

Sign Language

An implication of several aspects of the foregoing account is that the cortical organization of language does not simply reflect specializations for hearing and speaking; the language regions of the brain appear to be more broadly organized for processing symbols pertinent to social communication. Strong support for this conclusion has come from studies of sign language in individuals deaf from birth.

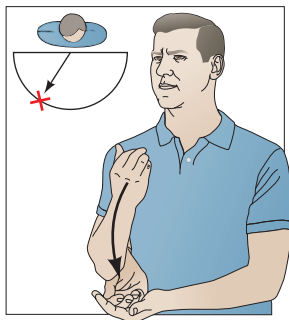
American Sign Language has all the components (grammar, syntax, and emotional tone) of spoken and heard language. Based on this knowledge, Ursula Bellugi and her colleagues at the Salk Institute for Biological Studies examined the cortical localization of sign language abilities in patients who had suffered lesions of either the left or right hemisphere. All of these deaf individuals had never learned verbal language, had been signing throughout their lives, had deaf spouses, were members of the deaf community, and were right-handed. The patients with left-hemisphere lesions, which in each case involved the language areas of the frontal and/or temporal lobes, had measurable deficits in sign production and comprehension when compared with normal signers of similar age (Figure 33.8). In contrast, the patients with lesions in approximately the same areas in the right hemisphere did not have such signing “aphasias.” Instead, as predicted from hearing patients with similar lesions, right hemisphere abilities

such as visuospatial processing, emotional processing, and the emotional tone evident in signing were impaired. Although the number of people studied was necessarily small (deaf signers with lesions of the language areas are understandably difficult to find), the capacity for signed and seen communication was predominantly represented in the same areas as spoken language in the left hemisphere. This evidence accords with the idea that the language regions of the brain are specialized for the representation of social communication by means of symbols, rather than for heard and spoken language per se.

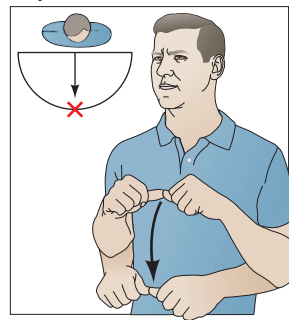
The capacity for seen and signed communication, like its heard and spoken counterpart, emerges in early infancy. Careful observation of babbling in infants with normal hearing shows the production of a predictable pattern of sound production related to the ultimate acquisition of spoken language. Thus, babbling prefigures mature language, and indicates that an innate capacity for language imitation is a key part of the process by which a full-blown language is ultimately acquired. The hearing offspring of deaf, signing parents “babble” with their hands in gestures that are apparently the forerunners of mature signs. Like verbal babbling, the amount of manual babbling increases with age until the child begins to form accurate, meaningful signs. These observations indicate that the strategy for acquiring the rudiments of symbolic communication from parental or other cues—regardless of the means of expression—is similar.

Patient with signing deficit:

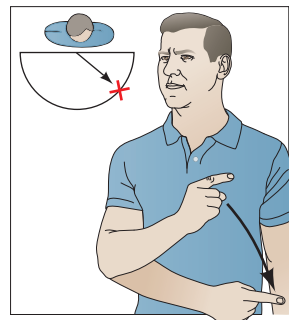
Arrive



Stay

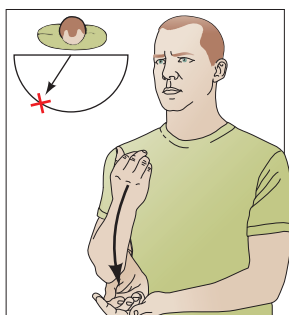


There

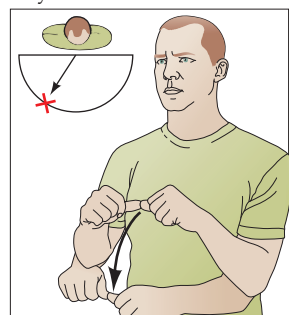


Correct form:

Arrive



Stay



There

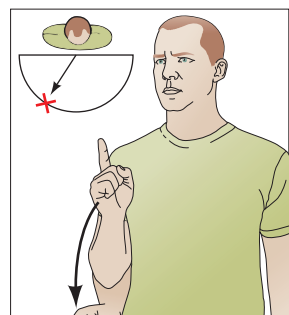


FIGURE 33.8 Signing deficits in congenitally deaf individuals who learned sign language from birth and later suffered lesions of the language areas in the left hemisphere. Left-hemisphere damage produced signing problems in these patients analogous to the aphasias seen after comparable lesions in hearing, speaking patients. In this example, the patient (upper panels) is expressing the sentence “We arrived in Jerusalem and stayed there.” Compared with a control (lower panels), the patient cannot properly control the spatial orientation of the signs. The direction of the correct signs and the aberrant direction of the “aphasic” signs are indicated in the upper left-hand corner of each panel. (After Bellugi et al., 1989.)

A Critical Period for Language Acquisition

Although a maturing child begins to lose the ability to hear non-native phonetic distinctions at a remarkably early age, the ability to learn another language fluently persists for some years. As is apparent from the experience of learning a new language in school or from watching friends and family who began learning a second language at various ages, becoming fluent nevertheless requires linguistic experience relatively early in life. This fact reflects a broader generalization about neural development—namely that neural circuitry is especially susceptible to modification during early development, and that this malleability gradually diminishes with maturation. The window for extensive neural modification supporting a behavior is referred to as the **critical period** (also called the sensitive period), and it is evident in the acquisition of language, and in many other cognitive behaviors.

Psycholinguists Jacqueline Johnson and Elissa Newport at the University of Rochester undertook a detailed study of this aspect of language learning, examining the critical period for the acquisition of a second language in Chinese Americans who had come to the United States at various ages (Figure 33.9A). Using a battery of grammatical and other tests of fluency, Johnson and Newport found that learning a second language before about age 7 results in adult performance that is indistinguishable from that of native speakers, although the details for second language learning are debated.

The requirement for experience during a critical period is also apparent in studies of language acquisition in children who become deaf at different ages. The effects on language skills tend to be more marked when the onset of deafness occurs early in life than when the onset occurs later in childhood or in adult life. Younger children who have acquired some speech but then lose their hearing suffer a substantial decline in spoken language because they are unable to hear themselves speak and thus cannot

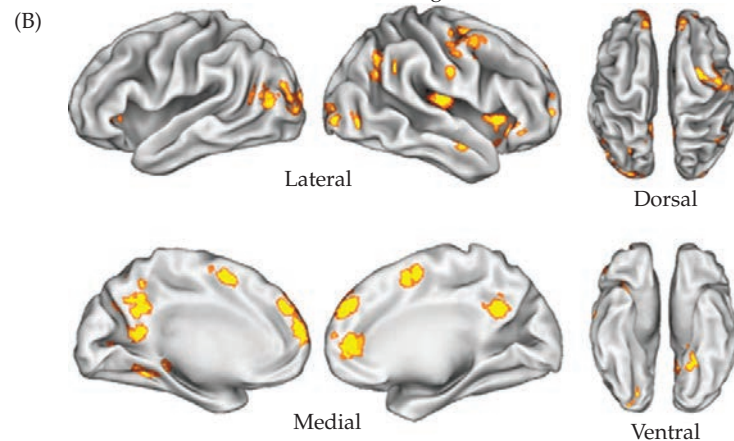
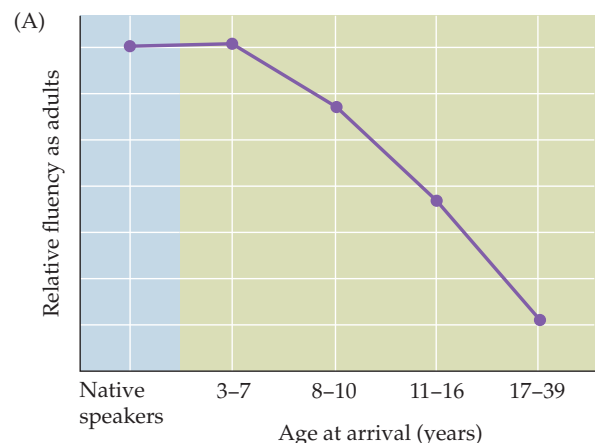
refine their initial efforts at speech by testing the relative adequacy of what they are trying to say through auditory feedback. Differences in brain activation observed in children and adults doing language-based tasks provide some indication of the neural regions pertinent to diminished language-learning skills in adults (Figure 33.9B).

An issue complementary to normal language learning concerns the effects of language deprivation, a topic already touched on in the consideration of the deterioration of language in hearing-deficient individuals as a function of age. A broader question, asked since antiquity, is what would happen if an otherwise typical child were never exposed to language. Would the child remain mute, or could he or she develop some ability to speak and, if so, what sort of language would she or he have?

The closest approximation to a realization of this sort of “thought experiment” is a handful of unfortunate cases in which children have been deprived of significant language exposure as a result of having been raised by deranged parents. In the most fully documented case, a girl in a Los Angeles suburb was raised from infancy until age 13 under conditions of almost total language deprivation (she is known in the literature as Genie). Genie was brought to the attention of social workers in 1970, who found her locked in a small room where she had been isolated and allegedly beaten if she made any noise. She was removed from these

FIGURE 33.9 The critical period for language learning.

(A) The critical period for fully fluent language learning is apparent in studies of the fluency of adult Chinese Americans as a function of the age of their arrival in the United States, marking the onset of significant exposure to English. Ultimate fluency starts to drop off when language learning begins after about age 7. (B) Areas in the brains of children and adults that are differently active during language-based tasks are shown in yellow. These differences provide a possible neural basis for the diminishing ability to learn a new language with increasing age, although more specific interpretation of this evidence is not yet possible. (A after Johnson and Newport, 1989; B from Brown et al., 2005.)



desperate conditions and taken to the children's hospital at the University of California, Los Angeles, where she was found to be in adequate general health. Given these highly unusual circumstances, a team of psychologists and linguists at UCLA studied Genie's language and other cognitive skills during the subsequent 5 years. Although Genie had little or no language ability initially, the investigators found no evidence of brain damage or mental retardation in the usual sense, and they described her overall personality as rather docile and generally pleasant. As might be expected, Genie also received extensive remedial training to teach her the language skills that she had never learned as a child. Despite these efforts, as well as daily life in more or less normal conditions in foster homes, Genie never acquired more than rudimentary language skills. Although she eventually learned a reasonable vocabulary, she could not put words together grammatically, saying things like "Applesauce buy store?" when she wanted to ask whether she might buy some applesauce at the store. Genie's case and a few similar examples starkly define the importance of adequate early experience for successfully learning any language, in accord with the more abundant evidence of a critical period for learning a second language.

In sum, researchers agree that the normal acquisition of human language is subject to a critical period of approximately a decade; exposure and practice must occur within this time for a person to achieve full fluency. Of course, some ability to learn language persists into adulthood, but at a reduced level of efficiency and ultimate performance. This generalization is consistent with much other evidence from neural development that underscores the special importance of early experience in the full development of cognitive abilities (see Chapter 25).

Reading and Dyslexia

Reading is obviously an interpretation of visual symbols closely related to language and is subject to some important disorders. Dyslexia, for example, is a common problem that affects a child's ability to read. Despite having normal or above-normal intelligence, dyslexics are poor readers and have difficulty more generally in processing speech sounds and translating visual to verbal information, and vice versa. Thus, in addition to suffering reading problems, dyslexics often have difficulty writing, are poor spellers, and are prone to errors arising from letter transposition. Because there is no specific diagnostic criterion, estimates of the prevalence of dyslexia vary widely; 5% to 15% of children are affected, with greater occurrence in boys. Although dyslexia is generally accepted as a learning disability, its cause is unclear, and some investigators have argued that this disorder is simply the lower tail of the distribution of performance in learning to read. There is, however, a strong tendency for the problem to run in families, implying a genetic basis.

Given these facts, dyslexia is a broad category with several causes. Nonetheless, researchers have understandably focused on areas of the brain concerned with reading. fMRI studies indicate that a specific set of left-hemispheric brain areas is activated during reading. Some of these areas are also activated by spoken language, but one of them, the *visual word form area* (VWFA) located in the region of the left occipito-temporal sulcus, is selectively activated by written characters but not by spoken words or low-level visual stimuli (Figure 33.10). The organization of the VWFA appears to depend on experience, and activation levels in this area in children and adolescents predict word–phoneme decoding abilities. Dyslexics tend to have a weaker BOLD signal in this general area compared with nondyslexics, as well as underdevelopment of the associated cortex and white matter tracts.

Evidence for a functionally specific brain region is surprising, given that until recently few humans have been literate. Thus, the VWFA could not have evolved to support reading per se, and may be better thought of as a brain region with specific processing characteristics rather than a brain region devoted to a specific stimulus class such as words. To make sense of these observations, Stanislas Dehaene and Laurent Cohen have argued that brain circuits "recycle" information for new, culturally specified functions. An extension of this idea is that cultural inventions such as reading and writing are constrained to specific brain circuits across cultures. For example, letters in all alphabets are made up of roughly three strokes, which might in turn be related to the efficient use of receptive fields by neurons at successively higher levels of visual cortex. The argument is that by matching the appearance of letters to the inherent functions of neurons involved in recognizing elementary objects, writing and reading systems are

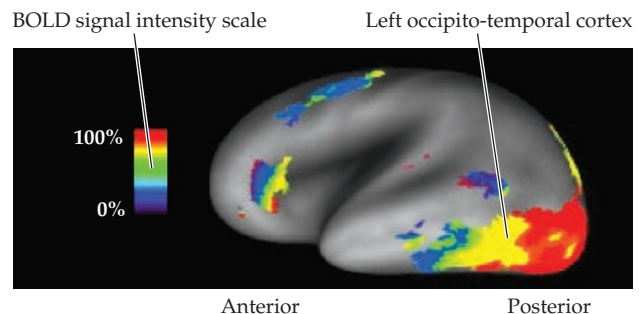


FIGURE 33.10 Hierarchical organization across the extent of the VWFA in the left occipito-temporal cortex.

The figure shows an anterior–posterior gradient of BOLD signal intensity as stimuli being read are progressively changed from single letters to complete words. In typical individuals, but less so in dyslexics, increasingly closer approximations to the usual appearance of words (i.e., shifts from false fonts to regular fonts) lead to increasing anterior activation in the left but not the right occipito-temporal cortex. (From Vinckier et al., 2007.)