
This chapter describes the physical and cognitive systems that support the process of reading. Dehaene begins with the physical movements of the eye as it processes words on a page, letter by letter, in tiny increments. After explaining how the human eye can decipher letter shapes, the chapter moves on to consider how the brain breaks down words into parts, mentally subdividing words into smaller units of sound and meaning. Recent scientific studies, Dehaene explains, have so far identified two main reading routes in the human mind, the phonological and the lexical routes. According to this current model, the brain constructs a word’s meaning by way of parallel, mutually-reinforcing processes. The brain 1) uses the sounds of the word as a way to access its lexical meaning (for infrequently used words), and 2) follows the existing pathway that links the combination of letters to lexical meaning (for frequently used words and those whose spelling does not correspond to their pronunciation). Finally, Dehaene outlines how the brain uses parallel processing to decide upon the meaning of a word once it has been visually recognized. He likens the brain to a “mental senate” whose multiple cerebral systems must go through some degree of debate before agreement leads to a single interpretation, all in fractions of a second.


This chapter’s goal is to offer a historical look at the invention of reading and writing, and to explain how basic constraints in brain organization may have shaped cultural practices of literacy. Dehaene argues that reading and writing are possible because our cerebral network links visual and language areas, and because this network is flexible enough to “recycle” itself to adapt to new tasks. The earliest systems of writing were ideographic, based on representing abstract ideas like numbers and time, and they evolved into pictographic systems like the Egyptians’ and Sumerians’. A significant limitation of pictographic systems, he suggests, lay in drawing pictures of abstract ideas, which relied on extensive training to decipher the meaning of a complex image, i.e. an egg next to a bird to symbolize giving birth. In response, these systems began to incorporate phonetic signs to overcome such lexical obstacles. Over the course of many hundreds of years, this eventually led to development of the first alphabetic system, which was based only on speech sounds. Dehaene argues that the letter shapes invented to comprise alphabetic systems the world over were chosen because they are based on shapes in the natural environment (e.g. L and T) and therefore conform to the limited set of shapes our primate brains recognize. The chapter suggests that the move from ideographic to alphabetic systems made reading and writing more cognitively accessible, since individuals could become literate after learning only a couple dozen signs instead of thousands.
This chapter summarizes scientific research on dyslexia, including psychological, neurological, and genetic studies, beginning with the earliest modern research conducted in the 1970s. The results of this research show that dyslexia is caused by genetic factors that impede development of the brain’s networks for literacy in utero. Specifically, the visual and language areas in the left temporal region do not develop a full connection in the dyslexic brain. The most salient effects of this disconnection are sensory deficits, which in the majority of dyslexic people are auditory/phonological deficits, and in a minority are visual deficits. The focus of this chapter is on phonological difficulties (the following chapter deals with deficits in visual processing), and it explains that the majority of dyslexic children encounter problems converting written symbols into speech sounds (phonemes), which is the root of their reading difficulties. Dehaene stresses that the biological nature of dyslexia should not discourage our attempts to work around the challenges it presents. To this end, researchers have designed a number of literacy intervention strategies aimed at increasing a dyslexic child’s ability to distinguish between phonemes. These strategies have been shown to initiate both partial reactivation of left temporal areas important to reading and compensatory activity in the right hemisphere. Dyslexic children may thus develop new reading skills through this cognitive intervention.


This neuroscientific study investigated nonconscious semantic processing: the capacity of a subject to recognize the definition of a word without having consciously accessed that semantic content. The researchers predicted that emotional words (e.g. danger) would be subliminally processed better than neutral words (e.g. color). Subjects were shown pairs of written words that were separated by varying temporal intervals, and the words in each pair were visible for varying lengths of time. Subjects were asked during the test to name the words they saw; after the test, they were asked to rate the words’ visibility. The results were twofold. First, they showed that the threshold for conscious access of emotional words is lower than for neutral ones. They propose that this result challenges psychoanalytic theory’s repression hypothesis, since conscious access to negative (“taboo”) words was enhanced rather than reduced in comparison to neutral words. They further posit that this low threshold for conscious access is beneficial to social cognition, because it increases the probability of conscious cognitive assessment of emotional stimuli in social situations. Second, the test showed that emotional words can be processed nonconsciously. The researchers hypothesize that nonconscious activation of the amygdala, associated with the processing and memory of emotional reactions, is responsible for this result.

This neuroimaging study investigated the brain regions that activate during syntactic and lexical processing. The researchers asked subjects to read sentences that varied in terms of their syntactic difficulty and in the frequency of the words they contained. For example, “The writer that the king attacked admitted the mistake at the meeting” compared to “The pundit that the regent attacked admitted the gaffe at the conclave.” (‘Frequency’ refers to how familiar the average reader will be with a particular word.) The results show that different linguistic-level brain processes, such as syntactic and lexical processes, involve the collaboration and even overlap of different brain areas. This result speaks to a larger debate within neuroscience concerning the extent to which the linguistic processes involved in sentence-level comprehension are localized to a specific area. Researchers advocating a localized account of linguistic processes argue that there are specific modules within the brain dedicated to specific types of language processing, and that this specialization is what leads to efficiency in sentence-level comprehension. Researchers advocating an interactive account argue that interaction among brain regions exists and is the source of efficient sentence-level processing. This study’s results provide evidence for the interactive model. Harder sentences—that is, those which combine increased syntactic difficulty with less familiar words—tend to create more interaction among brain regions, suggesting that multiple cognitive processes link to facilitate understanding.


This neuroimaging study tests the role of perspective-taking in the emotional comprehension of a narrative. Researchers set out to identify which brain areas are activated when subjects attempt to infer a protagonist’s emotional state after reading a pair of sentences about him/her. These paired sentences are meant to assess the reader’s ability to evaluate the protagonist’s likelihood of being emotionally affected by an incident. They offer two types of sentence pairs. In the first type, the protagonist of the first sentence is very likely to be aware of and affected by the action described in the second (“1. Kana is playing with her much-loved stuffed toy. 2. Kana’s stuffed toy was pecked and ripped by a bird in her room.”). In the second type, the protagonist in the first sentence is spatially distanced from the action described in the second sentence. (“1. Kana is watching her favorite comedy at the movie theater. 2. Kana’s stuffed toy was pecked and ripped by a bird in her room.”) In this spatially removed case, protagonist is less likely to be aware of the action. The study finds that it takes the reader longer, in consequence, to be able to guess the protagonist’s emotional reaction. The brain workload for perspective taking in the second case was also much greater. They found that three specific areas (the precuneus, the posterior cingulate cortex, and the temporoparietal junction) activated during this activity, along with the neural networks already known to activate while thinking about another person’s mental state. They conclude that these three specific areas are crucial to perspective-taking, and that they interact with the larger mentalizing network during narrative comprehension tasks.

This article reviews scientific work on cognitive psychology’s theoretical models of mind and recent neuroimaging studies to suggest that both narrative production and narrative comprehension involve similar mental processes and thus activate the same areas of the brain. According to Mar’s review, neuroimaging studies show the frontal lobes to be the most frequently activated areas with regard to narrative production and comprehension, especially the medial and the lateral prefrontal cortex. Mar explains that the frontal lobes are associated with goal-directed functions, and suggests that this may be why they are activated by narrative, which he describes as structured by causal and temporal relations. This article is based on the author’s interest in the centrality of narrative to our understanding of the social world. It argues that narrative is crucial to the composition of personal belief, to psychological health, and to the ability to understand the self and its identity over time.


This scientific study begins by reviewing literature from cognitive psychology and neuroscience that suggests reading fiction maintains and/or improves social processing skills, while reading non-narrative non-fiction weakens those skills. Narrative fiction, with its intentional agents pursuing goals that make up a plot, they argue, parallels the real social world, and therefore engages cognitive functions and neural substrates that activate in real-life social situations. Expository non-narrative prose, because it contains no such real-world parallels, lacks the ability to engage the reader’s social skills, a deficiency they propose is compounded by the solitary nature of reading. The authors then describe their own experiment on the subject, which identified participants’ reading habits and tested their empathetic capabilities according to a standard evaluation. They suggest it supports their hypothesis.


This chapter proposes that narratological theories about authoring, reading, and narrative content (i.e. characters’ mental life) can be clarified and grounded by applying conceptual frameworks from cognitive science, discourses that Margolin sees as particularly well equipped to describe and analyze the thinking mind. The author organizes his discussion by pairing descriptions of each of the four classical levels of narrative communication (from narratology) with a model from cognitive science meant to clarify or reformulate it. Of particular interest is the sub-section titled, “Discourses of Minds in Action: Fiction and Cognitive Science.” This section explains how fiction is able to offer readers direct access to various aspects of another’s mental life, which is not possible for cognitive scientists conducting research on real subjects. It concludes
by arguing that fiction’s highly individualized representations of mental life have particular value and thus have much to offer cognitive scientists, who are usually interested in generalizations about mental functioning. Over the course of this section, the author demonstrates the aptitude of cognitive scientific discourse for analyzing the thinking mind in fiction.


This article brings together existing neuroimaging studies on perspective-taking to propose that there is a specific network of brain areas that activates when a reader infers a character’s mental state, a psychological ability called Theory of Mind. The authors call this network the “protagonist perspective network,” which includes two brain regions that operate interdependently. The first is the dorsomedial prefrontal cortex, which allows us to “protagonist monitor,” that is, to track and update information about characters. The second region supports “protagonist simulation,” involving the temporoparietal junction, which supports our capacity to reason about a character’s mental states in order to create expectations about his/her behavior. The article also examines recent behavioral and neuroimaging studies on individuals with autism, whose theory-of-mind network is underconnected. Results from these studies support the authors’ proposal that a specific “protagonist perspective network” underlies Theory of Mind processing.


This fMRI study identifies and attempts to remedy a lack of neuroscientific research on referential processing. Referential processing refers to the brain’s management of relationships between words—the decisions involved in deciphering “who’s who, and what’s what” in a sentence. The researchers used pronouns to test referential processing. They asked subjects to read, for example, a referentially ambiguous sentence like, “Ronald told Frank that he had a positive attitude towards life,” in which the referent of he is unclear. Researchers also included sentences with referential failure (“Rose told Emily that he had a positive attitude towards life.”) and with semantic anomaly (“Ronald told Emily that he had a positive potato towards life.”). The results showed that each sentence type activated a qualitatively different neural network, which often lay outside of the traditional language network in the temporal-frontal cortex. The researchers call for more neuroscientific study of referential processing, arguing that language comprehension involves a great deal more than the semantic sum of individual words.

This study uses neuroimaging to compare reading musical notation to reading letter and number notations. Researchers wanted to find out whether there is a special neural network for reading music. They identified three areas involved in reading music that were not activated during verbal or number reading. These areas include a region in the right hemisphere associated with spatial orientation and a region in the upper rear of the brain associated with perceptual-motor coordination and visual attention. The third identified area, in the right hemisphere, participates in visual recognition. The researchers propose that this area may be the musical analogue to the visual word form area in the left hemisphere, which analyzes and identifies letter shapes. (See Dehaene, Chapter 2, “The Brain’s Letterbox,” for more on the visual word form area in reading).


This study engages a current debate within neuroscience regarding the brain localization of figurative language processing. While many researchers have argued that areas of the right hemisphere are exclusively responsible for processing figurative language, this study joins a growing body of evidence supporting the other side of the debate, which argues that the brain uses areas in both the left and the right hemispheres to process figurative language. The study used fMRI to track brain activation while participants evaluated the quality of meaning in three types of sentences: literal, metaphorical, and non-meaningful. The authors discovered that different brain areas are activated depending upon the type of sentence being read, which indicates that the nature of a semantic task affects where the semantic data will be processed. For example, an area in the left hemisphere was consistently activated when participants read metaphorical sentences, but not when they read literal or non-meaningful sentences. The study concludes that the brain process for grasping a sentence’s meaning in fact depends upon the type of sentence in question.


This article proposes that certain narrative structures, such as the plot twists of detective fiction, can provide a particular type of satisfaction in a reading or viewing experience. These narrative structures, Tobin argues, take advantage of what cognitive scientists call “the curse of knowledge.” The “curse of knowledge” is an egocentric bias in our social cognition: we are biased by our own knowledge when it comes to assessing a less-informed perspective, which leads to consistently overestimating what others know. While some researchers have assessed this trait negatively as inhibiting human creativity and/or learning, Tobin asks that we recognize the aesthetic pleasure offered by narratives that exploit this tendency. Such narratives work by creating repeated opportunities for readers to project the degree/nature of their own knowledge onto their estimation of what a character knows, and then by revealing that the character’s
knowledge is in fact less or very different—a move that Tobin calls a narrative “rug-pull.” The pleasure arising from this kind of surprise is produced by novels like Agatha Christie’s *Who Killed Roger Ackroyd?* and films like *The Sixth Sense*. Tobin explains that because understanding others during ordinary communication requires a high degree of inferencing, we use cognitive shortcuts, such as assuming others share our current knowledge. Although this cognitive bias may be a source of misunderstanding in everyday life, it can become a source of pleasure in reading as we experience a moment of unexpected surprise and literary novelty in recognizing our error.


This book on reading and the brain uses historical, sociological, and psychological approaches to provide an overview of reading’s invention, its development in the individual brain, and the multiple forms reading disabilities take. In this concluding chapter, Wolf reviews her book’s major claims. She argues that the most significant contribution reading makes to the brain’s cognitive functions is the “gift of time,” which allows us to think beyond the text and make associations, inferences, and analyses. Pointing to our society’s exponential increase in digital and visual media, Wolf argues for teaching younger generations to be “multitextual.” She suggests that this will allow them to take cognitive advantage of the multi-modal, integrative reading capacities developed through encounters with these genres without losing the ability for focused attention and analysis developed through reading books, poems, essays, etc.


This scientific study tests the consistency of brain activation during visual literacy tasks, specifically, viewing artwork. The researchers showed participants paintings by Dali and Picasso and simultaneously monitored their brain activation with fMRI. They also constructed a statistical decoder meant to evaluate fMRI activity patterns, and they used this decoder to analyze the data from the fMRI scans. They discovered that the decoder accurately predicted which painter’s artwork was being viewed based on fMRI activity patterns. This suggests that complex brain activity, like the type associated with viewing art, occurs with predictable regularity, so that the same specific areas are activated each time a particular artist’s work is viewed. Though similar general brain regions are involved in artistic viewing at large, individual works of art, this study suggests, produce a distinctive brain response, or neural signature—one distinctive enough that our technologies for measuring blood flow in the brain can identify and separate a brain viewing Picasso from a brain viewing Dali, without knowing in advance which image the subject is viewing.
This neuroimaging study investigates the relationship between brain activation and the narrative comprehension tool known as the “situation model.” A situation model is a cognitive mechanism that allows a reader to create a mental representation of a narrative. This cognitive tool is flexible, allowing us not only to create and maintain, but also to update knowledge about that narrative. Researchers wanted to find out whether there is a specific neural network responsible for this aspect of narrative comprehension or whether we process narrative using the same general coherence-building mechanisms that process sentences. They discovered that our ability to create and update a mental model of narrative relies on a particular area in the posterior region of the brain, largely responsible for spatial processing, while maintenance of that mental model, which happens automatically, draws on regions involved in general coherence-building. Of particular interest is their suggestion that the spatial processing area plays such a large role in this aspect of narrative comprehension. Researchers also concluded that situation models allow for deep narrative comprehension and, consequently, allow for more reliable recall of content.