“Asymmetry, Lateralization, and Alternating Rhythms of the Human Body”

Part 1: The Prevalence of Human Asymmetry and Lateralization

The human body is asymmetrical. This concept is popularly accepted from an internal organ perspective. The heart, stomach, spleen, and descending colon are on the left while the liver, gallbladder, and ascending colon are on the right. We have 3 lobes of lung on the right and 2 on the left. The right vagus nerve is longer than the left with different innervation patterns. The right gives rise to the celiac branch supplying the ascending colon and 1st 2/3rds of transverse colon while the left forms the hepatic branch innervating the liver and part of duodenum.

It is also commonly acknowledged that the human brain is lateralized with dominant speech and motor centers on the left with visuospatial and emotional centers on the right. It has been found that some parallel areas of the cortex develop at different rates and correspond to variations in asymmetrical gene transcription measured as early as 12 weeks old. (Zaidi, 2011)

Below is an outline of structural and functional brain asymmetries:

Brain Structure	Pattern of Increased Size on the Left	Pattern of Increased Size on the Right	Stated Correlation with Handedness
Central Sulcus (became apparent as early as 29 weeks gestation)	X		Yes
Prefrontal Cortex	X		Yes
Frontal Lobe		X	Yes
Occipital Lobe	X		Yes
Cingulate Gyrus	Posterior	Anterior	Yes
Hippocampus		X or no asymmetry	
Amygdala		X	
Wernicke’s Area in temporal sulcus	X		Yes
Broca’s Area (differences apparent as early as 1 year of age)	X		Yes
Somatomotor Cortex (7% increase in dominant hemisphere)	X		Yes
Corticospinal Tract		X (originating from the L hemisphere	
Optic Radiation	X		
Lateral Genticulate	X		
Medial Genticulate		X	
Uncinate fascicle (connects inferior-frontal with anterior-temporal cortex)		27% larger with 33% more fibers	
Arcuate fasciculus (showed up at 4 months of age)	X		
Lateral Ventricles (can show up as a neonate or within weeks after birth)	X		
Auditory Cortex	X		

Functional Brain Asymmetries	L Dominant	R Dominant
Learning, analytical and sequential processing; execution and coordination of movements; language organization (syntax, decoding, producing); discrimination; categorizations and local dynamics	X	
Emotional systems; visuospatial processing; relational aspects; perceiving		X

body signals; and global dynamics (taking in the big picture and intuitive reasoning)		
Handedness	X Cortex	X Body
Learned or conditioned fearful stimuli		X Amygdala (associated with increased cerebral blood flow to R and ANS activation)
Perception of innately fear related items such as photographs of threatening stimuli or faces	X Amygdala	
Infant head turning (begins at 10 weeks gestational age)		X Turning to R (2/1 ratio)
Facial Expression	X	
Smell Identification		Nostril and Hemisphere
Flavor identification	Nostril and Hemisphere	
Sexual Motivation		X
Sexual Involuntary Response	X	
Recognizing and Remembering Melodies		X
Rhythm and Pitch Functions	X	

In addition to visceral and brain asymmetries, the following table describes skeletal and vascular left to right differences.

Skeletal Asymmetries	Left	Right
Fetal bones	Been shown to be stronger and heavier in the dominant limb	
Facial (higher asymmetry associated with poorer health)	Varying reports on dominance. Even aesthetically pleasing shaped faces showed asymmetry. There may be a trend that at a younger age the right side is larger but shifts to the left side as one ages.	
Frontal Sinus	Considered normal to have asymmetry between them.	
Pelvic asymmetry	Common in both normal and populations with pain/dysfunction	
Clavicle	Increased length	Increased diaphyseal breadth
Upper limb bones		Heavier, humerus is the most asymmetrical upper extremity bone
Femur	Heavier and Longer per some sources	Heavier per some sources
Tibia and fibula	Longer	Heavier
Scapula		Heavier
Extremities	Upper extremity demonstrates more variable asymmetry than the lower with the right upper extremity being longer. The more proximal bones of both upper and lower have more asymmetry than distal.	

Vascular Asymmetries	Left	Right
Carotid Artery	Bifurcates more cranially	Bifurcates more caudally
Vertebral Artery (cranial)	Larger	
Femoral Artery		Larger

Studies have documented asymmetries in sex characteristics in both males and females. Prenatal testosterone exposure influences the development of extragenital sexual dimorphism and may also slow growth in some areas of the left hemisphere while promoting growth in areas of the right. This may influence handedness. Testosterone exposure in utero has been correlated to autism, dyslexia, migraines, stammering, autoimmune disease, sexual preferences, spatial, language, music, and mathematical abilities. A low ratio of length between the 2^{nd} digit and the 4^{th} digit is associated with lower testosterone and sperm levels in men and higher oestrogen and lutenizing hormone (LH) levels in women.(Zaidi, 2011)

The following describes findings related to genital asymmetries:

Genital Asymmetries	Left	Right
Testicles-size location related to handedness and cognitive skills. Ex-larger right associated with better spatial skills	Lower	Higher
Penis	Deviates toward	
Breasts	Higher asymmetry associated with increased risk of cancer (higher rate in the larger breast), decreased fecundity, and higher pre-term delivery rate	

Environmental factors that can influence asymmetry are increased asymmetrical manual labor or sports. There will be even more of an impact if the epiphyses have not been fused yet. Trauma or toxins in fetal or early life may influence asymmetry. Protein deficiency can diminish asymmetry. Industrial groups have less asymmetry than pre-industrial as well as decreased dimorphism asymmetry. (Zaidi, 2011)

Newborns exhibit a right head turning preference. There exists a theory that the right head turning preference is the result of the asymmetrical development of the vestibular system. The most common birth position is a left vertex position, where the fetus lies with its back to the mother's left ilium with the right side of the head facing outwards. This position can potentially facilitate right arm-hand movement and induce asymmetrical forces. The left-otolithic dominance hypothesis suggests that in this position the left otolith receives more stimulation via the hair cells as it detects the sharper backward deceleration as compared to forward acceleration when the mother walks (due to the braking effect). This, in turn, leads to more impulses to the brain stem terminating on the ipsilateral vestibulospinal tract connecting with the neck extensors and SCM thus creating a biased right head turning response. There may be a critical time period in the 3rd trimester when the cortico-vestibular pathways are being formed when this bias develops. Furthermore, research has shown a correlation between an asymmetrical Moro reflex (right biased) also hypothesized to be related to the vestibular imbalance. In addition to a lateralized vestibular system, there are likely other asymmetrical neural, genetic, and epigenetic influences on the head turning as well. (Rönnqvist, Hopkins, Van Emmerik, & De Groot, 1998)(Joganic, Lynch, Littlefield, & Verrelli, 2009)(Zaidi, 2011)(Domellöf, 2006)

The visual processing system is not symmetrical. The left visual field corresponds to the right hemisphere while the right visual field is analogous to the left hemisphere. The right hemisphere is dominant for processing global visual information (neuronal lower spatial frequencies) while the left is more adept for local (neuronal higher spatial frequencies). It has been hypothesized that the brain computes at least two kinds of spatial relation representations. The right hemisphere is more efficient at processing coordinate or metric distance information. Regarding interpretation of relational spatial characteristics such as "connected to" or "above" there is no asymmetry or a left dominance. There are also differences between the right dominant magnocellular visual processing (sensitive to low spatial frequencies, contrast, perception of motion and depth, localization of visual stimuli in space, global analysis of visual scenes, high temporal resolution, responds quickly and transiently to moving targets) and the left dominant parvocellular visual processing (sensitive to high spatial frequencies, color, acuity, and visual patterns of stationary targets.) (Joseph B. Hellige., 1996)

Additional significant findings regarding lateralization(Zaidi, 2011):

- Increased asymmetry is associated with increased aggression.
- Belief in the paranormal is associated with more asymmetry of finger length and is found more often in women. Paranormal belief is not correlated with education levels.
- Situs Inversus shows a reversal of the frontal and occipital petalia dominance patterns but the planum temporale and inferior frontal gyrus sizes were the same as non situs inversus.
- Higher asymmetry of the upper and lower limbs is associated with an increased chance of low back pain.
- There is a 7% increase in size of the dominant somatomotor cortex.
- Although both ears have bilateral cortical contributions, there is a stronger connection contralaterally vs. ipsilaterally. Typically, the left auditory cortex is larger.
- Choline acetyltransverase acitivity is higher in the left that right.

Based on all of the data that exists supporting the widespread prevalence of asymmetry within the human body one must ask whether or not it is beneficial to human beings and what is the significance of an asymmetrical system? Part 2 of "Asymmetry, Lateralization, and Alternating Rhythms of the Human Body" will provide an answer.

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