Hemisphere asymmetry - 40 years after Sperry

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Introduction

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The groundbreaking work by Roger Sperry and his associates in the 1960s on the different functions of the cerebral hemispheres laid the foundation for a new research agenda into the understanding of the two hemispheres of the brain. Sperry's research was crowned with the Nobel Prize in physiology and medicine in 1981, and is still inspiring new research in experimental and clinical neuropsychology and related disciplines. The time passing since the first split-brain studies on patients with severe epilepsy has witnessed a tremendous development and advancement of our understanding of the interplay between the hemispheres. Not only has the new functional neuroimaging techniques, like fMRI and PET, opened up a new pathway into the functioning human brain, but also theoretical advances have provided the researcher with new conceptual tools. Experimental studies have also explored different sensory modalities, like visual versus auditory laterality, and different stimulus properties, like verbal and spatial characteristics. The study of children has likewise opened for a developmental view of asymmetry, and recent patient studies have shown new ways of understanding hemisphere asymmetry. These issues will be covered in the symposium on hemisphere asymmetry, highlighting ongoing research in the Nordic countries.

Speakers and Abstracts

Auditory laterality and speech perception: Dichotic listening and functional neuroimaging

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Brain asymmetry relates to both functional and structural differences between the two cerebral hemispheres. Despite all research devoted to functional asymmetry, very little is known of corresponding structural, or anatomical, differences. One notable exception is the larger left planum temporale area in the upper posterior part of the temporal lobe, and the relation of this to functional differences for speech perception. In my talk I will review recent data on asymmetry of speech sound perception, from both a basic and clinical perspective. In particular I will make an argument that auditory hallucinations in schizophrenia may be instances of speech sound mis-perceptions, caused by pathology at the neuronal level in the left planum temporale area. Data using both behavioural and psychophysiological measures, focusing on fMRI studies of neuronal activation during dichotic listening to simple speech sound syllables, will be reviewed. The talk will also focus on hemisphere differences in other clinical groups, comparing healthy subjects with patients. A final topic that will be

covered is recent research showing how a bottom-up, stimulus driven, laterality effect can be top-down modulated through attention and executive functions, revealing an interaction between an in-built hemisphere asymmetry effect and cognitive modulation and flexibility.

Functional side-differences in neonates and infants motor performance suggests increased structural specialization from right-to-left

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Our current findings of asymmetries in neonates and young infants' motor repertoire strongly support the notion that the right-left differences found with regard to spatiotemporal organization of movements are associated with a biologically based developmental process. Furthermore, our findings suggest that the developmental pattern shows a similar and rather stable timetable in most typically developing infants. Thus, in line with the suggested proximal to distal trend in motor development, the neural systems controlling the proximal movements develop before the systems controlling the more distal movements. Additionally, there seems to be a parallel right-to-left activation, development and transfer process of the hemispheric projections involved. Yet, even if the early development of functional side differences is mainly biologically rooted, we have found that this developmental process of structural-functional motor asymmetries is vulnerable. In particular during the early establishment of neural connections, alterations seem to occur as a result of interruptions of this process due to influences of intrauterine exposure to teratogens, (e.g., alcohol) or by a premature birth. Thus, the development of structural and functional specialization is by no means "hard-wired" and an epigenetic perspective, including environmental effects on early neural development, is likely the most rewarding explanation of human lateralization.

Attention, laterality and age

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Dichotic listening (DL) test shows a distinct REA (right ear advantage), i.e. preference to report consonant-vowel syllables delivered to the right ear, in right-handed young adults. REA is even stronger when attending voluntarily to the right ear stimuli (forced right), and is balanced out and even reversed to LEA (left ear advantage) when attending to the left ear stimuli (forced left). This top-down control in forced left condition develops in childhood and declines again with aging. Moreover, it is vulnerable to learning and plasticity effects demonstrated by, e.g., early blind and musically trained persons. Does this phenomenon reflect language-related or executive processes (or both) and their changes with age? In order to reveal the underlying mechanisms, different types of auditory and visual divided attention tasks, in addition to the DL test, were applied to children of two different age groups, young adults, and senior citicens. The results indicate the existence of a more general, age dependent attentional/perceptual laterality, which bears slight resemblance to the dramatic symptoms of hemispatial neglect and/or extinction seen in patients following right parietal lobe lesions.

Space and the hemispheres

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Processing of the visual world around us critically depends upon the analysis of spatial relations *between* objects in scenes and of the subcomponents *within* complex multi-part objects. According to a current cognitive neuroscience model (e.g., Laeng, Chabris & Kosslyn, 2003), there is a split within the “dorsal” stream of visual information into two sub-networks that process qualitatively different types of spatial information. One type captures “coordinate relations” or relations within a metric space for action control and navigation. The alternative mode of perception captures “categorical” or abstract spatial relations and it is most useful in integrating shape with spatial information about the arrangement of the object’s parts. Although both human hemispheres embody computational subsystems that encode the two types of spatial representations, the subsystem that encodes categorical spatial relations is more efficient in the left hemisphere; whereas the one that encodes coordinate spatial relations is more efficient in the right hemisphere. This cognitive neuroscience model has been supported for the last 20 years by studies conducted with a variety of methods (e.g, brain-damaged patients, visual field lateralization in healthy humans, PET, fMRI, rTMS, and ERP, as well as studies with monkeys and computer simulations).