

they all arrive with some degree of phonemic awareness, depending on literacy exposure at home. They likely understand the differences in some onset sounds and know that *bet* has a different meaning than *pet*, and *bat* is different from *pat*. But are they ready for our surprise? Here is the essence of it.

“Boys and girls, remember those sounds you play with in your head when you speak? Well, do we have a surprise for you! Those sounds can be matched to written symbols (which, by the way, do not exist in the real world—we made them up, and not everyone in the world uses them). You may know them as the letters of the alphabet. Well, we are going to learn them, but we have just one teensy-weensy problem. There are about 44 sounds in your head, but we have only 26 letters to represent them. So sometimes the same letter can be matched to different sounds, and sometimes the same sound can be matched to different letters. Doesn’t that seem like fun?” Now the girls, many of whom are more advanced in language facility than the boys at this age, are delighted with this challenge. The boys, on the other hand, are asking themselves how they got into this mess and how they can get out of it. Given the anxiety such a situation can raise in beginning readers, it may help to keep this scenario in mind as you continue reading.



THREE PHASES OF LEARNING TO READ

In simplest terms, learning to read involves connecting two cerebral capabilities that are already present in young brains: the spoken language networks and the visual recognition circuits. Trying to understand how this connection occurs in the brain has been a challenge for many researchers over the past decades. In 1985, British psychologist Uta Frith developed a three-phase model of how the brain acquires the ability to read (Frith, 1985). Much new research about how we read has emerged since Frith’s model. Reading is far more complicated than we thought just a few years ago. Although the model’s simplicity belies the complex cerebral processes that we now know are involved in learning to read, it nonetheless still provides a useful outline of what the brain experiences (Dehaene, 2009). Here is a brief summary of the three phases:

- The first phase can be considered a *pictorial* stage, when the child’s brain photographs words and visually adjusts to the shape of the alphabet’s letters.
- The second phase is the *phonological* stage, when the brain begins to decode the letters (graphemes) into sounds (phonemes).
- The third phase is the *orthographic* stage, when the child is able to recognize words quickly and accurately.

All of these phases activate several different brain circuits, which, over time and with practice, eventually converge in a specialized area of the left hemisphere. This area is now referred to in the scientific literature as the **visual word form area**. Let us see how this amazing process occurs.

READING IS NOT A NATURAL ABILITY

Humans have been speaking for tens of thousands of years. During this time, genetic changes have favored the brain's ability to acquire and process spoken language, even setting aside specialized areas of the brain to accomplish these tasks, as we discussed in Chapter 1. Consequently, the brain's proficiency at hearing and quickly remembering spoken words is natural, though no less remarkable. Remember that children begin to learn words before their first birthday and during their second year are acquiring them at the rate of 8 to 10 per day. By the time they enter school, they have a well-developed language system consisting of an active vocabulary of about 3,000 words and a total mental lexicon of over 5,000 words. At some point, the child's brain encounters the written word and wonders, "Hmm . . . What are those symbols? What do they mean?"

Speaking is a normal, genetically hardwired capability; reading is not. Writing was born about 5,000 years ago in an area of the Middle East known as the Fertile Crescent. That time span is just a blip in evolutionary terms, and hardly enough time to develop specialized brain circuits for reading. Thus, reading is a relatively new phenomenon in the development of humans. As far as we know, our genes have not incorporated reading into their coded structure, probably because reading, unlike spoken language, has not emerged as a survival skill over the relatively brief time that humans have been reading. And yet we do read. How does that happen? What parts of the brain must be recruited to carry out this exquisitely complex process of matching sounds to corresponding lines and squiggles? Because no areas of the brain are specialized for reading, it is probably the most difficult cognitive task we ask the young brain to undertake. If reading were a natural ability, everyone would be doing it. But in fact, according to the National Institute for Literacy, nearly 40 million adults in the United States alone are functionally illiterate. The Canadian Council on Learning estimates that about 12 million Canadians have low literacy levels.

The Plasticity of Neural Networks

Although Frith's model is helpful, the real question is how a brain with no innate reading center learns to accomplish this complex task. How are brain regions not designed to read coopted to undertake that challenge? Psychologists and neuroscientists have wrestled with these questions for years. Now, thanks to the growing bank of thousands of brain images and other scans, as well as a large inventory of case studies, some new ideas have emerged about how the brain adjusts to the challenge of interpreting visual signals from print into sounds that have meaning.

We already mentioned that writing appeared in our culture too recently to have made alterations in our brain through the slow process of biological evolution. Yet the fact that we *can* read must indicate that our brain makes adjustments in its capabilities that do not require changes in the genetic code. In other words, momentous events in our culture, like the invention of writing, can apparently cause important cerebral adaptations to occur as a result of cultural learning. These adaptations occur because of