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CHAPTER 3

LITERARY NEUROSCIENCE AND HISTORY OF MIND

An Interdisciplinary fMRI Study of Attention and Jane Austen

NATALIE M. PHILLIPS

I.

JANE Austen's *Persuasion* (1818) begins with a distinctive scene of absorption. We find Sir Walter Elliot lost in the Baronetage, raptly reading the story of his ancestry:

> Sir Walter Elliot, of Kellynch Hall, in Somersetshire, was a man who, for his own amusement, never took up any book but the Baronetage; there he found occupation for an idle hour, and consolation in a distressed one... [and] there, if every other leaf were powerless, he could read his own history with an interest which never failed. This was the page at which the favourite volume always opened:
>
> ELLIOT OF KELLYNCH HALL[1]

Austen was deeply interested in the different degrees of focus one could bring to a book. As early as *Catherine of the Bower* (1792), we find the young writer comparing her heroine, "a great reader" of lengthy novels who remembers precise details about plot and scenery to Camilla Stanley, a young woman who has "missed them all" and complains her friend's favorite novel "is *so long*."[2] By *Pride and Prejudice* (1813), Austen has begun crafting complex webs of such comparisons—what Alex Woloch calls "character-systems"—framed around contrasting characters' habits of attention.[3] Mr. Bennet is "with a book... regardless of time," while Elizabeth reads even as she sustains an acute awareness of her social environment.[4] Mary is inevitably engrossed, "deep in the study of thorough-bass and human nature"; Lydia has an attention span of "half a minute."[5]

Austen's curiosity about different styles of concentration grew out of a larger fascination with focus during the eighteenth century, the topic of my current book project, *Distraction*.

It offers a literary history of the attentive and inattentive mind between 1700 and 1830, tracing key debates over concentration in modern neuroscience back to their Enlightenment roots. This essay will focus on an interdisciplinary experiment in neuroscience that emerged alongside my historical research. Our study used functional magnetic resonance imaging (fMRI), a technology for acquiring brain images of neural activity, to explore the cognitive patterns that emerge when we read a literary work with different kinds of focus.

Talking about both projects lets me put two key subfields in cognitive literary studies—the history of mind and the neuroscience of reading—in conversation to discuss a topic central to both: the nature of attention. As I will suggest, the style and degree of focus we bring to a work of art (be it a novel, a poem, a piece of music, a play, a painting, or a film) can radically change our engagement with it, not only at the level of subjective aesthetic experience, but at the level of cognition, expressed through unique patterns of neural activation. Discussing our fMRI study alongside distraction's eighteenth-century history, moreover, allows me to address two key methodological challenges in cognitive approaches to literature: (1) how to appreciate historical and cultural context more richly in scientifically informed literary scholarship; and (2) how to maintain ongoing reciprocity in the exchange between cognitive science and literary studies.

As I explain our experiment and early results, my chapter also traces points of connection and productive conflict between the history of distraction and the neuroscience of attention. Though our study draws on contemporary technologies for brain imaging, thinking about different levels of attention in reading was a profoundly eighteenth-century concern. According to Robert DeMaria, Samuel Johnson spent much of his life mapping out the distinctive modes of focus we bring to a book, distinguishing between study—or what he called "hard reading"—and reading for pleasure, which included light "perusal," "curious reading," and "mere reading."[6] The fact that I turn to Johnson and Austen to historicize an fMRI study on attention embodies what, for me, is the most interesting part of bringing together research in history of mind and literary neuroscience. As Jonathan Kramnick notes, cognitive literary studies can risk a unidirectional model of interdisciplinary scholarship. Despite "all the excitement... generated," Kramnick contends, cognitive approaches to literature often involve "one-way application[s] of work from the sciences to the humanities."[7] Here, I join a group of cognitive critics seeking to develop more reciprocal models of cross-field exchange, working to create a powerful balance of literary-historical and cognitive methodologies in the emerging field of literary neuroscience.

On a concrete level, working simultaneously on a literary-historical book about distraction and a neuroscientific study of attention enriched both projects. Reading cognitive studies of attention while researching eighteenth-century theories of concentration helped me see crucial subtleties in the period's literature that would have been obscured using traditional frameworks for understanding the Enlightenment mind, such as associationism or sensationalism. Working on distraction's eighteenth-century history, in turn, generated new questions for neuroscientific research. For much of the eighteenth century, writers defined attention as a voluntary stretch or reach of mind, an act of will or effort. Being immersed in these historical models of concentration helped to produce an experiment that departed in important ways from previous cognitive studies of focus. Whereas past experiments tended to separate attention studies and the neuroscience of reading, our fMRI study integrated them, investigating the levels of concentration we could *bring* to a book.

Finally, our group was organized in a way that facilitated richer interplay and exchange between humanities and sciences. The experiment brought together an interdisciplinary group of literary critics, neuroscientists, and experts in MRI to explore the cognitive dynamics of reading. At the beginning, one of my collaborators noted, we were all "working at the edge of our capacity just to understand even 30% of what each other were saying."[8] One of my favorite moments in the process, however, was when our group—three humanists and two scientists—met one evening to discuss the project. Something happened: the literary critics got excited about experimental variables; the scientists started waxing poetic about Jane Austen's style. Now, this kind of crosstalk has become part of our everyday lives. This opening exchange across disciplines has become integral to our fMRI's structure of collaboration as well as our ongoing data analysis. I (a literature professor) am the primary investigator, or PI, with Bob Dougherty (research director at the Stanford Center for Cognitive and Neurobiological Imaging) as co-PI. I believe such interdisciplinary frameworks have the power to create more reciprocity in cognitive literary studies. Neuroscientific tools can provide humanists with a richer picture of how our minds engage with art—or, in our case, the cognitive complexity of literary reading. Work in literature, music, history, art, and so on, can add a crucial qualitative element as well as cultural-historical dimensionality to experiments in neuroscience.

II.

Our experiment on Jane Austen used fMRI and fMRI-compatible eye tracking to explore cognitive differences between two modes of literary attention: pleasure reading and close reading. We defined pleasure reading as a more relaxed mode of focus that allowed readers to become immersed in a novel. Melanie Green, a leading cognitive theorist of absorption, describes this feeling of being lost in a good book as a "melding of attention, imagery, and emotion" where a reader is deeply "focused on story events" and often "los[es] track of time" while absorbed in the "story unfolding before them."[9] Literary close reading, by contrast, asks us to look more rigorously at a novel's form, analyzing structures such as plot, characterization, setting, voice, and mood that give that work its narrative power. As Elaine Showalter argues, close reading means self-consciously adjusting the pace of our narrative engagement. She calls close reading "slow reading,"

> a deliberate attempt to detach ourselves from the magical power of story-telling and pay attention to language, imagery, allusion, intertextuality, syntax, and form. . .. In a sense, close reading is a form of defamiliarization we use in order to break through our habitual and casual reading practices. It forces us to be active rather than passive consumers of the text.[10]

Close reading, here, is carefully distinguished from pleasure reading. In practice, however, the two often intermix. John Guillory argues that both modes of focus "are to be

found at the scene of humanist reading, which required the scholar to slow down or speed up at different moments, for different purposes."[11] We were particularly interested in the cognitive patterns that emerge alongside these shifts; as we will see, readers do far more than speed up or slow down.

In our experiment, we asked subjects—Ph.D. candidates highly trained in literary analysis—to switch between close reading and pleasure reading as they read a novel by Jane Austen. (In our pilot study, it was *Persuasion*. For the final experiment, we chose *Mansfield Park*). To cue reading for pleasure, we asked our subjects to read "as you normally would... as though you just picked up this book off the bookshelf, and are reading in your favorite place." For close reading, we prompted them to read as if they were preparing a formal literary essay, "[paying] attention to how the story's structure is constructed, or crafted, noticing literary details such as setting, narration, tone and characterization... [as well as] literary themes and patterns, word choice, syntax and the order in which sentences and ideas unfold." By investigating the cognitive changes that emerge when we actively direct our attention to literary structure, our experiment thus seeks to illuminates an element of close reading that often goes unnoticed. While many still define close reading as a formalist technique, or as an act of writing, our experiment calls attention to the modulations of focus in reading that *precede* essay writing. We define close reading not merely as an act of interpretation, but as a style of focus—a mode of noticing details about literary form—that serves as a springboard for later analysis, writing, and criticism.

Asking people to move between these two modes of reading, moreover, allowed us to explore the neural complexity of a core skill trained in the English classroom. "Teaching literature," writes Barbara Johnson, "is teaching [students] how to read. How to notice things in a text that a speed-reading culture is trained to disregard, overcome, edit out, or explain away."[12] By taking literary Ph.D. candidates as our subjects, we also tapped a contemporary debate currently raging over the value of humanistic training. While our data analysis remains at an early stage, preliminary results show unexpectedly widespread changes in brain activity when subjects moved between close reading and pleasure reading, pointing toward the cognitive complexity of this core skill in the liberal arts.

III.

To understand these early results, it's easiest to go through the study step by step and explain the technologies we used. fMRI gives us a dynamic picture of blood flow in the brain—basically, where neurons (which need oxygenation) are firing, and when. As neuroscientist Scott Huettel explains, fMRI lets us "characteriz[e] the patterns of brain activation associated with [cognitive] processes" and build intricate "maps that link brain activation to mental function," locating these regions noninvasively with high spatial specificity.[13] Our study also incorporated fMRI-compatible eye tracking, a technology that visualizes how subjects' eyes are moving as they read.[14] We can thus track patterns of visual attention, including saccades (micro-jumps the eye makes in reading),

fixation points, and moments when people speed up, linger, or slow down. As the data analysis progresses, we will correlate this information from the eye tracking with the brain activations to provide a more detailed picture of attention and reading over time.

Our project brought together 30 Ph.D. candidates in English and Comparative Literature from Stanford, Berkeley, and San Jose State (12 in the pilot, and 18 in the final study). Because our focus was on differences between close reading and pleasure reading, we chose a population that we knew could do both reliably. First, students read the opening chapter of *Mansfield Park* outside the scanner and recorded the time it took them from start to finish (fig. 3.1). This not only gave us a sense of how fast subjects were reading, but also gave participants a chance to get used to Jane Austen's style before the official experiment began.

Next, the students went into the MRI scanner (fig. 3.2). Lying on their back, they read the entire second chapter of *Mansfield Park* as we gathered data about brain activation,

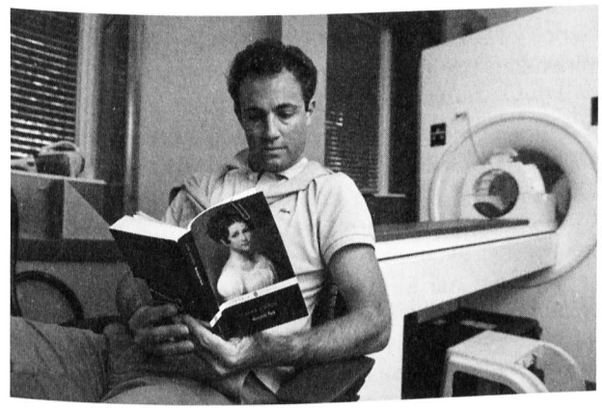

FIGURE 3.1 A subject reads the first chapter of *Mansfield Park* outside the scanner

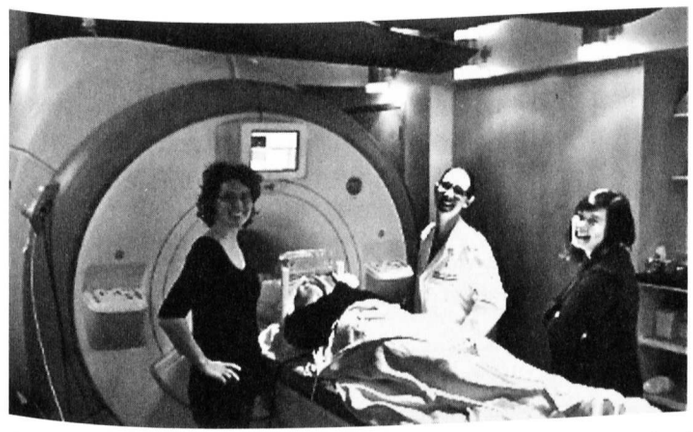

FIGURE 3.2 A student enters the MRI scanner to read a chapter of *Persuasion* in our pilot. Participants read a digital version of the text through a mirror above their eyes, which reflects the text on a screen at the back of the scanner.

recorded eye movements, and monitored heart rate and respiration. Each subject moved through the text at his or her own speed, paragraph by paragraph, pushing a button in his or her hand when ready for the next bit of text.

Each subject completed two sections of pleasure reading and two sections of close reading, alternating between these modes as they read Chapter two. Each block (about eight paragraphs) was preceded by a set of instructions, which told them when to read for pleasure or to close read. The color of the box surrounding the text alerted participants when to move into the next style of attention (fig 3.3): pleasure reading or close reading.

> The little girl performed her long journey in safety; and at Northampton was met by Mrs. Norris, who thus regaled in the credit of being foremost to welcome her, and in the importance of leading her in to the others, and recommending her to their kindnesss.
>
> Fanny Price was at this time just ten years old, and though there might not be much in her first appearance to captivate, there was, atleast, nothing to disgust her relations. She was small of her age, with no glow of complexion, nor any other striking beauty; exceedingly timid and shy, and shrinking from notice; but her air, though awkward, was not vulgar, her voice was sweet, and when she spoke her countenance was pretty.

> The grandeur of the house astonished, but could not console her. The rooms were too large for her to move in with ease: whatever she touched she expected to injure, and she crept about in constant terror of something or other; often retreating towards her own chamber to cry; and the little girl who was spoken of in the drawing-room when she left it at night as seeming so desirably sensible of her peculiar good fortune, ended every day's sorrows by sobbing herself to sleep. A week had passed in this way, and no suspicion of it conveyed by her quiet passive manner, when she was found one morning by her cousin Edmund, the youngest of the sons, sitting crying on the attic stairs.

FIGURE 3.3 Two sample paragraphs, or "chunks" from *Mansfield Park* marked for pleasure reading or close reading. In the experiment, these sections were continuous, the text-box marked for pleasure reading in green or close reading in red. We sustained this color-coding for all sections of the text to follow, providing subjects with a subtle memory prompt as they moved sequentially through the chapter.

At the end, the students left the scanner and drafted a short essay on the sections they read closely. They also completed a survey on narrative transport (Green's Transportation Scale, 2000) and answered questions about their fiction-reading practices, their relative ease of close reading and pleasure reading in the scanner, and their previous exposure to and present taste for Jane Austen.[15]

We chose Austen because we needed a literary work that could both invite pleasure reading and sustain literary analysis. While we started with *Persuasion* in the pilot study, we chose *Mansfield Park* for the final experiment because the latter is the least frequently read, providing the highest chance of an unbiased engagement.[16] To randomize the study, we alternated the sections marked for close reading and pleasure reading. We thus verified that changes in blood flow came primarily from the focus students *brought* to the text, not from specific sections of the novel—that is, particular linguistic, stylistic, or narrative details that caught readers' attention.

Data analysis is in progress, but the study's early results have far surpassed expectations. In both our pilot and the final experiment, individuals are demonstrating strong cognitive differences between close reading and pleasure reading—more significant and widespread differences than expected. Quite reasonably, most neuroscientists had predicted we would see changes only in specific, local regions associated with directed attention, if changes in blood flow were visible at all. Their rationale was that the stimulus presented remained stable; everyone was reading the same thing, a novel by Austen. They were simply reading it in two different ways. Thus, the biggest surprise to date has been the following: blood flow seems to be transforming dramatically across the brain as subjects move between close and pleasure reading. Close reading, in particular, activates diverse—almost global—regions, reaching areas far beyond those associated with attention and executive functions.

Though one might have expected the activation of pleasure centers for relaxed reading, and areas associated with attention and cognitive load engaged during literary analysis, what we are actually seeing in the scans is a far more complex picture. As we can see in figure 3.4, the images for close reading—cross-sections of one subject's brain—demonstrate truly widespread changes for literary analysis. Since blood is always moving through the brain and fMRI tracks neuronal activity via blood flow, fMRI images do not depict areas of activation in general, that is, places where things "light up" Instead, activated regions always show us results in comparison—that is, places where there is not just more neuronal activity, but a significant rise in average blood flow *as compared to* another cognitive state. Figure 3.4 shows brain regions with increased activity for close reading as compared to pleasure reading, a contrast with striking breadth.

Examining an individual case can help explain what is so intriguing about these early results.[17] During close reading, the participant shown in figure 3.5 activates unexpected regions of the brain (lighter shading), including the somatosensory cortex, an area we engage to place ourselves spatially in the world, and the motor

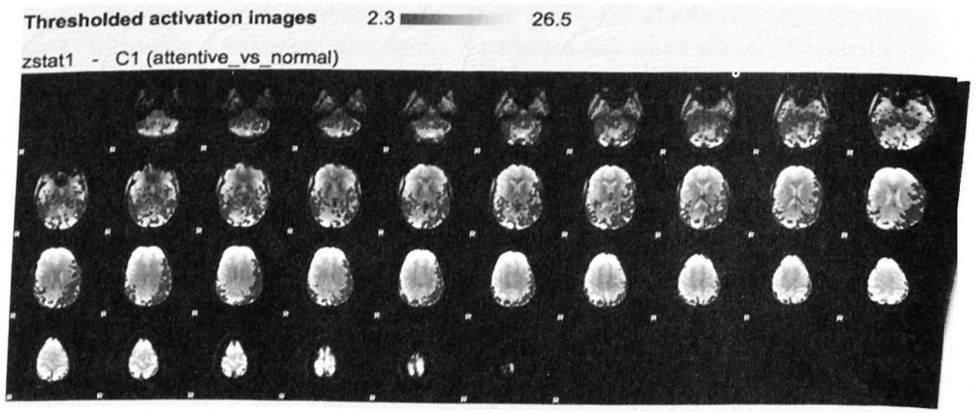

FIGURE 3.4 This subject (s4) demonstrates widespread activity across multiple regions of the brain while close reading *Mansfield Park*. This image depicts areas of increased blood flow across horizontal axial slices from the top of the brain to its base. Regions in darker gray represent statistically significant areas of increased blood flow for all sections of close reading as compared to pleasure reading.

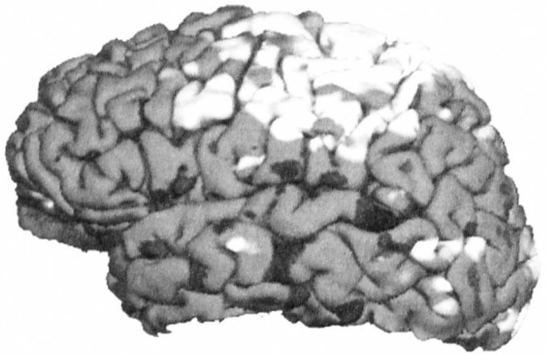

FIGURE 3.5 A brain image of a single subject (s4) from our pilot study of *Persuasion* that shows close reading and pleasure reading activating a number of distinct brain regions. Sections of the brain (in white) represent regions of heightened activity for close reading, while darker regions (in black) identify increased neural activity for pleasure reading. See note on interpreting individual results.

cortex, a region dedicated to physical activity. Our results, however, revealed yet another layer. It is not just the heightened attention of close reading that activates widespread response in the brain; this participant, like many, *also* displays regions of activity for pleasure reading (darker shading) that are elevated in comparison to close reading. For this participant, pleasure reading activates a number of distinctive regions, including portions of the temporal cortex associated with language processing (fig 3.5).

These early results clearly suggest that close reading does not merely describe an elevated attention to literature, with pleasure reading a "lesser" mode of focus—or, as Showalter put it, "active" versus "passive" reading. Instead, each style of literary engagement has its own cognitive demands and produces its own neural patterns. Pleasure reading and close reading activate overlapping, but distinctive, sets of brain regions to create what cognitive scientists call discrete "neural signatures." Most importantly, though close reading stimulates a truly broad set of regions, the best scenario for activating the most parts of our brain would be to sustain cognitive flexibility and read with both kinds of attention.

Cross-group analysis is necessary to finalize our results; yet current data analysis already shows trends that emphasize the complexity and value of attention in literary study. Scholars have long spoken about the value of the humanities—about reading difficult philosophical and literary texts—as a way to develop critical thought. If these trends in analysis hold, the results will suggest something more: it is not only the books we read, but thinking rigorously *about* them that is of value, with literary study engaging diverse regions across the brain. Indeed, teaching close reading may train us to move more flexibly between modes of focus. Finally, distinguishing these styles of attention means something more difficult than simply demarcating between relaxed and studious reading. Not only does reading move through a spectrum of intensities, but pleasure reading has its own cognitive demands; close reading, its own pleasures.

IV.

"Always historicize!" Lisa Zunshine urges in *Why We Read Fiction*, citing Frederick Jameson.[18] Yet when, where, and how to do so remains an open question in cognitive literary studies. One of the key conversations in our field over the last five years has thus revolved around the idea of "cognitive historicism."[19] Thinking through connections between our fMRI experiment and the history of distraction has led me to support and develop models of cognitive historicism that emphasize reciprocity between literary history and neuroscience, particularly when considering historical applications of contemporary cognitive studies. To present our experiment to interdisciplinary audiences, I discuss Austen's representations of attention (and their historical context), and I use her novel's complexity to suggest new solutions in neuroscience for testing natural reading in the scanner. Yet I also emphasize the challenges of applying our study to Austen's original readers, using examples from eighteenth-century pedagogy and the history of the book to illuminate key differences between these historical audiences and those of today. I find such moments of dissonance between literary and scientific methods valuable, able to create a more nuanced view of attention in both fields.

Exploring the cultural factors that shaped the focus of eighteenth- and nineteenth-century readers raised a series of important questions regarding how best to historicize neuroscience. One of the first questions I think we need to ask is: what kind of—and which—neuroscientific studies can be most reliably applied backwards? Certain

cognitive structures have been shown to be more stable than others. In *Reading in the Brain*, for instance, Stanislas Dehaene has shown that brain regions associated with reading—in particular, with dyslexia—remain remarkably consistent across languages and cultures.[20] Attention, however, is distinctive from reading as a cognitive faculty, and possesses a more flexible neurobiology.[21] As scientist L. D. Selemon explains, the regions associated with attention—particularly the prefrontal cortex, or PFC—is "the last brain region to mature," with "adolescent brain maturation. . . characterized by the emergence of executive function," or higher-order attentional networks.[22] Unlike the brain's visual systems for reading, which develop early and thus are more likely to remain stable in various cultures and contexts, the environmental stimuli impacting attention continue to shape the brain well into our teenage years. Because the brain develops different faculties at different ages, and different cognitive regions range in plasticity, it makes sense that not all neuroscientific studies will be equally historically applicable.

Studying attention requires us to delve more deeply into history and culture; not only does it develop later into life, its central function is to link mind and world. Environment shapes focus, producing habits of concentration that shape the connections and neural networks involved in attention, as well as how and what we focus on in future situations.[23] Certain cognitive limits on focus, such as inherent limitations on the number of items we can attend to and actively process, are likely more stable, determining what elements (and how much) of our surroundings we take in.[24] Still, in thinking about our fMRI study, the historical conditions surrounding reading and focus in Austen's day have changed radically—practices for teaching literacy, what and how often people read, and what they were trained to pay attention to—in ways that would influence neural pathways before the brain's executive functions have developed fully. [25]

Changing historical beliefs about mental states may also impact how individuals experience cognition. As Lorraine Daston and Katherine Park note in their history of wonder and curiosity from 1150 to 1750, "the felt substance of an emotion depends to a significant degree on the company it keeps."[26] Classical and early modern authors, they show, linked wonder to "reverence," praising it as the height of philosophical inquiry; simultaneously, curiosity was degraded and associated with "lust and pride." By the eighteenth century, however, this cognitive hierarchy had flipped. Enlightenment writers cast curiosity as the spur of scientific advancement while wonder "migrated to the pole of dull stupor."[27] In such moments of shifting meaning, Daston and Park argue, not only the definition but the subjective experience of these mental states changed:

> What might be called the dynamic of an emotion changes with its neighbors—not beyond all recognition, but enough to create new possibilities for the objects and attitudes that give an emotion outlet and outline. . .. Early modern curiosity was not simply Augustinian curiosity with a reversed moral charge; its emotional texture had also been altered.[28]

Ideas about a state of mind—in our case, eighteenth-century theories of attention—influence emotion, and thus cognition.

The Enlightenment was a period fascinated by rapt engagement, a preoccupation with absorption so deep that Michael Fried calls it "a master trope" of the eighteenth century.[29] In *The Rise of the Novel*, Ian Watt argues that eighteenth-century print in fact allowed for a new kind of narrative immersion: "Mechanically produced. . . letters," he claims, "can be read much more automatically: ceasing to be conscious of the printed page. . . we surrender ourselves entirely to the. . . world which the printed novel describes."[30] Writers of the period vacillated between praising and deriding this phenomenon of becoming lost in fiction. Isaac Watts, for instance, criticized pleasure reading. He claimed such readers "skim'd over the Pages like a Swallow over the flowry Meads in May" and thus missed key "Advances in the Pursuit of Truth" garnered by those who could "undergo the Fatigue" of study.[31] Jane Austen, by contrast, satirized such dismissive views of pleasure reading.[32] In *Northanger Abbey*, she criticizes novelists who refuse to show their heroines fiction-reading or apologize for them when caught: "I am no novel-reader—I seldom look into novels—Do not imagine that *I* often read novels," her narrator quips. "Such is the common cant." Reading novels for pleasure, in Austen, is a subversive (and implicitly valuable) engagement. Her heroines enjoy fiction, a genre she claims is able to convey "the greatest powers of the mind."[33]

Such Enlightenment discussions about attention and reading had a deep influence on our study as it emerged. The earliest experiment design, in fact, grew out of conversations with Franco Moretti that were as much about the history of reading as about cognition. They revolved, to a large part, around book historian Rolf Engelsing's claim that eighteenth century experienced a "reading revolution," in which shifts in literacy and book buying around the 1750s radically altered reading practices. Before the Enlightenment, supposedly, "intensive" reading was the norm, involving close repetitive readings of the few (often sacred) works families owned, such as the Bible. During the eighteenth century, however, rising literacy and decreasing publication costs gave people access to a far wider range of texts. The public, practicing what he calls "extensive reading," raced from one book to the next, skimming, devouring, and discarding numerous works in an increasingly ephemeral print culture.[34] Thinking about the complex historical phenomena behind Engelsing's binaries ("intensive" and "extensive reading") was particularly valuable; it started to illuminate—from a humanist perspective—the very range of reading styles we wanted to investigate in our fMRI study.

Our historical engagement with such questions encouraged us to take a new approach to cognitive studies of focus. Most previous experiments on attention explored the neural challenges presented by a stimulus: usually, a series of shapes to look at, sounds to listen to, or individual words to read. By necessity, few researchers tackled more than a word, phrase, or sentence. Core experiments in the field thus included: (1) the Stroop test of directed attention (in which the word "green," for instance, appears in red and subjects are asked to focus on either the color or the meaning);[35] (2) tests of "reading span" and working memory (where participants focus on the final word in a series and are tested on how well they remember these terms as the reading task becomes more difficult);[36] and (3) linguistic studies of cognitive load (experiments that explore sentence structures more likely to tax or capture focus, either through difficult vocabulary, syntactic density,

or unexpected phrase arrangements).[37] While the Stroop test isolated the ability to direct attention to one thing (color) as opposed to something else (content), and tests of working memory and cognitive load explored what might stress or ease attention, none of them examined the attention we actually bring to reading, especially not to a complex literary text. Our study is one the first to use fMRI to explore how the brain responds to literature, as well as one of the first experiments to investigate our cognitive responses to reading an actual novel—here, a full chapter by Jane Austen.[38] This more natural reading task allowed us to investigate more subtle modulations of focus, something difficult (indeed, impossible) to explore in experiments based on single words or phrases.[39] In the process, our work seeks to make a broader contribution to the neuroscience of reading by revealing the importance of how we concentrate. Dehaene describes the neural networks involved in reading as a web of "bi-directional. . . cortical connectivity," which activate not only expected regions (Broca's area, Wernicke's area, the visual cortex) but also more extended webs (the anterior temporal, the anterior fusiform, and the inferior frontal regions) that work together to link meaning, pronunciation, and articulation.[40] Investigating the brain regions involved in different degrees of focus, our study aims to reveal a still broader network of connectivity, pointing toward the wide system of neural exchanges involved in reading literary works.

Furthermore, returning to the eighteenth-century history of focus discouraged us from embracing a traditional positivist view of distraction as solely a condition of modernity. Complaints about audiences' decreasing attention spans, increasing multitasking, and diverted minds already concerned writers of the Enlightenment. Eighteenth-century poets and artists from Swift to Hogarth describe reading in London as occurring in an environment of high cacophony: chamber pots sloshing, street-noises and hubbub, wailing street criers "screeching" to advertise their wares.[41] Gay's *Trivia* describes London's street noise, for instance, as a surreal mixture of industrial and vocal tumult: "Now Industry awakes her busy Sons, / Full charg'd with News the breathless Hawker runs: / Shops open, Coaches roll, Carts shake the Ground, / And all the Streets with passing Cries resound."[42] In addition to these environmental factors, Enlightenment authors also worried deeply about the toll print overload was taking on audiences' focus. In *The Dunciad* of 1729, Alexander Pope describes a world in which "paper also became so cheap, and printers so numerous, that a deluge of Authors covered the land."[43] Samuel Johnson and Eliza Haywood similarly imagine that, even for short essays, readers will only "look into the first pages" before losing focus altogether.[44] This historical context discourages any false nostalgia about an idyllic past of easy attention and encourages a richer view of distraction: both ever present and culturally fluid.

Attention's complex Enlightenment history returns us to the methodological questions raised when considering historical applications of neuroscientific studies. As we know from research on neural plasticity, habits of concentration are both cognitively hard-wired and learned. According to Ira Black, "plasticity, the collective mechanisms underlying brain adaptability, emerges at multiple levels of the neuraxis" and includes "the genesis of new neurons and glia throughout life."[45] The brain, that is, is capable of generating new neural connections, as well as new growth, new cerebral tissue, and new

myelination. While attention has clear cognitive limits, the brain regions associated with focus are also unusually environmentally sensitive, which requires increased caution for using our experiment to think about the attention of historical readers. Brain images of Ph.D. students reading *Persuasion* or *Mansfield Park* today would differ in important ways from those of nineteenth-century readers, in no small part because "close reading" novels was not part of their cultural practice. We may share certain cognitive patterns with this historical audience: emotional responses to a well-written character, increased cognitive load facing a difficult (or simply ambiguous) sentence, and the activation of core neural networks for reading. Yet enough has changed in terms of cultural references, literacy, print technology, and education to make the more intricate networks surrounding the neurobiology of literary attention more flexible than at first might be acknowledged.

Engaging these challenges, particularly when thinking about the backward application of an fMRI study of attention and reading (including complex depictions of brain anatomy, neural networks, and blood flow), urges us to ask new questions when thinking about the relationship between cognition and history. Current work in cognitive historicism, quite reasonably, emphasizes similarities in human brain structure over time, using this as a stable framework for more local neural variation. As Alan Richardson wryly notes in *The Neural Sublime:*

> [T]he (scientific) fact of the mind's embodiment is [far from] trivial. Avoiding the relativistic extreme (which might hold that, for cultures that do not locate the mind in the brain, a serious head injury would not affect mental functioning), we can reliably assume that human minds have always and everywhere been instantiated in brains and required reasonably intact brains in order to function reasonably well. . .. The most refined idealistic philosophy could, in theory, always be challenged by a good blow to the head.[46]

Historical beliefs about the connection between mind and brain, Richardson argues, are always in flux; however, the brain's structure as a whole remains stable enough to act as a "counter" to various "idealistic philosoph[ies]" that separate the mind and brain, with "brain-based conceptions of mind [emerging]. . . throughout history in many times and places."[47] Ellen Spolsky argues, moreover, that "cognitive literary study must be embedded within the hard-won recognition of the historical imperative," urging cultural-historical critics, in turn, to "acknowledge the history of the human body and its mind."[48] As Spolsky emphasizes, cognition is both historical and embodied, "produced by the dynamic interactions among bodily structures and the world outside." The mind is deeply shaped by environment, and our development of neural pathways is profoundly responsive to local and cultural context.

Recognizing that neural processes are essentially embodied, as Spolsky does, and that cognition varies with changing environments and contexts is the first key step in historicizing cognition. Working in interdisciplinary neuroscience and on the history of distraction has led me to build on this model of cognitive historicism. Much work in the history of cognition, like Spolsky's, stops here—and reasonably so considering the challenges it

presents. Yet a key question remains: when, how, and how much should we emphasize environmental and cultural impacts for historical research on the brain? Addressing these queries requires additional neuroscientific and historical investigation. The second step is to determine *which* neuroscientific studies can hold most reliably across history. An important component of this step involves understanding the developmental timeline and relative plasticity of the brain regions involved with the specific cognitive processes one wishes to investigate. Cognitive activities associated with brain regions that develop early in life may remain more stable, with less time to be impacted—at least anatomically—by the surrounding environment; later developed regions are more likely to be shaped by specific historical context.[49] Such questions about historicizing neuroscience urge us, in addition, to investigate existing cross-cultural experiments on the aspect of cognition we are studying. Though we always need to pay attention to plasticity and relevant historical context, neuroscientific studies that have demonstrated stable brain activations *across* cultures and languages are more likely to translate historically.

Finally, cognitive historicism asks us to delve into relevant historical forces that may have impacted the neural pathways associated with a mental state. In addition to considering how tangible physical stimuli shape (and reshape) brain structures by producing new myelination, variations in local-global connectivity, and dynamic neural networks, I suggest a final step: to consider the impact that historical *definitions* of a mental state can have on neurobiology.[50] The eighteenth century, for example, witnessed the emergence of two competing definitions of distraction. In the older, more traditional paradigm, distraction carried a negative valence, signifying sin, wandering, or madness. Later in the century, distraction was redefined as a positive (even, sometimes, essential) quality of mind. As Diderot put it in his *Encyclopédie* of 1754:

> La distraction a sa source dans une excellente qualité de l'entendement, une extrême facilité dans les idées de se réveiller les unes les autres.
>
> [Distraction has its source in an excellent quality of the understanding, an extreme facility in allowing the ideas to strike against, or reawaken one another.][51]

For those raised according to the first model, the term (and thus the experience of) distraction would have carried strong negative connotations. Individuals exposed to more positive Enlightenment theories of distraction, by contrast, are more likely to have associated a valued creativity and innovation with moments of mind wandering. As Jonathan Posner demonstrated in a recent fMRI experiment on the neurophysiology of emotion (2009), our brains process words denoting emotion differently according to their positive or negative connotation, or valence. Words with a higher emotional charge, be it good or bad, activated a wide network that included "the left DLPFC [dorsolateral prefrontal cortex], bilateral medial PFC [prefrontal cortex], amygdala, cingulate gyrus, insular cortex, and precuneus." In addition, "increasing activity in the left insula accompanied increasing valence (increasingly pleasant stimuli), whereas increasing activity in the right DLPFC and right precuneus accompanied decreasing valence (increasingly aversive stimuli)."[52] In other words, associations with displeasure for a state of mind ("distressed," "depressed," or "bored,") activated different regions than those with pleasurable connotations ("happy," "content," and "excited"). Moreover, the more intensely positive or negative the emotional term was, the more extended, numerous, and varied the neural networks involved became.

Such considerations play a crucial role in integrating cognitive historicism and literary neuroscience, opening new doors to acknowledging the brain's richest levels of plasticity in response to changing environments. Using these tools, we can build on existing models for historicizing cognition to emphasize the cognitive and neuroscientific importance of environmental impact, accounting for stages of brain development, the presence of cross-cultural studies, and relevant historical meanings attached to mental states. Rather than suggesting that the brain can be infinitely rewired,[53] this careful re-emphasis on neural plasticity brings cognitive historicism closest to the ideal "horizontal traffic" essential to all interdisciplinary work; it adds neuroscientific power while giving history a value of its own, allowing us to produce more rigorous models of the mind for both fields.[54]

V.

Returning to literature and its historical context also opens up increased room to appreciate individual differences in reading. As Austen reminds us, individual readers can have radically different responses to the same book. Though *Persuasion* begins with Sir Elliot immersed in the Baronetage, the narrator quickly sets Walter's infatuation with this particular text against his daughter, Elizabeth's, disaffection for it. She can scarcely bear to pick up the book because it reminds her that she is unmarried—in particular of "a [marital] disappointment. . . which that book. . . must ever present the remembrance of."[55] Austen's rendering of how a character's relationship to a book can change his or her affective engagement drew our attention to a final point of interest for the study. Students, like the characters of Austen's novel, bring unique perspectives to their reading. One of our most important goals for future data analysis is to acknowledge these individual variables and how they are reflected at a neural level.

Fortunately, the combination of technologies we used, fMRI and fMRI-compatible eye tracking, have the potential to provide unique insights into individual differences in reader response. Moreover, methods for analyzing fMRI data have advanced significantly in the last five years, reaching a new height for appreciating the complexity of aesthetic response. An fMRI study from Japan in 2009, for example, found researchers could predict just from reconstructed brain images whether a student had been viewing an artwork by Picasso or Dalí.[56] In addition, the most exciting recent advance for literary neuroscience is a new method for analyzing fMRI data known as *functional connectivity*. Rather than seeking to isolate cognitive experience to a single brain region, functional connectivity examines synchronous patterns that emerge in parallel across the brain and investigates how these connections change as we engage with a stimulus over

time. Functional connectivity studies are particularly applicable to the neuroscience of narrative, storytelling, and film. One fMRI study from Princeton used this method to explore how we tell and listen to stories, revealing that the more someone listened to (and comprehended) a narrative, the more that listener's brain activities became aligned with that of the storyteller—that is, the more attention one paid, the more "neurocoupling" occurred.[57]

It is this dynamism and multiplicity that motivates our next steps for our fMRI study of Austen. First, we hope to add this kind of complexity to our analysis of readers' engagement with *Persuasion* and *Mansfield Park*. As mentioned, brain images from both our pilot study and the final experiment reveal striking differences between close reading and pleasure reading averaged together. The next task, however, is to create more sensitive methods for assessing subtle temporal changes in the brain as subjects read. Because our experiment uses fMRI (data about blood flow over time), fMRI-compatible eye tracking (data about changing points of focus), and ends with a final essay (intricate maps of what students noticed and remembered), we can begin to track these evolving patterns in attention—word by word, paragraph by paragraph—working to match them with the text being read.

The essays provide a particularly fascinating picture of participants' consciously recalled experience—a written record of what each person paid attention to. Amazingly, considering they have just left a loud scanner and no longer have the text at hand, many students actually quote specific words and phrases from *Mansfield Park*. Since the essays refer to particular passages in the text, we hope to combine the essays with the eye-tracking data to construct a richer moment-by-moment sense of readers' patterns of engagement.[58] Tracing these references in the essays and correlating them back to the brain data will reveal two important patterns. First, we can locate themes noticed by multiple subjects, and thus track moments of shared attention. A number of participants, for example, were drawn to moments in which the impoverished heroine, recently adopted by the rich Bertrams, is derided for her supposedly poor intelligence and education. One participant remembers a specific section where Fanny is derided for being "ignorant" in comparison to the Miss Bertrams' educated "accomplishments"; another describes a distinctive scene in which Lady Bertram says that Fanny is "stupid, [but] must take more pains," and then compares the heroine to her pug.[59] Narrative patterns in *Mansfield Park* may guide these trends in joint attention; even the repetition of simple words or phrases can cue a reader's heightened focus. ("Stupid," we found, appears six times in chapter 2; "Ignorance" or "ignorant" appear four times.) By creating intricate maps of keywords and themes and matching them with the eye tracking, moreover, we hope to use shared points of focus in the essays to provide a more intricate view of what captured subjects' attention in reading and correlate these moments back to the brain images.

As we trace links between the essays, eye tracking and brain images, our second goal is to begin mapping individual differences in focus. This work adds to the findings of Gabrielle Starr and coauthors, who used fMRI to investigate cognitive responses to visual art. Their experiment identified neural patterns for heightened artistic engagement across the group; they also tracked "individual differences in. . . aesthetic experience" and "emotional response." These distinctive aesthetic processes for individuals, they found, were being

"integrated by the same route," creating a shared "neural signature"—one that reveals the unexpected role of the default network for intense aesthetic experience (G. Gabrielle Starr, chapter 12 in this volume). Our study of Austen translates these questions about individual responses to visual art into the literary realm. The experiment's final essays will allow for the mapping of still more nuanced personal shifts in attention and engagement. Take for instance, these two examples from close readings of *Mansfield Park*.

> Subject 1
>
> It's Edmund who [first] notes to himself, after their heartwarming encounter upon the stairs, that Fanny had become "an object of interest." It is as an object, particularly a class object-lesson, that she has become useful to the family. Lady B's curious and equivocating defense of the girl "she was stupid, [but] must take more pains" but Lady B had always found "her useful in" suggests a barbed comparison between Fanny's value and that of Pug [the Bertram's dog], also good at "fetching" things, presumably, and "carrying."

> Subject 2
>
> Fanny's position as a member of the lower classes is marked primarily by her lack of education, or, as the text calls it, her "ignorance." The narrative emphasizes that Fanny can read and write, but does not have many skills beyond this, while her cousins are able to speak French, play music, and paint, making them "accomplished" young women.

Both readers focused on class politics and on the family's denigrations of Fanny's intelligence, a pattern we see emerging across the essays. Yet participants' responses also reveal important individual differences in attention for literary close reading. Subject 1, for example, noticed Austen's use of sibilance in describing a visit from Fanny's brother, recently gone to the navy: "(sea, sister, sailor, serious)." Subject 2 instead analyzed a moment when the narrator describes the Bertram children playing with "artificial flowers." As we gather data about blood flow, brain regions, and eye movements across the group, we also will be identifying these unique individual styles of focus. Each student may share patterns of attention—in their brain activation, in eye tracking, and writing—yet each response will reflect that person's distinctive engagement with *Mansfield Park*; no reading will be the same.

By investigating these more nuanced patterns of attention, our study draws out two points of complexity raised by Bortolussi and Dixon in their retheorization of immersive reading, "Transport: Challenges to the Metaphor" (chapter 25 in this volume). First, rather than being two completely distinct states of attention, close reading and pleasure reading ebb, flow, and intermingle. Readers transition naturally through these different kinds of focus as they move through a literary work, adjusting (often unconsciously) to the text at hand.[60] Second, as Bortolussi and Dixon note, individual differences play a strong role in how we experience literary transport and immersion. (They quote de Graaf et al., who emphasize that "paying more attention to a story. . . does not necessarily mean [all] readers feel as if they are in the narrative world.") Thus far, our study reinforces this finding. Some

readers responded more to the visual imagery and spatial detail that Green associates with being "transported into another world," some less so; participants also varied in how strongly they emotionally identified with characters. "Neither imageability nor emotional reactions of sympathy or empathy are necessary features of a transport-like experience," continue Bortolussi and Dixon: "If such a state exists, it must come in different stripes, and different texts induce different forms." A final example from our experiment reinforces this idea and adds complexity, revealing the unexpected importance of visualization to literary analysis. One student's essay, for instance, focuses on the moment when the heroine first enters the Bertram house, analyzing Austen's use of language to convey Fanny's feeling of smallness amid the mansion's vastness. "As Fanny arrives at the estate, Austen. . . allows her syntax to recall the immensity of the space: listing the many reasons for Fanny's fears, joining them with semicolons and colons, Austen suspends a block of text like a gothic vault over the 'little' girl" (Subject 9). Here, attention to the spatial language of *Mansfield Park* becomes a central part of the student's critical analysis. That said, the student is also clearly "immersed" in the story's themes and structures. Its architectural metaphors extend into the student's own writing: narrative arching over the heroine "like a gothic vault." The attention demanded by close reading, that is, may encourage just as much visualization as pleasure reading. At times, and for certain individuals, literary analysis may demand more.

Literary neuroscience is just emerging as a field, and what is most exciting lies ahead. Our Austen study has become a central project within our new lab in the Department of English at Michigan State University, Digital Humanities and Literary Cognition (DHLC), a space devoted to cultivating a range of interdisciplinary projects in literary neuroscience, digital humanities, and the history of mind. Here, our neuroscientific research on literary attention has springboarded a series of future projects, including an fMRI experiment on empathy and trauma narratives (MSU, Duke); an emerging study of poetry and cognitive rhythm (MSU); and a final project investigating patterns of distraction in fiction reading on an iPad or Kindle as opposed to a traditional book (MSU, Stanford, and Umea University in Sweden). Importantly, these new experiments are emerging in tandem with a series of important research projects in the history of mind. One of our Ph.D. candidates, whose research focuses on empathy and philanthropy in nineteenth-century literature, is using this work to help design our emerging fMRI experiment on trauma narratives, empathy, and service learning.[61] Another student is investigating eighteenth-century representations of artificial memory systems—that is, the historical equivalents of the iPad and Kindle—in literature from *Robinson Crusoe* to *Tristram Shandy*, rethinking intersections between attention and reading that will be important to our study of distraction and digital technology.[62]

Institutional spaces such as the DHLC make it possible to integrate literary neuroscience and history of mind more rigorously, creating what Peter Galison calls "trading zones," or moments of "local coordination" and specialist translation, here exchanges between science and humanities.[63] In particular, the lab is facilitating conversations

among faculty and students in English, Cognitive Science, Biology, Education, Neural Engineering, Radiology, and Linguistics, working to generate a new language for interdisciplinary research on the brain. Clearly, such work faces challenges. Things will be lost in translation, and these "trading zones" come with an extensive learning curve. While we might be tempted to focus on the smoother moments of disciplinary translation in our experiment, I believe it is the very gaps between humanities and sciences—the moments of productive dissonance—that provide the most important opportunities for cross-disciplinary work. In the back-and-forth between the neuroscientific and the narrative, between the literary historical and the cognitive, and the friction that emerges in the process, we find real space for reciprocity in cognitive literary studies. Most broadly, my goal is to demonstrate that there is a way for literary scholars to enter into a productive dialogue with cognitive science—not by raw importing or by applying its insights, but in fact shaping its studies; reshaping its methods; and producing a more reciprocal conversation about the history of science, reading, and mind.

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Notes

1. Jane Austen, *Persuasion* (London: Penguin, 1998), 5.
2. Jane Austen, "Catharine, or the Bower," in *Juvenilia*, ed. Peter Sabor (New York: Cambridge University Press, 2006), 241–95 (my italics).
3. Alex Woloch, *The One vs. the Many: Minor Characters and the Space of the Protagonist in the Novel* (Princeton: Princeton University Press, 2003), 27.
4. For a fuller discussion of these comparisons of attention, see my article on focus and characterization in Austen. Natalie Phillips, "Distraction as Liveliness of Mind: A Cognitive Approach to Characterization in Jane Austen," in *Theory of Mind and Literature*, ed. Paula Leverage (West Lafayette: Purdue University Press, 2011), 105–22.
5. Jane Austen, *Pride and Prejudice*, ed. Robert P. Irvine (Peterborough: Broadview Press, 2002), 51, 95, 238.
6. Robert DeMaria Jr., *Samuel Johnson and the Life of Reading* (Baltimore: John Hopkins University Press, 1997), 4.

7. Jonathan Kramnick, "Neuroaesthetics: Prospects and Problems," lecture, Wesleyan University, Middletown, CT, September 2011, 7.
8. Samantha Holdsworth, as cited in Mackenzie Carpenter, "How Reading Jane Austen Stimulates Your Brain," *Pittsburgh Post-Gazette* (Pittsburgh, PA), March 3, 2013, http://www.post-gazette.com/stories/news/science/how-reading-jane-austen-stimulates-your-brain-677726.
9. Philip J. Mazzocco, Melanie C. Green, Jo A. Sasota, and Norman W. Jones, "This Story Is Not for Everyone: Transportability and Narrative Persuasion," *Psychological and Personality Science* 1:361 (2010): 361. See also Green, "Transportation into Narrative Worlds: The Role of Prior Knowledge and Perceived Realism," *Discourse Processes* 38.2 (2004): 247–66; and Green and J. M. A. Carpenter, "Transporting into Narrative Worlds: New Directions for the Scientific Study of Literature," *Scientific Study of Literature* 1.1 (2011): 113–22.
10. Elaine Showalter, *Teaching Literature* (Malden: Blackwell, 2003), 98.
11. John Guillory, "How Scholars Read," *ADE Bulletin* 146 (Fall 2008): 11.
12. Barbara Johnson, "Teaching Deconstructively," in *Writing and Reading Differently: Deconstruction and the Teaching of Composition and Literature*, ed. Douglas Atkins and Michael L. Johnson (Lawrence: University of Kansas Press, 1995), 140.
13. Scott A. Huettel, Allen W. Song, and Gregory McCarthy, *Functional Magnetic Resonance Imaging* (Sunderland, MA: Sinauer Associates, 2009), 4.
14. Our ability to use a relatively new technology, fMRI-compatible eye tracking, allowed us to develop a more complex experiment design for investigating literary attention. Joined with a subject-based design participants could read at their own speed, something essential for comparing pleasure reading and close reading, as both are innately self-timed. For more on eye-tracking technologies and their integration with MRI, see M. Mele and S. Federici, "Gaze and Eye-Tracking Solutions for Psychological Research," *Cognitive Processing* 14 (2012): 261–65.
15. M. C. Green and T. C. Brock, "The Role of Transportation in the Persuasiveness of Public Narratives," *Journal of Personality and Social Psychology* 79.5 (2000): 701–21.
16. Rereading, as one might expect, is a different experience than reading something for the first time. In the United States, *Mansfield Park* is one of the least frequently assigned Austen novels, and the least frequently viewed in film adaptation, lowering this risk. We collected extensive information about subjects' readings of Austen, particularly *Mansfield Park*.
17. Such individual results must be interpreted cautiously, as readers' experiences can vary day-to-day. Only group analysis (or repeated individual testing) can provide robust statistical significance. For more on interpreting fMRI results, see Martin A. Lindquist, "The Statistical Analysis of fMRI Data," *Statistical Science* 23.4 (2008): 439–64.
18. Lisa Zunshine, *Why We Read Fiction: Theory of Mind and the Novel* (Columbus: Ohio State University Press, 2006), 153.
19. For a sample of recent criticism on cognitive historicism, see Lisa Zunshine, "Lying Bodies of the Enlightenment: Theory of Mind and Cultural Historicism," in *Introduction to Cognitive Cultural Studies*, ed. Lisa Zunshine (Baltimore: Johns Hopkins University Press, 2010), 115–33; Blakey Vermuele, "Machiavellian Narratives," in *Introduction to Cognitive Cultural Studies*, ed. Lisa Zunshine (Baltimore: Johns Hopkins University Press, 2010), 214–30; and Alan Richardson, *The Neural Sublime: Cognitive Theories and Romantic Texts* (Baltimore: Johns Hopkins University Press, 2010).

20. Despite strong differences in linguistic rules and characters, Dehaene notes, in comparisons of Japanese and English subjects the "brain scans of Japanese readers show[ed] that visual recognition of Kanji and Kana also relies on the left occipito-temporal area." For a more detailed discussion of these experiments, as well as cross-cultural studies of dyslexia, including Italian, French, English, and Chinese populations, see Stanislas Dehaene, *Reading in the Brain: The Science and Evolution of Human Intelligence* (New York: Viking Press, 2009), 98, 244–45.
21. See E. R. Sowell, D. A. Trauner, A. Gamst, and T. L. Jernigan, "Development of Cortical and Subcortical Brain Structures in Childhood and Adolescence: A Structural MRI Study," *Developmental Medicine and Child Neurology* 44 (2002): 4–16; J. R. Best and P. H. Miller, "A Developmental Perspective on Executive Function," *Child Development* 81 (2010): 1641–60; and Y. Goto, C. R. Yang, and S. Otani, "Functional and Dysfunctional Synaptic Plasticity in Prefrontal Cortex: Roles in Psychiatric Disorders," *Biological Psychiatry* 67 (2010): 199–207.
22. L. D. Selemon, "A Role for Synaptic Plasticity in the Adolescent Development of Executive Function," *Translational Psychiatry* 3 (2013): 1.
23. For more on attention's responsiveness to environmental and social context in early stages of development, see Mark H. Johnson, "Developing an Attentive Brain," in *The Attentive Brain*, ed. Raja Parasuraman (Cambridge: MIT Press, 2000), 427–43.
24. For a study of limits on our ability to multitask and its resistance to training, see Eyal Ophira, Clifford Nass, and Anthony D. Wagner, "Cognitive Control in Media Multitaskers," *PNAS* (2009): 15583–87.
25. Even reading's supposed neurobiological stability needs to be complicated when we turn to history, however. As Spolsky points out, "Children growing up in late sixteenth-century England—if they learned to read at all—learned from books without pictures. Those children's brains were simply not the same as the brain of the child who learned to read in Italy at the same time, and also different from the brains of rural English children who were not taught to read at all." Ellen Spolsky, *Satisfying Skepticism: Embodied Knowledge in the Early Modern World* (Aldershot: Ashgrave, 2001), 3.
26. Lorraine Daston and Katharine Park, *Wonders and the Order of Nature: 1150–1750* (New York: Zone Books, 1998), 305.
27. Ibid.
28. Ibid., 305–6.
29. Michael Fried, *Absorption and Theatricality: Painting and Beholder in the Age of Diderot* (Chicago: University of Chicago Press, 1980), 7.
30. See Ian Watt, *The Rise of the Novel*, ed. W.B. Carnochan (Berkeley: University of California Press, 2001), 198.
31. Isaac Watts, *The Improvement of the Mind: or, a Supplement to the Art of Logic* (London: Printed for J. Brackstone, 1743), 68–69.
32. For more on Austen's depictions of absorption see Adela Pinch, "Lost in a Book: Jane Austen's 'Persuasion,'" *Studies in Romanticism* 32.1 (1993): : 97–117.
33. Jane Austen, *Northanger Abbey* (London: J. M. Dent and Company, 1892), 26.
34. See Rolf Engelsing, *Der Bürger als Leser: Lesergeschichte in Deutschland, 1500–1800* (Stuttgart: J. B. Metzlersche and A. E. Poeschel, 1974). Engelsing's theorization of intensive and extensive reading need not rely on his argument about a precise "shift" around the 1750s. (For more on extensive reading in the Renaissance see Ann Blair, *Too Much to Know: Managing Scholarly Information before the Modern Age* [New Haven: Yale University

Press, 2010].) As John Brewer rightly suggests, this change was probably not from 'intensive' *to* 'extensive' reading, but "to more varied reading." John Brewer, *The Pleasures of the Imagination: English Culture in the Eighteenth Century,* (Chicago: University of Chicago Press, 1997), 170–71.

35. For more on the Stroop test and other experiments on attention, see Raja Parasuraman, *The Attentive Brain* (Cambridge: MIT Press, 2000); Michael I. Posner, ed., *Cognitive Neuroscience of Attention* (New York: Guilford Press, 2004); and Harold Pashler, *The Psychology of Attention* (Cambridge: MIT Press, 1998).
36. For more on working memory and reading, see J. C. McVay and M. J. Kane, "Why Does Working Memory Capacity Predict Variation in Reading Comprehension? On the Influence of Mind Wandering and Executive Attention," *Journal of Experimental Psychology* 141 (2011): 302–20.
37. See C. S. Pratt, T. A. Keller, and M. A. Just, "Individual Differences in Sentence Comprehension: A Functional Magnetic Resonance Imaging Investigation of Syntactic and Lexical Processing Demands," *Journal of Cognitive Neuroscience* 12 (2007): 1950–63.
38. To my knowledge, our experiment is the first to use fMRI to investigate continuous natural reading , much less novel reading or literary training. Other scholars working on such collaborative experiments include Gabrielle Starr, Lisa Zunshine, Angus Fletcher, and Deborah Jenson. See also the fMRI study of reading by Nicole Speer, Jeremy Reynolds, Khena Swallow, and Jeffrey Zacks, "Reading Stories Activates Neural Representations of Visual and Motor Experiences," *Psychological Science* 20.8 (2009): 989–99. They selected and adjusted four narratives from the book *One Boy's Day: A Specimen Record of Behavior* (Barker and Wright, 1951) that described psychological observations of "the everyday activities of a seven year-old boy." Unlike our study, which had students read Austen's chapter as a whole at their own rate, "each narrative was presented one word at a time, with each word remaining on the screen for 200 ms, followed by a 150 ms/syllable blank delay" (991).
39. See also Raymond Mar, Maja Djikic, and Justin Mullin, "Emotion and Narrative Fiction: Interactive Influences before, during, and after Reading," *Cognition and Emotion* 25.5 (2011): 818–33.
40. Dehaene, *Reading in the Brain*, 63.
41. Jonathan Swift, *A Tale of a Tub* (London: Printed for John Nutt, 1710); William Hogarth, *The Enraged Musician* (1741) Tate Britain, London; and Emily Cockayne, *Hubbub: Filth, Noise, and Stench in England, 1600–1770* (New Haven: Yale University Press, 2007).
42. John Gay, *Trivia: or, the Art of Walking the Streets of London* (London: Printed for Bernard Lintot, 1716), 22–23.
43. Alexander Pope, 1729, *The Twickenham Edition of the Poems of Alexander Pope,* gen. ed. John Butt, vol. 5, *The Dunciad,* ed. James Sutherland (New Haven, CT: Yale University Press, 1961).
44. Samuel Johnson, *The Rambler,* vol. 3 in *The Yale Edition of the Works of Samuel Johnson,* ed. W. J. Bate and A. B. Strauss (New Haven: Yale University Press, 1969), 16.
45. Ira B. Black, "Plasticity: Introduction," in *Cognitive Neurosciences III,* ed. Michael S. Gazzaniga (Cambridge: MIT Press, 2004), 107.
46. Richardson, *The Neural Sublime,* 13–14.
47. Ibid., 14.

48. Ellen Spolsky, "Cognitive Literary Historicism: A Response to Adler and Gross," *Poetics Today* 24.2 (2003): 164.
49. For more on periods of development for different brain regions as well as on intersections between brain structure and cognitive function, see P. R. Huttenlocher and A. S. Dabholkar, "Regional Differences in Synaptogenesis in Human Cerebral Cortex," *Journal of Comparative Neurology* 387 (1997): 167–78; J. N. Giedd et al., "Brain Development during Childhood and Adolescence: A Longitudinal MRI Study," *Nature Neuroscience* 2 (1999): 861–63; and N. Gotay et al., "Dynamic Mapping of Human Cortical Development during Childhood through Early Adulthood." *Proceedings of the National Academy of Science* 101 (2004): 8174–79.
50. This approach builds, of course, on important work historicizing theories of the mind and brain. See here Alan Richardson, *British Romanticism and the Science of the Mind* (Cambridge: Cambridge University Press, 2004).
51. Denis Diderot, *Encyclopédie ou dictionnaire raisonné des sciences, des arts et des métiers,* ed. Denis Diderot and Jean le Rond D'Alembert, vol. 4 (Paris, 1754), s.v. "Distraction."
52. J. Posner et al., "The Neurophysiological Bases of Emotion: An fMRI Study of the Affective Circumplex Using Emotion-Denoting Words," *Human Brain Mapping* 30 (2009): 888.
53. See Alan Richardson, "Of Heartache and Head Injury: Reading Minds in *Persuasion*," *Poetics Today* 23.1 (2002): 141–60. As Richardson notes in his reading of Louisa's fall in *Persuasion,* Enlightenment debates over the mind's relationship to the brain—including the mind's possible location in the chest or stomach—did not keep Jane Austen from articulating a clear relationship between a head injury to the skull and a sudden change in personality.
54. Jonathan Kramnick, "Literary Studies and Science: A Reply to My Critics," *Critical Inquiry* 38.2 (Winter 2012): 25.
55. Austen, *Persuasion,* 9.
56. Hiromi Yamamura, Yasuhito Sawahata, Miyuki Yamamoto, and Yukiyasu Kamitani, "Neural Art Appraisal of Painter: Dali or Picasso?" *NeuroReport* 20.18 (2009): 1632.
57. G. J. Stephens, L. J. Silbert, and U. Hasson, "Speaker-Listener Neural Coupling Underlies Successful Communication," *Proceedings of the National Academy of Science USA* 107.32 (2010): 14425–30.
58. The eye tracker records subjects' physical patterns of attention as they read (e.g., places in the text where their gaze returns, patterns of eye movement, and moments when we tune out or look away). Patterns in the eye tracking will reveal crucial information about how close reading's patterns of visual attention differ from reading for pleasure.
59. Jane Austen, *Mansfield Park,* ed. James Kinsley (Oxford: Oxford University Press, 2003), 17, 16.
60. Readers will not remain in a strict mode of attention for the entirety of any block of close reading or pleasure reading in our study. As Bortolussi and Dixon note, even when "readers. . . report that they 'couldn't put the book down until they finished it,' it is improbable that their attention remained entirely focused on the text during the entire reading episode." See Marisa Bortolussi and Peter Dixon, "Transport: Challenges to the Metaphor," chapter 25 in this volume.
61. Erin Beard is Lead Graduate Researcher in History of the Mind in the DHLC. Her dissertation project, "Empathy and Philanthropy: The Ethics of Realism in Nineteenth-Century Literature" is in progress in the Department of English at Michigan State.

62. Austin Gorsuch's honors thesis, "Artificial Memory: Eighteenth-Century Literature and Theories of Extended Mind," is in progress, sponsored by an undergraduate fellowship supporting interdisciplinary research in literature, neuroscience, and the history of mind. Another honors student, Paige Fouty, recently completed a thesis on intersections between neuroscience and education growing out of the study.
63. Peter Galison, *Image and Logic: A Material Culture of Microphysics* (Chicago: University of Chicago Press, 1997), 46–48.

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