technological change will also have social implications.

### **Historical Trends Indicate Future**

In the late fourth century, Saint Augustine described his contemporary, Saint Ambrose, reading—“When he read his eyes scanned the page and his heart sought out the meaning, but his voice was silent and his tongue was still” (Manguel, *A History* 42). This is the first definite example of silent reading ever recorded. During the Middle Ages, silent reading was still uncommon and not looked upon favorably by the Christian church. A text read silently “is no longer subject to immediate clarification or guidance, condemnation or censorship by a listener” (Manguel, *A History* 51). Texts read aloud could be shared— the text could be explained or debated. Reading aloud was a social activity with accompanying constraints. Reading silently was an isolated activity that allowed more freedom. Although most reading is done silently

today, the choice to read a print book or an e-book parallels the choice to read aloud or silently. Print books advertise themselves with their covers while e-readers privatize book choice by showing casual observers only choice of e-reader brand. Print books, like reading aloud, communicate to society something about the reader and what they are reading. E-books, like reading silently, privatizes the reading experience. Each has advantages and disadvantages.

Book choice can communicate information about the reader to society. When an observer makes a positive connection to a reader's choice, a positive experience ensues. For example, Alberto Manguel recounted a common positive experience, "Sitting across from me in the subway in Toronto, a woman is reading the Penguin edition of Borges's *Labyrinths*. I want to call out to her, to wave a hand and signal that I too am of that faith. She, whose face I have forgotten, whose clothes I barely noticed, young or old I can't say, is closer to me, by the mere act of holding that particular book in her hands, than many others I see daily" (Manguel, *A History* 214).

In *A History of Reading*, Manguel discusses his experiences with the social implications of book choice, not all of them positive. Some books were off limits due to gender, their "covers were a warning brighter than any spotlight, that these were books no proper boy would read. These books were for girls" (Manguel 226). Earlier this year, I sat, chatting with other students waiting for an English class to start. Inevitably the subject of books came up. In the course of this discussion, one student stated that he had always wanted to read *Lolita* but felt he couldn't because others might judge him as being perverted or "weird-in-a-bad-way." The other students discounted *Lolita* as being off-limits to a male college student because it could be easily explained away as an assignment, but other books like Kathryn Stockett's *The Help*, John Green's *Looking for Alaska*, and Neil Gaiman's *Stardust* were declared off-limits to men because

the content of these books are considered more feminine than masculine. Later in life, Manguel was told by friends that they could not be seen with the book he was co-editing because, as it was an anthology of gay fiction, they did not want to be mistakenly identified as homosexual for reading it. Essentially, “to venture into the literature society sets aside, condescendingly, for a ‘less-privileged’ or ‘less accepted’ group is to risk being tainted by association” (Manguel, *A History* 228). New York Times book critic, Dwight Garner, has said that printed books have the advantage in that a woman reading a penguin classic is sexier than a woman reading popular trash fiction but that “because e-books don’t have covers, teenagers may find it easier to consume the books some parents used to confiscate — “Forever,” by Judy Blume, “Flowers in the Attic,” by V. C. Andrews. Their parents will think they are playing Angry Birds” (Garner).

In these cases, the print medium becomes a limiting medium that e-books alleviate. E-readers provide the anonymity to break through gender and sexuality barriers and allow readers to get around certain censorships of reading material without fear of reprisal. Clearly, changing what the individual is allowed or willing to read is a social change on a small scale. The thing about small social changes across large groups of people, though, is that they tend to snowball and turn into large, albeit gradual, changes. Manguel argues in his *A History of Reading* that social divides in reading material amongst literate people has always existed. Perhaps someday it will not. If men can covertly read books that are “for women,” eventually they will realize that other men are also and begin to talk about it. Eventually, this gender divide could lose significance and disappear. The same could happen for other literary-consumption constraints.

In the mid-1960s, Ted Holm Nelson predicted that nearly all reading and writing would be available on screens by the end of the 20<sup>th</sup> century (Chadwyck-Healey). Hypertext, as Nelson called it, advanced more slowly than that but by the 1990s reference books on CD had become

popular. Project Gutenberg, a digital library of public domain works, began in 1971, transitioning to website form in 1994 (“Project Gutenberg”). In 2004, Google announced its effort to digitize all published books (“Google Books”). As the concept of e-books left the relatively small worlds of academia and publishing and entered the public consciousness, predictions of the downfall of the publishing industry were common. But “as the luminaries raced to diagnose Literature as if they were doctors on the season finale of *House*, 21st-century Literature was going viral on the Internet and in the little magazines” (Arnold). Indeed, “far from killing off the book, the digital age is proving a boon to innovative publishers and authors, many of whom are using new technology to breathe life back into old ideas” (Skidelsky). E-books have reintroduced and are attempting to reinvigorate several defunct (or going-that-way) forms of publishing, such as long-form journalism, the short story, and serial publishing.

A few years ago, Amazon introduced its Singles. Kindle Singles are works that fall under the “vast spectrum of reporting, essays, memoirs, narratives, and short stories” touted as being the “length best suited to the ideas they present” (Amazon.com). They generally range in length from slightly longer than a magazine article to slightly shorter than a novella. This is, in part, an attempt to recommercialize the short story. But others, such as Wired.com’s Charlie Sorrel, see it as a likely candidate to save long-form journalism (Sorrel). Either way Amazon Singles gives a home to the works that became unpopular by fitting imperfectly into both the worlds of newspapers and magazines and full-length books. Best-selling author Jodi Picoult’s Kindle Single, *Leaving Home* is a collection of three short stories. Amazon also has Kurt Vonnegut’s novella *Basic Training* available through Kindle Singles. On the nonfiction front, Amazon offers Joshua Hammer’s work of narrative journalism *The Kalinka Affair* and Homer Hickam’s (author of *Rocket Boys*) short essay, *Paco*. The prices range from \$0.99 to \$2.99. Because readers are

willing to buy shorter works for a lower price, publishers are more willing to publish, making it more worth writers' time to write in these forms. Amazon has done what every fiction workshop class will tell you is impossible— they have made the short story an economically viable option. Publishing giant Penguin introduced its Penguin Shorts, essentially the same idea as Kindle Singles, in late 2011 (Skidelsky). Surely more online booksellers will follow.

In Victorian England, serial publications were a popular format for books. Stories were published one section at a time over weeks or months. Readers could subscribe to the publication, could pick up a copy at a store, or wait until the story was finished and bound into larger books. Nearly all of Charles Dickens' books were published this way. In recent times, this format seemed to have died away completely. The occasional long, narrative nonfiction published serially in newspapers the only remnant of this once wildly popular practice. But despite appearances to the contrary, the form did not die away entirely and with the internet seems to be making a comeback through e-books. Digital serial books are currently still very much experimental. Like authors in Dickens' day, many contemporary authors of serial publications work on a deadline, writing the stories extemporaneously, often taking reader reactions into account. A few, apparently less popular, authors simply cut prewritten stories into sections and release sections on schedule (Friedman). Episodes, as the sections are called, are released to readers on a set schedule and then rereleased as a full novel. The full novels tend to sell better than the individual episodes because readers prefer to fully immerse themselves in a work but the serialization does drive up interest and awareness (Friedman). Strong rapport between writer and reader are more easily forged with serialization. Plus, the author gets immediate feedback, before the novel is complete rather than after (Morris). While serialization

is nowhere near the level of success it found during the Victorian era, it may someday thrive once again.

### **Concern over Culture**

There are concerns about what kinds of books will be read with e-books. It is extremely difficult for a new author to be published by traditional publishers. This could equate to a rough form of quality control, but, as Mary Cross suggests in “Game Change: The Book Goes Viral” this also limits traditional publishers’ willingness to publish and absorb the costs of experimental work. E-books make it easier for books to be published and distributed independently. This makes room for experimental work but may also flood the market with unedited, possibly lower quality work. Books have long been illuminated with artwork and photographs, but e-books present the new possibility of integrating video into books. This is one of the more popular predictions of experimental writing specific to e-books. Generally, e-book specific experiments are what seem relevant, but the ease of storage and marketing for self-published e-books is so great that more traditionally experimental work also has a place in this category. Many of the successful self-published e-books around today were made successful because the author had a strong web presence and a built-in audience with their internet following. Serial e-books are proof positive that self-published or indie publisher published experimental books can exist and succeed.

Aside from the possible loss of a quality-check safety net, another concern for the future of our collective literate culture is that e-books offer no physical connection to the past. One participant in my survey lamented that books have souls and e-books are like brains without souls; no individual touch. A book might have water marks dotting a particularly moving

passage, the proof of past tears. Another might have highlighted sections and notes scribbled in the margin. An oft repeated argument against e-books is the loss of the past; E-books do not possess the marks of past readings and past owners. E-books cannot be handed down, special because the owner's grandfather wrote in it. E-books checked-out from a library do not give-away fellow patrons through wear and tear on the book. Despite this desire to hold on to the past via marginalia and highlights, of the FSU students surveyed, 55% do not mark their texts by highlighting or annotating. The majority, 82%, of those who do not mark their texts also read only print books. The habit of marking a text does not seem popular among those who deem it important.

There is one exception among e-books: Amazon's Kindle allows users to hide or show popular highlights in the works they are reading. All popular e-readers allow users to highlight and add notes to texts only browser-based e-books (such as books from Project Gutenberg) lack this functionality. Amazon is, so far, the only platform on which you can view what others felt noteworthy. This is not a replacement for the potential to connect to distant past readers through marginalia but it does reinstitute the social connectivity of readers through textual response and furthers it from intratextual response to intertextual response.

When a student buys a used textbook, occasionally the previous owner will have highlighted the text in an effort to direct their own study. Generally, the new owner then pays particular attention to the highlighted text. An external presence affects the user's reading of the textbook. This interference is generally limited to a small handful of past owners. In Amazon's Kindle, highlights are inconspicuous lines drawn under a selection, with a small number indicating the number of highlighters. The presence of these highlights may influence the way in which the reader reads the text. Knowing that someone else felt a specific part of the text was

important, forces the reader's attention to that quotation. When the reader's attention is forced onto the selection, the highlighted section is no longer just another part of the text, left for the reader to assign value to, but has external value which the reader is then prompted to accept or reject. The number of people who have highlighted the same quotation is influential, as well. If a large number of people have highlighted the same section, a reader may be more inclined to highlight the section themselves because the reader thinks it must be something important, something worth marking and returning to. Each person who buys the book potentially has the biases of hundreds of readers projected into their reading. This crowd of added input is similar to the crowds surrounding and providing feedback to an ancient reader— albeit in a more limited way. Although, if a reader finds popular highlights unduly interfering or distracting, there is an option to turn them off.

Although the Kindle is the only e-reader that allows users to see popular highlights, all of the major e-readers are somehow connected to social media websites, giving users an easy way to instantaneously share passages, quotations, or even just that they have finished reading a certain title. Comments can be made, shared, and read within communities of readers unconnected by anything else. The major e-readers focus on Face-book and Twitter, allowing users to create posts with quotes and announcements about reading material in less than five seconds. Approximately two-thirds of the participants in my survey reported using social media to discuss books.

### **Access and Organization**

There comes a time in every person of the Digital Era's life when their digital data must be organized. Word documents in dizzying amounts all saved, unsorted into a general documents



folder. Photos saved in some haphazard manner chosen by the computer that is sometimes, but not always, the order in which they were taken. Content is impossible to find. Organization is key to a happy digital life. Fortunately, e-readers are incredibly easy to organize. Users are no longer limited to the three most common ways to organize a physical bookshelf: alphabetically, by genre, or “oh-look-it-will-fit-into-this-cranny-here-if-I-shove-a-bit.”

Barnes and Nobles’ Nook allows users to organize their libraries into collections called shelves, giving each shelf a name. Amazon’s Kindle and the iBook app for Apple iOS products also allow users to organize their e-books into collections. Unlike print books, e-books can simultaneously appear in multiple collections. Founder of the Warburg Library, Aby Warburg ran into problems when attempting to organize his books. “He demanded from his collection a fluidity and vivacity that neither enclosure by subject nor restrictions of chronology allowed him” (Manguel, *Library*). Warburg would have been a fan of electronic organization.

“What makes a library a reflection of its owner is not merely the choice of the titles themselves, but the mesh of associations implied in the choice” (Manguel, *Library*). In addition to the virtually limitless collections one can create on their e-reader, several book-oriented social media websites allow users to create their own “libraries” either out of books they actually own or books they have read. Roughly half of all FSU survey participants are involved in book-oriented social media. Additionally, everyone who indicated reading primarily e-books also reported participating in book-oriented social media sites.

One of the best examples of social media, books, and digital organization is the website, LibraryThing.com which allows users to create a library and collections within that library. Each book entry can also be tagged by the user. Tags are descriptive labels attached to the entries.

Tags are an organizational and associative tool. For example, the tags associated with *Pride and Prejudice* on LibraryThing include “British Literature,” “Classic,” “50 Book Challenge,” and “Preconceived Notions.” British Literature and Classic are more traditional classifications, easily accessible by an outsider. 50 book challenge is certainly a more personal but still utilitarian tag. Preconceived notions is a less obvious way to organize books. However, it is no less useful. This tag will lead you to other books on the site, or in the original user’s library, in which the subject of preconceived notions is a major conceit.

The same fluidity of e-books that allows flexibility in organization creates a problem. Every year thousands of dollars of merchandise goes missing from bookstores across the country. It is rather difficult to shoplift books. This is partially because of how bulky books are and partially due to the presence of bookstore employees. E-books, though, are easy to steal. Hundreds of books can be downloaded in a matter of minutes. As e-readers become more popular, e-book piracy becomes more prevalent. One study by technology company Attribution and associates, Macmillan and Kensington Publishing Corp, found a 54 percent increase in piracy demand from August 2009 to January 2010. Despite this rather unsurprising but dismaying display of lack of morality is somewhat assuaged by another finding from the same study and that is that when a would-be e-book pirate was presented with a link to legally buy the book, one-fifth of them did so (Carnoy). Additionally, although e-book piracy seems to be on the rise, the PEW Research Center study found that e-book readers were more likely to buy books than borrow or otherwise acquire books (Rainie et al).

E-books may not only change how we read on a superficial level (a simple change from paper to screens) but also how we engage with each other over our reading. The social aspects of reading are changing. E-books create a distinct area of public privacy for readers. When one

reads an e-book it is not immediately obvious what they are reading nor is the language, length, or genre communicated to outside observers. Yet e-readers tend to facilitate the socialization of readers in part by prompting integration of social media such as Twitter and Facebook in the reading experience.

Public discussion on e-books, though, seems to focus on a different aspect of change. Is the change from print to screen actually simple? Do e-books affect our brains?

## **The Neuroscience of the Literate Brain**

The human brain is an ever changing organ. Brains physically change due to environmental changes, injury, exposure to chemicals, and learning. This phenomenon is called neuroplasticity. Although the largest changes tend to happen during critical periods in childhood, small changes continue throughout life (Kalat). With the brain so susceptible to changes, do e-books create a different brain than print books? As is often the case with new technologies, researchers have skipped asking this and gone straight on to predicting how e-books might affect the brain in a more practical, if less than purely scientific manner. Cognitive neuroscientist and professor of child development, Maryanne Wolf worries that while electronic text allows for vast amounts of creativity, it will hinder future generations in learning how to read deeply (Wolf, Barzillai). Jakob Nielson, a web usability expert and researcher, suspects that e-books change reading memory (Szalavitz). Robert Sutton, a Stanford professor of Management Science and Engineering and Organizational Behavior, also worries that he and his wife do not remember as well when reading on Amazon's Kindle than when reading traditional print books (Sutton). In order to assess these claims, we must first understand how the human brain reads in the first

place. Basic knowledge of the brain is necessary prior to this explanation and a short guide to the brain has been provided below.

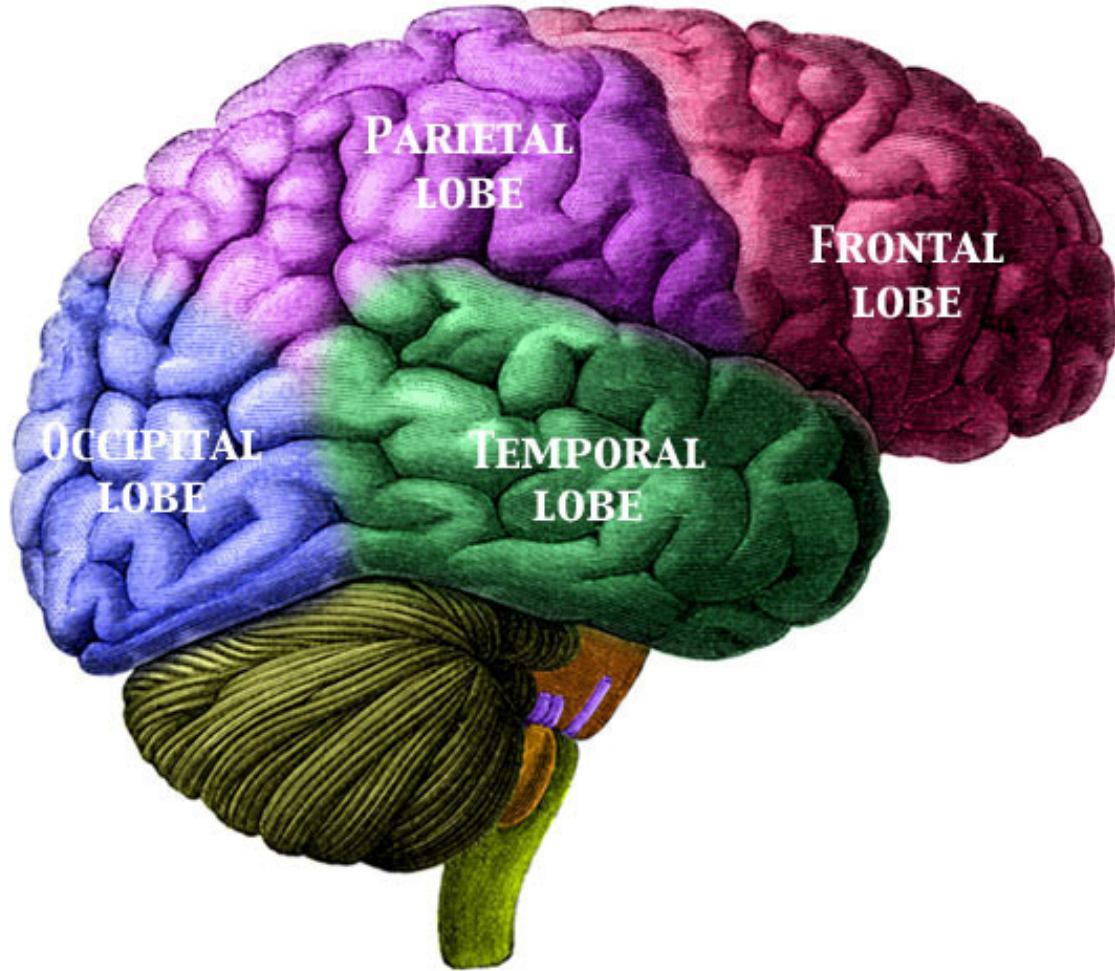


Figure 1  
Brain viewed from the right side showing the 4 major cerebral lobes.  
Source: Charles Morel and Mathias Duval, *Manuel de L'anatomiste*, 1883.

## An Introduction to the Brain

“Composed of close to one hundred billion cells, the human brain is the archetype of a massively parallel system where all neurons compute simultaneously” (Dehaene, 63). The brain is a mysterious organ. It is difficult to run tests and experiment on the brain for obvious ethical reasons. This, of course, impedes our ability to learn about the brain. However, researchers have been able to identify the function of several structures in the brain. Unfortunately, many of these structures are ill-defined. This is made further complicated to the uninitiated because each section of the brain has more than one name in current use. This is due to the various ways in which it is possible to organize the brain. I will only be going over the basics here.

There are four major lobes in the brain: the frontal lobe, parietal lobe, temporal lobe, and occipital lobe [see figure 1]. The frontal lobe is primarily responsible for reasoning, planning, judgment, impulse control, movement, problem solving, memory, expression of personality, and higher order associations. The parietal lobe receives information pertaining to limb position, temperature, pain, touch, eye movement, and portions of language-important association functions. The temporal lobe receives auditory input, is important in language and speech production, and memory association. The occipital lobe is the primary visual processing area (Kalat).

The brain can also be split into two hemispheres— left and right. In popular culture, it is assumed that the left hemisphere deals with logic and the right with creativity. This is correct only in a broad sense. According to neuroscientist James W. Kalat, “in most people, the left hemisphere is specialized for language and ‘analytical’ processing. The right hemisphere is specialized for certain complex visual-spatial tasks and ‘synthetic’ processing” (Kalat).

There are two structures in the left hemisphere that are particularly important to language, Broca's area and Wernicke's area. Broca's area, located in the left frontal lobe, primarily deals with language production. Wernicke's area, located in the left temporal lobe, primarily deals with language comprehension (Kalat).

The cerebellum (located on the base of the brain, shown above unlabeled in lined yellow-green) is known as the little brain. It contributes primarily to control of movement but also contributes to language learning (Kalat).

## The Physical Process of Reading

Writing was invented approximately 5,500 years ago. According to Stanislas Dehaene, the brain could not have evolved to read in such a short time (Dehaene). Maryanne Wolf considers it a miracle humans ever learned to read at all (Liu et al). “Even more surprisingly [than the invention of reading], the same mechanisms, in all humans, are systematically housed in identical brain regions, as though there were a cerebral organ for reading” (Dehaene, 10). The brain uses essentially the same areas to read regardless of language or writing system. There are slight differences in processing paths when comparing readers of different writing systems, Chinese and English, for example, but the differences are so slight that they are negligible in this context (Wolf). The skill of reading “rearranges the circuits and connections among older structures; it capitalizes on the ability to commit areas to specialization, particularly pattern recognition; and it illustrates how new circuits can become so automatic that more cortical time and space can be allocated to other, more complex, thought processes” (Wolf, 216). Dehaene calls this neuronal recycling. In neuronal recycling, the brain must follow genetic precepts but is plastic enough to reuse and reorganize some areas to take advantage of new skills (Dehaene). A form of neuroplasticity, neuronal recycling is how we are able to do many things, including reading.

With most actions, the more one performs the action, the more efficient one is at completing the action. Reading is the same. Children just able to truly read, on their way to fluency, expend much more effort in reading than do fluent adults. This is “reflected in the large amount of cortical space needed in the visual areas of both hemispheres, and also in a slower, less efficient pathway from visual areas to upper temporal and lower parietal regions to the frontal regions” (Wolf, 141). Maryanne Wolf posits that this bi-hemispherical route gives the



child more time to determine phonological and lexical meaning. Once the reader becomes more practiced, the brain switches to a route based in the left hemisphere, speeding word recognition and increasing the brain's ability to engage in bi-hemispheric comprehension (Wolf, 142). By the time the reader becomes a fully fluent, expert reader, it takes a mere half second for the reader to read a word (Wolf 145). How does this occur?

There are several ways to break this down. The first is by time. The first 100 milliseconds in the reading process are used to disconnect from distractions, shift attention, and focus on the word (Wolf, 145). According to an MIT study, at this point the brain cannot distinguish between different visual stimuli. However, at the 150 millisecond mark the brain has sorted the visual stimuli, sending letters to the left hemisphere of the brain. Not only has the brain decided whether or not the object in the field of vision is made up of letters, but it can determine whether or not the letters are from a language the reader knows and if these letters represent “a permissible pattern in our language (bear versus rbea), and whether a permissible word in a real word or not (bear versus reab)” all by 150 milliseconds (Wolf, 149). It is important to note that the brain in “a time span too brief for conscious perception, extracts the identity of a letter string regardless of superficial changes in letter size, shape, or position” (Dehaene, 74). A literate person can read virtually any font without needing to learn how to read that font. Our brains also treat corresponding majuscule and miniscule letters as if there were no visible difference between them. For example, the literate brain can read a sentence LiKE tHiS just fine. The letter ‘R’ is a good example of how remarkable this is as ‘R’ and ‘r’ are completely different shapes. This is called invariance. Without our ability to do this, our capacity to read would be greatly reduced, so much so that it is doubtful writing and reading would have flourished as it has.

Between 150 milliseconds and 200 milliseconds the frontal lobes have been activated and the brain decides if the reader has seen enough information to move forward and continue reading or if the reader has not seen enough information and must retreat in the text (Wolf, 149). After 200 milliseconds have passed, other areas relevant to reading such as Broca's area, Wernicke's area and the right cerebellum are activated. These areas are particularly involved in connected text (such as sentences and paragraphs) and perform "feed-forward, feed-backwards operations" (Wolf, 154). Take the sentence fragment, "the bow on the boat," To understand that bow refers to the front part of a ship instead of a physical movement, a tied ribbon, or part of a musical instrument, your brain must comprehend the word "boat" and put it into context with the word "bow." It does this so quickly that you likely understood what was meant the first time you read the phrase and perceived being able to do so immediately.

Interestingly, although scientists have been able to pinpoint approximately how long it takes the average brain to enter each stage in the reading process, they have also found that it is actually the speed of the eyes that control the speed of reading. If "a full sentence is presented, word by word, at the precise point where gaze is focalized, thus avoiding the need for eye movements, a good reader can read at staggering speed—a mean of eleven hundred words per minute, and up to sixteen hundred words per minute for the best readers, which is about one word every forty milliseconds and three to four times faster than normal reading!" (Dehaene).

Neuroscientist Stanislas Dehaene and his colleagues theorize that the brain learns to recognize systems of writing by using object-recognition circuits. He hypothesizes that one such circuit, the "brain's letter-box," as Dehaene colloquially calls the visual word form area located in the left occipital-temporal area, is essential to reading. This letter-box is located within Brodmann's area 37. Area 37 is an area of the brain identified prior to and independent of

Dehaene. This is important because not all researchers agree with Dehaene's theory, but do agree that this area is involved with object recognition. Dehaene hypothesizes that his letter-box "is the filter through which visual information must flow in order to enter the language system. It selectively analyzes incoming images for the presence of letters" (Dehaene). According to Dehaene's research, this letter-box is universally present in the same location in readers despite differences in languages, reading direction (left to right, right to left, etc.), and skill level. Areas surrounding the visual word form area are activated by other visual stimuli such as faces and landscapes. That this small specific area is universally reserved for words in the reading person's brain is surprising because the human brain could not have evolved regions specific to reading in the 5,000 years reading has been around so one might reasonably expect a more random placement of the visual word form area than occurs (Dehaene). Although small from a non-neurological view point, Area 37 is composed of millions of neurons. Groups of neurons may react to individual letters and words, allowing the brain to only activate small groups of cells to read a word rather than a much larger, less efficient area (Wolf). The existence of neuroplasticity indicates that the brain is capable of changing enough to allow letter-specific neurons to exist. Once recognized as letters, area 37 "forwards them to other brain areas that subsequently transform them into sound and meaning" (Dehaene). Whether or not one believes in the letter-box theory, it is inarguable that "the literate brain contains specialized cortical mechanisms that are exquisitely attuned to the recognition of written words" (Dehaene).

From the visual cortex, words follow two major parallel processing routes, the phonological and lexical routes. The phonological route translates the text into sounds while the lexical route applies meaning to the text. The routes activate simultaneously (Dehaene). Although the routes are activated simultaneously, they do not encode at the same speed. A

word's spelling is activated between 20 and 30 milliseconds after it comes into view. The word's sound is not encoded until 60 to 70 milliseconds into the reading process (Dehaene). The lexical processing route requires that words be broken down into morphemes, graphemes, and phonemes. Morphemes are "unit[s] that cannot be analysed into smaller units" (OED). Graphemes are units of "written expression that cannot be analysed into smaller meaningful units" (OED). Phonemes are "unit[s] of sound in a language that cannot be analysed into smaller linear units" (OED). Graphemes are automatically converted into syllables as well as more complex grapheme units like 'ough' and 'ea' (Dehaene). "Actual measurement of response times clearly shows that our brain does not stop at the single-letter level. Our visual system automatically regroups letters into higher-level graphemes, thus making it harder for us to see that groups of letters such as "ea" actually contain the letter 'a'" (Dehaene). This allows phonological processing to phonemes to be more efficient. Although the phonological route encodes more slowly in proficient readers, giving lexical access more quickly, it is nevertheless important to reading because it allows readers to understand a text with spelling errors, phonetically spelled accents, and is responsible for the existence of puns (Kalat).

From this process it seems easy to conclude that, given a stable medium, the medium does not matter much in reading. Clay, parchment, paper, screen: none of these things interrupt the reading process. The brain is going to go through the same processes. None of these processes are contingent upon the materiality of the text. However, researchers have identified several areas of concern when it comes to e-books and the brain.

## Potential Problems- Deep Reading

Maryanne Wolf and Mirit Barziliai are concerned that the ability of the children of the digital age to engage in deep reading, defined here as “the array of sophisticated processes that propel comprehension and that include inferential and deductive reasoning, analogical skills, critical analysis, reflection, and insight” (Wolf, Barziliai). This ability is “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, Barziliai).

In my survey, I asked participants if they read mostly e-books, mostly print books, or an even mix of both. Of the 80 participants, 25% responded that they mostly read e-books, 56.25% mostly read print books, and the remaining 18.75% read an even mix of both. When asked if they feel they primarily read deeply (actively engaging in the text by reading every word, comparing the text to other texts, and analyzing the text) or shallowly (skimming quickly for information), 87.5% reported reading deeply and 12.5% reported reading shallowly most of the time. FSU students are reportedly still reading deeply. However, although most students in the 18-25 age range grew up using computers and accessing information digitally, this upbringing in no way rivals the digital upbringing of kids today. For example, Lake Minneola High School in Lake County, Florida, is the first high school in central Florida to transition to using completely digital textbooks. The students are provided with ipads loaded with the necessary textbooks and apps (Orlando Sentinel). Some Miami-Dade County public schools have started to integrate e-learning labs into schools. E-learning labs are classrooms in which students use a computer lab to take online courses. The classes are overseen by a proctor rather than a teacher (Herrera). Every year students opt to take classes through Florida Virtual School, doing the coursework at home in

addition to their regular school coursework. And, of course, there are e-readers dedicated to young children, like the Vtech E-reader recommended for children ages 3 to 7 years old.

Wolf's basis for her concern is that although it takes expert readers just milliseconds to begin engaging in deep reading and they do so automatically, it takes years of learning how to read to become an expert reader. If kids are more distracted, they will be less able to learn to engage in deep reading. I think this is a valid concern that deserves research attention, but I must point out that it seems unlikely that children will be so profoundly affected. Wolf is forgetting her own point in that humans were not "designed" to read. Our brains are certainly plastic enough to accommodate changes in the reading environment. It may actually be easier for young children to adapt to digital reading and e-books because, unlike adults now, children do not have to adapt from print to digital reading. They are learning to read digitally from the start.

According to Dr. Allen Liu, "Initially, any new information medium seems to degrade reading because it disturbs the balance between focal and peripheral attention" but that degradation disappears as that new technology is integrated into society (Liu et al). Children of the Digital Age might have slightly different brains than those who learned to read with print books, but e-books do not remove the associative areas of the brain that allow deep reading in the first place.

### **Potential Problems- Comprehension**

One of the other concerns many people have had with e-books is of reading speed and comprehension. "Is there a difference in the way the brain takes in or absorbs information when it is presented electronically versus on paper? Does the reading experience change, from retention to comprehension, depending on the medium?" asks the New York Times (Liu et al).

*Time* health writer, Maia Szalavitz, has professed her concern for an alleged slow in reading times and the implications thereof, specifically that it is a “particularly troubling trend for academia, where digital books are slowly overtaking the heavy tomes” (Szalavitz). The basis for this concern seems to be studies from the 1980s and early 1990s when the personal computer was first introduced into homes. These studies showed a 20- 30 percent decrease in reading speed on a screen versus reading speed on paper. However, these studies were flawed in execution, as in “inconsistencies in earlier findings could largely be attributed to variations in visual quality of the two presentations, in that like was rarely being compared with like” (Noyes). Screen quality was not at a very high level in the 80s and 90s, either. Nor had the participants lived in a highly digital world as is the case now. Current research has all but abandoned reading speed as relevant, preferring to focus on reading comprehension. “What is apparent... is that the situation is changing and it is probably fair to conclude that greater equivalence is being achieved today than at the time of Dillon’s (1992) literature review” (Noyes). As noted earlier, eye speed is a primary factor in determining the speed of reading. As long as the screen is of a high quality so as not to hinder eye speed, reading speed should not suffer.

Essentially researchers have moved past an issue that is suddenly presented as relevant for the public, resulting in much unnecessary worried hand-wringing. In my informal survey of FSU students, I found that none of the respondents perceived a difference in reading speed. The only difference reported in regard to speed was about the time in which it took to “get into the book.” Even this was inconclusive with only one more person reporting faster immersion with e-books over print than the other way around. It is noteworthy that these responses were not to a

specific question I gave, but were volunteered responses to the open-ended question, “Do you perceive a difference in your reading when reading in print versus reading an e-book?”

Unfortunately, there is not much research about the effects of e-books on reading comprehension. Current related research suggests a larger concern over the affect of the internet on comprehension due to high levels of distraction. Personally, every reading comprehension test I have ever taken outside the reading portions of the FCAT and SAT have been tests given on computers. When I was in elementary and middle school, students were required to take AR (Accelerated Reading) tests on the books we had read. AR tests were short quizzes designed to ensure that the student in question had actually read the book and understood what they read. Used over a period of time, the AR program creates an assessment of each student’s reading and comprehension level. The combination of the continued use of a critically-evaluated computerized reading comprehension testing system that has been in use since 1993 and the lack of formal research indicates to me that the assumption that reading on a screen inhibits comprehension is likely faulty. Furthermore, there is nothing about the neurological process of how the brain reads that indicates there should be a problem with screens.

Most of the voices concerned with digital reading and degradation of reading ability seem to be primarily speaking about computers and reading on the internet. Unfortunately, they do not specify this. They lump all digital reading together, equating the Kindle with a blog. But these are entirely different mediums, directing readers to approach reading in different ways. In a *New York Times* article entitled, “Does the Brain Like E-books?” all five of the experts consulted on the topic chose to write, at least partially, about reading online. Four of the five gave only the briefest mention of e-readers. The fifth was too preoccupied with putting computer chips into print books to think about existing e-readers. This is a complete failure to understand what is



meant by e-books. E-books may absolutely be read online from a computer. However, that is not the only option. If any accuracy in the discussion about e-books is to be had, one of the first problems that must be addressed is the tendency to lump the internet and e-readers together. E-books are one product that can be viewed on multiple platforms and yet one of the platforms is dominating the discussion and, most grievously, ascribing its own attributes to the other platforms.

## **Conclusion**

How e-books will affect reading is a question with many facets that cannot be answered accurately until e-books have been in common use for a longer period of time.

E-books are a part of a larger cultural change that is the result of the existence and heavy usage of the internet and mobile electronic devices. Unlike the more immediate social differences between some of the devices and their previous counterparts, like a cell phone and a home phone, e-books provide subtle changes. The most obvious of these changes being convenience of access and distribution. Because e-books are available on dedicated e-readers, tablets, desktop computers, laptops, cell phones, and ipods they are accessible to a wide range of people. Less immediately obvious is that e-books are tools of freedom: abolishing social limitations on choice in reading material, allowing a much broader range of textual formats to be feasible.

There does not seem to be any reason why e-books should change the brain in any noticeable manner. However, some of the platforms e-books are available on may have some affect. More research on how the internet and various applications on computers change our brains should be done. The term e-book needs to be separated from the rest of the internet. It is

important to know if flashing advertisements and too much stimulation prevents children from learning how to think and read deeply. This research is distinct from e-books although the results can be applied to e-books.

## Methodology

A convenience sample survey of FSU students was taken inquiring about their reading habits in general and as pertains to ebooks and print books. A total of eighty FSU students participated. Students could choose to take the survey on paper or using an iPad 2.

When reading, do you highlight, record notes or thoughts?	Yes: 5% Sometimes: 40% No: 55%
Do you mostly read for long periods of time at once or in short bursts?	Long Periods of Time: 75% Short Bursts: 25%
Do you mostly read deeply (making connections, analyzing, etc.) or shallowly (skimming, skipping sections, etc.)?	Deep Reading: 87.5% Shallow Reading: 12.5%
How well do you remember what you have read?	Very Well: 68% Well: 30.75% Poorly: 1.25%
Roughly how many hours per week do you spend reading?	This was an open ended question. All answers were between 4 hours per week and 30 hours per week.
Which of the following statements best fits you? I read mostly e-books, mostly print books, or an even mix of e-books and print books.	Mostly e-books: 25% Mostly print books: 18.75% Even Mix: 56.25%

<p>Do you participate in any book oriented social media?</p>	<p>This was an open ended question (to give the option to name the websites). Just under half the participants indicated that they participated in some kind of book-oriented social media.</p>
<p>Do you use social media to discuss or share what you read?</p>	<p>This was also an open ended question. Just over 81% of participants indicated that they used social media to discuss reading.</p>
<p>Do you perceive a difference in your reading in print versus reading online or reading an e-book?</p>	<p>A few of the responses mentioned the convenience of e-books. Some mentioned a preference based on eye comfort— half of these comments indicated a preference for print because of a screen’s propensity to dry out eyes. The other half preferred screens for various reasons, like adjustable font sizes and adjustable light brightness settings.</p>

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