The Sound of Language and its Impact on Human Mind: A Neuroanatomical Approach to Understand Language Acquisition.

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Abstract

This paper highlights the process of integration of sound to form a language and the consequent effect it poses on human mind both on a neurological and psychological basis. Here, we display the chronological sequence of language development starting from the root vibration level. The origin of sound and subsequent creation of the universe is explained in brief and then the influence of nature's sound which poses on human beings to develop a language of their own is shown here. An analysis of the language being acquired is made on a neuroanatomical ground. Further, in this paper, discussions are made on people affected with aphasia, a language impairment and possible solutions to aid such people are suggested.

KEYWORDS: Vibration, Sound, Neuroanatomical.

Sound: The Wave of Creation

The origin of the universe is the origin of everything. Many scientific theories and ancient myths try to explain the creation of this universe, although the most widely accepted theory is the Big Bang Theory. In this theory, it is assumed that the universe originated as a hot infinitely dense point, which was only a few millimeters wide and it was similar to a supercharged black hole. About 13.7 billion years ago, this infinitely dense point violently exploded and it is from this explosion that matter, energy, space and time was created. Now the question arises, how? Through the lens of String Theory, it is assumed that every particle in this universe is created by a tiny vibrating string of energy. In physics, sound is a vibration that typically propagates in an audible wave of pressure, through a transmission medium. According to the Big Bang Theory, the universe was set up in vibration of several low and high frequencies which gave rise to what is called the "first sound".

"Everything in Life is Vibration"- Albert Einstein.

According to the saying of the eminent scientist, the law of nature states that everything has a certain vibration and there is absolutely no solidity in this universe. The form which appears solid is due to the underlying vibration. Vibrations have the capability to express in various geometrical figures and as a result it is able to build up a crystal. It is also believed that the shapes, structures and designs which flowers, snowflakes etc display is due to the fact that it responds to some sound in nature. A beautiful conclusion to this is the fact that crystals, flowers, human body, etc, are visual manifestations of sound, rather music.

The Language of Nature

Nature's language is the first language from which all the other languages we use today has evolved. The sound of the oceans, shushing of leaves, all the events of nature has some language to offer.

Human beings tend to respond to those natural sounds and experimentally it has been proved that they are relaxing as it synchronizes the brain waves.

The discovery of language was revolutionary as it was the key to express the thoughts of man. All the discoveries, theories, hypothesis, inventions are accessible today because of the common language we share to communicate our thoughts. Human language is unique among all forms of animal communication. Human language is open ended, meaning that it allows humans to produce an infinite set of utterances from a finite set of elements. We can do this because human language is based on dual code, where a finite number of meaningless elements (e.g, sound, letters or gestures) can be combined to form units of meaning (words and sentences).

Human language is also known as the natural communication system because it is not only for communication through one media or channel, but through several – for example, spoken language uses the auditive modality, whereas sign language and writing use the visual modality and Braille writing uses tactile modality.

Phonetics and Phonology

The level concerned with the smallest units of language is phonetics. Phonology is on the other hand, the functional classification of the sounds of a particular language.

Phonetics is subdivided into three branches-

• articulatory phonetics (emission of sounds)

• acoustic phonetics (transmission of sounds)

• auditive phonetics (reception of words)

Articulatory phonetics

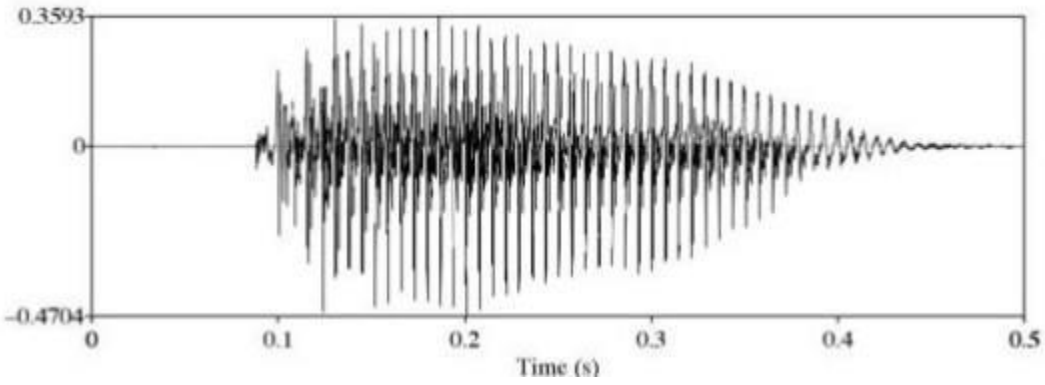
Articulatory phonetics is the study of the production of human speech sounds. It is concerned with the manipulation of the shape of the oral tract to change the shape of resulting sound waves, creating human speech. Human beings have evolved a very precise oral mechanism that allows the production of an amazing number of sounds that are then combined into meaningful words and phrases.

The International Phonetic Association was founded in 1886, with the goal of creating a comprehensive yet simple to use collection of symbols representing the sounds created in languages. The phonetic alphabet chart is separated into two sections: consonants and vowels.

Acoustic phonetics

Acoustic Phonetics is the study of the physical properties of speech, and aims to analyse sound wave signals that occur within speech through varying frequencies, amplitudes and durations.

One way we can analyse the acoustic properties of speech sounds is through looking at a waveform. Pressure changes can be plotted on a waveform, which highlights the air particles being compressed and rarefied, creating sound waves that spread outwards. A tuning fork being struck can provide an example of the pressure fluctuations in the air and how the air particles oscillate (move in one direction rhythmically) when we perceive sound.



Waveform of a vowel – Ogden 2009: 30

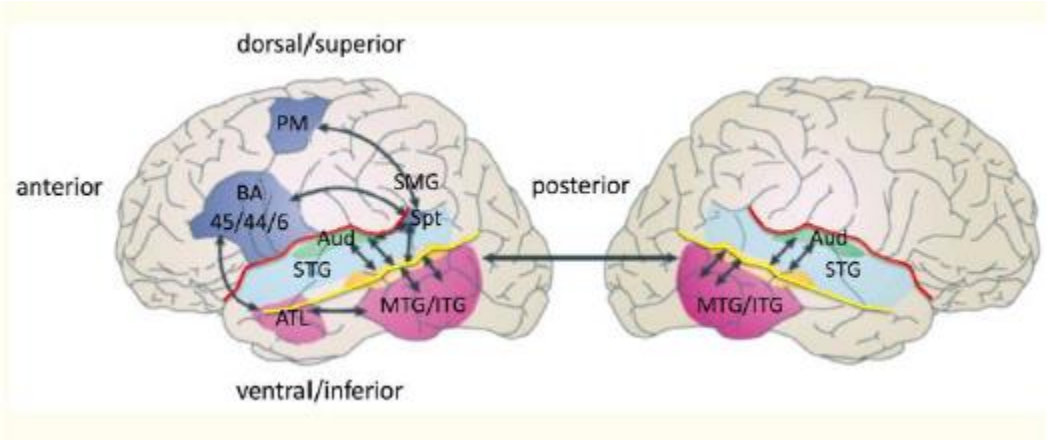
Auditory phonetics

Auditory phonetics deals with the perception of sounds or the way in which sounds are heard and interpreted. In auditory phonetics, we are dealing with two distinct operations which are closely interrelated and influence each other: on the one hand we can talk about audition proper, that is the perception of sounds by our auditory apparatus and the transforming of the information into a neural sign and its sending to the brain and, on the other hand, we can talk about the analysis of this information by the brain which eventually leads to the decoding of the message, the understanding of the verbal message

The transformation between thought and acoustic wave form and back again is a multistage computation process. The processing stages are likely to be computed "centrally," that is, within the cerebral cortex.

Neurophysiology of the language centre

The transformation from the acoustic speech signal into a conceptual representation involves multistep processing in the auditory periphery. Figure shows some of the relevant anatomy and functional organization that will be discussed throughout the review.



A Unified Dual Stream Model

The processing of acoustic information in speech recognition and speech production involves partially overlapping, but also partially distinct neural circuits. Speech recognition relies primarily on neural circuits in the superior temporal lobes bilaterally, whereas speech production (and related processes such as verbal short-term memory) relies on a fronto- parietal/temporal circuit that is left hemisphere dominant. This divergence of processing streams is consistent with the fact that auditory/phonological information plays a role in (i) accessing lexical-semantic representations on the one hand and (ii) driving motor-speech articulation on the other. As lexical-semantic and motor-speech systems involve very different types of representations and processing mechanisms, it stands to reason that divergent pathways underlie the interface with auditory/phonological networks.

The dual interface requirements with respect to auditory/phonological processing, is captured neuroanatomically by the Dual Stream model. The model is rooted in dual stream proposals in vision which distinguish between a ventral stream involved in visual object recognition ("what" stream) and dorsal stream involved in visual-motor integration (sometimes called a "how" stream).

Accordingly, the Dual Stream model proposes that a ventral stream, which involves structures in the superior and middle portions of the temporal lobe, is involved in processing speech signals for comprehension (speech recognition), whereas a dorsal stream, which involves area Spt and posterior frontal lobe, is involved in translating speech signals into articulatory representations in the frontal lobe. The suggestion that the dorsal stream has an auditory-motor integration function differs from earlier arguments for a dorsal auditory "where" system, but has gained support in recent years. As indicated above, it is likely that a spatially-related processing system co-exists with, but is distinct from the sensory-motor integration system.

In contrast to the typical view that speech processing is mainly left hemisphere dependent, the model suggests that the ventral stream is bilaterally organized (although with important computational differences between the two hemispheres); thus, the ventral stream itself comprises parallel processing streams. This would explain the failure to find substantial speech recognition deficits following unilateral temporal lobe damage. The dorsal stream, on the other hand, is strongly left-dominant, explaining why production deficits are prominent sequel of dorsal temporal and frontal lesions.

Aphasia: A Speech Disorder

Aphasia is a disorder which causes inability to comprehend or formulate language because of damage to specific regions of the brain. These damages are mainly caused due to cerebral muscular accident or head trauma. Aphasia does not impair the person's intelligence. People who have aphasia may have difficulty speaking and finding the "right" words to complete their thoughts.

They may also have problems understanding conversation, reading and comprehending written words, writing words, and using numbers.

What Are the Types of Aphasia?

There are types of aphasia. Each type can cause impairment that varies from mild to severe. Common types of aphasia include the following:

- Expressive aphasia (non-fluent): With expressive aphasia, the person knows what he or she wants to say, yet has difficulty communicating it to others. It doesn't matter whether the person is trying to say or write what he or she is trying to communicate.
- Receptive aphasia (fluent): With receptive aphasia, the person can hear a voice or read the print, but may not understand the meaning of the message. Oftentimes, someone with receptive aphasia takes language literally. Their own speech may be disturbed because they do not understand their own language.
- Anomic aphasia. With anomic aphasia, the person has word-finding difficulties. This is called anomia. Because of the difficulties, the person struggles to find the right words for speaking and writing.
- Global aphasia. This is the most severe type of aphasia. It is often seen right after someone has a stroke. With global aphasia, the person has difficulty speaking and understanding words. In addition, the person is unable to read or write.

- Primary progressive aphasia. Primary progressive aphasia is a rare disorder where people slowly lose their ability to talk, read, write, and comprehend what they hear in conversation over a period of time. With a stroke, aphasia may improve with proper therapy. There is no treatment to reverse primary progressive aphasia. People with primary progressive aphasia are able to communicate in ways other than speech. For instance, they might use gestures. And many benefit from a combination of speech therapy and medications.

Conclusion

It is interesting to see how language originated and human language processing developed over the ages. Despite this highly advanced Unified Dual Stream Model of the brain, it encounters problems in some particular cases, namely disorders like aphasia.

The technologically advanced world has taken a step forward to aid those suffering from such language disorders. Brain Computer Interface is one such effective measure to do so. Brain Computer Interface (BCI) is a platform which receives brain signals, measures and analyses them, providing a pathway for the human brain to interact with external utilities in real-time. It is entirely independent of normal output of peripheral nerves and muscles.

It is expected that in the coming decades the processing time of BCI will be reduced considerably and the devices will be made cost effective to be available to the common mass.

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