Skim, Dive, Surface

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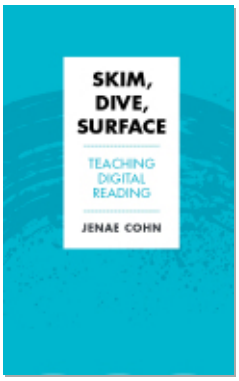

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CHAPTER 3

THE BRAIN ON BOOKS:

WHAT THE NEUROSCIENCE OF READING CAN TELL US ABOUT READING ON SCREENS

It is a miracle of the human brain that you can read the words typed on the page before you right now. Just think about it: a small, central portion of your retina, called the *fovea*, processes the shapes on the page and then sends a signal to your brain, which interprets them and turns them into what you consider "words." Even though our eyes are only physically capable of reading twenty words in a visual space at a time, our brains can process the words quickly enough to make sense of much larger chunks of text from there. Regardless of what language we're reading in or how we learn to read in the first place, the same parts of the brain are always activated (Dehaene, 2009, p. 71). As it turns out, every human brain is conditioned to operate in the same way because of the uniquely complex interplay between visuals and semantic meaning-making.

That said, humans were never born to read. If we were, we would all instantly know how to read the second we popped out of the womb in the same way that our brains instantly know how to process acts like responding to our parents' voices. Reading must be taught because it's a social act. But our brains and bodies have been conditioned to respond to those social acts, and biologically speaking anyway, our bodies are capable of engaging in the activity that our social conditioning catalyzes. In fact, neuroscientist Stanislaus Dehaene (2009) explains that we cannot separate cultural uptake of reading knowledge from the brain science of reading at all. That's because of a phenomenon that he identified: the *neuronal recycling hypothesis*. Dehaene's theory is that our brains manage to recycle preexisting pathways for purposes that our brains were not hardwired to do (p. 7). When the brain recognizes that a certain activity may be similar to one that it has already formed a pathway to do, the brain will recycle that existing pathway. Dehaene gives the example of how our brain's visual system has enough plasticity to allow us to recognize and interpret words, letters, and sentences, even though the visual system is not *technically* designed to decode words (p. 7). In his words, "human brain architecture obeys strong genetic constraints, but some circuits have evolved to tolerate a fringe of variability" (p. 7). That means that the brain is not a blank slate for learning new things; there are limits. But the brain is *flexible* enough that it can recycle some processes, like vision, to engage in other processes, like reading.

Cultural interventions push the brain into the recycling process Dehaene describes. Maryanne Wolf (2018) clarifies that although reading may emerge from our brain's ability to recycle particular processes, oral communication is, in fact, hardwired (p. 17). Our hardwired language abilities

can be recycled, so to speak, but to engage in reading, our brains need instruction to coax the recycling process into motion. In Wolf's words, "we must have an environment that helps us to develop and connect a complex assortment of basic and not-so-basic processes, so that every young brain can form its own brand-new reading circuit" (2018, p. 18). Wherever we read, whether that's on-screen or on the page, to create the kind of environment that encourages the brain's ability to read, we need to foster the reading process culturally. We can't expect our brains to do all of the heavy lifting for us, even if they often give us a pretty strong assist.

For those of us concerned with how the brain responds to reading acts, the neuronal recycling hypothesis makes one thing clear: our brains may not be using the exact same pathways for reading on-screen as they are for reading on paper, but they are already recycling those pathways anyway. Because our brains are already recycling so many of our hardwired cognitive processes (like oral language) to allow us to do what's been culturally instantiated (like reading), our brains have a flexible-enough capacity to adapt to what it might mean to read in a new environment. As Paul van den Broek and Panayiota Kendeou (2015) suggest, "multimedia processing may simply be an extension of existing processes—just as additional extensions will come to exist with future developments of information technologies" (p. 111). Basically, even if we might feel like our brains are slipping away from us when we spend hours seeking dopamine rushes on social media feeds or when we feel like we can't make our way through reading a long novel, that doesn't mean that our brains are broken.

Cognitive psychologist Daniel Willingham (2017) affirms that digital devices themselves can't erase all of the

complex cognitive work that our brains are capable of doing when we read deeply. His reasoning is that

> cognitive systems (vision, attention, memory, problem solving) are too interdependent. If one system changed in a fundamental way—such as attention losing the ability to stay focused on one subject—that change would cascade through the entire cognitive system, affecting most or all aspects of thought. I suspect the brain is too conservative in its adaptability for that to happen, and if it had happened, I think the results would be much more obvious. The consequences wouldn't be limited to our interest in reading longer texts; reading comprehension would drop, as would problem-solving ability, math achievement, and a host of higher cognitive functions that depend on attention and working memory (p. 172).

What Willingham affirms here is that our ability to maintain higher-order thinking is not what's really at stake if we practice more of our reading in digital spaces. Rather, it is where we are motivated to pay attention and what practices we can establish in order to sustain that motivation. We may worry about what our brains without books might look like, but what matters is why we care about our brains on books in the first place.

In this chapter, we move away from binarizing narratives around whether screens make us stupid and printed books make us smart. Instead, we examine what kinds of cognitive strategies are available to us when we read in a variety of different environments. This chapter, in fact, aims to resist what rhetorician Daniel Keller (2014) identifies as a "deterministic" narrative around the relationship between reading and technology, that "increased media exposure (and that alone) will rewire brains differently from the

'normal' wiring, which assumes all media exposure besides books will rewire the brain in a similar direction/pattern" (p. 123). After all, as we established in Chapter 1, historically, we've seen ourselves trot out the same sets of concerns about how reading technologies will change the way we think and live for centuries. Why should we fall back on those same arguments and assume that reading off of anything that is not a paper book will rewire our brains for the worse? This chapter aims to explore the beauty and mystery of our brains on books to help us better understand what is at stake when we start to open up options for reading in a variety of media and spaces.

This chapter functions largely as a literature review of the cognitive impacts of reading to help establish what we know, what we don't know, and where we can go from here. This context also shapes the pedagogical chapters to come, as we consider how what we know about the reading brain might shape how we approach our teaching. If we are to adopt digital reading practices in our classrooms, we need to be able to help our students, our administrative stakeholders, and our peers understand *why* these choices are meaningful. We need to know how our brains work in order to justify the work that we do, because our brains, quite simply, are the engines of all of our thinking.

An Inside Look: What Does Digital Reading Look Like in the Brain?

In order to understand what digital reading looks like in our brains, we first need to take a step back and understand what any kind of reading process looks like in our brains (at least in some very basic terms). For a start, there is no

single region of the brain where language activity happens. Rather, several different regions of the brain activate when we're engaged in a reading task or a listening task (though it should be noted that *seeing* words activates different parts of the brain than *hearing* words does). As David Rose and Bridget Dalton (2009) describe, the brain is a "distributed processor," where, broadly speaking, its distributed systems tend to accomplish three things while reading: one system recognizes patterns, another system generates patterns, and a third system determines which patterns are important to us (p. 77). If these three systems are not activated or engaged in readers (that is, if we don't help readers decode language, apply meaning to language, and identify value in language's meaning), that's when problems with reading can occur. Fortunately, there are many pathways to engage these three systems, and they might look different for different individuals. When we throw digital reading into the equation, these systems may activate differently.

So, how does the interaction of these distributed systems make way for deep reading in particular, the kind of reading we might worry about when we worry about digital reading in the first place? I use Maryanne Wolf's (2016) definition of deep reading here to explain that

> deep reading processes *underlie* our abilities to find, reflect, and potentially expand upon *what matters* when we read. They represent the full sum of the cognitive, perceptual, and affective processes that prepare readers to apprehend, grasp, and assimilate the essence of what is read—beyond decoded information, beyond basic comprehension, and sometimes beyond what the author writes or even intends (p. 112).

This definition captures what we want students to do in higher education learning environments: to fully contextualize and

describe why a piece of text matters for what they're trying to learn and understand. Engaging in these kinds of deep reading processes, however, is even less natural than the act of simply decoding itself, and developing these abilities requires sustained guidance. Wolf (2018) explains that "it takes years for deep-reading processes to be formed, and as a society we need to be sure that we are vigilant about their development in our young from a very early age" (p. 38). We can't just expect deep reading to happen because it is possible for our brains to engage in deep reading; we have to be aware of what conditions make readers amenable to engaging in acts of deep reading in the first place.

Dozens of empirical studies have been conducted over the last 20 years that have aimed to measure how well reading comprehension and retention happens from paper-based and digital-based reading environments, and the results affirm the complexity around what makes deep reading possible. Many of these studies have primarily measured comprehension of concepts from text in timed or controlled settings. For example, Anne Mangen, Gérard Olivier, and Jean-Luc Valey (2019) conducted a controlled study where they asked young adult readers (without learning disabilities) to read a 28-page fictional, plot-driven story in a limited time setting as a way to determine whether the kinesthetic and material affordances of a printed book would impact the ability to retain meaning and reconstruct the narrative components of the plot. Although they were not necessarily testing deep reading skills, they were interested in assessing memory and comprehension.

To conduct this test, one of the groups read a short mystery story in a printed book form (i.e., a codex, or what you might think of when you think of a paperback book) and one of the other groups read the same story on an Amazon

Kindle e-reader device (p. 4). Of the selected fifty participants, only two regularly read on a Kindle for all of their reading (including literary or pleasure reading), and these two participants were put in the test group of users who read the story from a Kindle device. In order to assess differences in comprehension between the paper book and the Kindle device, Mangen et al. (2019) measured factual recall of key plot moments, asked readers to identify where in the text particular events occurred, and asked readers to reconstruct plots. They also correlated understandings of where readers found events in the text and how able they were to reconstruct particular plots.

On most of these measures, Mangen et al. (2019) found that there was no significant difference between the Kindle book and the printed book for comprehension (p. 7). The researchers suggest that these results reveal that reading particular genres or types of texts (i.e., linear, plot-driven texts like the ones from literature that they tested) are similar across media because the cognitive processes around accessing and engaging with these texts may be the same. Because the texts were read on a Kindle device that was not hooked up to the internet, the affordances that we may think of as unique to digital environments, like hyperlinks, were not part of the reading experience, which likely also impacted the lack of significant difference in the results. The researchers also suggest further research that explores the affective dimensions of reading as well as the influence of device ownership and comfort with device usage to complicate the findings (Mangen et al., 2019).

The complex interplay of material affordances, readers' feelings toward particular texts, exposure to particular texts, and time spent with particular texts have been tested in other studies too. A group of researchers at the

University of Valencia (Delgado, Vargas, Ackerman, & Salmeron, 2018) conducted a meta-analysis of research on digital reading, collecting studies published between 2000 and 2017 that concern individual, silent reading of print text (i.e., text that does not take advantage of specific features of digital reading environments, like hyperlinks or web navigation). The researchers identified 54 studies that met their criteria, which included participants from a wide range of educational levels, spanning from elementary, middle, and high school to undergraduate students and graduates/professionals.

In this meta-analysis, Delgado et al. (2018) found that the outcomes of most studies showed that paper-based reading groups tended to demonstrate greater reading comprehension than digital-based reading groups, across different sample sizes and studies (p. 34). Their investigation found that some moderating factors had a significant effect on the studies' outcomes; for example, the advantage of paper-based reading for comprehension was significantly larger when a time limit for the reading task was imposed, whereas the advantage for paper-based reading was not as great when the reading was self-paced (Delgado et al., 2018, p. 34). The finding about pacing may have something to do with the expectations around the kind of reading that can happen within a time-limited task. Putting a time limit on a task may yield shallower or more superficial readings because the learner's expectations may be to absorb and then recall superficial facts quickly rather than to take the time to study or understand a concept deeply. This finding may also tell us something about the media students are conditioned to use to prepare for timed reading tasks.

One of the most important findings that Delgado et al. (2018) discovered was related to the increase in the screen

inferiority effect over the past 18 years; that is, younger readers struggled more than older readers to comprehend information from the screen than on paper, and the intensity of the struggle increased in more recent studies than in earlier ones (p. 34). Even with the increased presence of digital devices in classrooms for younger students, the ability to comprehend or navigate through a digital text is not improved by mere exposure. We likely did not need any more reasons to debunk the myth that digital natives will just be able to figure out how to navigate digital environments, but here is yet another evidence-based reason not to subscribe to the idea that students who have grown up around digital devices will necessarily know how to use them for comprehension-based reading tasks. The ways that digital reading tasks are framed is crucial, and we're clearly not doing a good enough job at any educational level.

Reader expectations around how to navigate what to read also factors into the trend that favors print-based reading. Delgado et al. (2018) noticed that the genre of the text affected the severity of the screen's inferiority too. For studies that used only narrative texts, rather than informative texts, to assess comprehension, there was no marked difference in how the media impacted readers' comprehension (p. 35). However, for studies that asked readers to comprehend informational texts, the screen proved to be more consistently an inferior option (Delgado et al., 2018). This particular finding has multiple implications: first, readers engaging with informational texts may need to develop different reading skills for different purposes. The act of engaging in passive reading, where information is simply taken in without much processing, analysis, or annotation, only works successfully for certain kinds of texts, like narratives, for remembering information.

This finding corroborates decades of reading research that students' abilities to remember information depend largely on their ability to navigate that information and the infrastructures or environments of which that information is necessarily a part (Rodrigue 2017b; Howard, Serviss, & Rodrigue, 2010). A second implication of this finding is about the design of informational texts on-screen. Specifically, texts where users tend to access information may be designed to replicate the spatial and organizational logic of a printed text, even though we know from user research that a reader's patterns of scanning information online often differ vastly from how a user engages with a printed text (Nielsen, 2006; Pernice, 2017). Although we cannot ascribe retention problems entirely to design, we want to take into account that different kinds of materials require different strategies for reading, as Mangen et al. (2019) also identified in their research.

Strikingly, clear trends about the superiority of print for retention tasks have emerged over the past twenty years of reading comprehension research. A reasonable conclusion to reach from these findings is that particular habits, behaviors, and attitudes toward reading contribute to the greater challenge that many students experience when engaging in reading for information recovery in digital environments. So, as educators, what can we do with this information?

We can't necessarily blame our smartphones, our laptops, or any of our other digital devices for cognitive change; we have to look at the cognitive strategies we can develop through social practice in combination with our biological hardwiring. Does that mean that developers of digital technologies are off the hook in terms of designing extractive and addictive devices? Not at all. In fact,

as consumers of digital devices, we should still work to resist the distractions built into the designs of technologies themselves where we can. But it does mean—and this should be reassuring!—that, from the perspective of brain science, we can control our reading destinies. And part of controlling that destiny might be naming the moves that are possible in digital reading processes.

An Outside Look: What Does Digital Reading Look Like in Practice?

In 1999, communications scholar James Sosnoski noticed that he increasingly read from screens, yet he found that his colleagues often preferred to read from printed-out copies. This observation prompted Sosnoski to reflect on theorizing the differences readers might experience when encountering text on-screen *and* understanding the pedagogical adaptations that may be necessary in response. He predicted that we would have "pocket computers" where reading would often be accessible and that, as educators, we needed a working pedagogical praxis to respond to this growing need (Sosnoski, 1999, p. 161–62). Sosnoski named several characteristics of hyperreading, from *filtering* through search engine results as a reading practice and *trespassing* on digital texts by copying, pasting, and remixing written content to *skimming* and *pecking* to locate keywords and concepts actively (p. 163). Sosnoski predicted the anxiety that we would lose the ability to read deeply in digital environments, and in response, suggested that he does not see hyperreading as a corrective or even a full-blown alternative that could replace print reading. Rather, he sees hyperreading as productively augmenting print

reading as multiple possible practices, creating a world where reading might take much more diverse and multiple forms (Sosnoski, 1999).

Hyperreading is a more visible practice in digital spaces, expanding our conception of what is possible, but it is also a practice that is applicable to print reading, where we can just as easily move quickly in, across, and around the vast number of texts that we may be able to access. In fact, semiotician Gunther Kress (2003) suggested that any theory of reading in digital spaces should be attentive to the multiplicity of possible reading practices. He argued that many of the practices that Sosnoski outlined, like skimming, are examples of what he calls a *reading path*. He contends that reading a page that is simply text may invite readers to start at the top-left corner, read across to the right, and then return to the left one line down. However, he suggests that texts that may include other pieces of information, like images, subheaders, and perhaps even the inclusion of audio, would invite readers to move in other pathways (Kress, 2003). Kress contends that, aside from the cultural difference that may dictate whether alphabetic text is read in a different direction (if, for example, alphabetic characters are to be read from right to left rather than from left to right), the ways that we navigate and manipulate reading pathways should be an individual choice born out of different goals and purposes. Kress expresses that concern with skimming, scanning, and other nonlinear reading pathways is born out of a "challenge to social power"; he goes on to suggest that on-screen texts open up new ways of representing information that may be more inclusive of nondominant perspectives (p. 160). In other words, Kress sees digital reading as opening up new meaning-making possibilities and inviting in new voices.

In user experience research, researchers have engaged in eye-tracking studies to see where web readers' attention gets focused when reading on-screen. Jakob Nielsen (2006) of the Nielsen Norman Group, a research-based user experience group, found, through using eye-tracking technology, that many people tend to scan web pages and phone screens in an F-shaped pattern. This pattern suggests that users first read in a horizontal movement, usually across the upper part of the content area, and then they move further down the page for yet another horizontal movement. But at the end of the reading process, readers have tended to read more vertically, scanning for information more quickly. Nielsen's study suggested that the first two paragraphs are the ones most heavily read by web readers and that the inclusion of subheads, paragraphs, and bullet points may catch users' attention when they are engaging in the F-shaped scanning behavior on-screen.

Sixteen years later, another researcher from the Nielsen Norman Group, Kara Pernice (2017), revisited Nielsen's eye-tracking research and discovered, yet again, that the F-shaped pattern is alive and well both for readers on laptop screens and on mobile phones. Yet Pernice's study complicates Nielsen's original research, as she and her team found that readers engage in a variety of other scanning patterns when reading on-screen, including the *layer-cake pattern*, which "occurs when the eyes scan readings and subheadings and skip the normal text below," the *spotted pattern*, which "consists of skipping big chunks of text and scanning as if looking for something specific," and even the *commitment pattern*, where readers do, in fact, fixate on almost everything on the page (Pernice, 2017). Pernice concludes that web design still influences how readers engage in reading and encourages

web designers and user experience specialists to adopt a number of strategies when developing text-heavy web pages, including using headings and visually grouping small amounts of related content together with different backgrounds or borders. However, Pernice complicates this conclusion by explaining how the variety of patterns her research team discovered in 2017 shows that users' scanning behaviors online are dictated not only by design, but by users' motivations and the goals they are trying to achieve via the page's content. Rather than relying on the F-shaped pattern for understanding how readers interpret web content, Pernice cautions writers and web designers to "optimize content and presentation" instead of "rely[ing] on the arbitrary words that people may fixate on when they scan in an F-shape" (Pernice, 2017). In other words, Pernice suggests that writers not worry too much about developing writing or design in a way that accommodates F-shape reading, but rather, that they design writing and web pages that are attuned to the goals and purposes of readers themselves.

As user experience designers have complicated hypotheses about hyperreading, educators remain concerned about what hyperreading patterns might mean for student learning. Even if these multiple pathways for reading exist, it can be challenging to decide when to employ these options or how to best leverage them for learning. With multiple choices for deploying reading options come multiple possible pedagogies, all of which must be chosen based on the larger learning goals and contexts. For example, Katherine Hayles (2010) grapples with the conversations on reading in digital spaces, from the neuroscientific evidence to anecdotes from educators, and reaches, in many ways, a similar conclusion to Sosnoski: we must think about how we

help students toggle between close reading, hyperreading, and an understanding of machinic or algorithmic reading that impacts what appears in our search engines. Applied linguist Julio Alves (2013) also worries that students who engage in hyperreading may be compelled to engage in fast information-finding, whereas accessing printed books in the library's stacks encourages the more purposeful and slow pursuit of information while also offering students incidental knowledge that fuels acts of creativity and discovery. Hyperreading as a practice, then, needs to be named as one practice that may accomplish certain reading goals while hindering others. Daniel Keller (2014) argues for the value, in fact, of breaking down the binary between slow and fast reading that often predominates conversations about what digital reading practice looks like. He suggests that fast digital reading, like Sosnoski's hyperreading, is not a problematic approach, and what we can explore is how digital reading can be viewed more on a continuum where we understand that "for certain purposes and audiences, slower rhetorics work well; for others, faster rhetorics would be more appropriate" (p. 96). In other words, even if hyperreading may feel like a temptation for students who may otherwise not be inspired to read deeply, we can help students understand the rhetoricity of their choices, and why they might choose one kind of reading practice over another in different situations and circumstances.

Janine Morris (2016) also makes a call for breaking down the binary between print and digital reading, between hyperreading and slow reading because "it ignores the incredible overlap between the reading strategies we use to read both print and digital texts" (p. 126). Just as Keller suggests

that instructors should help their students recognize when slower or faster rhetorics might be appropriate for reading different kinds of texts, Morris (2016) calls for instructors to help recognize the difference between the different kinds of texts that they encounter online. In other words, she argues that we should help students understand that reading a Tweet may call for a different way of reading than reading an online scholarly article (p. 127). Plus, Morris points out that hyperreading is not necessarily unique to digital environments; skimming and scanning documents quickly is possible in either printed or digital spaces, even as digital space may facilitate hyperreading practice (p. 128). When students note that this kind of practice can happen in a variety of spaces, their practices can get productively defamiliarized. That way, they have a broadened understanding of their options for reading both in print and in digital spaces. This might not necessarily change the results of the empirical findings; indeed, reading a narrative text on paper might still be the best way to get immersed in a really great story. However, what matters is being intentional in the choice—recognizing that our brains on books might adapt to our different circumstances when aligned with our particular goals and purposes.

Now that we understand a bit more about what digital reading looks like in the brain and in practice, we'll dig into the environmental and spatial conditions that make digital reading possible. After all, our bodies always affect what our brains process, remember, and retain. The more that we can understand how our bodies impact what our brains process, the easier it might be to understand the complexity of measuring the efficacy of reading in different environments.

Looking Inside and Outside: How Our Bodies and Brains Work Together to Help Us Learn

Cartesian logic posits that our bodies and our brains operate in separate domains from each other, meaning that what we do to and with our bodies has no effect on our intellectual capacity. Although Cartesian logic has long been debunked, many of the myths that Cartesian logic generated remain. I remember in graduate school that the advice I heard most often about writing was just to sit myself in a chair and stay there until ideas developed. Sound familiar to you too? Although there is something to be said for protecting mental time and energy when completing a project, the logic that stillness alone generates ideas was born out of a kind of modified Cartesian logic. How we use our bodies to generate intellectual thought is deeply personal; our experiences vary with our bodies' differences. It is just as fallacious to assume that sitting in a chair until ideas form will be helpful for everyone as it is to think that taking regular runs might be helpful for everyone. For most people, producing creative work or cultivating intellectual focus probably requires a variety of techniques within the ranges of stillness and activity (whatever that might look like for each individual reader and writer) precisely because the brain is not just an organ in our heads.

When we develop greater awareness of the diverse ways that our brains and bodies work together, we can work to avoid using language to describe reading that may malign certain behaviors as less valuable than others. As Deborah Wolter (2018) suggests, "Viewing people through a deficit lens leads to erroneous assumptions about their ability to learn language and literacy and unwittingly creates a

vicious cycle of opportunity gaps, which in turn, creates achievement gaps in our schools and employment gaps in our workplaces" (p. 107). When it comes to reading across print and digital spaces, then, we risk falling into the same kinds of opportunity gaps that Wolter describes, thereby excluding reading behaviors, experiences, and bodies.

Up until this point, we have been discussing cognition from what we might call *standard cognitive science*, a domain that philosopher Lawrence Shapiro (2011) explains tends to cover perception, memory, attention, language, problem solving, and learning via standard methodological practices, like reaction-time experiments, recall tasks, and dishabituation paradigms (p. 2). Embodied cognition builds upon some of these methods to explore how concepts like perception, memory, and attention, for example, are linked to embodied action, which broadens the methodological approaches with which standard cognitive science engages (p. 52). Understanding what *embodiment* is gets us into even deeper philosophical territory, but in short, we might understand embodiment as the experience of having a body with sensorimotor capacities and using those sensorimotor capacities to engage in psychological and cultural contexts (Shapiro, p. 52). Diving into the field of embodied cognition and all the complex work that it does falls outside the scope of this particular book, but scholars are still grappling with the full implications of examining the complex interplay of circumstances that may impact how people think and learn.

What we do know is that our brains are constantly communicating with every other part of our bodies to dictate how we experience the world: materially, physically, and, intellectually. Learning scientist Guy Claxton (2011) describes how, contrary to popular belief, the brain is not

dictating everything the body does, but rather, the body and brain work synergistically. He describes how the body is, in fact,

> like a medieval moot, a meeting that can reach a conclusion only by a process of respectful and attentive debate. A "moot point" is one to which there is no easy or obvious answer and which therefore has to be referred to the moot. Much of the work of the body does have routine solutions, so no brain-based conversation is needed. But—especially in complex social worlds—moot points continually arise, and for these the central conclave is essential (p. 81).

What Claxton's metaphor of the medieval moot illustrates is that all parts of our bodies work together continuously to regulate our experiences. Much of the misunderstanding about the connection between body and brain arises from some of the conditions that have, perhaps, made the concerns with digital reading so acute: that the experience of reading on-screen is so tied simply to visual stimulation that we may feel like the experience of reading is disembodied from holding a book in our hands, for example. Claxton also describes how touch is a critical component of how we make sense of the world and that anticipating what objects feel like allows us to generate "interwoven webs of expectation that link movement to sensation" (p. 58). The sensations of reading, the ways in which the tactile information of holding a book as object and feeling the weight and texture of pages, may, in fact, be linked to our anticipations of what engaging in reading as a cognitive process feels like. Once we divorce our expectations of those tactile sensations from the experience of reading, our bodies might expect something entirely different that may not fully prepare us for the cognitive task of reading.

Space itself impacts how we remember what we read and how we experience acts of reading. For example, researchers found that readers take longer to read sentences that describe greater spatial distance or a longer period of time. Willingham (2017) uses the example of reading a text about a soccer game to illustrate this complexity. Experts and novices alike would generally know that, in a text about a soccer game, the goal would be to track events to determine if the soccer team is going to win or lose since sports contests are about wins and losses. But a soccer expert probably has an even better idea of how to track these events than the novice and a clearer sense of what details might really matter to determine the team's success or loss. In Willingham's words: "Your situation model is colored by information outside of the text, namely other relevant knowledge from your memory. If that knowledge is missing, the situation model won't be the same" (p. 124). The body and brain, therefore, work together as in Claxton's moot court model, helping the reader process not only how they might imagine the physical experience of distance and space but also how their prior knowledge and experience with spaces might impact their orientation to and imagining of that space for themselves.

When it comes to remembering what you've written down too, the body and the brain also work together. Rhetorician Christina Haas (1996) studied how writers engaged with and remembered information from something they had written on a piece of paper in contrast to something they had written in a word processor. After observing the strategies that writers used to explain the structure of their texts, from pointing at their paper or screen to moving their materials to change their visual perspective on a text, she coined the term, *text sense* to describe

> the mental representation of the structure and meaning of a writer's own text. It is primarily propositional in content, but includes spatial and temporal aspects as well. Although text sense—as an internal construction—is distinct from the written textual artifact, it is tied intimately to that artifact. Text sense is constructed in tandem with the written text and seems to include both a spatial memory of the written text and an episodic memory of its construction (p. 118).

Haas (1996) found that writers had stronger text sense when they examined their writing on a sheet of paper because of the ways they could interact with the artifact of the papers themselves. Developing this stronger text sense also strengthened readers' working memories of the text, and Haas concludes that "it may be that these physical interactions provide a link—via bodily interactions—between the material tools and artifacts of text production and the mental processes and representations of writers" (1996, p. 133). Haas's research demonstrates that engagement in bodily interactions can help readers and writers make sense of one's body in tandem to one's practices as a way to develop working memory.

In fact, many writing and composition scholars have pointed out the ways in which writing practices are essentially corporeal and, therefore, embodied (Dolmage, 2014; Arola & Wysocki, 2012; Fleckenstein, 1999). Hannah Rule (2017) describes how she used a process of embodied simulation with her composition students to help students understand language through "visual, spatial, motor, affective, and other sensory modalities" (p. 21). Rule (2017) led students in guided visualization exercises, where students imagined how different sentences in passive and active

voice revealed and created different visions or understandings of action based on the sentence construction. For example, Rule offered a sentence—"Jim builds his daughter a sand castle at the beach"—and asked students to try and imagine the scene at the beach (p. 30). She then prompted students to think about who received *action* in this sentence, and she and her students quickly had a discussion about the relationships at play in the full scene, rather than focusing on abstract grammatical concepts, like direct and indirect objects. Rule (2017) found that "once [embodied] simulation becomes the baseline for understanding the work of sentences, new ways emerge to understand and act upon familiar writing concepts" (p. 31). Although not all instructors who engage with reading may necessarily want to unpack and embody grammar in the way that Rule advocates, her exercise demonstrates the tremendous power in offering embodied visualizations of sentences and ideas from text to help students gain understanding and recognition of concepts that might otherwise be challenging to understand in a disembodied act of reading.

Because so much of our experience of the world is tied to how we move through it, touch it, smell it, see it, and hear it, we need to acknowledge that bringing digital reading into our cognitive practice may require understanding how that sensory experience of reading on-screen may shape our understanding and processing of the information. Readers and writers alike may need to find ways to manipulate and take advantage of how a screen can alter the material conditions of a text through moves like changing the appearance of a font (from its size, spacing, and type face, to color) or having one's work read through a text-to-speech application. In fact, many disabled readers rely upon digital technologies, like screen readers and color contrast

modifiers, to help them engage in sustained ways with texts that enhance their embodied engagement to form deep reading pathways (Gierdowski & Galanek 2020). And as it turns out, everyone can benefit from using these same technologies for their own reading experiences. Although some components of text sense, like flipping pages or folding paper, may not be (and really shouldn't be) fully replicable on-screen, there may still be ways to develop active material engagement with digital reading. Digital reading practices have potential for capitalizing on the deeply intertwined body-brain relationship that is critical to processing complex ideas.

Regardless of how our bodies differ, most people experience interruptions and distractions within their embodied environments. How can our bodies and brains handle learning new information if we are trying to process lots of changes or ideas at once?

Losing Focus: Distractions and Multitasking

It might be weird to think about, but your brain is changing all the time. In fact, as you read this book, your brain is changing. Isn't that strange to imagine since we can't feel or see those changes? Remember that *neuroplasticity* is a tremendous property in human brains; it is what allows our brains to change pathways and shape faster than other animals' brains. Neuroplasticity is part of what makes humans so much more evolutionarily secure than other animals; we thrive because we have been able to adapt not just physically, but cognitively.

When it comes to learning, neuroplasticity should be good news since it is what allows us to learn and apply new

intellectual concepts quickly and to a variety of circumstances. What potentially makes something like neuroplasticity scary for educators, however, is that what our brains positively respond to does not entirely feel under our control. Yes, we can adapt to learn new things quickly. Yes, we can be flexible in our approaches to others. But we can also be subject to the whims of a brain evolutionarily conditioned to respond quickly to novelty and external stimuli. Our neuroplastic brains are not brains conditioned to respond to quiet and focus; they are brains conditioned to respond to noise, to light, to movement.

The dopamine rush we experience, for example, when we see notifications pop up or new messages populating our inboxes is a hardwired response to novelty and change. We may very well recognize our own patterns and experiences with the endless stimulation of scrolling through a social media newsfeed, reading interesting stories, and staring at amusing photos with no end. We know that we can't always control all of the environmental conditions that affect our ability to learn, and we can often feel powerless over them.

Our neuroplastic brains, and their desire to change in response to dopamine-inducing stimuli, also get purposefully manipulated through the addictive design of new technologies. According to writers like Adam Alter (2018) and psychologist Natasha Schüll (2014), developers of new apps know the tricks to keep our brains hooked to the tools that we use. That's good marketing and business, of course. Even developers of educational technology tools use similar strategies to try and keep us hooked and engaged with their applications or software. The language learning app, Duolingo, for example, activates our desire for novelty through notifications and small prizes and awards that learners can receive as they work through the learning modules and sections.

Duolingo's approach is known as *gamification*, and it's but one strategy developers use to hook people into apps and keep them there. Sometimes, gamification, as in the case of Duolingo, can be used for good. Other times, it can be used to keep people invested in unhealthy experiences.

When it comes to engaging with addictive technologies, we know that it's not always our fault. Again, we are hardwired to enjoy exciting, novel experiences. But the question of how these "addictive" experiences can change our ability to learn is an important one for us to grapple with, especially in light of thinking about how our brains constantly change anyway, and to a variety of stimuli, not just the addictive kind. In truth, it's challenging even for the most sophisticated neuroscientists to name exactly what the long-term consequences are of the constant changes our brain experiences. Changes can happen so quickly and in such undetected ways that measuring their effects can be challenging.

Instead, we have to pay attention to the internal signals that we have available to us and remain mindful, to the extent that we can, of how certain environments, conditions, and circumstances make us feel and how they affect our own abilities to understand what's happening in the world around us. So, how do we help our students recognize when they might be getting sucked into addictive and unhealthy engagements with their technology and also help them develop enough awareness of these responses so they can prevent them from happening?

One way that we might help students combat these engagements is by understanding that, whenever they set out to engage in a task, whether it's an academic task or not, they are likely switching between a variety of cognitive engagements. And when they switch to different forms of

cognitive engagement, they are conditioning themselves to respond and behave in particular kinds of ways. Educators Douglas Hartman and Paul Morsink (2015) explain that reading, whether it is on-screen or on paper, is yet another cognitive strategy, like solving a puzzle or calculating a mathematical operation, and the strategies we use for reading naturally mutate over time, depending upon the social and environmental conditions that may make way for reading to occur. In fact, reading strategies

> can and do coexist and thrive together, side by side in an ecosystem of many practices, many epistemic beliefs, many conceptions of literacy, and many purposes for reading. Coexistence is often peaceful or even symbiotic; however, some practices may also be in "competition" with others. In the latter situation, some practices will become more widely adopted and used while others may die out . . . The reading practices that prevail are simply better adapted for success in a particular environment, under particular conditions, when used for particular historically situated purposes (Hartman and Morsink, p. 82).

What is helpful about Hartman and Morsink's observation here is that digital reading may just be an evolutionary extension of reading's evolution over time. Reading on paper and reading on screens can potentially *coexist* as cognitive reading strategies and may, in fact, be symbiotic in terms of how the approaches can support and inform each other. Wolf (2018) offers similar language for encouraging us to see digital reading as yet another cognitive strategy: we have to become bilateral users of digital and paper technology in order to sustain our ability to read, and read well, in a variety of spaces. So, part of avoiding the feeling that we are being addicted to our technologies or that we're being sucked into

feelings outside of our control is recognizing when, how, and why we might shift between different forms of strategies and engagements.

But all of this talk of switching between different strategies and engagements may sound a little overwhelming to some readers. It also may evoke another cognitive process that we know we are wont to engage in when we read in digital spaces too: multitasking.

Multitasking has received a lot of attention in educational research because it is often cited as a reason why students should part ways from their digital devices when doing cognitively demanding tasks. *Multitasking* refers to switching between multiple, different tasks that are unrelated to each other. That might look like reading while playing a television program in the background or reading while responding to text messages at the same time. It may also take the form of reading while folding laundry or cooking dinner. The point is, multitasking refers to balancing two or more distinct tasks simultaneously. And we've known, for years, that multitasking means that no single task will ever get completed to full satisfaction or competence.

It is not news to say that multitasking is much easier to do when you are reading in the space of a digital device than reading a paperback book. After all, when you are reading a PDF in a software application or in a web browser, a notification can pop up in the upper-right corner of the screen that will then take you to your text messages, or to a social network, or to wherever else you receive notifications. When you are reading a document in the browser on your phone, you'll see text messages begin to stream in or a push notification from the *New York Times* app. There are a lot of tempting opportunities to veer away from the task at hand when switching between distinctly different tasks

is at your fingerprints. Plus, if you are moving between different sets of written materials, from an in-depth article to a text message to a Tweet, your ability to understand any of those texts will come at a significant cost to your learning. As Paul van den Broek and Panayiota Kendeou (2015) put it, "Switching between documents comes with a cost to attentional resources and hence jeopardizes the comprehender's ability to attend to related information simultaneously and, thereby, to infer meaningful connections" (p. 108). In other words, you might be able to dive more deeply into a reading when you are following a citation trail and remaining present in the idea that a particular reading presents, but if you are trying to process one reading assignment while you are attempting to read a news article or a friend's status update, your memory, comprehension, and analysis of the text will inevitably falter.

It should come as no surprise that many empirical studies have measured that students' abilities to perform successfully on exams are compromised by multitasking, which may include text messaging, taking cell phone calls, responding to instant messages, or browsing social networks (Froese et al., 2012; Burak, 2012; Harman and Sato, 2011; Smith, Isaak, Senette, & Abadie, 2011; Kirschner and Karpinski, 2010; Levine, Waite, & Bowman, 2007). In a controlled study, researchers at the University of Southern Maine (Thornton, Faires, Robbins, & Rollins, 2014) found that students engaged in tasks that required increased attention and focus were slowed down even by the mere presence of a cell phone, even if they were not using it to distract themselves from the task at hand (p. 485). These kinds of results are initially quite alarming, as they suggest that the presence of materials themselves can inhibit students from engaging fully with the content of their learning.

Some multitasking studies have been contested, in large part because it is challenging to measure what distraction might look like in the controlled environments within which empirical studies tend to take place. For example, Eyal Ophir, Clifford Nass, and Anthony Wagner (2009) found that users who engaged in chronic media multitasking, or a constant switching between tasks on different media devices, tend to privilege exploratory information processing rather than the attentional control of a single task (p. 15585). However, when Wisnu Wiradhany and Mark Nieuwenstein (2017) replicated Ophir et al.'s study, only three of their seven tests replicated Ophir et al.'s findings (p. 2629). In fact, they did not find that chronic media multitaskers were any more vulnerable to distraction than those focused on a single task (p. 2629). Wiradhany and Nieuwenstein went on to conduct a meta-analysis of other existing literature on media multitasking and distractibility and found that the links were also relatively insignificant (p. 2639). This work does not necessarily mean that media multitasking *isn't* a problem for all students (it is), but that we should take the findings from controlled studies with an understanding of their contexts and limitations.

Other kinds of reading behaviors, like task switching and background multitasking conditions, may also be valuable for us to examine to develop a more nuanced understanding of the different forms that reading can take. For example, Lin Workaday, Tip Robertson, and Jennifer Lee (2009) found that expert and intermediate-level readers actually performed better on reading comprehension exams when there were background multitasking conditions, which included reading with a video playing in the background (p. 179). Although having a video playing in the background while a student is reading is fundamentally a different

circumstance than multitasking proper, it is evidence that reading itself may not always look like silent concentration. To that end, Lin et. al (2009) contend that "it is possible that people perform better in an environment when they have more control and flexibility, and are more comfortable and confident. The media multitasking, therefore, becomes part of the individual comfort and control for learning and performance" (p. 182).

Researchers at Central Connecticut State University (Bowman, Levine, Waite, & Gendron, 2010) corroborated Lin et al.'s findings by exploring how a range of readers, from experts to novices, performed better on reading comprehension exams with varying levels of distraction during their reading process. They found that, although students took longer to read a text while they were being instant messaged, their performance on a test measuring comprehension of the reading did not suffer as a result (p. 932). What this suggests is not that engaging in instant messaging while reading is necessarily recommended, but that students can task switch without significantly impairing comprehension outcomes. Of course, as Bowman et al. (2010) caution, the lengthened time that students take to engage in the reading task while distracted suggests that significant costs to engaging in distractions while attempting to read remain. Multitasking itself remains a cognitively inferior approach, but students' agency over constructing their reading environment matters.

When students develop the agency to question, consider, and critique their means of learning, they tend to engage in deeper academic performances. In 2017, Maura Smale and Mariana Regaldo conducted surveys and interviews with students within the CUNY system and discovered that the students who earned the highest grades and felt

the most connected to their academic work were also those who constructed holistic views of what Smale and Regaldo call their *academic taskscapes*. These academic taskscapes refer to choices around which devices students used to complete their schoolwork and when they used those devices. Smale and Regaldo concluded that "their holistic view of their taskscapes led them to make decisions about when and where to study that took into account the advantages and constraints of different locations and times" (p. 74). Encouraging students to develop the agency to make choices about where, when, and how they engage in academic work is critical to helping students foster metacognitive awareness of their learning.

In sum, we must be careful not to appropriate multitasking research to adopt a one-size-fits-all pedagogy toward our students' various reading practices. As Keller (2014) explains, "If we accept popular conceptions of attention and multitasking, instead of pursuing a more sophisticated understanding of the phenomenon, our perceptions of students' technology use may lead to ineffective pedagogy" (p. 103). Research on the reading brain has real, concrete implications for our students, and, at times, it may not be relevant to the work that we are trying to do.

It may seem simple to say that understanding the brain science of reading is as easy as understanding what helps people concentrate, retain knowledge, and analyze a text for the purposes of comprehension and engagement. However, the more that we unpack this statement, the more complicated we realize it is, as our ways of concentrating, retaining knowledge, analyzing, and comprehending texts may differ dramatically based on the social, environmental, and individual conditions that we find impact our brains. Our brains change and are impacted by the conditions around

us, but not necessarily in the same ways. We cannot assume that one set of practices, one set of habits, or one set of styles will always help all people learn.

Consequences: What Does This Mean for Teaching and Learning?

I'd like to briefly acknowledge the very valid worries that we might have about the consequences of constant engagement with and access to digital reading as a cognitive strategy. After all, at this point in the chapter, you might be starting to wonder how we maintain our awareness of our environments and our shifting concerns with the affordances and limitations of those environments at all times. This awareness requires immense maturity and metacognitive development. Journalist Michael Harris (2014), in his book *The End of Absence*, describes how exhausting it is to become "responsible for the media diets of our children in a way that past generations never were. Since our children are privy to a superabundance of media, we now need to proactively engineer moments of absence for them. We cannot afford to count on accidental absence any more than we can count on accidental veggies at dinner" (39). Harris worries, then, that if adults do not manufacture moments of absence or disconnection from devices for children, they may not stumble into those moments quite as readily and may, instead, remain online, hooked to digital screens and devices without ever unplugging or accessing the range of options that both printed and digital reading make available to them.

The response to this concern brings us back to understanding that our brains and our bodies are connected. Yes, our brains absolutely are going to be altered when our necks

are craned downward to stare at our phones all the time. Yes, our brains will absolutely be changed if we spend all of our waking hours curled over a keyboard at our desks. So, regulating reading habits is about drawing awareness to these activities. When we can help students to access and find themselves in different physical environments as often as possible, we can make space for the different kinds of intellectual experiences that reading across both printed and digital spaces may afford them.

Reminding students of reading's purpose and how our embodied experiences of reading may impact our purposes may also be a helpful practice. Broadly speaking, when we read, why are we reading? Who are we reading for? What work do we want reading to do for us? When we are able to answer these questions for ourselves, we can develop an even clearer sense of what tools—and their affordances and limitations—can do for us. Recognizing our purposes cannot always be the answer to curtailing feelings of being addicted to our technologies, but it can, at least, help us recognize why we're engaging in particular behaviors.

Equipped with our understanding of the attitudes, histories, and science that impact why and how we read, we can now consider how we bring these perspectives into our classroom. What does it look like to bring what we know into pedagogical spaces? That's what we explore in the second part of this book as we consider how to apply a digital reading framework to the ways that we engage our students in reading experiences.