Reading is a Two-Way Communication Process: That's What Brain Research Tells Us

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Reading is grounded in the brain's capacity to form expectations and make predictions, a basic cognitive function that all humans develop, starting in earliest infancy. Understanding this ability is essential to understanding reading and knowing how to help children learn to read. It's useful to think of this aspect of brain functioning as a two-way communication process.

Signals In, Signals Out

In one direction, sensory data enter the brain through the sense organs and follow neural pathways to the cortex, where they are used to construct perceptions that are stored in memory. For example, when an individual touches surfaces, tactile data are sent from the skin to the cortex and are used to construct perceptions of texture. The same process occurs when sound waves reach the eardrum and when light waves reach the retina: The data are sent to the cortex and are used to construct auditory and visual perceptions. The sensations from the environment are raw data; they are only signals. The cortex responds to the signals by constructing meaningful perceptions that are then retained as memories.

But the process involves more than *sensation* > *meaning*. For every signal that comes into the cortex, about ten signals are sent from the cortex to the sensory organs (Strauss, Goodman, and Paulson, 2009). That's because the cortex does more than construct meanings and retain them as memories. It also generates a continual stream of expectations and predictions that are based on previously-constructed meanings. These predictions actually guide the senses, while the brain uses the incoming data to confirm, refute, or revise the predictions. In fact, with whatever the organism is doing, the predictions emanating from the cortex are as important as the data entering the brain from the sensory organs (Gilbert and Sigman, 2007; Cullen, et al., 2018).

The cortex delivers predictions and expectations so rapidly to the sensory organs that the individual is not consciously aware of them, but they are as essential to the processes of perceiving and understanding as are incoming data from the sensory organs. Hawkins & Blakeslee (2004) refer to this two-way process as the *memory-prediction system* and note that it is active all the time, in all that we do. As they say, "It is the ability to make predictions about the future that is the crux of intelligence" (page 6).

The bi-directional signals take numerous pathways because multiple senses, interacting with each other, are almost always involved. All the senses are continually and simultaneously feeding information into the cortical area of the brain, while the cortex is continually sending predictions to the sensory systems, affecting the operation of those systems and monitoring how well the incoming data match the predictions. This process occurs when we walk down the street, play music, eat a meal, drive a car, or engage in any number of other activities. The back-and-forth signaling along our neural pathways is at the heart of all we do.

This adaptive, constructive intelligence makes its appearance very early in life. Gopnik, Meltzoff & Kuhl (1999) show how infants are effective constructors of meaning, using this bi-directional signaling system. They learn to walk and talk, interpret, and react to a wide variety of communications (language, non-verbal signals, facial expressions, signs, etc.), and in countless other ways observe and respond intelligently to the world around them. As these authors note,

"Babies begin by translating information from the world into rich, complex, abstract, coherent representations. Those representations allow babies to interpret their experience in particular ways and to make predictions about new events" (page 142). These findings build on the observations Jean Piaget made about how children assimilate information from the environment, fitting it into ever-evolving schemas, and accommodate to the updated schemas by adjusting their perceptions and behaviors (e.g., Piaget, 1957). Numerous studies have been conducted on this process, which is sometimes referred to as *predictive coding.* See Heilbron and Chait (2017) for a useful review. Ongoing discoveries of neocortical functioning are revealing additional complexities of this system (Hawkins, 2021; Rosso, 2018), building on the basic principles described here.

The Two-Way Communication Process of Reading

By the time children begin to read, they have been using their well-honed memory-prediction systems to make sense of what they see, hear, touch, taste, and smell since their very first days of life. Strauss, Goodman, and Paulson (2009) note that reading is one of a number of meaning-making activities that involve prediction (originating in the cortex, with reference to stored memories) and data collection (originating in the sensory organs and sent to the cortex). Because of this, young readers are primed to use visual input from the text, combined with expectations from their brains, to make sense of what is on the page. Their expectations are based on what they know about the syntax, semantics, and phonology of language, about the world around them, and about the topic at hand.

To make sounding out words the priority places all the attention on sensory inputs to the brain while neglecting the intelligent expectations and predictions that the child's cortex is constantly generating. Yet the cortical outputs are as important as the sensory inputs in reading; it is quite clearly a two-way communication process.

Understanding the process is essential for understanding how to align instruction with the strengths children bring to the task. For example, when young readers encounter an unfamiliar word, it's effective to ask at the outset: *What word would make sense there?* Some maintain that this elicits inappropriate guessing. However, this question simply prompts children to use what they know about language and what they have gleaned from the text so far to make a meaningful prediction about what the word is. The next step is to have the children check the prediction by seeing if the sequence of letter-sounds in the word matches the predicted word. This is best characterized as hypothesis formation based on the expectations that are already emanating from the child's cortex. The teacher who asks *What word would make sense here?* is invoking and supporting the natural back-and-forth between cortical output and sensory input that is the essence of intelligence applied to reading. Asking the child to sound the word out while ignoring the expectations and predictions that are already streaming from the child's cortex is to ignore half of the process. We will help youngsters most effectively by understanding the two-way process and aligning our teaching with it.

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