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Human Communication from the Biological and Neurological Perspective: A Review Study

Saadia Anwar Pasha[1]

[1]Assistant Professor Department of Mass Communication Allama Iqbal Open University, Pakistan.
Correspondence: saadia_pasha@aiou.edu.pk[1]

ABSTRACT

Aim of the Study: Communication in human life is a continuous and life-long process. The importance of communication can be determined by the fact that it is one of the factors behind survival and existence. By keeping in view, the importance of communication, this article also focuses on highlighting and discussing communication from biological and neurological perspectives.

Methodology: The researchers have addressed these relevant bases by using the applied-descriptive method to provide support to communication, particularly human communication.

Findings: Both biological and neural perspectives revealed the complexity and importance of different features and organs playing a significant role in sustaining the human communication process.

Conclusion: Study concluded that communication is a complex phenomenon particularly, and human communication involves biological and neurological basis that run the relevant process through different organs and brain cells.

Keywords: Communication; Vocal Biology; Neurology; Verbal Communication; Non-Verbal Communication.

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Introduction

Communication is an integral part of our everyday life. We communicate to send our message and get the desired response. We need both verbal and nonverbal communication at every step of our life. We resort to communication to convey our thoughts, ideas, and emotions (Bostan et al., 2010). According to (Ganmote, 2019), a person cannot survive without communication ability. It is a continuous and life-long process that starts from our breath until the grave. Just like food, water, and air, communication is another necessity, without whom a person, if not impossible, at least finds it difficult to survive. As noted by (Huang, 2020), communication smoothens one's daily life activities. For instance, communicating with the group members in an organization not only helps in task management but also helps the person to survive, earn their livelihood, cope with professional and personal challenges, and increase organizational productivity.

Similarly, (Sarpparaje & Phil, 2018) argues that people who can communicate are more likely to be mentally healthy and comparatively more active than those with weak communication abilities. As (Doyle, 2020) stated, communication is important to ensure that a message is sent, reaches other people,

and can be acted upon. However, compared to today, communication in ancient times was limited, yet its effectiveness was witnessed by the current evolving communication process and approaches.

Similarly, while highlighting the importance of communication in general, being humans, we have two primary bases of communication ability, including biological and neurological (Hoffmann, 2021). According to (Clough & Duff, 2020), communication's biological and neurological bases indicate communicative attributes common among the human species. It also involves the development and modifications of organs and all the other factors of communication that differentiate humans from other creatures. As noted by (Klaus Zuberbühler, 2010), human communication is surprisingly different from other specifies. From the evolutionary perspective, human communication is striking as the communication system among humans has evolved during a long phylogenetic historical background. Notably, human communication is based on those particular acts of communication through which signalers draw recipients' attention. It is possible linguistically (through arbitrary acoustic conventions) and non-linguistically (through gestures or non-verbal communication). According to (Romanski, 2017), besides biological attributions, human communication involves a multisensory process in which information about emotional expressions, gestures, face identity, and mouth movements all come together. Thus, by keeping in view both the biological and neurological basis of communication, in this article, the author will briefly discuss and highlight t the primary basis associated with the human communication process.

Thus, this article also highlights and discusses communication from biological and neurological perspectives. The researchers have addressed these relevant bases as supporting communication, particularly human communication. Hence, this article is divided into different sections. The first section involves highlighting and discussing communication in a broader context that further helped narrow down the research problem. The second section involves a brief discussion about the methods, while the third section involves analysis and discussion. Finally, the researchers have made conclusions in the fourth section, and limitations and recommendations are addressed accordingly.

Research Method

Research methods are an important part of an enquiry that further help to highlight the structure and plan of data analysis (Stevens et al., 2002). According to (Brown, 2016), research methods should be suitable and in line with the statement of the problem to generate generalizable and useful outcomes. Thus, in this research, the researchers have used the applied-descriptive method as the discussion and conclusion generated from this research can be further used to examine the communication from different perspectives. Besides, from the epistemological stance, this study is critical and pragmatic as it will lead the readers and future researchers to reality (Al-Maroof et al., 2020; Salloum & Shaalan, 2018).

Analysis and Discussion

Gesture

When people talk, it is a gesture. A gesture is a substantial part of communication that adds more meaning and importance to a spoken language and reflects the communicator's experiences and background knowledge. Gestures as non-verbal communication is a process of conveying meanings without words. Common gestures mainly involve waving, using fingers to indicate, and nodding. According to (Clough & Duff, 2020), theoretically, gesture and speech propose that they are strongly interlinked as having potential integrated relations and a mutual conceptual origin. Indeed, people from all geographical and cultural backgrounds resort to gestures as they are a fundamental part f human communication and the meaning-making process. For example, people move their hands while talking as a gesture which is a robust phenomenon focused on ages, tasks, and cultures. The importance of gestures can be determined by the fact that people blind by birth also show gestures serving different purposes. However, (SusanGoldin-Meadow, 1999) further argues that sometimes gestures even serve as a substitute for

speech, having a clear communicative function. If accompanying the full communication process, gestures are just like a language with sentence levels and word structure.

On the other hand, if gestures are accompanied by speech, they come analogue and imaginary. Gestures also serve as a research tool, interpreting the communicator's unspoken thoughts. (Patel, 2014) sees gestures as an extension of the unspoken words, leading to improved speech-making as also proposed by Gilbert Austin's Chironomia and Charles Darwin.

Vocal Communication

Voice is important for humans to communicate and interact with each other. Through voice, we directly communicate with the outside world, share our idea and thoughts, and show our emotions. Vocal communication is a strong emblem of a communicator delicately woven into the fabric of speech. Here, (Permatasari et al., 2018) describe speech anatomy from a biological point of view as exhaling a suitable amount of air from the lungs that further passes through the larynx. The vocal folds create vibration in the larynx as they are tied together, leaving a narrow slit that further converts the air into sound. The exhaled air then passes through the pharynx to the mouth and nose. Along with the changes in the throat and mouth anatomy, humans confront enlargement and compartmentalization of the brain (See Figure 1 for the graphical illustration of the anatomy of the communication process).

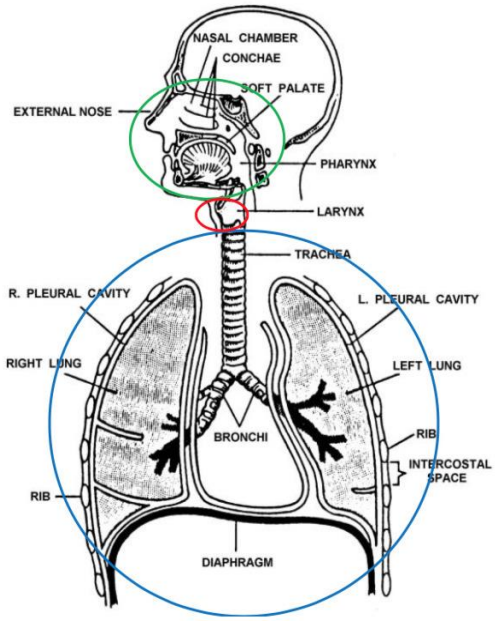

Figure 1: The anatomy of the communication process (Cappella, 1991)

In simple terms, the lungs ensure a suitable airflow to help the vocal folds vibrate. These vocal folds vibrate to utilize airflow from the lungs to create the audible pulses that further formulate the laryngeal sounds. The muscles in the larynx then adjust the vocal folds to a fine-tuned tone and pitch. Then the articulators filter the sound from the larynx and interact with the laryngeal airflow to weaken or strengthen it as a source of the sound. According to (Cappella, 1991), vocal folds, with the help of articulators, produce highly intricate types of sounds. Here the voice tone is accompanied by various expressions such as anger, happiness, excitement, sadness, etc. Nevertheless, the human voice not only expresses emotions but also helps to express the gender and age of the speakers.

Larynx in Vocal Communication

The larynx is an important part of our respiratory system. A hollow tube bridges the gap to ensure air is transferred from the pharynx (throat) to the trachea. The larynx is also known as the "voice box" as it contains vocal cords that are an important part of our speech anatomy. According to (Orlikoff, 2008), the anatomy of the larynx mainly involves Epiglottis, False Vocal Cords, Thyroid Cartilage, and Vocal Cords. The Epiglottis is a flaplike projection at the upper part of the larynx and is located at the upper part.

The central part of the larynx has two slit-like openings having large folds regarding the mucous membrane lining the larynx. The first is called "vocal cords", and the second is known as "glottis" or "true vocal cords". The muscle attached to the vocal cords both directly and indirectly facilitates the closing and opening of the folds (Story, 2015). Voice is produced when air from the trachea strikes the vocal cords, setting up vibrations when the air passes through them. Raw sound produces and passes the upper cavities known as "resonating chambers" and then passes through the mouth to reach the tongue, hard and soft places, and teeth. However, if the larynx is removed, the oesophagus will work as the sound source, yet pitch and volume control would be impossible (Zhang, 2016).

Human Tongue

(Serrurier et al., 2008) the tongue is a gift of speech as it enables us to communicate and express ourselves verbally. Different flexible tongue muscles control the sounds in our speech. These muscles also help the tongue move into different positions, as altering the airflow from the lungs causes variations in the pitch. The functional capacity of the tongue can be determined by the fact that it can produce over ninety words in one minute. Regarding the anatomy, two terms are potentially attributed to the tongue, including "suffix gloss" and "prefix gloss". About these terms, the word "glossopharyngeus" stands for the muscle attached to the tongue and inserted into the pharynx.

Likewise, another term, "hyoglossus", indicates another important muscle inserted into the "hyoid bone" and is also attached to the tongue. Notably, the tongue is embryologically divided into "anterior and posterior" parts. The posterior part of the tongue is the postsulcal or pharyngeal part, whereas the anterior part is the presulcal or oral part of the tongue. Finally, the base of the tongue is the postsulcal part of the tongue that is associated with the floor of the oral cavity. According to (Bordoni et al., 2018), several structures surrounding the tongue are limited laterally and anteriorly by the lower and upper dentures. Posterior and anterior palates also board the tongue. Internally, the root of the tongue is in line with the mucosa of the oral cavity, along with the vascular bundles and salivary glands located below the mucosa of the oral cavity.

Speech Encoding

The articulatory features distinguishing different vowels are traditionally described in line with a dichotomous coordinating system that indicates the highest position tongue, especially during the articulation (Yi et al., 2019). For instance, in the International Phonetic Alphabet (IPA), the two axes of the relevant system are backness and height. By backness, we mean tongue position, particularly on the back of the mouth, and height means the vertical position and size of the tongue to the jaw aperture (HynekHermansky, 2019).

Notably, the neuroanatomy of speech production and the process is described sufficiently by multiple imaging stimulation and lesion studies. They include supplementary, premotor, and primary areas. Superior temporal gyrus (STG), Broca's rea, anterior cingulate cortex (ACC), and another frontal and medial region. The temporal dynamics of neural activity were studied in Broca's area. However, the primary encoding of speech features in the firing patterns of neuronal populations is still unknown. As noted by (Hasegawa-Johnson & Alwan, 2003), speech encoding is a process to attain the representation of vocal signals for efficient transmission of the communication process. Traditional speech coders are an important part of the communication process (Fowler, 1987; Tankus et al., 2012).

Neural Basis of Communication

We normally think that human communication mainly relies on a primary and conventional coding-decoding process. Yet, the role of the brain is important that shapes this communication having an inferential nature of vocal communication and its background. As noted by (Hoffmann, 2021), human communication comprises a potential pragmatic interference apart from hints, sarcasm, humour, and other expressions. Further, an instant conversion the thinking into language and actions is phylogenetically and ontogenetically a distinguished ability among humans.

Using vocal communication to share information and create and sustain social relations is widely seen among humans. However, the human vocal communication process is seen as an extreme form of communication compared to the other species. Unlike other land vertebrates, speech ability among humans is a learned behaviour that requires early auditory feedback and sensory exposure for its maintenance and development. Existing literature on human communication provides a detailed view of the neural basis of vocal communication. Also, it helps to delineate the brain circuits across the cortex, cerebellum, and basal ganglia in generating vocals (Konopka & Roberts, 2016). Vocal communication in different species, particularly humans, has an organized rhythmic pattern of muscle contractions that generate sounds in many forms. Existing literature on the neurology of vocal communication among humans reveals that this rhythmic indicates the emerging vocal hindbrain spinal cord compartment that involves both vocal pacemakers and vocal motor neurons. According to (Pylayeva-Gupta & Kelsey C. Martin Mhatre V. Ho, 2012), the specific feature of the relevant compartment contains an extended size of rhombomere that is also known as caudal of the "embryonic hindbrain segments" that include ancestral neural patterns generator for vocal communication ability mediating the social signalling among humans. This neural network for social communication originated centuries ago among Sarcopterygii and Actinopterygii.

Notably, the modern human brain is the largest having critical importance for the language ability as it is sufficient to store, process, and produce complex human languages, especially from a wider cultural perspective (Permatasari et al., 2018). As noted by (Tiwari & Tiwari, 2012), our utterances not only carries a message but also reflect an audible signal of our reference groups (social system, culture, family, thinking patterns, psychological state). Notably, vocal communication is also considered a part of media through which we recognize others. Here (Laukka, 2017) cited an example of DNA analysis. As argued, although DNA examination to identify our association is the most effective technique, our vocal communication indicating our attributions and associations also work similarly. DNA cannot speak itself and cannot be recorded or planned to show an expression or deliver a message. On the other side, (Krauss, 2001) considers vocal communication as complex, having some inherent limitations yet having an important part of the human communication process. Although some linguists also consider vocal communication as having an abstract nature, there are some sets or patterns of the sequence of vocal communication and sequence of meanings. In this context, what is most important for the communicator is versatility as a channel of the communication process. Vocal communication is considered an ability to survive, as all living beings communicate proficiently in one way or another. However, flexibility and precision are present only in human communication as humans have a unique ability to communicate and make meaningful interactions.

Cortical-basal Ganglia Circuits and Human Speech, Language, and Cognition

The cortical basal ganglia circuit, also known as the cortico-basal ganglia-thalamic loop (CBGTC Loop), consists of a system having neural circuits in the brain. This CBGTC Loop includes associations between basal ganglia, the cortex, back to the cortex, and the thalamus. According to (Paul et al., 2017), CBGTC Loop contains modulatory dopaminergic projections from the pars compacta of the ventral tegmental area and substantia nigra. Also, it contains excitatory glutamatergic from the cortex to the striatum, where these synapses relay back to the cortex. The CBGTC Loop was initially proposed as a component of the

basal ganglia known as the parallel processing model that is now modified into another model known as the "surround model" (Sánchez-Valpuesta et al., 2019).

Current literature characterizes the cortical basal ganglia circuit as separate parallel processing that indicates a minor convergence of distinct cortical areas in the basal ganglia that further helps to describe the topographical functionality of the striatum. Arriaga & Jarvis, (2013) stated that the striatum is placed on a rostrocaudal axis with caudate and rostral putamen serving different cognitive and associative functions. In this regard, the role of basal ganglia in speech, cognitive, and motor functions is of greater importance. The basal ganglia surround the basal diencephalon and consist of five sub-cortical nuclei, i.e., putamen, substantia nigra, and the subthalamic nucleus of Luys (STN) caudate, and globus pallidus. According to Leisman et al., (2014), basal ganglia has expanded during its evolution, and today, it is divided into paleostriatum and neostriatum.

(Achiro & Bottjer, 2013), further argued that the major output from the basal ganglia results from the internal part of the pars reticulata and globus pallidus of the putamen. The nuclei project in the thalamus is caused by ventral anterior nuclei, medial-dorsal nuclei, and ventral lateral nuclei. Internal parts of the globus pallidus are projected to the central median of the thalamus. Here the striatal neurons are involved in receiving sensory input to major motor areas such as the premotor cortex and intralaminar thalamic nuclei caused by several modalities to merge the behavioural responses. These different modalities contribute to the functioning of the sensory input causing the motor response. The basal ganglia are directed by motor, premotor cortices, and the prefrontal cortex of the frontal lobe. Generally speaking, several cortical loops in the basal ganglia include the limbic and prefrontal association cortex. As a result, basal ganglia play major cognitive functions through these loops that are similar to their role regarding motor functions. Besides, basal ganglia are also involved in enabling and selecting several cognitive-emotional and executive programs in the other cortical areas of the brain (Bostan et al., 2010).

Moreover, previous literature attributed basal ganglia and cerebellum to the motor and cognitive functions. However, the role of both these also remains significant in language processing. Booth et al. (2008) noted that basal ganglia and cerebellum are involved in a different language and reading tasks. The accuracy of identifying phonological anomalies is related to the caudate nucleus, and a fast phonological process is related to the greater activation in the left putamen. Detection of syntactical anomalies is related to greater activation in the left caudate.

Additionally, early neural firing in the semantic process is well-replicated in abstract vs concrete judgment. However, judgment is not linked with motor output. Thus, the relevant justification provides provocative evidence that the basal ganglia are potentially linked with the language process functions (Sánchez-Valpuesta et al., 2019).

Transcriptional Factors

The human brain has always been under-studied at histological and morphological levels. Its molecular mechanisms remain still hidden. Different studies consider the human brain, especially its cognitive and vocal ability, near that of a chimpanzee. The human brain has shown potentially striking morphological modifications attributed mainly to our cognitive abilities (Solanyk et al., 2009).

According to (Yap & Greenberg, 2018), these changes are not only associated with morphological modifications but also with the communication and expression levels of transcripts and genes. Over the past few years, several studies have investigated these transcription factors (TFs), also known as regulatory gene regulatory factors and transcriptional circuitries in which transcription factors (TFs) perform as the central nodes. Transcription factors (TFs) either work alone or with others by promoting or blocking the recruitment of RNA polymerase to specific cells. (Lipponen et al., 2018) further describe five basic transcription factors (TFs) in the human brain, mainly abbreviated as TFIIA, TFIIB, TFIID, TFIIE, TFIIF, and TFIIH, that contribute effectively to thinking, communication, and action. Studies on transcription factors (TFs) have primarily focused on the functional characterization of human brain-

specific transcription factors (TFs), indicating their interactions, pathways, and target genes implicated in the brain development process and disorders. To understand the complex cognitive function of the human brain (Lovell et al., 2018), consider studying transcription factors (TFs) according to their specific circuity and pathways. Using the human brain as the centre of attention, researchers such as (Paul et al., 2017) have studied 35 million years of evolution to infer the networks of the ancestral transcription factors (TFs) that exist in important regions of the human brain. However, many approaches are still required to merge the multiple transcription factors (TFs) networks from the human brain's frontal lobe.

Conclusion

Communication is a complex phenomenon particularly, and human communication involves biological and neurological basis that run the relevant process through different organs and brain cells. Biologically where the role of lungs, larynx, tongue and other organs have a significant role neurologically, basal ganglia, frontal lobe, thalamus, caudate, globus pallidus, and others also play an important role in cognitive, emotional, and vocal functions. Existing literature on both biological and neurological perspective on human communication provide a strong insight, yet more empirical evidence is required to examine and highlight the evolving human body and brain, leading to certain alteration in cognitive and communication abilities

Limitations and Recommendations

Despite this study providing a potential overview of the biological and neurological perspective of communication, it has some limitations. First, this research is not based on any quantitative or qualitative design. Second, the research does not represent findings related to any geographical region, further narrowing its scope. Finally, in its scope as communication from a sociological and psychological perspective, this research is another dimension that can further advance the relevant discussion. However, the researchers recommend more studies, especially on highlighting the communication from a sociological and psychological perspectives, that may provide an in-depth understanding of communication as a continuous process.

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Conflict of Interest

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ORCID iDs

Saadia Anwar Pasha [1] https://orcid.org/0000-0002-6416-7358

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