

Cognitive neuroscience: The hemispheric war

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Early findings

The scientific inquiry into the differences of functions between the left and the right cerebral hemispheres in man is one of the most exciting and active areas of research in neuroscience in recent times. Speech, the grand culmination of evolution that sets apart *Homo sapiens* from all other species, is controlled by the left half of the brain. Curiously, in more than 40 patients with aphasia (loss of speech), Marc Dax, an obscure country doctor in Montpellier, France, found signs of damage to the left half of the brain. He presented his observations before a medical society in 1836 (ref. 1). No one, however, paid any attention at that time to this seminal discovery of far-reaching significance. Subsequently, other functional asymmetries between the left hemisphere and the right hemisphere, have come to be known through clinical data. Damage to the right hemisphere leads to perceptual and attentional problems in spatial orientation (patient may be disoriented even in familiar surroundings). Such patients may have difficulty in recognizing familiar faces and they may also pay no attention to the left side of the body (such as, for example, not taking care of the appropriateness of the left side of the dress). On the contrary, damage to the left hemisphere usually does not produce such severe and long lasting neglect of the right side of the space.

The brain asymmetries have been brought home dramatically through the work of Roger Sperry on split brain patients, whose corpus callosum, the major nerve fibre tract connecting the left and right cerebral hemispheres, has been surgically severed, in order to cure them of intractable epilepsy. He was awarded the Nobel Prize in Physiology or Medicine for his pioneering work in 1981 (ref. 2) (see Figure 1). Limiting the stimuli to one hemisphere, a procedure known as lateralization, produced startling results in such patients. If a blind-folded split brain patient feels an object with the right hand (which is controlled principally by the left hemisphere), he or she will have no difficulty in naming the object. But if the procedure is repeated with the left hand, the patient will be

unable to name the object as the information about the object does not reach the speech centre located in the left hemisphere. Using visual and auditory stimuli to one hemisphere at a time, significant differences in the functions of the two hemispheres have been demonstrated in split brain patients (see Table 1).

The dichotomania

The above essentially physiological paradigms have led to extensive philosophical discourse on dual consciousness in the intact normal brain under certain conditions. Robert Ornstein, the psychologist, claimed that the traditional dualisms of intellect versus intuition, science versus art and the logical versus mysterious are not simply a reflection of culture or philosophy³. According to him, the old belief in distinct eastern and western forms of consciousness has a physiological basis in the differences between the two hemispheres. Joseph Bogen, a neurosurgeon involved in split brain research, argued that the current emphasis on the acquisition of verbal skills and analytic thought processes neglects the development of important non-verbal abilities, thereby showing the implications of research on hemispheric differences for education⁴. The flip side of this research has, however, been the tendency to interpret every behavioural dichotomy (rational versus intuitive; deductive versus imaginative) in terms of left brain and right brain, derisively named 'dichotomania' by some.

Current research and the clinical applications

Nevertheless, the recent discoveries using techniques such as the non-invasive optical spectroscopy and imaging of human brain function, which allow the virtual mapping of the functional states of different loci of the brain, while a normal subject is performing a task either verbal or non verbal, confirmed the differences of functions in the left hemisphere and the right hemisphere⁵⁻¹⁰. Besides the obvious clinical implications, the practical utility of such discoveries is being realized, of late, even in India

through clinical programmes to help children with learning disabilities¹¹.

Anatomical basis for the functional differences

Concomitant with the functional differences, structural asymmetry between left and right cerebral hemispheres has been discovered. One of the first asymmetries to be recognized was the greater length of the sylvian fissure on the left side of the brain. This difference is due to the increased extent of Wernicke's area in the left hemisphere¹² (Figure 2). This asymmetry is considered as probably the most marked manifestation of a single genetically determined asymmetry in the human brain. Direct correlation of lack of such asymmetry or reduced asymmetry and schizophrenia was reported in the post-mortem studies of hospitalized patients^{13,14}.

Speech and schizophrenia

One very important upshot of this research has therefore been the attempt to understand schizophrenia as failure of hemispheric dominance for language in recent

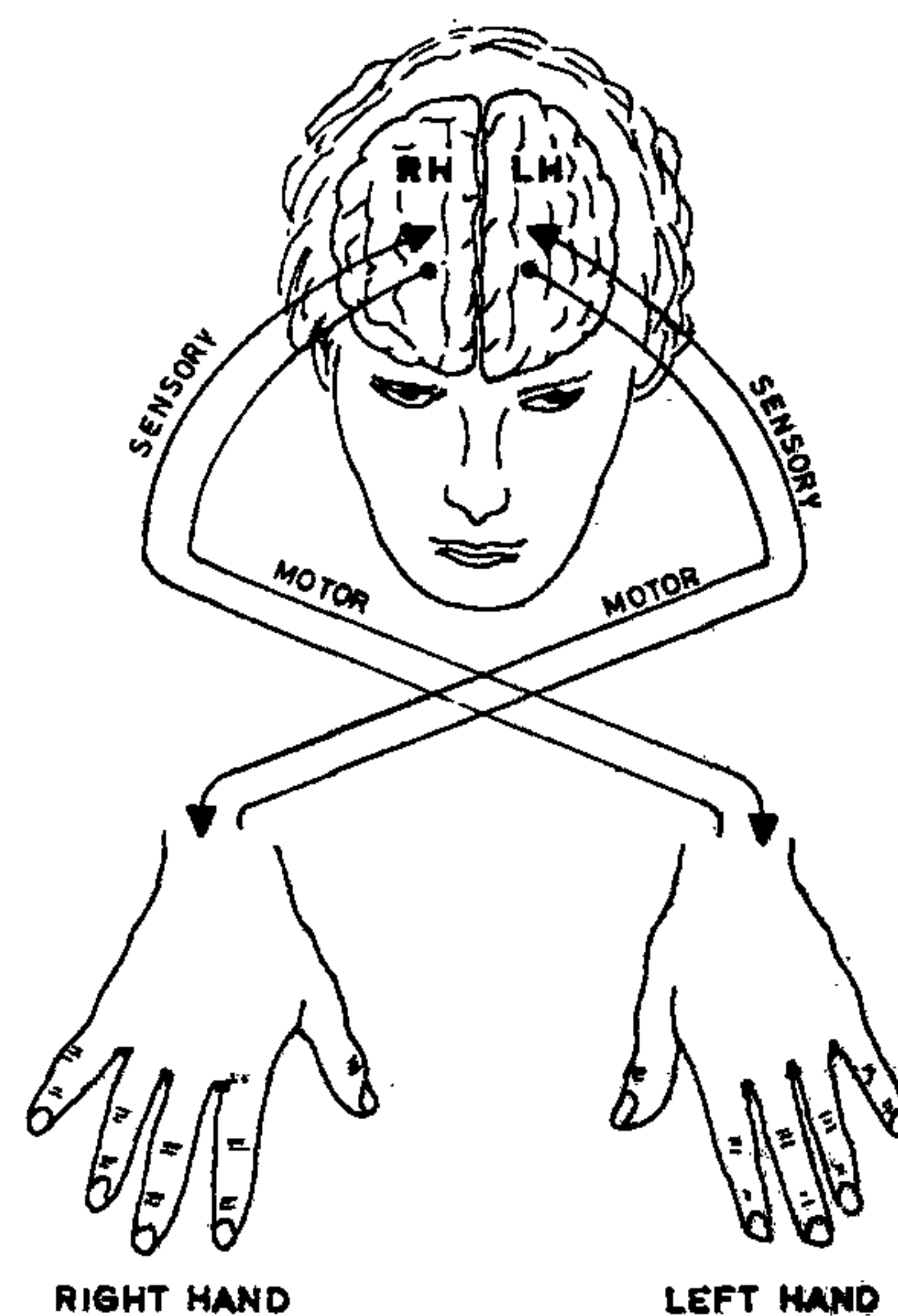


Figure 1. Motor control and sensory input between the brain and hands. RH, right cerebral hemisphere; LH, left cerebral hemisphere.

Table 1. Functions of left hemisphere and right hemisphere

Left hemisphere	Right hemisphere
Analytic processes	• Spatial skills
Production and understanding of a language	• Musical abilities
Sequential processing of input	• Simultaneous and holistic processing of input

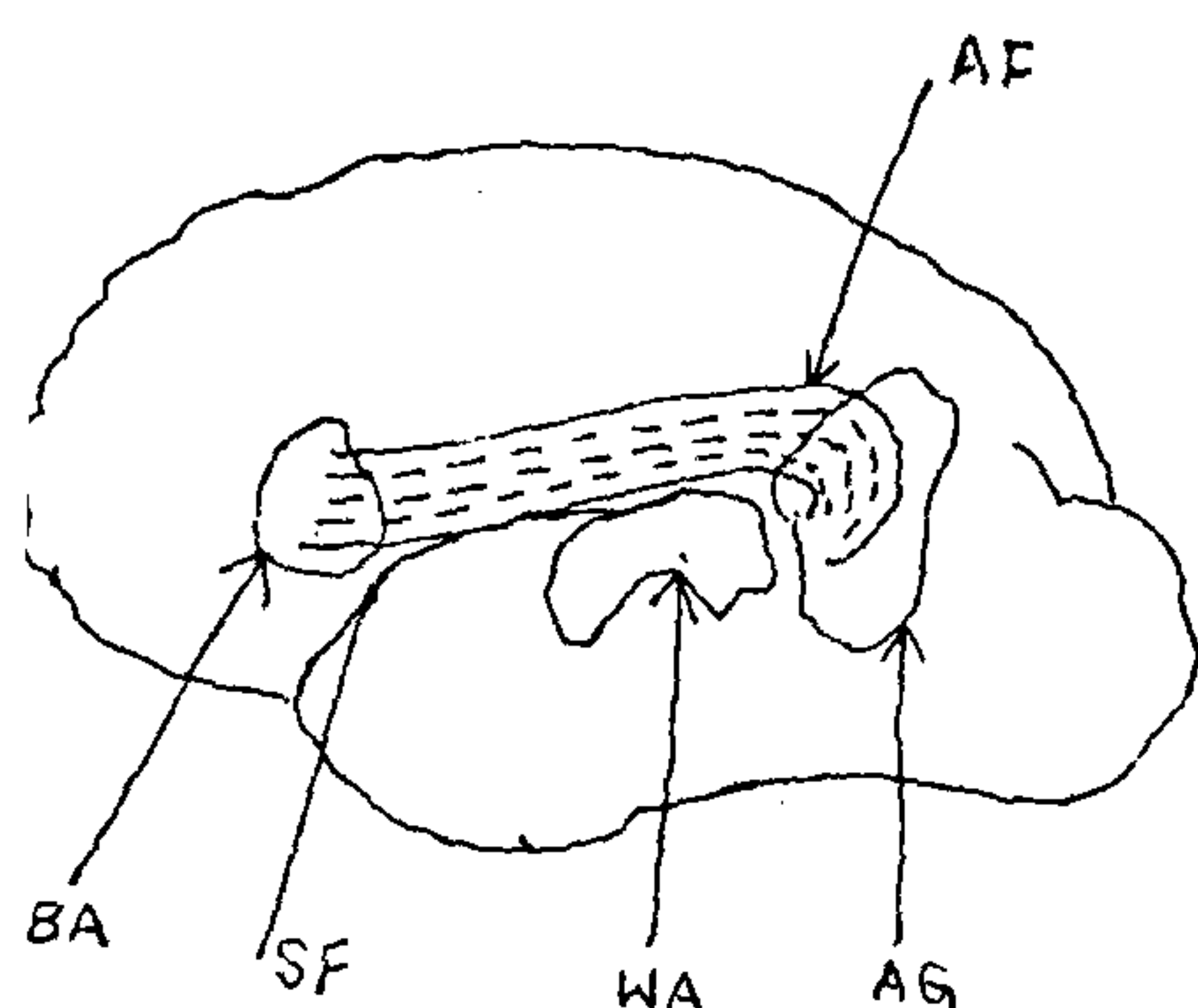


Figure 2. The areas of the left cerebral hemisphere associated with speech and language. BA, Broca's area; SF, Sylvian fissure; WA, Wernicke's area; AG, Angular gyrus; AF, Arcuate fasciculus.

times¹⁵. The positive symptoms of schizophrenia are hallucinations, delusions and formal thought disorder indicating the dysfunctions in the language systems. Hearing spoken voices is central to the auditory hallucinations. Delusions are the result of a pathological change in the meaning of words. Thought disorder is the cause for a disorder of speech. The capacity for rational thought springs from orderly and directed language. As Crow says, 'Indeed without language, it is difficult to imagine that an individual could contemplate the world, develop ideas—delusional or otherwise'. The superior temporal gyrus corresponding to Wernicke's area in the human brain is usually activated by listening to spoken language but appears to be inhibited during self-generated speech (see Figure 2). Such inhibition signals the feedback process for distinguishing the self-generated from externally-elicited speech. In patients suffering from schizophrenia, no such inhibition was recorded during the PET scanning procedure¹⁶. The hemispheric asymmetry and perhaps the consequent dominance of left hemisphere for speech is characteristic of majority of the right-handed individuals in the population who

constitute the majority. However, populations of patients with schizophrenia are characterized by a more variable and less completely lateralized pattern of manual preference that is an increase in mixed or ambiguous handedness¹⁷.

Development and the 'battle for dominance'

Inasmuch as the cerebral asymmetry and the specialization of function are acquired during development at about the age of 7–8 years (earlier in the case of females), it may be hypothesized that due to failure of such normal development leading to the absence of asymmetry and dominance of left hemisphere for speech, certain individuals may get predisposed to schizophrenia. As the ontogeny repeats phylogeny, does it mean that the left cerebral hemisphere in such individuals, while reenacting the evolutionary history of lateralization somehow loses the 'battle' for dominance which may eventually lead to the loss of 'war' during adulthood, owing to several other yet to be known precipitating factors converging on this lack of dominance? While the structural asymmetry may be likened to a 'battle' which must be won, during development, the functional integrity in terms of self-generated speech inhibiting Wernicke's area in the left hemisphere may be likened to the 'war' which cannot perhaps be won later on when such unknown precipitating factors converge on this already existing structural deformity, which translates into the manifestation of schizophrenia. As Crow suggests, 'Schizophrenia, a condition which apparently occurs in all societies with approximately the same incidence, may best be understood as an anomaly of the function which is most characteristically human, i.e. language'¹⁵.

The era of human cognitive function

Whether Crow's optimism is well placed

leading to better understanding of 'language' as a unique and highly specialized human function and the eventual amelioration of schizophrenia through such understanding, Masao Ito's prediction that the year 2000 AD will usher in the era of human cognitive function in neuroscience at brain level will possibly come true¹⁸. It is a long time ago that one used to hear that psychologists have hijacked physiology. It is time that physiologists returned the compliment.

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