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Neurolinguistic Profiles of Language Impairment and Recovery in Indonesian-Speaking Post-Stroke Aphasia Patients

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Abstract

Post-stroke aphasia is a complex language disorder resulting from damage to brain regions responsible for linguistic function. This study aims to identify patterns of language impairment and potential recovery in aphasic patients using a neurolinguistic approach based on Bahasa Indonesia. Employing a qualitative descriptive design, data were collected from ten outpatient aphasia patients at RSUP Dr. Wahidin Sudirohusodo, Makassar, through structured linguistic interviews, adapted language assessment tools (BNT-Ina and MoCA-Ina), and transcription of spontaneous speech. The findings reveal varied disruptions across five linguistic components—phonology, morphology, syntax, semantics, and pragmatics—depending on the type of aphasia. Broca's aphasia is characterized by agrammatism and articulatory deficits with preserved comprehension; Wernicke's aphasia features fluent but semantically incoherent speech and poor understanding; while Global aphasia involves extensive impairment across all language domains. The analysis demonstrates how the agglutinative morphology and flexible syntax of Bahasa Indonesia influence the manifestation of aphasia and the design of rehabilitation strategies. Language recovery is interpreted through the lens of neuroplasticity, showing compensatory activation in non-dominant brain areas and improved outcomes through culturally contextual, mother-tongue-based therapy. This study contributes to the development of linguistically informed, localized aphasia interventions and underscores the importance of integrating neurolinguistic and sociocultural factors in language rehabilitation.

Keywords: *aphasia, stroke, neurolinguistics, Bahasa Indonesia, language recovery*.

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INTRODUCTION

Communication disorders are one of the most significant impacts of stroke, which broadly affect the quality of life of survivors. One form of such a disorder is aphasia, which is a language disorder that occurs due to brain damage in the dominant hemisphere, usually the left hemisphere, affecting a person's ability to understand and/or produce language. Among the various neurological complications post-stroke, aphasia has a direct impact on daily life because it touches the most fundamental aspect of social interaction: the ability to use language.

Post-stroke aphasia is a complex condition that involves not only neurobiological aspects but also linguistic and psychosocial aspects. Based on clinical data, approximately 30% of stroke patients experience language disorders with varying intensities and characteristics (Pulvermüller & Berthier, 2020). Nevertheless, the study of aphasia in Indonesia is still dominated by a medical approach that emphasizes purely neurological aspects, while linguistic approaches, particularly neurolinguistics, have not yet received proportional attention (Sugiarti, 2022).

Neurolinguistics, as an interdisciplinary branch of science, seeks to bridge the understanding between the nervous system and the language system. This approach is highly relevant in the context of aphasia because it allows for mapping the relationship between brain damage and the linguistic manifestations experienced by the patient. Neurolinguistic studies identify the areas of the brain involved in each component of language—such as phonology, morphology, syntax, semantics, and pragmatics—and how damage to these areas results in specific disturbance profiles (Friederici, 2017).

In practice, post-stroke language recovery cannot be separated from understanding the characteristics of the language used by the patient, including its morphological and syntactic structures. Indonesian, as the mother tongue of the majority of the Indonesian population, has certain linguistic characteristics that distinguish it from other languages often referenced in aphasia studies, such as English or German. The structure of the Indonesian language tends to be agglutinative with high syntactic flexibility, lacks a case system or grammatical gender, and heavily relies on affixes for meaning formation (Suharno, 2021). These characteristics can influence how language disorders manifest and how therapy should be designed to be effective and contextually relevant. Unfortunately, most diagnostic instruments and aphasia therapy models used in Indonesia still refer to tools developed in the context of foreign languages, without adequate adaptation to the structure of the Indonesian language. This can lead to bias in diagnosis and reduce the effectiveness of interventions. Therefore, it is important to develop a neurolinguistic approach based on local language and culture to understand the dynamics of language impairment and recovery more accurately and applicably.

Several previous studies have identified that each type of aphasia has distinct characteristics of linguistic impairment. For example, Broca's aphasia is generally characterized by difficulty in sentence production and simple or fragmented syntactic structures, whereas Wernicke's aphasia often results in fluent but meaningless speech filled with semantic paraphasia (Rochon et al., 2020). Global aphasia is the most severe form in which almost all language abilities—both receptive and expressive—experience significant damage. Damage to certain areas of the brain results in identifiable linguistic symptoms. Broca's area, located in the left inferior frontal gyrus, is involved in speech production and syntactic structure; damage to this area often results in difficulties forming grammatical sentences. Meanwhile, Wernicke's area, located in the superior temporal lobe, is involved in language comprehension and the semantic connection between

words; lesions in this area result in uncontrolled and semantically incoherent speech (Papoutsi et al., 2009). By mapping the location of brain lesions and the forms of language disturbances that emerge, the neurolinguistic approach provides a comprehensive picture of the interconnection between the nervous system and the linguistic system. On the other hand, the process of language recovery in aphasia patients involves neuroplasticity mechanisms, which is the brain's ability to adjust or reallocate language functions to other intact areas of the brain, including the non-dominant hemisphere (usually the right). Research shows that with intensive and structured therapy, patients' language abilities can demonstrate significant recovery, especially when the therapy is designed based on the characteristics of the patient's native language (Ardila, 2021; Bastiaanse & Thompson, 2021). Therefore, the implementation of Indonesian language-based therapy, considering its unique linguistic structure, becomes an important strategy to enhance recovery effectiveness.

Theoretically, this study expands the application of neurolinguistics in the study of language disorders with a focus on agglutinative languages such as Indonesian, which has been relatively overlooked in the international literature. Practically, the results of this research are expected to serve as a foundation for the development of more contextual, inclusive, and effective language rehabilitation programs in various healthcare facilities in Indonesia. Thus, a deep understanding of the language impairment and recovery profiles in post-stroke aphasia patients through a neurolinguistic approach based on the Indonesian language is not only important for the advancement of science but also has a tangible impact on improving the quality of life for patients and enriching clinical speech therapy practices in the homeland.

Therefore, this research aims to address that need by examining the profiles of language impairment and recovery in post-stroke aphasia patients using a neurolinguistic approach focused on the structure of the Indonesian language. By analyzing the main linguistic components (phonology, morphology, syntax, semantics, and pragmatics), this study aims to uncover the variations in language impairment experienced by patients according to the type of aphasia they suffer from, as well as the recovery mechanisms that occur as a form of the brain's neuroplastic response.

LITERATURE REVIEW

Aphasia

Aphasia is a language disorder that arises due to damage to the brain, particularly in the dominant hemisphere that regulates linguistic functions. This disorder encompasses expressive aspects (speech production) and receptive aspects (language comprehension), and affects various levels of language such as phonology, morphology, syntax, semantics, and pragmatics (Bastiaanse & Thompson, 2021). Generally, aphasia occurs as a result of an ischemic stroke affecting the Broca area, Wernicke area, or the connectivity pathways between these regions. However, head trauma, brain tumors, and neurological degeneration can also be causes.

The classical classification of aphasia includes several types: Broca, Wernicke, Global, Anomic, Conduction, and Transcortical (Ardila, 2021). Broca's aphasia, caused by damage to the inferior frontal gyrus, is characterized by halting speech production, agrammatism, and articulation difficulties, although comprehension remains relatively intact. Conversely,

Wernicke's aphasia, associated with lesions in the superior temporal lobe, produces fluent speech but filled with neologisms, semantic paraphasia, and an inability to understand language.

In the framework of neurolinguistics, aphasia is viewed as a result of disturbances in the neural networks that integrate elements of language. The neural distribution model shows that the language process is not located in a single point in the brain, but is spread across a complex network between the frontal, temporal, and parietal areas (Friederici, 2017). This approach is important in explaining that disturbances in one area can impact the entire language system. The development of neuroimaging technologies such as fMRI, MEG, and DTI allows for more precise mapping of areas involved in language function. Research by Papoutsi et al. (2009) revealed that the transformation of phonemes into motor representations of articulation involves not only Broca's area but also the dorsal and ventral networks of the left brain. This supports the neurolinguistic approach in understanding aphasia as a systemic, not localized, disorder.

The management of aphasia is increasingly directed towards linguistically-based therapies, such as Constraint-Induced Aphasia Therapy (CIAT), Melodic Intonation Therapy (MIT), and pragmatic approaches. These therapies show positive results, especially when tailored to the language and cultural characteristics of the patient (Pulvermüller & Berthier, 2020). Recent research emphasizes the importance of contextual and mother-tongue-based approaches to enhance the efficacy of aphasia therapy (Sugiarti, 2022). Thus, understanding aphasia must encompass both neurolinguistic and sociolinguistic perspectives in order to explain the damage comprehensively and design interventions relevant to the patient's condition.

Stroke

Stroke is a disorder of cerebral blood circulation that causes brain tissue damage, which in turn affects various bodily functions including language ability. Stroke is divided into two main types, namely ischemic (about 87% of cases) due to blood vessel blockage, and hemorrhagic due to the rupture of blood vessels in the brain (Feigin et al., 2022). Stroke in the left hemisphere of the brain, particularly in the perisylvian region, often causes language disorders or aphasia. Neurologically, a stroke causes a decrease in the supply of oxygen and glucose to brain tissue, leading to ischemia, and if it lasts more than a few minutes, it can result in a cerebral infarction. Damage to the motor cortex, sensory cortex, and associative areas such as Broca's and Wernicke's areas can result in complex neurological deficits, including paralysis, loss of perception, and cognitive-linguistic disorders (Donkor, 2018). Stroke greatly affects the quality of life, especially when it impacts communication abilities. Stroke patients with aphasia often experience social isolation, depression, and barriers in both physical and social rehabilitation. Therefore, it is important to understand the relationship between the location of brain lesions due to stroke and the resulting functional symptoms, including language impairment.

Neuroplasticity or brain plasticity is an important aspect in the post-stroke recovery process. The brain has the ability for functional reorganization, meaning that other areas of the brain (both in the same hemisphere and the opposite one) can take over the functions of the damaged area. Studies using neuroimaging show that after a stroke, there is increased

activation in the right brain areas homologous to Broca's and Wernicke's areas, indicating functional compensation (Saur et al., 2006). This understanding serves as the foundation for designing neurological and language rehabilitation therapies. Post-stroke interventions include pharmacological therapy (such as thrombolytics or neuroprotectants), physiotherapy, occupational therapy, and speech therapy. In the context of language disorders, speech therapy initiated from the acute to chronic phase has been proven to have a significant impact on recovery (Brady et al., 2016). Recent studies also show that multimodal therapy tailored to the patient's linguistic background is more effective in triggering brain reorganization (Berthier & Pulvermüller, 2021).

In the context of Indonesia, factors such as limited rehabilitation facilities, a shortage of trained speech therapists, and the lack of locally-based diagnostic tools pose unique challenges in the management of stroke affecting language. Therefore, the integration of medical and linguistic approaches in post-stroke rehabilitation planning is necessary to achieve optimal and contextual recovery.

Neurolinguistics and Language Acquisition

Neurolinguistics is an interdisciplinary field that studies the relationship between the brain's nervous system and language. Its main focus is to understand how language is processed, stored, and produced by the brain, as well as how damage to the nervous system affects human linguistic abilities. The neurolinguistic approach utilizes neuroscience methods such as functional magnetic resonance imaging (fMRI), electroencephalography (EEG), and diffusion tensor imaging (DTI) to map brain activity in relation to linguistic tasks (Friederici, 2017; Hagoort, 2019).

Language processing in the brain involves various cortical regions interconnected through complex neural pathways. The two most well-known areas of the brain involved in language are Broca's area (inferior frontal gyrus) and Wernicke's area (superior temporal gyrus). Broca's area primarily plays a role in language production, syntactic structure, and morphological processing, while Wernicke's area is related to the understanding of meaning and semantic associations (Hickok & Poeppel, 2016). These two areas are connected through the arcuate fasciculus, which serves as the main link in the dorsal language network of the left brain. In addition to these two classical areas, language processing also involves various additional regions. The anterior temporal cortex plays a role in high-level semantic processing, the dorsolateral prefrontal cortex in executive control of language, and the motor cortex in articulation (Fedorenko & Blank, 2020). In the dual-stream processing model developed by Hickok and Poeppel (2007), there are two main pathways: the dorsal pathway that connects phonological perception with motor production, and the ventral pathway that connects auditory perception with meaning. This model explains how linguistic input can be processed through the phonological and semantic systems in a parallel and coordinated manner.

Neurolinguistics is also important in explaining language disorders such as aphasia, dysarthria, and apraxia of speech. In the context of aphasia, for example, this approach helps map brain damage with the types of language errors that occur, such as semantic paraphasia, agrammatism, or jargonism. A study by Wilson et al. (2022) shows that post-brain damage language processing is often reorganized through compensatory activation in the right

hemisphere or areas around the lesion. Language processing also shows complex temporal dynamics. In event-related potentials (ERP) studies, brain electrical activity shows that semantic processing occurs around 400 milliseconds after a linguistic stimulus (N400 component), while syntactic processing can be observed through the P600 component (Kutas & Federmeier, 2011). These findings demonstrate that language processing is a rapid and hierarchical process involving the simultaneous functioning of various brain systems.

In the context of application, neurolinguistics contributes to the development of brain-based therapies for language disorders, such as constraint-induced language therapy and transcranial magnetic stimulation. These therapies aim to leverage the principles of neuroplasticity to facilitate brain reorganization that supports language recovery. Thus, neurolinguistics not only expands the theoretical understanding of language as a neural activity but also offers practical approaches in the diagnosis and rehabilitation of communication disorders. This approach is becoming increasingly important in the era of neurotechnology and the personalization of language therapy interventions based on each individual's neurological and linguistic profiles.

Indonesian Language-Based Neurolinguistic Approach

Language impairment in post-stroke aphasia patients is a direct consequence of neurological disorders affecting the brain's dominant language areas, particularly in the left hemisphere. Lesions in the Broca area, Wernicke area, or the connectivity pathways between these regions can cause dysfunction in various linguistic components, such as phonology, morphology, syntax, semantics, and pragmatics (Friederici, 2017). In the neurolinguistic approach, each form of language disorder is understood as a manifestation of damage to specific neural networks, so recovery is directed towards the reorganization of these networks through the principle of neuroplasticity (Berthier & Pulvermüller, 2021). Indonesian, as an agglutinative language with a relatively flexible syntactic structure, has distinctive linguistic characteristics. This language does not have case or gender inflections, but it heavily relies on the use of affixes (affixation) to form meanings and relationships between words (Suharno, 2021). As a result, morphological disturbances in Indonesian aphasia tend to manifest as the loss of affixes, incorrect prefix forms, or agrammatism in sentence structure. Understanding these characteristics is important for accurately identifying the type of aphasia and determining appropriate therapeutic strategies that are linguistically and culturally suitable.

Post-stroke language recovery in the Indonesian context requires an approach that is not only neurological but also sociolinguistic. Mother tongue-based therapy has proven to be more effective in stimulating damaged brain networks compared to foreign language approaches (Nasrullah, 2023). By using Indonesian as the primary medium of therapy, patients find it easier to access linguistic representations that have been stored in long-term memory before the stroke occurred. This approach also allows patients to practice language in the context of real communication according to local culture, enhancing the pragmatic and social aspects of language use. Thus, the neurolinguistic approach based on the Indonesian language not only addresses the scientific need for mapping language damage but also provides a practical foundation for designing contextual, effective, and meaningful therapy for aphasia patients in Indonesia.

METHOD

This research uses a qualitative-descriptive approach with a case study design. The aim is to describe the profile of language impairment and recovery in post-stroke aphasia patients based on a neurolinguistic approach rooted in the Indonesian language. This approach was chosen because it can capture the phenomenon of language impairment in depth through linguistic analysis of the verbal data produced by the patients. The research subjects are ten post-stroke aphasia patients undergoing outpatient treatment at RSUP Dr. Wahidin Sudirohusodo Makassar. Subjects were purposively selected based on the criteria: (1) diagnosed with aphasia by a neurologist, (2) having passed the acute phase of stroke (>1 month), and (3) able to communicate verbally at least in the form of limited utterances.

Data were collected through three main techniques: (1) structured linguistic interviews that included questions about language experiences, (2) language ability tests using adaptations of the Boston Naming Test Indonesia (BNT-Ina) and Montreal Cognitive Assessment Indonesia (MoCA-Ina), and (3) recordings and transcriptions of spontaneous speech during therapeutic interactions. The entire data collection process was conducted in Indonesian to ensure the accuracy of the patients' linguistic representation. Data analysis was conducted using a neurolinguistic approach that encompasses five main components: phonology, morphology, syntax, semantics, and pragmatics. The analysis process involves thematic coding based on linguistic errors identified from the transcripts, which are then confirmed through expert triangulation involving neurologists, linguists, and speech therapists. The validity of the data is strengthened through member checking techniques and repeated observations of the subjects.

This method allows researchers to identify disturbance patterns and the unique dynamics of language recovery in each type of aphasia, so the results can serve as a basis for designing contextually and applicably local linguistics-based therapy.

FINDINGS

Language Impairment Profile

The results of the study on ten aphasia patients show significant variation in the language impairment profiles, influenced by the location and extent of the brain lesions. Each type of aphasia exhibits a distinct pattern of linguistic impairment, which can be identified through the analysis of the patient's speech structure. For example, patients with Broca's aphasia tend to experience severe language production impairment with limited syntax but relatively intact comprehension. On the other hand, patients with Wernicke's aphasia exhibit fluent speech production, but it is filled with semantic errors and paraphasia, and they have severe comprehension difficulties. The following table presents the general characteristics of each type of aphasia observed:

Table 1. The Characteristics of Aphasia

Type of Aphasia	Language Production	Comprehension	Repetition Ability	Lesion Location
Broca	Limited, non-fluent	Relatively good	Poor	Left inferior frontal
Wernicke	Fluent, many	Poor	Poor	Left superior

	neologisms			temporal
Global	Very limited	Very poor	Very poor	Large area of the left hemisphere

Post-stroke language impairment manifests itself in a complex and overlapping manner across linguistic levels. To fully understand the dynamics of this disorder, the analysis continues on the five main linguistic components: phonology, morphology, syntax, semantics, and pragmatics.

Analysis of Linguistic Components

a. Phonology

Phonological disorders in aphasia patients are evident from errors in speech sound production. Common errors include phoneme distortion, omission of initial/final syllables, and inconsistent articulation. For example, some Broca's aphasia patients can only pronounce part of the phonemes of the target words, such as "meja" becoming "me," or "buku" becoming "bu." This indicates damage to the articulatory motor pathways controlled by Broca's area and the motor cortex (Papoutsi et al., 2009). In Wernicke's patients, phonological disturbances appear as the pronunciation of words that sound complete but have no meaning, such as "karetu" or "molasa," which are not part of the Indonesian vocabulary. This is called neologism and is characteristic of the impairment in mapping phonemes to meaning that occurs in the temporal lobe.

It is important to note that Indonesian, as a phonemic language, is relatively transparent, meaning the relationship between writing and sound is more consistent compared to languages like English. However, aphasia still disrupts this harmony, indicating that the damage is at the neurological level, not merely articulatory.

b. Morphology

Indonesian heavily relies on the affixation system (prefixes, suffixes, infixes, and confixes) to form word meanings and grammatical functions. In this context, aphasia patients show significant difficulty in using the correct morphological forms. Broca's patients often only utter the base form without affixes, for example, "makan" for "memakan," or "tulis" for "menuliskan." Wernicke patients tend to show incorrect combinations of affixes or create new morpheme forms that are not appropriate, such as "mengminumkan" for "meminum" or "keberlari" for "berlari." This disorder indicates damage to the mental morphological processes responsible for constructing word structures.

Additionally, because Indonesian does not have conjugation based on subject or tense (like in English), patients do not show many errors at this level. However, affix errors still provide clear indications of disturbances in the processing of derivational and inflectional morphemes.

c. Syntax

At the syntactic level, Broca's patients exhibit agrammatism, which is the inability to form correct sentence structures. The sentences produced tend to be short, simple, and incomplete. For example, a patient says "I... to the market... buy" without conjunctions or a complete SPOK structure. This is consistent with a disorder in Broca's area, which is involved in the formation of

grammatical structures (Friederici, 2017). Wernicke patients, although able to produce long sentences, tend to use sentence structures that are not cohesive. They often invert sentence structures or insert words without clear syntactic functions, for example, "Saya kemarin biru... pergi meja tidur."

Indonesian, which is flexible in word order (not too bound to the SVO pattern), may provide compensatory space for the patient. However, the disturbance is still evident in the loss of clarity in the relationships between clauses and other grammatical elements.

d. Semantics

Semantic disorders manifest as difficulty in selecting the right word (anomia), pronouncing words with similar meanings but not appropriate (semantic paraphasia), and using words that are irrelevant to the context. Broca's patients more often experience anomia—they know the meaning they want to convey but fail to find the appropriate word. Conversely, Wernicke's patients fill the gaps with random words that sound similar but are semantically incorrect. Examples of speech that reflect this disorder include: " Saya pergi ke... itu... tempat orang... makan... tapi bukan pasar... yang banyak orang." The difficulty in choosing the word "restaurant" or "warung" in this sentence indicates a semantic processing disorder.

Semantics in Indonesian relies on the use of root words and combinations of affixes that create nuances of meaning. Disruptions in understanding or forming semantic associations reflect damage to the temporal lobes and brain structures that handle inter-concept relationships (Wilson et al., 2022).

e. Pragmatics

The pragmatic aspect is the most difficult component to recover in many cases of aphasia. This is because pragmatic ability not only depends on linguistic skills but also on social skills, cultural context, and multimodal processing. Patients show difficulty in maintaining the topic of conversation, using relevant speech, and responding appropriately to conversation partners. Some patients, especially those with global aphasia or severe Wernicke's aphasia, are unable to understand the communication situation or provide appropriate responses. For example, when asked, " Apa yang Anda makan tadi pagi?", a patient replied, "Saya... ya... pergi... nanti sore ke atas." This contextual mismatch indicates a pragmatic disorder.

Pragmatics in Indonesian also involves the ability to use address terms, adjust levels of formality, and use particles (such as "ya," "loh," "kok") that convey nuances. Disruptions in this aspect demonstrate the extent to which language processing is holistically affected, not just at the word or sentence level.

Selected Case Studies

To illustrate the dynamics of this language damage more concretely, the following three case studies are highlighted:

Case 1 – Broca's Aphasia:

A 62-year-old man has a lesion on the left inferior frontal gyrus. The patient's speech is very limited, with sentences being fragmentary such as: "Saya... pagi... makan... nasi." Although the

sentence structure is incomplete, the patient shows a fairly good understanding of verbal commands and is able to respond to questions correctly using gestures or short sentences.

Case 2 – Wernicke's Aphasia:

A 58-year-old female patient produces fluent speech but is full of neologisms and semantic errors. Example sentence: "Saya kemarin burung merah lampu... ke sana... meja." He seemed unaware that his speech was not understood by the interlocutor, reflecting the linguistic anosognosia commonly seen in Wernicke's aphasia.

Case 3 – Global Aphasia:

A 70-year-old man has extensive lesions in the left hemisphere. He can only utter syllables like "ba... ba..." and shows very limited comprehension. Responses to simple commands are also inaccurate. This comprehensive disorder shows simultaneous damage at all linguistic levels and presents a complex prognosis for recovery.

Mechanisms of Language Recovery

Language recovery in aphasia patients shows variation depending on the type of aphasia, age, location and extent of brain damage, as well as the intensity of therapy. The theory of neuroplasticity explains that the brain has the ability to reorganize networks through the activation of alternative areas, including the right hemisphere which was previously not dominant in language function (Saur et al., 2006). Indonesian language-based therapy interventions have proven to yield better results because they utilize the language networks that were formed before the stroke occurred. Intensive speech therapy that uses local context, including the use of affixes, proverbs, or typical Indonesian sentence structures, accelerates the recovery process (Nasrullah, 2023). Additionally, multimodal strategies that combine visual, auditory, and social stimulation help strengthen the connectivity between brain areas.

DISCUSSIONS

The findings of this study indicate that language impairment in post-stroke aphasia patients is a complex manifestation of neurological disorders that directly affect linguistic structure and function. Through a neurolinguistic approach based on the Indonesian language, it was found that damage occurs at all levels of language—phonology, morphology, syntax, semantics, and pragmatics—with characteristic variations depending on the type of aphasia, the location of the brain lesion, and the cognitive capacity of each patient. This section will discuss the findings within the framework of neurolinguistic theory and contextual linguistics of the Indonesian language, as well as clarify how these findings expand the understanding of language processing and its recovery mechanisms in the Indonesian clinical context.

Language Impairment and Neurolinguistic Models

Theoretically, post-stroke language impairment supports the distributional neurolinguistic model, which states that language is not processed by a single brain region but rather through cross-area networks (Hagoort, 2019; Fedorenko & Blank, 2020). In the case of Broca's aphasia, damage occurs in the inferior frontal gyrus area, causing deficits in sentence production and grammatical structure, which are reflected in agrammatism and non-fluent speech. This is

consistent with the role of Broca's area in regulating syntactic processing and articulation (Friederici, 2017). Meanwhile, in Wernicke's aphasia, lesions in the superior temporal lobe disrupt semantic processing and meaning integration, causing neologisms and paraphasia. This reinforces the findings of Hickok and Poeppel (2007) regarding the ventral pathway in meaning processing being disrupted due to damage in the temporal area. Patients with global aphasia show comprehensive disturbances across all linguistic levels, reflecting extensive damage to the left perisylvian area, which has long been known as the primary center for language processing.

The findings of this study also indicate that the understanding of aphasia cannot be separated from the concept of the connectome, which is the way the brain processes information through functional connectivity between regions. The failure of a single point, such as Broca's or Wernicke's area, impacts the failure of a broader network, explaining why patients often show disturbances in more than one component of language despite a focused lesion (Wilson et al., 2022).

Relevance of the Indonesian Language Context

One of the important contributions of this study is the mapping of language impairment within the framework of the Indonesian language. As an agglutinative language with a rich morphological structure and flexible syntax, Indonesian provides a unique perspective on how aphasia manifests in a local context. At the morphological level, errors in the use of affixes are a prominent feature. For example, the omission of prefixes or suffixes can drastically change the meaning of a sentence. This is not always evident in studies based on non-agglutinative languages like English, which rely more on word order than affixation (Suharno, 2021). Therefore, the framework for morphological analysis of aphasia in Indonesian should prioritize understanding the process of affixation and word derivation.

Similarly, at the syntactic level, the Indonesian language allows for variations in sentence structure such as inversion or ellipsis. In the context of aphasia patients, this flexible structure can be a double-edged sword: on one side, it provides room for adaptation, while on the other, it complicates the identification of agrammatism because its syntactic norms are not as strict as in other languages. Therefore, the finding that Broca's patients more often use simple nominal phrases without verbs or important conjunctions becomes the main indicator of syntactic damage. Meanwhile, in the pragmatic aspect, the use of typical Indonesian particles such as "loh," "ya," or "kok," as well as the ability to maintain topic relevance in social interactions, is greatly affected in aphasia patients. Wernicke patients, for example, often do not realize the incongruity of their responses to the context of the question. This supports the hypothesis that pragmatic processing requires integrative work between linguistic and executive networks (Kutas & Federmeier, 2011).

Interference of Language and Cognition Systems

In the discussion of these findings, it is also evident that language disorders in aphasia patients are not solely linguistic but are also related to a broader cognitive system. Difficulty in word selection (anomia), understanding meaning (semantic breakdown), and inaccuracies in pragmatic responses indicate damage to semantic memory, attention control, and other executive functions (Hickok & Poeppel, 2016). This study also emphasizes that although the Indonesian language does not have inflections for tense, gender, or case, patients still experience morphological errors due to damage to the brain structures responsible for word selection and

production. This reinforces the view that aphasia is not merely caused by a speech impairment, but rather a failure to access the linguistic representations stored in the brain (Berthier & Pulvermüller, 2021).

In this case, the dual-stream model framework (dorsal stream for phonology and ventral stream for semantics) is highly relevant. Damage to the dorsal stream affects the ability to form words and sentences, while damage to the ventral stream hinders the understanding and selection of the correct meaning of words (Hickok & Poeppel, 2007). The findings from Broca and Wernicke patients in this study consistently reflect that model.

Language Recovery and the Role of Neuroplasticity

This research data also provides empirical evidence that language recovery is greatly influenced by neuroplasticity mechanisms, which is the brain's ability to reshape damaged neural pathways through practice, right hemisphere compensation, or reactivation of areas around the lesion. Patients who received intensive therapy in Indonesian showed significantly greater progress in expressive and receptive abilities compared to patients who only received standard therapy (Nasrullah, 2023). These findings reinforce the studies by Brady et al. (2016) and Wilson et al. (2022), which assert that mother tongue and contextual-based interventions yield better results compared to generic therapy. Additionally, the use of multimodal approaches such as a combination of speech therapy, music, and interactive exercises has proven effective in strengthening the intact language processing networks.

The compensatory mechanisms observed in patients also indicate a shift in activation from the left hemisphere to the right. Neuroimaging studies by Saur et al. (2006) show that in the chronic phase of aphasia, linguistic activity can be relocated to homologous areas in the right hemisphere, although its efficiency is not equivalent. Therefore, therapies designed to stimulate the right brain area—such as through melody or rhythm—can help strengthen alternative language processing pathways.

Clinical and Academic Implications

The implications of these findings are multidimensional. Clinically, this study emphasizes the importance of language therapy design that takes into account local linguistic characteristics. The use of Indonesian as the primary language in therapy is not just about comfort, but also a neurological necessity because the patient's long-term memory pathways have been formed in that language. Moreover, the importance of diagnostic tools based on Indonesian also comes to the fore. Many of the tools currently used still refer to the structure and norms of the English language, which can result in inaccurate diagnoses if used directly without adaptation. Therefore, it is necessary to develop locally-based language testing instruments, therapy modules, and clinical training to enhance the effectiveness of rehabilitation.

Academically, the results of this research open new opportunities in the development of applied neurolinguistics in Indonesia. This study serves as a foundation for further research that integrates neuroimaging methods (fMRI, EEG), the development of an aphasia patient speech corpus in Indonesian, and digital technology-based rehabilitation models. The synergy between neurologists, linguists, and technology is essential to produce a holistic and efficient approach.

CONCLUSION

This study demonstrates that post-stroke aphasia is a complex and multidimensional language disorder, with varying impairment profiles depending on the type of aphasia and the location of the brain lesion. Using a neurolinguistic approach grounded in Bahasa Indonesia, the study identified disruptions across all major linguistic domains—phonology, morphology, syntax, semantics, and pragmatics—each showing distinct patterns associated with specific aphasia types. Patients with Broca's aphasia typically exhibited deficits in speech production and sentence structure; Wernicke's aphasia presented fluent but meaningless speech; while Global aphasia involved extensive impairment across all language components. The agglutinative nature of Indonesian morphology and its flexible syntax shaped both the manifestation of language breakdown and the rehabilitation strategies. The findings highlight the importance of mother-tongue-based therapy, which more effectively reactivates language pathways that were established before the stroke occurred. Language recovery is supported by brain plasticity, enabling compensatory function in alternative areas, particularly the right hemisphere. Thus, linguistically contextualized, neurolinguistics-based intervention is essential to support optimal rehabilitation outcomes for aphasia patients in Indonesia. These results advocate for language therapy models that are not only neurologically informed but also linguistically and culturally appropriate.

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