The Neanderthal Enigma

On Neanderthal Speech (Part I)

Neanderthals (NT) are the extinct hominid most closely related to contemporary humans.

The first documented fossil of NT was discovered in Germany in August 1856 in the valley of Neander (‘*thal*’ means valley, in the local dialect), 12 kilometers from Dusseldorf. It was presented by Dr Herman Schaaffhausen at the scientific meeting of the Lower Rhine Medical and Natural History Society in June 1857. The German discovery precedes by three years Charles Darwin’s publication of ‘On the Origin of Species’.

Neanderthals populated Europe at least 400,000 years ago and Western Asia about 150,000 years ago; eventually, they mysteriously disappeared shortly after 30,000 years ago.

Their world was confined to Euroasia, stretching from Uzbekistan (central Asia, beautiful mountain scenery), including the Attai region of southern Siberia, to the Iberian plateau in Spain.

Human beings today are classified as *Homo sapiens* (HS). The HS´s language is the expression of specifically human cognitive tendencies.[1]

The first HS began to appear nearly 200,000 years ago and moved from Africa into NT habitat about 80,000 years ago.

According to genetic studies, Human-chimpanzee divergence is set to 6,000,000 years and an average human-NT divergence time of 500,000 years.

Most genetic studies suggest that NT and modern humans were not closely related, but had a common ancestor about 550,000 years ago.

The period of contact, from living together side by side with modern human to NT total disappearance took 50,000 years and ‘*apparently*’ without interbreeding. About 25,000 years ago the NT disappeared from the fossil record.

The discovery of genetically possible hybrids (that is, the offspring of genetically dissimilar parents, also a hybrid word, hybrid plant) suggests that we still have not fully completed the NT story.

Were they a separate species –*Homo neanderthalensis*—, a branch on the evolutionary tree that withered and died, or a dead end—highly evolved in their own direction but not in the direction of modern humans, or real ancestors of some people living today? Some NT features in early Europeans may suggest that considerable interbreeding may have taken place between NT and Homo sapiens (HS), coexisting for 50,000 years; certainly a lot of time.

A 2010 analysis of NT Genome indicates that interbreeding may have occurred. Those of us who live outside Africa carry a little NT DNA in us.

The proportion of NT-inherited genetic material is about 1 to 4 per cent. It is a small but very real proportion of an ancestry in non-Africans today. This indicates a gene flow from NT to modern humans, that is, interbreeding between the two populations.

Comparative Observations on Neanderthal Fossils and Human Skeletal System

Neanderthal males stood about 165-168 cm (5.5-5.6 ft), and weighed 84 kg (185 lbs); they were heavily built with robust bone structure having particularly strong arms and hands. Females stood about 150 cm (5ft) and an estimated weight of 80 kg (176 lbs).

Neanderthals´ forehead had prominent brow ridges and a low sloping forehead; their heads were longer from front to back in comparison with ours, with a prominent external occipital protuberance (inion), and a suprainiac fossa, a groove above the inion. NT had bony projections on the sides of nasal opening and a broad projecting nose.

Characteristically, they had a flat basic cranium contrasting with the base of neurocranium of HS, which slopes upward from the basal part of the occiput posteriorly to the cribriform plate of the ethmoid bone anteriorly, an inclination of about 40 degrees. The oblique surface of the sphenoid and ethmoid bones in HS forms the juncture between the neurocranium and the facial cranium. The flexure of the cranial base in combination with decreased prognatism is a single shift in the human lineage.

However, the basicraneal flattening is normal in human neonate and young children and may be observed exceptionally in adult modern humans.

The NT brain was as large as that of modern man; the brain case has been measured from 1,200 to 1,740 cubic centimeters. The female NT brains were about 200 cubic centimeters smaller than those of male. |

The posterior cranial fossa is formed by the temporal and occipital bones, and contains the cerebellum and the brain stem; several foramina pass through the basal walls of this fossa. The anterior condylar (hypoglossal) canal transmits the hypoglossal nerve (CN XII). The purely motor **hypoglossal nerve** innervates all the **intrinsic muscle of the tongue** and three extrinsic muscles of somatic origin: the styloglossus, the hyoglossus, and the genioglossus. The hypoglossal nerve contributes to stabilize the muscles of the hyoid bone and the thyroids cartilage, of crucial importance during phonation and deglutition, and innervates the seventeen muscles of the tongue.

The anterior condylar (hypoglossal) canal of HS and NT have a greater diameter in comparison with that of the chimpanzee, which cannot speak[2]. In 1998 researchers from Duke University published their measurements on size of the hypoglossal canal in NT crania and concluded about the great diameter variations.

The male chimpanzee brain is 399 + 7.0 and the female one 366 + 6.5 cubic centimeters on average. Members of the genus Homo have larger brains and smaller ape-like faces. It is clear that upright bodies and bipedal locomotion long preceded the evolution of large brains: NT 1,450 and HS 1,345 cc on average.

The **NT mandible** looks very strong. However, it has small molars, but incisors are relatively large and show very heavy wear. The mental foramina located at each side inferiorly to the second pre-molar tooth transmit the mental artery and the mental branch of the inferior alveolar nerve. The NT mental foramina are larger, compared with HS´ones, which indicates a greater facial blood supply and might be related to the extreme cold weather at that time. The mental tubercle (the point at the tip of the chin) is pronounced in HS and absent in NT, suggesting that HS has more gross control of the lower lip. The mental tubercle is the attachment point of the *depressor labii inferioris* and the *mentalis* muscles. These two muscles provide fine motor control of the lower lip and are essential in the perfect and controlled speech in HS.

In addition, branches of Facial nerve (CN VII) supply the orbicularis oris muscle and muscles of the cheek and upper lip (*levator labii superioris, zigomaticus major, risorius, and depressor anguli oris*). This facial musculature -the muscles of the facial expression- play an overall role in phonation and deglutition.

The word **hyoid** is derived from the Greek word *hyoeides* meaning ´shaped like the letter *upsilon* (U)´. A bone in the NT man, almost identical in size and shape to the hyoid of today's population, was discovered in the Mugharet el-Kebara cave, located on the western side of Mt. Carmel in Israel by Baruch Arensburg and coworkers, making it possible to argue that the NT had the capacity to speak[3,4]. The skeleton found at Kebara cave is about 60,000 years old. The skeleton is lacking its entire cranium except for the hyoid bone. This U-shaped free-floating bone consists of a median body, paired lesser horns (cornua) laterally and paired greater horns posteriorly. It does not articulate with any other bone; muscles provide support and stability. It is tethered by the stylohyod ligament which runs between the styloid process and the lesser horns on each side.

We will shortly resume the concept of the hyoid bone due to its central function during phonation and deglutition.

Complexity of Phonation and Deglutition Functions: The Anatomical Concept.

Paleoanthropological studies on the origin and evolution of human speech have been classically centered mainly on the descent of the larynx during infancy and early juvenile period as an anatomical prerequisite for speech. This "unique" morphological feature related to speech has been examined through comparison with extant primates.

However, recent research in chimpanzees, using magnetic resonance imaging, shows rapid laryngeal descent in early infancy too[5]. On the other hand, larynx with varied shapes has been around for millions of years; all mammals have a larynx.

In fact, in humans the anatomy of descent of the larynx is accomplished through both the descent of the laryngeal skeleton relative to the hyoid and the descent of the hyoid relative to the hard palate and mandible. Laryngeal descent has not much to do with language; it is rather more important in swallowing.

Thus, the human supralaryngeal vocal tract develops to form a double resonator system with equally long horizontal from the posterior wall of the oropharyngeal tract to the lips and a vertical from the true vocal folds (cord) of the larynx to the soft palate (velum components) and the epiglottis. Actually, sonic vibrations are transmitted to pharyngeal, oral, and nasal passages, as well as to the paranasal sinuses producing resonance. The articulation is accomplished by varying the resonance characteristics of the nasopharynx, and oral cavity to produce the vowel sounds; interrupting the resonance produces consonant sounds.

Lingual and palatine musculature changes the shape of the oropharinx and intermittently limits access to the nasopharynx altering resonant characteristics.

The mandibular, lingual, and facial musculature about the lips changes the shape of oral cavity, also varying the resonant characteristics.

In combination, the tongue, palate, teeth, and lips modulate resonance.

However, *"from an anatomical and physiological point of view, the larynx is identical in all human beings. Yet, there are not two human beings whose voice sounds strictly the same. For all practical purposes, each person, as an individual, is a mystery to science."*[6]

The laryngeal skeleton, including the vocal folds is the physical foundation for phonation and the hyoid provides the basis for the tongue movements.

Acoustically, such configuration, in combination with tongue motility, enables human complex speech.

In fact, absolutely the most important piece in the complex laryngeal skeleton is the two true vocal cords. We know as cardiovascular surgeons that difficult removal of a large descending thoracic aneurysm may damage the left inferior (recurrent) nerve, a branch of the vagus nerve, when trapped below the ligament arteriosum. The patient eventually has a paralyzed left vocal cord adopting a middle flaccid position as atrophy occurs; the lack of vocal cord tension produces a permanent hoarseness.

The floor of the oral cavity is formed by the mylohyoid , the anterior belly of the digastric, the geniohyiod and genioglossus muscles and are called the suprahyoid muscles.

The mylohyoid nerve, a branch of the mandibular division of the trigeminal nerve CN V), innervates the anterior belly of the digastric muscle and the mylohyoid muscle. The digastric branch of the facial (CN VII) innervates the posterior belly of the digastric muscle and the stylohyoid muscle. Fibers from spinal nerve C1 that continue with the hypoglossal nerve (CN XII) innervate the geniohyoid muscle.[6]

Now, the anterior and posterior bellies of the digastric muscle elevate the hyoid bone. The stylohyoid muscle raises and retracts the hyoid. The mylohoid muscle raises the hyoid, thereby elevating the floor of the mouth. The genihoid muscle draws the hyoid forward. Working together this muscle group stabilizes the hyoid bone and larynx during deglutition and phonation. The superior constrictor of the pharynx and the palatopharyngeous muscle, innervated by the vagus, raises the oropharynx to establish the velopharingeal seal to close the nasopharyngeal isthmus during deglution and phonation.

On the contrary, the sternohyoid, sternothyroid, and omohyoid muscles, called infrahyoid muscles, lower the hyoid bone and larynx during deglutition (swallowing) and phonation. On the thyroid cartilage the thirohyoid raises the larynx during deglutition and phonation[7]. Working together this muscle group stabilizes the larynx. The infrahyoid muscles are innervated by the ansa cervicalis (CI-C3).

Six cranial nerves –trigeminal (CN V), facial (CN VII), Vagus (CN X), glossopharingeal (CN IX), spinal accessory (CN XI), hypoglossal (CN XII) and fibers from spinal nerve (C1) that continue with the hypoglossal nerve (after the superior ramus of the ansa cervicalis separates) innervate the geniohyoid muscle.

The purely motor hypoglossal nerve innervates seventeen intrinsic muscles of the tongue and three extrinsic muscles, the styloglossus, hyoglossus and genioglossus muscles; every muscle that ends in the suffix "glossus" is innervated by this nerve with the single exception of the palatoglossus muscle that is innervated by the vagus nerve.

Elevation of the hyoid bone by contraction of the digastric and mylohyoid muscles draws the hyoid bone cranially; this action also moves the attached larynx cranially under the tongue so that the epiglottis assumes a more horizontal position, placing the larynx itself against the epiglottis in deglutition.

The re-establishment of the respiratory tract and phonation is accomplished by reposition of the larynx by contraction of the infrahyoid muscles (sternohyiod, sternothyroid, omohyoid) to draw the larynx inferiorly. Contraction of the hyoglossus and genioglossus muscles returns the tongue to the floor of the oral cavity.

The palatoglossus raises the base of the tongue to squeeze the food through the fauces into the pharynx; the styloglossus muscle draws the base of the tongue posteriorly, propelling the bolus into the oropharynx. The trigeminal (the tympanic cord), the glossopharyngeal, and the vagus participate in the sensitivity of oral cavity and oropharynx.

The Functional Concept

This incredible concurrence of central cranial nerves in HS including the three first spinal nerves to take care of the motility and sensitivity during phonation and deglutition functions could not be possible without the fine coordination of motor and sensory nuclei of the brain stem and the command of specific language centers in the brain. Unproven explanations regarding the cranial base flattening and the lacking of an anatomical descending laryinx have been speculated as an impossibility to speak in NT.

The problem should be approached looking at the brain function. Certainly, today the only estimation possible in this aspect is the study of reliable genome sequences obtained from fossil analysis.

In the next Thesaurus issue we will be discussing FOXP2, which is thought to be a language gene, because humans who have one FOXP2 inactive have speech impediments and deficiencies in orofacial movements. Fortunately, FOXP2 gene is present in the DNA of NT fossils[8].

This Thesaurus –issue number 33- is a continuation of the previous ones and contains a brief outline for the only purposes of humanistic and cultural education of our university students. The next issues will continue with the same line of research.

The bibliography will be completed in the next issue (Part II)

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Bibliography

1- Lanneberg E H. 1967. Biological foundations of Language, John Wiley & Sons, Inc..

2- Kay R F et al. 1998. The hypoglossal canal and the origin of human vocal behavior, Proceedings of the Natural Academy of Science 95 (9): 5417-5419.

3-Arensburg B et al. 1989. A middle Paleolithic human hyoid bone, Nature 338:758-760.

4- Arensburg B et al. 1990. A reappraisal of the anatomical basis for speech in Middle Paleolithic hominids American Journal of Physical Anthropology 83,(2): 137-146.

5- Nishimura T et al. 2003. Descent of the larynx in chimpanzee infants Proceedings of the Natural Academy of Science 100(12):6930-6933. (Dr Nishimura, from the Primate Research Institute in Kyoto University).

6- Liotta D. 2007. Amazing adventures of a heart surgeon. The Anatomy Lesson, The Existential two sides of Medical Science, Chapter 31, 282-285, iUniverse Inc. New York.

7- April E W. 1997. Clinical Anatomy, 3rd Edition, Williams & Wilkins, Chapter 34:573-577.

8- Green RE et al. 2006. Analysis of one million base pairs of Neanderthal DNA, Nature 444:330-336.

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