**THEORIES AND MODELS OF NEUROLINGUITICS/ LINGUITICS AHASIOLOGY**

There are theories, which have an influential impact on the connection between human brain, language and its disorders which were elaborated in the perpetuity from localist to holistic further combined with eras from preclassical to contemporary as mentioned below.

**Theories according to the time:**

According to eras in historical period, ideas about Brain and Language and aphasia has been discovered and related to different neurologist in different periods. These periods were coined as pre-classical period (on and/ or before 1800); 2. Classical period was considered from 1860s to early mid-19th century; 3. Modern era came into picture before the discovery of brain scanning systems like CT scan and finally the contemporary era is continuing since the development of several instrumental analysis of brain, that is since 1970s to till date.

**Theories according to localization are presented in figure 1.2:**

Theories once combined with time, classifies the localist, associationism/ connectionist, hierarchical and holistic theory under classical period of history whereas neoclassical and dynamic localization of function theory belongs to modern era.

**Ideas about Brain, Language and Aphasia according to the epochs of the history combined with localization theories.**

I. The period of pre-classical (till 1860s) era had documented the first known references evincing the brain as the center of language and brain pathology leads to language disorder as appeared in Egyptian so-called Edwin Smith Papyrus, about 1,500 BC, which may be copied from an older papyrus written between 3,000 and 2,200 BC.

Around 400 BC, Greek antiquity of Hippocrates’ Corpus framed the role of brain in language disorders. Hippocrates suggested that the brain was the biological structure responsible for human’s intellectual capacity and any damage to this structure will lead to specifically two different types of language disturbances correlating with two major aphasic syndromes. Hipprocrates was referred to the first direct forefather of contemporary aphasiology.

It was Plato’s (4th century BC) proposal that the areas in are in one-to-one relationship with various functions while second school of thought of Aristotle, schemed a psychological process arising from the sensory organs communicating with cognitive ability which are congruous with the motoric functions. These thoughts influenced future models, highlighting the harmony between brain and language functions.

During 17th century, the monogram of Speech Amnesia, Johann Gesner (German Physician) postulated that speech disorders are caused by passivity in the connections between the different parts of the brain resulting in disturbances while correlating lingual symbols and signs related to various abstract thoughts, pictures, or images. Hence, he also considered speech disorder as a disorder of memory.

To add up, it can be convinced that during 19th century, several theories, and knowledge, expressed neurolanguage disorder as the disconnection between language and damage of brain areas responsible for linguistic functions. **It was also presumed that any insult** to the structures accountable for intelligence or memory and organization processes can be blameworthy for the detachment of “thoughts to its lingual signs. Several coined the term aphasia for neurolanguage disorder.

**Classical period neurolinguistic theories (1861-1945):**

Localist, associationism/ connectionist, hierarchical and holistic theory are grounded under the classical period of neuroscience and neurolinguistic development.

1. **Localist aka localism theory:**

Localist theory suggests that the cortex in the brain and other areas hold the responsibility of higher functions like linguistic, meta cognitive and meta linguistics, which are altogether synchronise for various language function.

Well-known localists including Gall and Broca had suggested that aphasia resulted from a lesion in such language center of brain.

**Anatomy of brain theory postulated by Gall:**

Franz Joseph Gall was the first anatomist connoting that the tissues and membranes of the brain grows and expand along with its assigned function for providing nutrition to the brain. He put forth that structurally, the cortex considered as the gray matter is a uniform and continuous layer of neural tissues and nerve cells, proposed to be the highest level of organization of the brain. He stated that both right and left hemispheres contain different elevated ridges or convolutions called as gyri on the surface of brain, varying in every single human.

Assumptions of Gall highlighted that the cortex size will be directly responsible for the skull growth. Cranioscopy procedure was developed imparting that it would be “almost” possible to examine the cortex by observing the cranium, supported the assumption. His studies disclosed that the frontal lobe of brain contains two areas for language, one for speech production and the other for storing lexicons in memory.

To sum up, Gall’s opinions were localizing the structures and functions of human brain.

**Neurolinguistic evolution by Broca**

Paul Broca was founder of the field resulting the birth of neurolinguistics in 1861, when he presented his theory at the Anthropological Society of Paris in 1861, based on a patient named Leborgne’s major difficulties in producing speech that he was almost mute with only utterance of ‘Tan’. After death of the patient, the autopsy of his brain revealed the probable cause of speech disorder as a lesion in the particular area of the brain which was later came to be known as Broca’s area, located in the posterior inferior frontal gyrus of dominant hemisphere, that is mostly the left hemisphere.

In 1865, Broca concluded that the left hemisphere is the dominant hemisphere in right handers, solely responsible for language and vice versa. He also suggested that a recovery from aphasia might be possible if the right hemisphere would dominantly accomplish the functions of left hemisphere. To summarise, it can be concluded that Broca’s proclamations were quite localist and later given rise to connectionist theories.

**II. Associationism/ Connectionism or connectionist theory:**

Associationism later renamed as Connectionism or connectionist theory also termed as the classical or neoclassical, former based on Wernicke - Lichtheim view and later one based on Geschwind view. This theory assumes that higher functions were depended on the connections between different centers in the cortex needed for linguistic function like the association between the images and words, whereas aphasia results from broken connections between these centers. This theory somehow correlates with Gesner’s hypothesis during 17th century.

In a nutshell, the clinical study of neuroscience in nineteenth century, was dictated by the study of aphasia, established by the work of Pierce Paul Broca. The localization of linguistic capabilities in the designated areas of brain and role of cerebral dominance for language were the highlights.

**Wernicke, father of Associationism/ Connectionist theory:**

During early 1870s, neurologist named Carl Wernicke, presented a theory based on his dissection of patients with language disorder and correlated it with Broca’s findings. Based on his theory, Wernicke proposed a well know connectionist model representing several other language syndromes related to brain areas along with the classification of aphasia. The connectionist model represents the language processing in the brain and its relation to various aphasic syndromes.

Postulations of Wernicke’s connectionist theory are:

1. Brain has allocated areas for receiving the final connection of auditory system. These areas are juxtaposed to the cortical area in the brain.
2. This area was called as an association area for more complex functional processing of sensory and motoric information.
3. Wernicke's area in the first temporal gyrus was considered as second language center after Broca’s area as first center for language. Wernicke’s area became the memory store house of words perceived auditorily, due to nearness to auditory pathway in the brain.
4. He described those patients with reduced language comprehension had lesions in Wernicke’s area, the posterior part of the first or superior temporal gyrus and adjacent areas (parts of the angular gyrus, the supramarginal gyrus, and the second temporal gyrus are included).
5. He also postulated that there was a specific “language gyrus” ranging from Wernicke’s area (responsible for the receptive function) to Broca’s area (responsible for the expressive function) and aphasia could be caused by lesions in either of these areas (Wernicke’s / sensory aphasia or Broca’s / Motor Aphasia). Later, according to Norman Geschwind, a lesion affecting the bundle of fibers called arcuate fasciculus, connecting the Wernicke’s and Broca’s area can be responsible for conduction aphasia.

**Connectionist models by Lichtheim:**

Ludwig Lichtheim (1885), a German Physician set forth a proposal of elaborative aphasic syndromes based on connectionist model of representing brain and language. He adopted Wernicke's views for providing a model with respect to Broca's area (M) being responsible for the motor representations required for articulatory (repetition) utterances and Wernicke's area (A) for auditory input and analysis into auditory word representations as the two major areas involved in language comprehension and expression.

He postulated a third language center as the “concept center” with an unspecified localization in the model of language function based on Wernicke’s model. Lichtheim generated the diagram representing the complete classification of aphasia in 1.3.



Lesion to:

* **A= Wernicke’s area**
* **B= Concept centre**
* **M= Broca’s area**

1 🡺 M 🡺Motor aphasia/ Cortical Motor / Broca’s Aphasia

2 🡺 A 🡺 Sensory Aphasia /Cortical Sensory Aphasia/ Wernicke’s

3 🡺 Conduction aphasia

4 🡺Transcortical Motor Aphasia

5 🡺Subcortical Motor Aphasia

6 🡺 Transcortical Sensory Aphasia

7 🡺 Subcortical Sensory Aphasia

Figure 1.3: Source: quizelet.com

Depending upon the nature of information flow between the various components, this model would be predicting the types of aphasia. The following kinds of aphasia exist in Lichtheim’s model:

* A lesion of M will cause the *classical Broca's aphasia*, in which *language comprehension* is s*pared* and *articulatory language is disturbed*.
* A disorder of A will cause *Wernicke's aphasia* with the symptoms.
* A disorder of the connecting pathway will cause the "*conduction" aphasia*, where ability of a patient to repeat would be impaired.

**Transcortical Motor Aphasia (4):**

* This is due to the lesion between **M and B.** This will produce the same type of output seen in Broca’s aphasia, but as in the transcortical sensory aphasia, repetition ought to be normal because the basic pathway involved in repetition is intact.

**Subcortical Motor Aphasia (5):**

* This resulted in dysarthria, a motor speech disorder on account of lesion between **M and the oral musculature**.

**Transcortical sensory aphasia (6)**, due to a disruption of the path between **B** and **A**, would result in a *difficulty in comprehension.*

* Words perceived via auditory sensation remains intact, however there is a disturbance in its connection to the concept center. As an outcome, the individual with such aphasia, can no longer comprehend the meaning of language perceived acoustically or auditorily.
* *Repetition ought to be intact.*

**Subcortical Sensory Aphasia (7):**

* The memories for the auditorily perceived words stored in Wernicke’s area are intact and can be transmitted to the motor centers.
* However, due to the interruption in the pathway carrying the information from the periphery to sensory area denoted by ‘A’, disturbs the comprehension and processing of spoken speech sounds, termed as “*pure word deafness”* where the person is unable understand any verbally spoken expression.

To conclude, the Connectionist models are one type of "faculty" models in which brain is accountable for language functions as a processing of focused task.

The connectionist model represents each of the language learning skills that is hearing, speaking, reading, and writing - single entity. All the four language learning skills are interconnected with each other and share interaction between them as all are interdependent. The notion of "center" consisting of individual skill relates to the cortex responsible for storing language components is located somewhere in brain, as emerged most clearly in this model.

The Broca’s area oversees the motor programming involved in the production of spoken language, also called as motor speech centre. The posterior language area holds the comprehension of verbal and expressive language in form of sound patterns of words.

**Extension of connectionist theory:**

In relation to extension of connectionist theory, Joseph Jules Dejerine (during early 19th Century) located a language area around the Sylvian fissure in the dominant hemisphere.

After his patient’s autopsy, Dejerine postulated about alexia and stated that the left parietal lobe manages reading and the alphabet sounds are coupled with their orthographic or grapheme forms.

**Criticism of associationism/ connectionist theories and models:**

Several neurologists across the globe disparaged the analysed theory and models related to connectionism. Sigmund Freud, Henry Head are among others who had shown their disparity regarding model.

**Disparity by Freud:**

In 1891, Sigmund Freud censured the connectionist model documented by Wernicke’s and Lichtheim’s by raising questions regarding the concluded logic related to neurolinguistic theory and aphasia. He also stated that basic observations made by the connectionists were incorrect.

According to Freud, language should be mapped in the areas between the lobes of brain responsible various sensory and motoric functions. For example: frontal lobe for language production; temporal lobe for auditory perception while occipital lobe for visual perception and discrimination. He draws the inference that there were several lacunae in these models in general.

**Disagreement by Head**

During late 18th Century, Henry Head disagreed with the analysis of symptoms of language disorders and viewed the whole concept of model and the center as a diagram. He also challenged the locations in the brain for language functions.

He discredited the connectionist model as it failed provide any solution to neurolanguage disorders. According to him, the model was the compilation of simple formulas based on selected assumptions where the defected language functions were portrayed through damage to the center or discontinuation of pathways. He also stated that language disorder cannot be evaluated in form of task involving language as there are individuals who can follow simple and single commands but not the complex or multidirectional commands.

On a final note, there was a denial from Head’s side regarding the neurological and psychological involvement in the connectionist model.

III. Hierarchical or Evolutionary theory:

**III. Theory of holism/ holistic.**

During 19th century, localism and associationism were on its peak. However, holism was gaining its support in different fields. Neurologist like Henry Head and Psychiatrist like Kurt Goldstein were holistic influencers.

Holistic theories suggest that the extensive areas of the brain are working together to handle many language functions which was called as “cognitivism. Holism suggest that all designated parts of brain interact and works together to achieve higher functions and skills like “meta cognitive skills or intellectual,” “logical thinking”, figurative ideas,” or “abstract thoughts,” also being handled by the cortex. However, aphasia signifies not only loss of linguistic ability rather in general it may be cognitive loss also. Damage to the brain results in a reduced mental process and this was acclaimed by a holistic school of neurologists and psychologists.

**Holistic view of Head**

Henry Head (1861 – 1940) presented an original quadruple classification of aphasia based on the functional disturbance. The types of aphasia were named after the functional difficulties like deficit in verbal expression (as verbal aphasia), grammatical, sentence structure or syntactic deficits (syntactic aphasia/agrammatism), naming difficulties (as nominal aphasia), and deficit in understanding the language meaning or semantic (semantic aphasia).

Head’s theory highlighted the following:

1. The most complex functions of brain (cognitive skills, thought and language processing) are affected first followed by all levels of activities in case of brain damage.

2. At the damaged level, negative exhibitions were noted on the site lesion.

3. A lesion causes effects that are positive and disinhibits activities that are normally controlled by functions at the damaged level.

4. The sensory and motoric functions have hierarchically developed in a top down fashion or lower to higher as per the neurological mapping of the central nervous system.

5. In order to execute the activities in a best possible way, the central nervous system integrates all the functions based on the best possible physiological activities.

During early 19th century, Head also introduced some general guidelines to carryout testing in aphasics and compelled to use empirical procedures to diagnose the type of aphasia.

**Holism by Goldstein:**

A German psychiatrist named Kurt Goldstein, was considered with a reputation of a liberal minded neurologist working more on speech problems. In mid-19th century, he coined a term as “abstract attitude” which was an umbrella term describing the personality of an individual. For example, abstract attitude allows an individual to initiate a task, prioritise and memorise the important things out of the rest. Importantly, how a person stand alone in the external surroundings.

According to Goldstein, these abstract attitudes are remarkably absent in individual aphasics who have naming difficulty (anomic), difficulty in producing sentence structures and grammatical correction. He combined the psychological, language efficiency and physiological factors to describe these abstract attitudes. In person, if these attitudes do not persist, then it will give rise to language disorders.

Goldstein also classified the cerebral cortex into peripheral and central part, whereas the disturbances in the central part will result in deprivation of abstract attitude.

**IV. Hierarchical Evolution/ Transformation-based theories**

This theory propounds on answering certain questions like:

1. The development of brain by piling of layers upon layers, formation of gyri, sulcus and other cortical, subcortical structures and areas.
2. The role of cortical, subcortical structures and areas language processing and production.
3. The relationship between the evolution of brain and language over time in different species.
4. The acquisition and development of linguistic features and language in children.
5. The adult’s performance on various functions of language.

All these questions were represented by Jackson and Brown in form of their school of theories.

**Jackson’s school of cognition and intellectual**

John Hughlings Jackson was known for postulating the role of brain in language processing and communication. He supported the connection between cognition and language however he was not into the anatomy of brain. Jackson was more interested in finding the types and complexity of human reactions and responses towards various stimuli. He proposed automatic and propositional classification of language.

The automatic part contained few rotted stereotype answers with newly formed words whereas propositional part consists of syntactic and semantic form of linguistic. According to him person with aphasia won’t be able to rationalise the propositional level indicating some loss of cognition followed by thoughts and language however speaking ability persist based on paralinguistic and suprasegmental aspects.

Jackson also supported the hierarchical function brain from simpler form to complex, where information passes from lower organised structural centers to higher complexed one fuelling automaticity of speech and language into complex form.

**Theory of Jason Brown:**

Brown’s theory on aphasia was impacted from Jackson’s where brown combined the evolution of brain with functional views of aphasia. He dwelled more on bonding between suprasegmental aspects influenced by emotions, voluntary function, creativity and aspects of language.

Brown’s theory on microgenesis is a classical example of hierarchical evolution where he predicted that every action of language passes through all the stages that is from depth to surface level of brain. According to Brown, neurological and psychological functions are counterpart of each other.

**Rediscovery of associationism or introduction of neoclassical theory by Geschwind:**

Norman Geschwind aka behavioural neurologist became the influential personality to redefined associationism as “connectionism,”. He expanded Wernicke’s classical theory and models for the classification of aphasia while discovering the neoclassical school of neurolinguistics during 1960s. these models were well named as **Wernicke-Geschwind model** for processing and interpreting linguistic. This model represented language processing through 7 major anatomical areas of brain. According to him, auditory cortex and Wernicke’s area are responsible for decoding and encoding of language perceived auditorily. The encoded information passes on to Broca’s area via Aricuate fasciculus and finally, primary motor area coordinate to produce the speech. Primary visual cortex and angular gyrus contributes to processing the visual language in form of reading. These seven anatomical components function in an interconnected fashion in dominant hemisphere (left) of brain to yield the out of language processing.

In the western world, Geschwind mentored the clinical and theoretical analysis for neurolanguage disorder/ aphasia. He explained the cortical language disorder as disconnection syndromes/ disconnection language disorder. Conduction aphasia is an excellent example of such disconnection syndrome, resulting from lesion in arcuate fasciculus which disconnect the pathway for transferring encoded information from Wernicke’s to Broca’s area. The anatomical view of disconnection syndrome is shown in Fig. 1.4



Fig 1.4: the image is directed toward the important source of language processing. Source:(from www.4.4 Language in the Brain – Psychology of Language (opentextbc.ca)

**V.** **Theory on Dynamic Localization of function**.

This theory came into limelight during 20th century i.e., modern era period. According to this theory, there are several sub functions of language that are circumscribed to various dynamic parts of the brain which are further combined to perform a prodigious function. However, complexity rises after the brain damage at site of lesion and functional disturbance in language.

In mid 1900s, renowned psychologist Ivan Pavlov emphasized that the linguistic complexity and behaviours are matured as the dynamic system considered to be brain get develop and mature. The dynamic system contains the interconnected anatomical structures within the centra nervous system.

Furthermore, Leg Vygotsky focused on localizing the discontinued function of language rather than the place or site of lesion of damaged brain. Disturbed linguistic functions should be considered based on the origin and hierarchy of development.

According to him, various organs work in a dynamic cooperative manner to complete a task while this cooperation are handled by several neural anatomical structure located in an assorted form all over the brain. He posited a connection between language and thought.

In 20th century, this dynamic localization theory was influenced by the contribution of Alexander Luria, famed aphasiologist and psychologist. He viewed brain as several interconnected functional structure for carrying out different complex activities requiring cooperation of each structure. He divided brain into 3 forms of blocks are.

1st block consists of subcortex (limbic system) and brainstem maintaining the gait, posture and regulation of emotions and any damage to this will be resulting in loss of tonicity and balance.

2nd block contains all the three lobes (temporal, parietal and occipital excluding frontal) of posterior cortex in brain responsible for receiving and assessing stimulations from various sensory organs and storing the information. These structures are meant to process and organize the phonetic segments, vocabularies, meaning, smallest form to structure varying from simple to complex form of language (semantics and syntax).

3rd block consists of frontal lobe the largest lobe (front of brain or pre cortex separated by precentral gyrus) contain motor and premotor areas. It solely accountable for programming and controlling all the higher cognitive and linguistic activities and motoric movements. It is responsible for carrying out the verbal expression and arranging the utterances of linguistic form.

He classified different types of aphasia based on site of lesion of the 2nd and 3rd blocks. Classifications of aphasia are as follows:

Damage to 2nd block leads to (1) Afferent motor aphasia (2) Sensory aphasia (Acoustic-gnostic) (3) Acoustic-mnestic aphasia and (4) Semantic aphasia (Amnestic aphasia) whereas dynamic and efferent motor aphasia are resulted from damages to 3rd block.

Luria focused on relation between cognitive, linguistics and neuropsychology. He had targeted the restoration of lost functional ability of the system which became the stepwise clinical framework for assessment and management of aphasia in current generation.

**Summary:**

All through the centuries, various neurologists, and psychologists, all over the globe has immensely contributed to the world of brain, its relationship with language processing and functions, role of intellectual/cognition and neurological language disorder aka aphasia. The development of neurolinguistic has been quantified by shedloads of theories and models, postulated regarding brain, language and aphasiology, creating abundant knowledge and essential details which were refurbished from generation to generation. Starting from preclassical before 18th century period (Hippocrates) to continuation of modern period in 20th century (Luria), aphasia has been the center of all neurologists since last 2 centuries.

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