Title
Brain Research: Implications for Second Language Learning

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Implications for Second Language Learning

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There has been a longstanding interest among second and foreign language educators in research on language and the brain. Language learning is a natural phenomenon; it occurs even without intervention. By understanding how the brain learns naturally, language teachers may be better able to enhance their effectiveness in the classroom.

Brain Development: Can Teaching Make a Difference?

It has long been known that different regions of the brain have specialized functions. For example, the frontal lobes are involved in abstract reasoning and planning, while the posterior lobes are involved in vision. Until recently, it was believed that these specialized regions developed from a genetic blueprint that determined the structure and function of specific areas of the brain. That is, particular areas of the brain were designed for processing certain kinds of information from birth.

New evidence suggests that the brain is much more malleable than previously thought. Recent findings indicate that the specialized functions of specific regions of the brain are not fixed at birth but are shaped by experience and learning. To use a computer analogy, we now think that the young brain is like a computer with incredibly sophisticated hardwiring, but no software. The software of the brain, like the software of desktop computers, harnesses the exceptional processing capacity of the brain in the service of specialized functions, like vision, smell, and language. All individuals have to acquire or develop their own software in order to harness the processing power of the brain with which they are born.

A number of studies support this view. However, all were carried out on animals, because it is not possible to do such research with humans. Caution is called for when extrapolating these findings to humans. The studies discussed below reveal the incredible neural flexibility of the developing (and aging) brain. (See Chapter 5 in Elman et al., 1997).

Cortical tissue transplanted from its original location to a new location in the brain of young animals takes on the structure and function of its new location and not those of its original location. More specifically, neurons in the visual cortex of rodents have been transplanted to regions of the brain that are normally linked to bodily and sensory functions. The transplanted tissue comes to function like somato-sensory neurons and loses the capacity to process visual information (O'Leary & Stanfield, 1985). Likewise, if input from the eyes is rerouted from what would normally be the visual area of the brain to what is normally the auditory area of the brain, the area receiving the visual input develops the capacity to process visual and not auditory information; in other words, it is the input that determines the function of specific areas of the brain (Sur, Pallas, & Roe, 1990).

Greenenough, Black, and Wallace (1993) have shown enhanced synaptic growth in young and aging rats raised in complex environments, and Karni et al. (1995) have shown expansion of cortical involvement in performance of motor tasks following additional learning—in other words, the cortical map can change even in adulthood in response to enriched environmental or learning experiences.

These findings may have implications for language educators: for one thing, that teaching and teachers can make a difference in brain development, and that they shouldn't give up on older language learners.

Learning Through Connections

The understanding that the brain has areas of specialization has brought with it the tendency to teach in ways that reflect these specialized functions. For example, research concerning the specialized functions of the left and right hemispheres has led to left and right hemisphere teaching. Recent research suggests that such an approach does not reflect how the brain learns, nor how it functions once learning has occurred. To the contrary, "in most higher vertebrates (humans), brain systems interact together as a whole brain with the external world" (Elman et al., 1997, p. 340). Learning by the brain is about making connections within the brain and between the brain and the outside world.

What does this mean? Until recently, the idea that the neural basis for learning resided in connections between neurons remained speculation. Now, there is direct evidence that when learning occurs, neuro-chemical communication between neurons is facilitated, and less input is required to activate established connections over time. New evidence also indicates that learning creates connections between not only adjacent neurons but also between distant neurons, and that connections are made from simple circuits to complex ones and from complex circuits to simple ones.

For example, exposure to unfamiliar speech sounds is initially registered by the brain as undifferentiated neural activity. Neural activity is diffuse, because the brain has not learned the acoustic patterns that distinguish one sound from another. As exposure continues, the listener (and the brain) learns to differentiate among different sounds and even among short sequences of sounds that correspond to words or parts of words. Neural connections that reflect this learning process are formed in the auditory (temporal) cortex of the left hemisphere for most individuals. With further exposure, both the simple and complex circuits (corresponding to simple sounds and sequences of sounds) are activated at virtually the same time and more easily.

As connections are formed among adjacent neurons to form circuits, connections also begin to form with neurons in other regions of the brain that are associated with visual, tactile, and even olfactory information related to the sound of the word. These connections give the sound of the word meaning. Some of the brain sites for these other neurons are far from the neural circuits that correspond to the component sounds of the words; they include sites in other areas of the left hemisphere and even sites in the right hemisphere. The whole complex of interconnected neurons that are activated by the word is called a neural network.

The flow of neural activity is not unidirectional, from simple to complex; it also goes from complex to simple. For example, higher order neural circuits that are activated by contextual information associated with the word *doggie* can prime the lower order circuit associated with the sound *doggie* with the result that the word *doggie* can be retrieved with little direct input. Complex circuits can be activated at the same time as simple circuits, because the brain is receiving input from multiple external sources—auditory, visual, spatial, motor. At the same time that the auditory circuit for the word *doggie* is activated, the visual circuit associated with the sight of a dog is also activated. Simultaneous activation of circuits in different areas of the brain is called parallel processing.

In early stages of learning, neural circuits are activated piecemeal, incompletely, and weakly. It is like getting a glimpse of a partially exposed and very blurry photo. With more experience, practice, and exposure, the picture becomes clearer and more detailed. As exposure is repeated, less input is needed to activate the entire network. With time, activation and recognition are relatively automatic, and the learner can direct her attention to other parts of the task. This also explains why learning takes time. Time is needed to establish new neural networks and connections between networks. This suggests that the neural mechanism for learning is essentially the same as the products of learning—learning is a process that establishes new connections among networks and the new skills or knowledge that are learned are neural circuits and networks.

What are the implications of these findings for teaching? First, effective teaching should include a focus on both parts and wholes. Instructional approaches that advocate teaching parts and not wholes or wholes and not parts are misguided, because the brain naturally links local neural activity to circuits that are related to different experiential domains. For example, in initial reading instruction, teaching phonics independently of the meaning of the words and their meaningful use is likely to be less effective than teaching both in parallel. Relating the mechanics of spelling to students' meaningful use of written language to express themselves during diary writing, for example, provides important motivational incentives for learning to read and write. Second, and related to the preceding point, teaching (and learning) can proceed from the bottom up (simple to complex) and from the top down (complex to simple). Arguments for teaching simple skills in isolation assume that learners can only initially handle simple information and that the use of simple skills in more complex ways should proceed slowly and progressively. Brain research indicates that higher order brain centers that process complex, abstract information can activate and interact with lower order centers, as well as vice versa. For example, teaching students simple emotional expressions (vocabulary and idioms) can take place in the context of talking about different emotions and what situations elicit different emotions. Students' vocabulary acquisition can be enhanced when it is embedded in real-world complex contexts that are familiar to them. Third, students need time and experience ("practice") to consolidate new skills and knowledge to become fluent and articulated.

Are All Brains the Same?

Brains are not all the same. Take the early research on left-right hemispheric differences with respect to language. For most individuals, the left hemisphere is critically involved in most normal language functions. We know this because damage to the left hemisphere in adults leads to language impairment, which is often permanent. However, approximately 10% of normal right-handed individuals have a different pattern of lateralization; their right hemispheres or both hemispheres play a critical role in language (Banich, 1997, pp. 306-312). Males and females have somewhat different patterns of lateralization, with males being more left-hemisphere dominant than females. In the domain of reading, brain maps of students with dyslexia demonstrate that there are very large individual differences in the areas of the brain that underlie their difficulties (Bigler, 1992).

We also know that the areas of the brain that are important in specific domains of learning can change over the life span. There is increasing evidence of right hemisphere involvement in early language learning but less in later learning. Young children with lesions to their right hemisphere demonstrate delays in word comprehension and the use of symbolic and communicative gestures. These problems are not found in adults with right hemisphere lesions. Stiles and Thal have argued that there may be a link between the word comprehension problems of children and the right hemisphere, because "to understand the meaning of a new word, children have to integrate information from many different sources. These sources include acoustic input, but they also include visual information, tactile information, memories of the immediately preceding context, emotions—in short, a range of experiences that define the initial meaning of a word and refine that meaning over time" (Stiles & Thal, as cited in Elman et al., 1997, pp. 309-310). We know from a variety of sources that integration across domains of experience is a right-hemisphere function.

By implication, brain research confirms what we know from education research: that educators must make provisions for individual differences in learning styles by providing alternative grouping arrangements, instructional materials, time frames, and so on. Instruction for beginning language learners, in particular, should take into account their need for context-rich, meaningful environments. Individual differences in learning style may not be a simple matter of personal preference, but rather of individual differences in the hardwiring of the brain and, thus, beyond individual control.

Conclusions

Our understanding of the brain is continually evolving, thus our interpretation of the implications of findings from brain-based research for teaching and learning should also continually evolve. Brain research cannot prescribe what we should teach, how we should organize complex sequences of teaching, nor how we should work with students with special needs. Educators should not abandon their traditional sources of insight and guidance when it comes to planning effective instruction. They should continue to draw on and develop their own insights about learning based on their classroom experiences and classroom-based research to complement the insights that are emerging from advances in brain research.

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