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Review

The Role of Neurolinguistics for Language and Speech Disorders

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A B S T R A C T

This paper explains the significance of neurolinguistics as one of interdisciplinary fields of linguistics encompassing the analytical procedures on individual speech disorders in producing and using language. The result of analysis is used for designing a model and strategy to improve their language capacity. Neurolinguistics roadmap covers some previous researches done by Sastra et all since 2006. Those studies investigate language and speech disorders including thinking ailments, and answer the inherent question on neurolinguistics contribution for addressing the individual problems to express themselves. Those problems are caused by some disorders on the left and right hemispheres of the brain. Science wise, neurolinguistics will always develop because the language phenomena always happen in human life through thinking and speech.

I. INTRODUCTION

The rapid development of psycholinguistics consists of the following sub-disciplines (Chaer, 2003) such as theoretical psycholinguistics (focuses on human mental aspects in language use), psycholinguistics of growth and development (focuses on first and second language acquisition), social psycholinguistics (on social aspects of language as an internal bind), educational psycholinguistics (language and language teaching), experimental psycholinguistics (on the experiments of language activities and verbal behavior), neurological psycholinguistics and neuro-psycholinguistics (on the relationship of language, language in use, and human brain), applied psycholinguistics (the application of all sub-disciplines of psycholinguistics into other fields such as education, neurology, psychiatry, literary criticism, and communication).

Those sub-disciplines of psycholinguistics develop on its own thanks to the birth of psycholinguistics in 1953. R. Brown opened psycholinguistic special program at Ph.D. level. Eric Lenneberg graduated as the first scientist in this field. However, psycholinguistics was believed to be born in 1955 when Lenneberg conducted his first research. Lenneberg's research proves that the humans have a biological tendency to acquire language. The animals do not have this behavioral trait. There are some reasons

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for that as follow: 1) There are specific regions in human brain for language development and use, 2) All human babies share similar way of acquiring and developing language, 3) there are many obstacles to stop human language development, 4) Other living being on earth cannot learn language like the humans do, 5) All languages in the world share the universal aspects.

Moreover, psycho-neurology or neuro-psycholinguistics also developed on a good course. The neurologists often asked about the process of human brain processing the language input and programming the language output. The linguists, on the other hand, were attracted to study the verbal aspects occurring if someone suffered from language disorder caused by brain ailments. There were more researches on the relationship of language and the brain. Therefore, neuro-psycholinguistics was finally known as neurolinguistics. This era began since the dawn of joint research of neurologists and linguists on observing the human brain and language.

Both neurologists, Broca and Wernicke, study the localization of brain function and its relationship with language disorder. Broca found Pincas P. Gage, a worker in a factory suffered from a serious injury caused by an explosion propelling the iron bar thrusted deeply into his cheek and protruded from his forehead. This worker survived the accident until 12 years later. He did not have any thinking disorder whatsoever, but he showed a language disorder grammatically. His attitude also underwent some changes, he became more emotional, less patient, and full of anger. This case proves that there is a different brain function regulated by left and right hemispheres. Serious injury on left side of the brain will damage one's language proficiency, whereas the injury on the right side of the brain does not have any impact to human language capacity whatsoever. Thus, it is evident that the language function regulated by the left hemisphere of human brain.

Furthermore, Wernicke is the first researcher who explains the differences of expressive aphasia found by Broca from the receptive aphasia. Expressive aphasia causes human to be able to comprehend the utterance but has no capacity to speak it up directly. Moreover, the people suffered from receptive aphasia cannot comprehend the utterance but they have the capacity to speak up in wrong grammatical rules. Wernicke show the relationship of receptive disorder with the damage in temporal lobes on the left hemisphere of the brain. Broca explains the expressive aphasia occurs because of the damage on the regions closed to motoric cortex, whereas, the receptive aphasia, according to Wernicke, happens caused by the damage in the regions closed to auditory cortex on the rear-end of left-brain hemisphere. This cortex regulates all audio stimulation and utterance.

Both hemispheres of the brain have different functions for sure, but language wise, their function support each other. The segmental function of language regarding the grammatical rules is regulated by the brain left hemisphere, but language has no meaning without supra-segmental aspects such as tone and intonation controlled by the brain right hemisphere. The use of language for communication is also controlled by other pragmatic aspects like feeling, meaning, and any other communicative components of the human utterances. The right hemisphere of human brain regulates this function. This phenomenon shows human emotional quotient is based on the function of brain right hemisphere (Dharmaperwira-Prins, 2004). In some cases, the right hemisphere of the brain can take over some function of the left hemisphere. It is not about the right hemisphere taking over the full function of the left hemisphere like what happens to the left-handed people. Precisely, the right hemisphere connects the language regulated by left hemisphere of the brain to the aspects of perception, emotion, and the way of using language.

Therefore, the use of both hemispheres is required for better communication in human life including verbal and non-verbal communication. The verbal communication is supported by human capacity to use language although most people do not share the same proficiency. There are also normal and abnormal language capacity. That is there to it any way. Being normal in using language equals to being able to use language in proper linguistic rules such as grammatical aspects, tone, and intonation. On the other hand, being abnormal is all about suffering from disorders in neurological cells and psychological aspects regulating the use of language for communication and interaction at the individual level. This so called abnormal also means being incapable in the context of normal human. It causes the failure in communication.

People with abnormal language use found in numbers in the society. This abnormality is caused by some factors such as the neurological damage in the language regions inside the brain as a result of serious injury, the damage in articulatory organs, and stress. Moreover, there is also another case called cortical motoric aphasia, meaning, he or she has lost the capability to express the thought in the utterance (Kusumoputro, 1993). Someone with this syndrome is actually able to comprehend both written and oral expression but they have no capability of verbal expression since they barely understand non-verbal expressions. Furthermore, the dysfunction on both left and right hemispheres of the human brain also cause many disorders in verbal and non-verbal expression. These disorders hurt the communication.

In this era of technology, there are factors causing verbal and emotional disorders that also result language and speech disorders. In essence, neurolinguistics is a discipline for observing and studying those disorders in a wider conceptual spectrum including linguistic and non-linguistic aspects.

II. DISCUSSION

2.1 Neurolinguistics

Neurolinguistics also defines as language neurology, meaning, an interdisciplinary linguistics studying human brain functions on language comprehension and processing. This discipline also studies the disorders in understanding and producing language (Arifuddin, 2010; Sastra, 2011). This field explains the human brain structures normally required in language processing before comprehending one's lingual symptoms through verbal expression and capability in the communication.

The are some neurolinguistic rules as follow: 1) brain damage hurts language processing, whereas the injuries in the heart, lungs, liver and kidney do not have a direct impact to language function. It is evident that the brain is an organ for the center of language processing. The brain damage often causes specific language dysfunction so called the aphasia; (2) the damage on the left hemisphere causes the problems in processing the language, meaning, even though one can listen to the utterance but she or he cannot comprehend those utterances. The damage in the right hemisphere does not cause this disorder. Mostly the damage occurs on the left hemisphere of the cerebrum.

The left hemisphere regulates many functions including language processing, whereas the right hemisphere is responsible for other capabilities such as distance and visio-spatial processing, language and mind creativity, emotion, pragmatic control, later it develops as neuro-pragmatics, a study on individual communication considering the aspects of socio-cultural and the environment of the speakers and hearers. (3) The brain damage on frontal region also causes disorders in responding to linguistic stimulation for speaking and writing, whereas the damage on rear-end location causes disorders in listening and reading. Different hemispheres regulate different mental function. It defines as the function of localization.

Therefore, the damage on left side of the brain also disrupts the process of language understanding. The brain damage also causes disorders for understanding the senses of smell (agnosia) such as the capability to recognize the aroma of orange, durian and other fruits. This problem also causes the lack of ability to do a common motion such as licking the lips under a command, or speaking clearly. It is evident, a damage of the brain causes disorders in language processing (aphasia) and is possibly responsible for the inability to understand the sensory organ for the smells (agnosia). This problem also causes people to do spontaneous and uncontrollable motion (apraxia), and the obvious disorders to speak clearly (dysarthria).

2.2 Language and Speaking disorders

Language disorder is the inability to produce and understand any utterance fluently and correctly (aphasia). Blumstein (1985) states the one suffered from motoric aphasia experiences difficulties to say words. The patience shows a great effort just to say a word. Therefore, the patience shows verbal expressions in mix results, some words are fluently spoken, the other are not. Bastiaanse (1995) put aphasia into three categories as follow: 1) fluent aphasia, 2) non-fluent aphasia, 3) sensory aphasia.

Fluent and non-fluent aphasia cause many issues in human utterances and the way of using the organs of articulatory. The damage occurs in Broca region is the causal factor. Obler & Gjerlow (2000) states the injury in 43rd area of Brodmann taxonomy causes the Broca syndrome. Geshwind (1981) explains the Broca region is closed to the motoric cortex on frontal hemisphere. It regulates the face muscles, tongue, chin, and throat. The stroke attacks to Broca region will render the left side of the face paralyzed. The speech muscles are also in paralysis causing the evident disorders in verbal expressions, meaning, the patience undergoes speech or language disorders.

Thus, the patience suffered from aphasia experiences many difficulties in speaking caused by the paralysis of the articulatory muscles. This paralytic state occurs because of the damage in motoric neurons in the center of neurons or in some regions of the brains. These damages are no physically visible, but the brain regions experience disorders such as the left and right hemispheres, and the brain stem.

The brain stem functions for transferring the message from the brain or for the brain. The disorder in this region causes the paralysis and other disorders in the sensory organs either left or right side of the body. This brain stem also has its own function for regulating the motion of the eyes and consciousness. It controls other motions such as swallowing, throwing up the sputum and coughing. Language wise, the brain stem regulates the words construction and the utterance proficiency, but it is not responsible for the message or meaning. The people suffered from stroke experience the difficulty to say words or to speak the words although they clearly understand what they really mean. This condition defines as dysarthria.

Kohn (1993) states the patience of Broca aphasia shows a strange phenomenon, they have difficulty to speak up. The errors also occur on the initial syllable and the repetitive syllable. Although they can produce the phoneme but it is repeated on wrong syllable. The repetition occurs on the syllable and sound indicates non-fluent aphasia. Moreover, temporary stop with or without utterances mostly occurs.

A temporary stop done by the Broca aphasia patience shows an attempt to produce a correct sound and syllable. This aspect only happens to the fluent patience, not only the one suffered from the Broca aphasia but also other categories of language disorders such as stammering. Actually, most people once experience normal disorders in language use such as temporary stop, or repetitive words, but the problem of aphasia occurs as paralysis

in some regions of the brain, it is not about a daily habit of using language.

In essence, aphasia is not the only language disorders. There are other disorders as follow: dysphasia (language disorder of the children), dyslexia, dysgraphia, and alexia (disorders of reading, writing, figuring out and writing the letters), dementia, Alzheimer, and Parkinson (intellectual degradation in producing and recognizing the language), amnesia (memory loss/memory and parts of speech), auditive perceptive and visual disorder (the disorder of sound and face recognition), agnosia (the inability to recognize goods and visual loss), apraxia (the loss of reflex), dysarthria (the loss of motoric for language use caused by damage on the brain stem), myasthenia (the disorders of muscle reaction to the stimulation of motoric neurons), cerebral palsy (the disorders of speaking caused by injuries in motoric neurons).

Many studies on language process or mechanism in the brain show the right hemisphere also has specific function in the communication. This function does not relate to the aspects of linguistics, but it categorizes as the social function since the damage in the brain right hemisphere will cause some language disorders socially affecting the people in the social environment. The right hemisphere regulates some aspects of language, the damage or injury in this area will cause the following disorders: expressive and receptive lexico-semantic disorder, expressive and receptive macro-structures disorders, pragmatic disorder, prosody and its components disorder, lexicon disorder, syntactic disorder, emotion and conversation disorder, proper conversation disorder, etc.

Speech disorder is actually different from language disorder, but it is often confused with language disorder (Ingram, 2007). Speech is all about speaking; it shows one's voice or sound of the words. On the other hand, language is about expressing and accepting information in a specific way. Language is a means of communication. A child suffered from language disorder perhaps can utter a word correctly, but he or she cannot construct two words grammatically. Other children, for example, cannot enunciate a word clearly but they are able to construct the words grammatically to express what they want.

The adults use language encompass their full linguistic competence. This process activates the neurons in the brain, whereas speaking is about their capability to express the messages or thoughts after language processing. The results are verbal expressions produced by speech organs. In fact, speech disorder occurs because the speech organs (language and speech) experience some disorders caused by either internal or external factors (Travis, 1971). Some cases on the children such as: speech delay, disorders on speech organs such as pulmonal disorders, laryngeal, lingual, resonance, deformed upper lip, malocclusion (teeth factors), multifactor disorders like uncontrollable utterance in extremely fast manner, slower speaking, propulsive speaking (non-fluent), mutism (no speaking caused by psychological issue), psychogenic speech disorder, sassy speech style (phonological syndrome), stammering speech, latah (Southeast Asia-based abnormal verbal behavior of startle disorder, *ekolala*: an abnormal verbal behavior to repeat other people's words and *korprolala*: an abnormal verbal behavior to speak dirty, repetitive verbal tendency).

2.3 The role of neurolinguistics research

Neurolinguistic researches on the patience suffered from language and speech disorders have been done by Sastra et all (2014). These researches focus on the aspects of phonological and lexical disorders such as aphasia, dysphasia, cerebral palsy, dyslexia, speech delay, autism, dysarthria, mentally disabled, myasthenia, stammer, etc. Now the research will focus on listening disorder on the patience suffered from auditory syndrome. Moreover, this research will also develop a speech therapy model to treat those

disorders. The model has been tested to the patience.

The further research on bioacoustics is needed to examine the improvement of patience's communication proficiency. This research is about studying the change mechanism of the sound wave from the human voice. Speech analyzer-based spectrogram analysis can be used for this purpose. This software has been used in the USA and Europe, but it is rare to be used in Indonesia.

There are some researchers in Indonesia using spectrogram software for neurolinguistic research as follow: Sastra (2013) on stroke patience, some graduate students of Linguistic department of Andalas University under Sastra supervision (Dewi, 2013; Putri, 2014; Johan, 2014; Satria, 2015; Anggraini, 2015)

The researches on neurolinguistics have been done by Sastra et all since 2012. The results of those studies can be a good reference and comparisons for therapists, neurologists, linguists and the people who have a family member suffered from speech disorders. The results of these researches also function as the knowledge or materials for another field of science such as information technology in building a software of speech therapy. Europe and United States have done that development. Furthermore, Sastra et all also develop a model on behavior therapy (MTP) to improve the communication proficiency of the patience of speech and language disorders.

Activities	2005-2008	2009-2012	2013-2016	2017-2020	2020-2024	2025-dst
Spin off		The result of neurolinguistic analysis	Model and bioacoustics	The Application of Neurolinguistic Therapy		
Feasibility test					Speech Therapy Software Development	Competitive and the application of receptive and productive therapy
Prototype disorder				Bioacoustics of listening disorder	Optimization of the use of software for therapy	
Advanced Application			Bioacoustics of *speech analyzer* on numerous speech disorders	Test of speech analyzer for patience with numerous disorders		
Basic Application		Analysis on some receptive and productive disorders	The development of speech therapy model to improve the communicati on.			
Advanced Research	Neurolinguistic Analysis on some speech disorders	Neurolinguistic analysis on some thinking and pragmatic disorders				
Basic Research	Neurolinguistic analysis on some language disorders.					
Activities	2005-2008	2009-2012	2013-2015	2017-2020	2020-2024	2025-so forth

Fig. 1. Roadmap of Neurolinguistics Research

These neurolinguistic researches have been conducted by Sastra et all in more than ten years. Every study contributes for linguistics and neurolinguistics in theoretical aspects and applied purposes for the society. The models of speech therapy have been developed and tested in some medical centers for rehabilitation, meaning, the linguists or neuro-linguists can work together with medical science and doctors. Furthermore, this research on bioacoustics is expected to examine the proficiency level of the patience suffered from speech disorders.

One of the researches on speech disorders done by Sastra et all in 2016 entitled: Bioacoustics for the Patience of Mild Listening Disorder. The subject of the research is the people suffered from listening disorder. Sastra et all also conducted a research on model development of language and speech therapy funded by competence grant scheme of Dikti Indonesia in 2012-2016.

III. CLOSING

All human beings have a natural biological tendency to acquire language for the following reasons: (1) There are specific regions or centers in human brain functioning to regulate language, (2) All human babies share the same way of developing and acquiring language, (3) All humans experience difficulties in developing and acquiring language, (4) learning language is not possible for any other creatures, (5) All languages on earth share the universal components.

1. There are many researches on the relationship of the brain and language. Therefore, the sub-discipline of neuro-psycholinguistics was later coined as neurolinguistics. This term translates as the starting point when neurologists work together with linguists in studying brain and language.
2. Broca and Wernicke are two neurologists who study the localization of brain function and its relationship with language disorder.
3. There are some aspects to consider for formulating neurolinguistic rules as follow: 1) Brain damage affects language processing directly, 2) Damage on the left hemisphere of the brain causes difficulties in processing the language, 3) Damage on the frontal region of the brain causes disorder to linguistic stimulation for speaking and writing, whereas the damage on the rear region of the brain causes disorders to linguistic stimulation for listening and reading, 4) brain damage also causes disorders for understanding the sensory organs of the flavor (agnosia) and the ability of language processing.
4. Language disorder is the difficulty for producing and understanding the utterance fluently (aphasia). Being adults use language is all about using their full linguistic competence through activating all functions of the neurons in the brain. On the other hand, speaking translates as one's capacity to express his or her thought after undergoing a language processing. The results of this process become the utterance produced by the speech organs verbally.

Sastra have conducted numerous neurolinguistic researches for more than ten years. All those studies contribute for linguistics, neurolinguistics, general health, and medical science in theoretical aspects and applied purposes.

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