In Press: Encyclopedia of Human Development. Neil Salkind (Ed) Sage Publications

Brain Lateralization

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The two hemispheres of the human brain are anatomically and functionally asymmetric.

Anatomical asymmetry

Anatomical differences between the two hemispheres are observed in gross sulcal and gyral patterns and size. The left sylvian fissure is more often branched, longer, and more horizontal than the corresponding structure in the right hemisphere (RH). The planum temporale (PT), associated with language processing, is larger in the left hemisphere (LH) in 2/3, larger in the LH in 1/10, and symmetrical in approximately 1/4 of the population. In addition, the posterior portion of the superior temporal gyrus (area Tpt) is generally larger in the LH, and its size is correlated with that of the PT. Primary auditory cortex (Heschl's gyrus), commonly contains a double gyrus in the RH, but not in the LH. There are also known neurochemical asymmetries, with greater abundance of dopamine neurons in the LH and that of the noradrenergic neurons in the RH. Such chemical asymmetries may play a role in lateralized functions.

Lateralized functions

In the majority of right-handers, the LH is specialized for syntactic and semantic aspects of language whereas the RH seems to be specialized for spatial and affective processing including associative learning to emotional stimuli. Lesions in Broca's area in the left frontal cortex disrupt language production and syntax. Lesions in Wernicke's area in the left temporal cortex disrupt semantic processing. The role of RH in language processing lies in prosody and pragamatics. RH is also specialized for spatial attention, vigilance, and arousal. Visuospatially, LH is more sensitive to high spatial frequencies (e.g., fine-grained features) whereas RH is sensitive to low spatial frequencies

(global, holistic form) with an advantage in face recognition and discrimination.

Roles of development and gender

Anatomical differences between the LH and RH are evident in the fetal Sylvian fissure and PT after the gestational midpoint, and rates of hemispheric growth alternate. Following the initial predominant growth of the RH in the first six months after birth, a period of predominant LH growth continues for the next 4-5 years, which includes the critical period for language acquisition. Handedness, a reliable behavioral signature of hemispheric dominance, is not completely established until about 7-12 years of age but hand or side preference is usually consistent from infancy. Laterality in part is modulated by gender primarily through the effects of testosterone during gestation. Both sexes are exposed to testosterone, but the exposure is greater in males. Testosterone may delay the development of the Sylvian fissure and Wernicke's area, thereby favoring earlier development of the RH in males. Some studies have reported increased right-handedness and spatial abilities, and reduced verbal abilities in males than in females, and these functional sexual dimorphisms may be subsumed by differential gestational exposure to sex hormones. RH cortical thickness is also greater in males than in females.

Other species

Brain lateralization may not be specific to humans but more extreme in our species. Larger LH areas, especially the regions homologous to the human PT and the left inferior frontal gyrus operculum (Broca's region) were observed in the majority of chimpanzees studied. Additionally, captive chimpanzees show LH dominance in approximately two thirds of behaviors studied. LH dominance is also pronounced in the orangutan. Some species of birds and fish also show evidence of asymmetry, often biased towards the LH.

For Further Reading

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