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Phonological Errors on Impaired Language Modality Produced by Individuals with Broca's Aphasia

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Abstract

Nearly all of Broca's aphasic patients have the tendency to produce phonological errors in their non-fluent speech output. The grade of errors may vary depending on the severity of brain pathology, affected language area, and the scope of impaired sounds. Any types of the phonological process might be found in their weakening language modalities. So, the present study investigates the severity of the aphasics' language modality, phonemic and phonetic errors of the impaired speech. This descriptive study analyzes Balinese speech produced by three individuals who suffer from Broca's aphasia. To find out, they were requested to repeat words, name pictures, answer questions and read short text orally. As the result, their language modalities were categorized severe. The listeners required some hard efforts to conclude, question and predict what the informants said and further communication was impossible on more complex words. They produce not only distortions as phonetic errors but also substitutions, deletions, insertions, and metatheses as phonemic errors. Sound substitutions mostly appeared in a greater percentage for every phonological task given. By analyzing the errors with generative phonology, the findings suggest that the PND can lead a better phonetic realization, one of which is by substituting the target sounds in terms of their phonological features similarity. Though phonemic processing is more common in fluent aphasia, non-fluent aphasics also produced sonority substitutions. Furthermore, there was not synchronous coordination between the underlying form in the posterior region and phonetic representation in the anterior region due to the loss of the linguistic message.

Keywords: non-fluent aphasia, phonological errors, sonority, neurolinguistics

1. Introduction

Language function is one of the most prominent components in behavioral neurology because the most specific feature of human beings is their ability to express notion, information, and emotion through speech and language. A language disorder can happen to anybody especially adults if there is a lesion in the left hemisphere of the brain caused by traumatic brain injury (TBI) or any kinds of a cerebral vascular accident (CVA). Stroke can cause so many changes in human behavior components, one of which is considered as language disorder or aphasia. Den Ouden (2011.p.321) states that aphasia is an acquired impairment of language in adult, resulting from focal brain damage. Lesion in the posterior area can trigger impairment in phonemic level and the lesion in the anterior area can contribute the phonetic disorder (Gandour, 1998). However, both can cause individuals to suffer from a non-fluent aphasia with the diagnostic syndrome of slight mutism, phonological anomia, repetition, reading, and writing (Benson, 1979). Previous research findings have contributed empirical pieces of evidence about additional types of phonemic or phonetic disorder produced by Broca's aphasic patients. However, the notion of disorder either at the phonetic level, which may influence phonological processing or at the phonemic level, which may influence phonetic processing, remains to be explored.

Therefore, this study tries to find out the shreds of evidence of phonemic and phonetic disorders in Balinese speech output spoken by three individuals with Broca's aphasia. Phonological investigation on the aphasics' speech output has been very few in Bali, however, the number of

stroke patients are increasing gradually. After the stroke, they used body language to communicate due to the difficulties of expressing ideas or responding simple orders. They can say two or three words bit clearly but other words seem to be very hard to express. An example of this phenomenon is when one of them wants to ask 'do you have any money?' and the target sounds are: //*sube ngelah pipis*// but it is realized as [bə…lah pieh]. This phonological phenomenon is very challenging to be further investigated by applying the theory of generative phonology and the description of a neurolinguistic side of view. By identifying the phonological errors either at the phonemic level or at the phonetic level, the evidence of aphasics' decreasing language modality can be used as feedback not only for scientific purposes but also for further rehabilitation treatments. In fact, this study might find a description of the impaired sound that differs from any other findings.

In spite of the fact that those three informants are able to pronounce vowel sounds of /a/, /i/, /u/, /e/ and /o/ and other consonant sounds of /p/. /t/, /k/, /b, /d/, /g/ etc. independently, they can not sequence the sounds functionally into correct syllable structures. When the segment is combined together to form morphemes and from the morphemes into syllables, the segments influence one another by assimilating, substituting, deleting or adding other segments. Based on initial observation of their speech output a couple of weeks after stroke, each individual had different speech output for the same words or for the same pictures. One could say a written word but could not name a picture of the word he mentioned and the other one could not mention both of them correctly. The target sound of /kipas/ 'a fan' was realized by three of them as [ipas], [apah], and [ipat]. One thing can be observed here is they had difficulties in starting words that are commonly known as phonological anomia; one syndrome of Broca's aphasia. They had a strong spirit to say things to keep up the conversation but they often made phonological errors of each word given.

In the line of the example given above, the speech of Broca's patients is mainly composed of one and two-word utterances, mostly content words known as telegraphic speech (Cera & Ortiz, 2010). Many of Broca's aphasics produce phonemic errors in speech production but comprehension is relatively intact (Bastiaanse, Gilbers & Linde, 1994). The phonemics errors occur due to disorders in phonetic processing that involves planning and executing articulatory programs. Phonological errors across diagnostic categories of Broca's aphasia refer to inaccurate phonetic articulation and inappropriate concepts of phonemes. Empirical studies claim that the impaired sounds are dominated by substitution of a target sound with the sound that has neighboring features. In this case, a Balinese Broca's aphasic, KW has phonological errors in saying /juju/ 'a crab' and it is realized as [juluh]. He can not say /j/ in the second syllable and tend to substitute the phoneme with /l/ because it belongs to the same group of similar features called *Phonological neighborhood density* (PND). Munson & Solomon (2004) define PND as the number of words that differ from a target word by a single phoneme. This is well known as sonority substitutions, the errors in which one segment is replaced by another that differs only one step on the sonority scale (Bastiaanse, Gilbers & Linde, 1994).

The scientific investigation of phonological errors on speech output produced by Brocas's aphasics may not be partially approached by only linguistics side of view but it must be also slightly viewed from neurolinguistics points of description (Bambini, 2012, Kemmerer, 2014). Neurolinguistics covers three interrelated domains namely thought, brain and language (Fromkin dan Rodman, 1989). According to Bambini, (2012), the theory of neurology explores parts and brain structure and mechanism of the brain functions, meanwhile linguistic theory explores how structure and language system functions. The goal is to comprehend how the cognitive capacity for language is controlled by biological tissues of the brain (Kemmerer, 2014, Bambini, 2012). So this study describes the relationship between phonological errors of non-fluent speech output produced by Broca's aphasics and the underlying lesion in phonological aspects of the brain.

To lead the phenomenon to the analysis, this present study investigates the forms and sound structures of speech produced by Balinese Broca's aphasics and categorizes the severity of their language modality. All the phonemic and phonetic processing can show how the phenomenon of phonological error can appear. Thus the study is conducted to investigate the forms and structures of the phonological errors and types of phonological processing of speech output of Broca's

aphasics. All the error cases will be classified and categorized into types of errors. To analyze the phenomenon, the theories applied are generative phonology and neurolinguistics.

Concerning literature cited in this paper, it has been proposed that the phonetic errors are tightly related to non-fluent aphasia. Phonetic disintegration, an articulatory failure to realize sounds with the correct precision, would be characteristic for the speech of non-fluent aphasia (e.g., Lesser, 1995). There is a great dichotomy between phonemic disintegration for fluent aphasia and phonetic disintegration for non-fluent aphasia, however, there is some degree from both disintegrations. Blumstein (1973) has investigated aphasic speech and has found evidence of many phonological patterns of that. Blumstein reports in the three other studies, the number of substitutions lays a lot higher than the amount of substitution in fluent aphasia. Related to phonetic disintegration, the studies of phonological errors have been ever conducted by using software speech analyzer or PRAAT (Adam, 2014, Marotta, Barbera, & Bongioanni, 2008). This property can explain sound system phenomenon, especially phonation, frequency duration, and intonation produced by aphasics. Studies in phonetics and phonology on aphasia have been exposed by Buckingham & Chrisman (2008), Gordon & Ledoux (2008), and Gandour (1998).

In line with substitution sonority, the notion of sonority provides a definition of the syllable. According to the Sonority Sequencing Principle (SSP) (Romani & Calabrese, 1998), a syllable is a string of sounds organized in such a way that sonority rises from the beginning to a peak and then falls (vowels always correspond to syllabic peaks since they have the highest sonority value) (Coda, & Ball, 1994). For example, in Balinese the word ‘pripit’ meaning ‘stingy’ is sequenced by /p/ to /r/ and from /r/ to /i/ and drops. It is not legal syllable if the sequence of sounds is constructed /r p i pit/, because there is a drop in sonority between the beginning of the syllable and the peak. The substitution sonority can happen to the word ‘pripit’ which is realized as [pli..pit].

Therefore, the theory of generative phonology is considered appropriate to analyze the phenomenon of substitution, omission, distortion, reduplications, and metatheses. Schane (1992) elaborates that generative phonology is a mechanism of any mental sounds process that occurs in every language. A phonological process is the alteration or changes of segments in sequences of morphemes that are neighboring and combined to form words. Sound changes can also occur outside of its clustering environment, i.e. in initial, middle and final distribution, or between vowels in which the second one is stressed. Sounds change into four phonological processes, including assimilation, syllable structure, weakening and strengthening, and neutralization. Phonological disorder in Broca's aphasia may be commonly related to the semantic disorder, especially the difficulty of naming and repeating words or sentences. In the line with phonological processing, Gandour, (1998.p.209) states that generative phonology organizes features in a hierarchical tree structure. The majority of phoneme substitution errors manifest feature changes within a single tier rather than across tiers (Blumstein, 1990).

The theory claims that the smallest sound units are not known as phonemes but their distinctive features. The phonological process, according to Schane, (1992) consists of three stages, lexical representation, phonological representation, and phonetical representation. There are three components which are used as fundamental analysis in generative phonology; (1) underlying representation (UR) is known as mental or basic representation using the notation of / /, (2) phonological rules /and (3) phonetic representation (PR) using the notation of [ ]. It is al structured in the brain. In general, neurolinguistics is concerned with the relationship between language and the brain (Bambini, 2012). Its final goal is the comprehension and explanation of the neural bases for language knowledge and use (Gandour, 1998). Neurolinguistics is by its nature an interdisciplinary enterprise and straddles the borders between linguistics and other disciplines that are connected to the study of the mind/brain (Bambini, 2012). From the perspective of the neurosciences, neurolinguistics focuses on how the brain behaves in language processes, both in healthy and pathological conditions; conversely, from a linguistics standpoint, neurolinguistics aims at clarifying how language structures can be instantiated in the brain

Based on the description of the phenomenon, related reviews, and theory above, we hypothesized that 1) the phonemic representation may be obscured by phonetic processing of speech output produced by patients with Broca's aphasia and 2) PND may lead the selection of target sound, one of which by substituting the closest level of the features group.

2. Method

Badung Regional Hospital in Bali had 36 patients with stroke and after the language disorder test, this study involved 3 patients, KW, NS and MD who were positively suffering from Broca's aphasia and the rest of the patients were diagnosed dysarthria. From each patient, one or more audio tapes were available containing spontaneous speech. The tests were in the form of four phonological tasks, namely words naming, pictures naming, answering questions and oral reading. Each task had 65 words or pictures that mainly represented consonants and vowels in different distributions. The recorded data were then phonetically and phonemically described and classified into phonological errors. The number of errors is then calculated to determine the sound severity on four different language modality. To ensure the errors of consonant and vowels sound, the doubtful interpretations were double checked by using a software program, that is speech analyzer. All alterations were analyzed by using generative phonology to know the phonological process of speech output, such as substitutions, omissions, insertions, reduplications, and metatheses. Aphasia Severity Rating Scale of Boston test is used to measure the language modality of the informant that ranges from a scale of 1 to 5 with specific criteria. All total correct and incorrect sounds were calculated to find out the percentage of the deficit. After severity level was found, the numbers of types of errors were definitely measured to know what errors were more and less dominant. All quantitative data are presented in tables and figures.

3. Results

Benson (1979) lists the syndrome of Broca's aphasia as that of impairment of spontaneous speech, repetition, naming, and writing. Thus, to measure the language modality, all participants were given phonological tasks that is an act of asking them to name listed words, naming pictures, answering some short questions and reading a short reading passage. Each constructed task consisted of words which may enable the researcher to obtain knowledge of phonological errors.

3.1 Severity of Language Modality

KW, NS, and MD were shown 65 words, 65 pictures, 65 words in spontaneous speech and 65 words in the reading text. The speech was then recorded and tabulated. Each word was then phonetically and phonemically transcribed and then classified into 4 different phonological errors, namely phonemes distortion, substitution, addition, and omission. All data were then observed comprehensively both to find linguistic phenomenon and underlying pathology in his language area. The data were counted to determine the percentage of correct, incorrect sound and sound severity. To know each participant's ability in performing the task, only one data out of 65 words are listed for each task presented here.

Table 1. Representation of speech output of Broca's aphasics

KW	*Target*			*realization*	*errors*
Word naming	*roko*	'cigarette'	/roko/ ⟶	[lokoh]	substitution
Picture Naming		'fan'	/kipas/ ⟶	[ipas]	omission
Spontaneous answer 'Where does your wife work?'	*petani*	'a farmer'	/pətani/ ⟶	[penadi]	metatheses
Oral reading	*Ada katuturan satua I Siap Selem*	Once upon a time, lived a black hen	/adə katuturan satuə i siap	⟶ [Sade..adə katuturan.cu pulia..pula..	Addition, distortion, omission,

			sələm	eyap ketem]	substitution
NS					
Word repetition	*pianak*	'children'	/pianak/ ⟶	[pilanak]	insertion
Picture naming		'a hen'	/siap/ ⟶	[ipas]	metatheses
Spontaneous answer 'Have you got any rice?'	*Tyang suba ngelah bas*	'I have you got some rice/	/Suba⟶ ŋelah bas/	[..be….lah bans]	omission insertion
Oral reading	*Ada katuturan satua I Siap Selem ngelah*	Once upon a time, lived a black hen	/adə ⟶ katuturan satuə i siap sələm	[...adə ka..tut..turan sa..sahua..i seyap elem,.	Submission omission
MD					
Word repetition	*Emas*	'gold'	/ əmas/⟶	[əmah]	substitution
Picture Naming		'a comb'	/suwah/⟶	[hu..iah]	substitution
Spontaneous answer 'Would you like coffee or tea?'	*'Tyang minum kopi'*	'I drink coffe	/tiakopi/⟶	[ko..pik]	addition
Oral reading	*Ada katuturan satua I Siap Selem ngelah*	Once upon a time, lived a black hen	/adə ⟶ katuturan satuə i siap sələm/	[...ahdə..tura n sa..cahua… se……yap elem,..	omission substitution distortion addition

Based on the data above, phonological errors in every speech output of KW, NS, and MD indicated their decreasing language modality. It can be seen from the errors they made in words naming, pictures naming, answering short question and reading. It was clear that they tended to prolong the stress in the first vowel of the first syllable, in contrary Balinese words, are usually stressed in final syllable. There were a lot of silence and murmuring sound. Every participant had different speech output even though they had the same task to do and the same syndrome of aphasia they suffer from. It can be observed here that different stimulation triggered different speech output even though the target is the same. The informants' language modality is summarized as follows.

Table 2. Distribution of Broca's aphasics on phonological task

Informants	Phonological Task	Total Correct (n=65)	% correct	Phonemic errors/ Total errors	% errors = phonology	Level of severity
KW	Word naming	21	0.32	35/44	0.80	severe
	Picture Naming	25	0.40	37/40	0.92	severe
	Question	19	0.29	40/46	0.87	severe
	Oral reading	22	0.34	38/43	0.89	mild
	Total	87	1.35	150/173	3.48	severe
NS	Word naming	19	0.29	80/46	1.74	severe
	Picture Naming	27	0.41	30/38	0.78	mild
	Question	15	0.23	26/50	0.52	mild
	Oral reading	13	0.20	42/52	0.83	severe
	Total	45	1.13	178/186	3.87	severe

MD	Word naming	10	0.15	90/55	1.64	severe
	Picture Naming	15	0.23	60/50	1.20	severe
	Answering	12	0.18	30/53	0.57	mild
	Oral reading	8	0.12	52/57	0.91	severe
	Total	45	0.68	232/215	4.32	severe

Referring to the criteria of 5 of Aphasia Severity Rating Scale of Boston test, KW had 1.35% correct sound and 3.48% incorrect sound in which the errors are mainly dominated by phoneme substitution. NS had 1.13% correct sound and 3.87% incorrect sound that consisted of errors of substitution. MD was considered weak in expressing verbal language. He achieved 0.68% correct sound and 4.32% incorrect sound due to the number of substitution was quite high that is 4.32%. Based on Aphasia Severity Rating Scale of Boston test, KW's, NS's and MD's speech performances were categorized severe. They could not perform fluent verbal expression, i.e. double repetition of the first syllable. It was required some hard effort for the listener to conclude, question and predict what he was trying to be said. They showed limited information range and communication burden was on the listener's side. They had difficulties in repeating words and articulating sounds. Rating showing decreasing language modality is presented below.

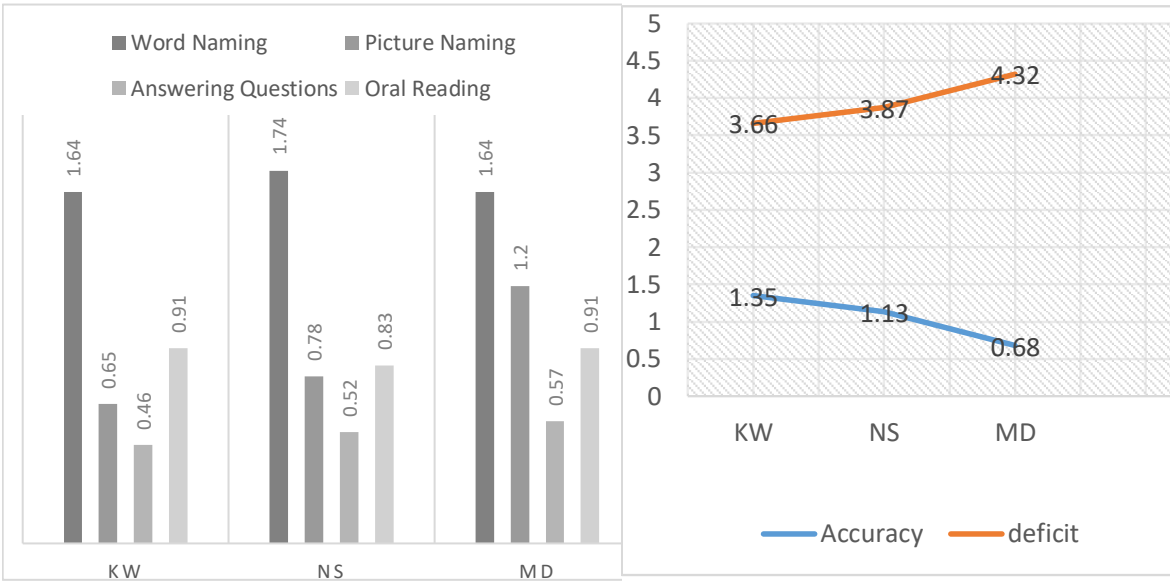

Figure 1. Graph Showing the Language Modality of Broca's Aphasic

From the graphic above, it can be kept in mind that the language modality of the informants was gradually decreasing after the stroke. KW had problems in pronouncing vowel and consonants sound at the beginning of words and so did NS and MD. One of the aphasics' syndrome is called anomia which means the difficulty of starting words. All informants tended to substitute the phonemes with the closest features with the target. To know the real phenomenon of phonological errors of the words mentioned by the informants, here is the list of distribution of Broca's aphasic errors.

Table 3. Distribution of Broca's aphasic errors

Broca's	KW	NS	MD
Phoneme substitution	65%	68%	71%
Distortion	20%	20%	18%
Omission	5%	11%	10%

addition	10%	1%	1%

Compared to the previous findings, Blumstein (1973) reports in the three other studies the amount of substitutions lays a lot higher with 61.5% being the lowest percentage. In this study, there was a different amount of phoneme substitution which was the dominant error type. KW made 65% substitution in his words, NS produced 68% substitution in his words and MD had the highest substitution error type. This type was then followed by other rank order of the error types: distortion, omission, and addition. Ferreres (1990) showed a somewhat similar distribution of error types for Spanish speaking people with Broca‟s aphasia. Substitutions were the error type most often made (59%), followed by omissions (29%), then insertions (10%) and at last metathesis (2%). So these findings show that the amount of phoneme substitution which was the dominant error type compared to the previous study. Rating showing phonological error produced by KW, NS and MD and acoustic features of vowels can be seen in the following figure

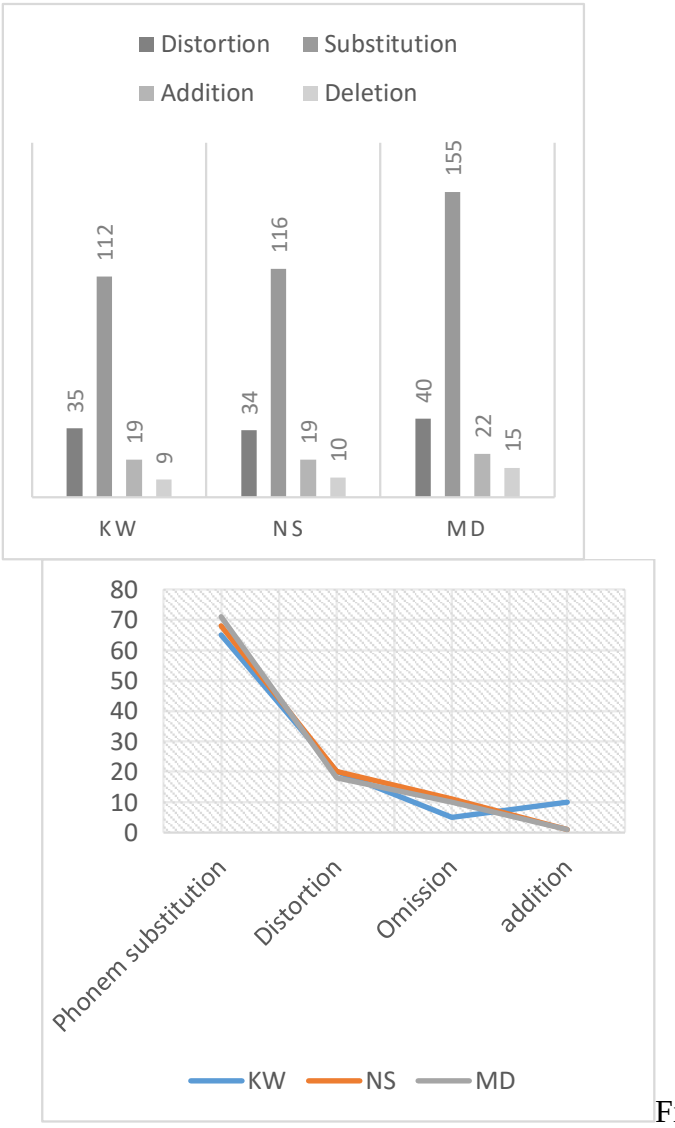

Figure 2. Rating Showing Phonological Error Produced by KW, NS, and MD

Phonological errors produced by KW, NS and MD covered two domains; phonetics errors, and phonemic errors. Phonetic errors are related to an inaccuracy of individual sound articulation, either place of articulation or manner of articulation. The phonetic errors can be recognized from formant value and physiology of speech sounds. Meanwhile, the later ones were related to neighboring sounds rules, in which a sound segment in a word can undergo a phonological process

due to the characteristic or distinctive features and position in identical or contrast environment (Schane, 1992).

3.2 Phonological Errors

Phonological errors that were produced by informants listed above are mainly attributed to a breakdown in phonological processing, that is, in transforming the underspecified lexical phonological form into a phonemic representation. Gandour, (1998) states that the deficit at the phonological level due to posterior lesions are discussed in relation to phonological features, markedness, syllable structure, and sonority. Meanwhile, the segmental deficits at the phonetic level due to anterior lesions are discussed in terms of parameters of vowel and consonants, segmental coarticulation and speaking rate effects. A phonological process can be explained as an articulatory phenomenon or conceptual (Schane, 1992). In this study, the phonological errors produced by Broca's aphasics are discussed in two levels; phonetic level and phonemic level.

3.2.1 Phonetic Errors

There are two types of phonetic variation in this study: 1) almost accurate and 2) least accurate. The sounds simplification in this study belongs to almost accurate, meanwhile, the phoneme substitution and distortion belong to the variation of the least accurate. Simplification in this study includes vowel assimilation, devoicing and sonority substitution. For example, /titi/ ‘bridge' was realized as [tɪdɪ]. This phenomenon is shown in acoustic features by analyzing the target sound on the left and the realization sound on the right spectrogram of speech analyzer below.

almost accurate /titi/ least accurate [tidɪ]

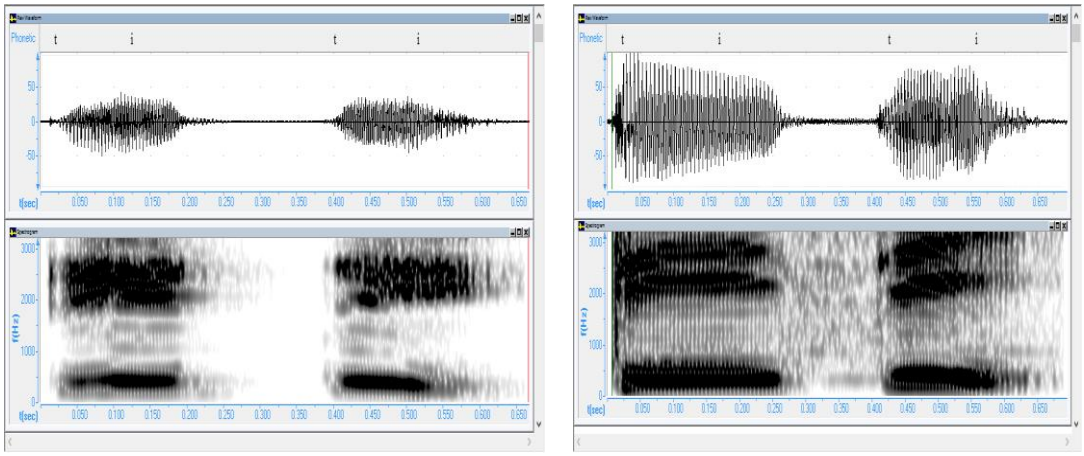

Figure 4. Graph Showing the Articulation of /i/ and /t/

The graph shows a significant difference between sound wave on the left and other one on the right. The formant value tells the condition of a specific place and manner of articulation. Briefly, the formant value for the shape of the lips (F3) on the left graph in articulating /i/ was lower than the value of F3 in the right graph. It means that the lips were not widely spread aside as normally. The right graph is much darker than the left, meaning that the informants had more stress, intensity, and prolongation on the first syllable. Silent wave for stop sound /t/ in ‘titi' in left graph and the right was slightly different. The right was bright and there was not any dark band below (F0). It means that this sound was /t/. However, the right graph had a darker silent wave which means that the larynx vibrated and the sound produced was /d/. The final /i/ for the word ‘titi', the formant value of F2 in the right graph was slightly raising and on the other hand, there was the decreasing formant value of F1 as an indicator of lack vowel /ɪ/. This can be seen from the formant value of F1 and F2 ranges between 300 Hz and 2500 Hz. It means the pharynx was narrow due to the lowering tongue. In Balinese, the lack vowel of /i/ is usually in the closed position in final. To

know the difference between the acoustic variations in the study, the graph showing the formant values of three informants in articulating vowels in sequences of word sounds is presented below.

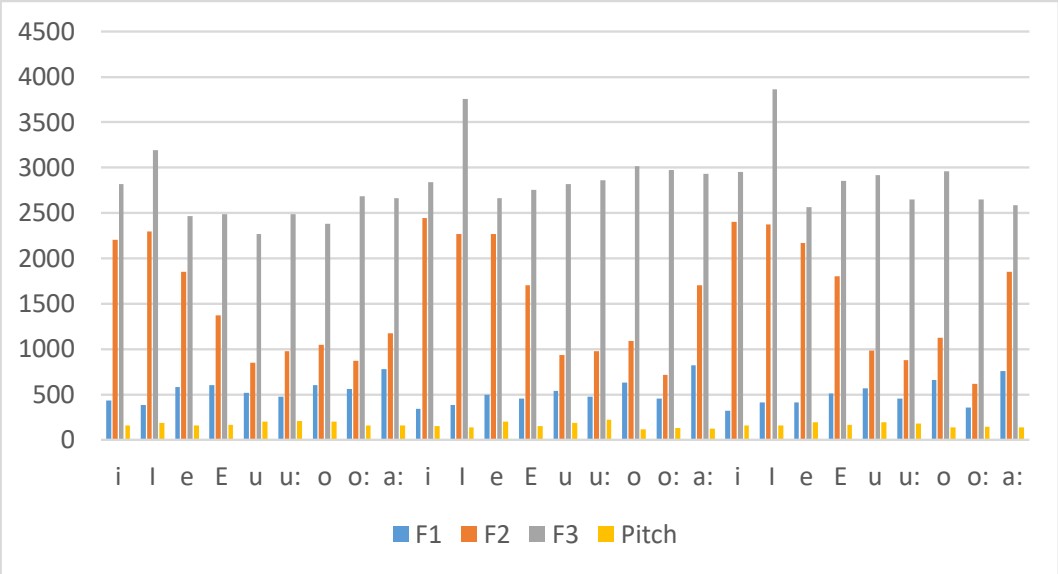

Figure 5. Formant values of Broca's aphasic in articulating vowels

3.2.2 Phonemic Errors

In the present study, some evidence were found that the Broca's aphasics also produced phonemic errors resulting from the lesion in the posterior. This may occur due to a disorder in phonetic processing, namely, planning and executing the articulatory programmes. The type of phonemic errors included substitution, assimilation and syllable structure. To know the phonological process of the speech error produced by Broca's aphasics, all contributions are presented below.

(1) Phoneme forwarding

There were pieces of evidence showing phoneme substitution by forwarding the features from + coronal into + anterior (from velar sound to alveolar sound or from alveolar sound to bilabial sound). A substitution based on phonological neighborhood density may also occur. Referring to sonority scale, phoneme forwarding may occur from trill sound to lateral sound. This finding is in the line with an investigation conducted by Bastiaanse, Gilbers & Linde (1994). Here is some evidence of one type of substitution.

Target	meaning	underlying form	realization	Notation
kasur	'mattress'	/kasur/	[satul]	/r/ —▶[l]
ngangah	'hurt'	/ŋaŋah/	[naŋah]	/ŋ/ —▶[n]
cicing	'dog'	/ciciŋ /	[seice]	/c/ —▶[s]

(2) Stop actualization

The term of stop actualization is a term of the phonological process in which fricative sounds are substituted by stop consonants. This process happened to any sounds that were produced by Broca's aphasia patients, such as /c/-[p], /s/-[b] dan /c/-[k]. Here is some evidence of substitution with stop actualization.

Target	meaning	underlying form	realization	Notation
cedok	'bucket'	/cedok/	[peye]	/c/ —▶[p]
selem	'black	/sələm/	[pənləm]	/s/ —▶[p]
cerike	'little'	/cərike/	[kəlike]	/c/ —▶[k]

(3) Nasal actualization

The term of nasal actualization refers to the substitution of a segment with nasal sounds. Different to nasalization, nasal actualization is a phonological process of substituting all segments into nasal. In this study, there was some evidence of this type of substitution as follows.

Target	meaning	underlying form	realization	Notation
entip	'rice'	/əntip/	[nitip]	/e/ → [n]
sumping	'cake'	/sumpiŋ/	[numpiŋ]	/s/ → [n]
lindung	'eel	/linduŋ/	[ninduŋ]	/l/ → [n]

(4) Trill substitution

The phonological process of substituting the trill sound into lateral is known as lateralization. This process refers to the substitution /r/ by [l]. Most of the informant of this study could not produce /r/ in the correct manner, therefore, based on the evidence, all /r/ were substituted by [l] in any position. Here is some evidence of trill substitution.

Target	meaning	underlying form	realization	Notation
rerama	'parent'	/rəramə/	[ləlamə]	/r/ → [l]
guru	'teacher'	/guru/	[kulu]	/r/ → [l]
murid	'student'	/murid/	[muhlib]	/r/ → [l]

(5) Assimilation

Assimilation is one type of phonological process in which a segment changes other segments by adapting the features of that segments. Assimilation occurs when one segment modifies the proceeding. For example, the target sound of /entip/ was pronounced by the informants as [empit]. The sound /t/ was substituted by [p] and modified /n/ into [m] because they have identic feature [+nasal, +anterior]. This can be stated that [+coronal] is substituted by [+anterior].

(6) Harmonization

Consonant harmonization occurs when a consonant assimilates another neighboring consonant, either by place of articulation or manner of articulation. Phoneme substitution by assimilation is associated with the strong influence of PND. For example, the voiceless velar at final changed the voiced velar in initial by taking the voicing feature. Here is some evidence of consonant harmonization.

Target	meaning	underlying form	realization	Notation
guak	'crow'	/guak/	[kuak]	/ g/ ↔ [k]
beteg	'swollen'	/bətəg/	[botek]	/t/↔ [k]
rebab	'violin'	/rəbab/	[papa]	/p/↔ [p]

(7) Syllable structure

Syllable structure is a term that refers to the omission of a segment in all distribution. This type of reduction can occur in initial, in the middle or at the end of a syllable. Broca aphasics tended to delete the initial phoneme because they suffer from anomia; difficulties of starting words. Here is some evidence of initial omission.

Target	meaning	underlying form	realization	Notation
bulu	'crow'	/bulu/	[uluh]	/b/ → Ø
tomat	'swollen'	/tomat/	[opat]	/t/ → Ø
kipas	'violin'	/kipas/	[ipas]	/k/ → Ø

(8) Consonant cluster reduction

Reducing one segment of a cluster is omitting one segment either the first or the second. The reduction can be related to the ability to blend one of the segment due to the impairment in phonetic level or phonemic level. Here are some evidence of a

consonant cluster reduction

Target	meaning	underlying form	realization	Notation
sambel	'sauce'	/sambəl/	[saməl]	/b/ →Ø

(9) Haplology

Haplology is a term of a phonological process that changes the sound target by omitting the consonant in middle position. In this study, it only omits the semivowel /w/ and /y/. Here are some evidence of haplology

Target	meaning	underlying form	realization	Notation
suwah	'comb'	/suwah/	[suoh]	/w/→Ø/ V-V
sayah	'starving'	/sayah/	[saah]	/y/→Ø /V-V

4. Discussion

Of the other three types of phonological errors, sound substitutions mostly appeared in all position. Based on generative phonology, sound segments may alter other segments, either with homorganic features or distinctive ones (Schane, 1992). The mental process of sound judgment occurs from underlying representation into a phonetic representation. We argue that different speech stimulation could trigger sound inconsistency for the same word. The sound [k] that starts the word 'kapak' in repetition task was substituted by lateral sound [l] resulted in a non-word [lapak]. However, the sound [k] both in initial and final was substituted by glottal fricative [h] as [hapah] in pictures naming task. Sound distortion in aphasia refers to errors caused by prolongation and devoicing. Distortion which is related to phonetic errors due to the lesion in anterior also indicated to occur when the second syllable was put forward before the target sounds were completed. The evidence of error pattern is listed below.

1) /V1-C1-V2-C2/ → /V2-C1-V2-C2
   [i]- [p]-[a]-[h] → [a]-[l]-[e]-[h]
2) V1-C1- V2 -C2 → C1-V2- C 1 V1 -C1-C1-V2-C2
   [a] - [l] - [u] -[h] → [l] -[u] [l] [a] -[l] -[l]- [u]- [h]
3) C1-V1-C2-V2 → C3-V2–V3 C1-V2 – C2-V –C3
   [b]- [a]- [t]- [ə] → [d]- [ə]- [e] [b]- [a] –[t]- [o]-[h]
4) C1-V1-C2-V2 → C2-V2-C3 C1 -V1-C2-V2-C3
   [b] -[a]-[t]-[u] → [t]-[u]-[h] [b] - [a]-[t]-[u]-[h]
5) C1-V1-C2-V2 → C1-V1-C2-V2 C2-V2
   [k]-[a]-[s]-[a] → [s]-[a]-[s]-[ə] [s]-[ə]

A high front vowel /i/ was altered into a low middle vowel [a] and in the second syllable, the vowel /a/ was substituted by [e]. These errors commonly occurred in aphasia speech production when semantic layer moved to lemma selection and finally to phonological encoding did not work properly due to a breakdown in phonetic implementation (Dell, et, al 1997). Alteration of syllable structures from a standard system was caused by a failure of the phonological processing to phonetic implementation. Lexical knowledge of KW, NS, and MD was packed in three layers of networks known as the semantic layer, word layer and phonological layer each of which is connected bidirectionally from semantic feature to phonological features. (Dell, 1997. Schwartz, et. al, 2006). Word naming was begun from encoding the orthography, to word concept, and to phonetic representation.

The phonological errors were related to a breakdown of phonetic processing (Bastiaanse, Gilbers & Linde, 1994). Based on the pieces of evidence, it can be stated that PND leads the selection of

target sound, one of which by substituting the closest level of the group features. Another finding related to PND is sonority. The pieces of evidence in substitution sonority occurred when one segment [+sonorant] was substituted by one level of another segment [+sonorant] in sonority scale. The word /linduŋ/ was realized as [ninduŋ], so /l/ was substituted by /n/. This evidence is considered as exception of sonority hierarchy that operates the segments from the least sonorant to the most sonorant. Thus, sonority is a structural, rather than an articulatory pattern in phonology. The implementation of segments in aphasia may change either into identical features or distinctive ones. Voiceless sound /k/ was altered by voiced sound /g/ or voiced sound /g/ was altered by voiceless [k] before high back vowel /u/. The word 'guru' was realized as [kulu] or 'guak' was pronounced [kuak]. Instead of voicing, segment alteration may be determined by place of articulation distinctive features; trill sound /r/in the word 'murid' was realized as [muhlid]. These errors were produced by informants because there was not any appropriate coordination between underlying form and phonetic representation due to the lesion in the anterior zone.

As hypothesized, the conclusion from this study is that that the phonemic representation was obscured by phonetic processing of speech output produced by patients with Broca's aphasia under investigation. This study relays some evidence that patients with Broca's aphasia tend to substitute, omit, insert and mutate the phonemes as part of phonemic errors. In other hand, distortion which refers to prolongations and devoicing belongs to phonetic errors. However, previous studies claim that these two terms do not belong to distortion types of errors. In fact, all substitution occur due to the complexity of articulation. The more complex the sound is, the more possibility the sound is substituted, especially by a more sonorant segment. Based on the fact that the substitution of one segment is influenced by neighboring segment in the features groups of sonority scale. Those phonological error types are not only based on the features of sonority hierarchy but also partial role of PND. PND leads the substitution of the target sound by using the closest level of the features group and features environment.

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Notes:

1. Mostly, the patients with Broca’s aphasia produced non-fluent speech output by repeating initial or final syllables, forwarding the second syllable or substituting the target sounds based on hierarchy sonority scale.
2. The sounds with marked features are mostly substituted by the markedness features and this leads to the fact that there are more phonemic errors than the phonetic ones in speech production without comprehension problems.
3. Bastiaanse, Gilbers & Linde, (1994) propose the rank of sonority from the least sonorant [obstruent] to the most sonorant [vowel] but in this study, the substitution was constructed by the patients in reverse ordering or within the group’s features rank.

Appendix A

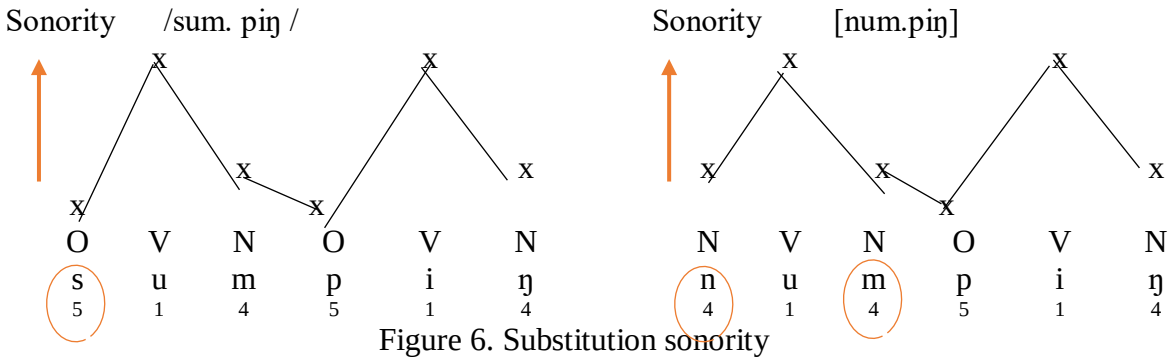

Figure 6. Substitution sonority

Appendix B

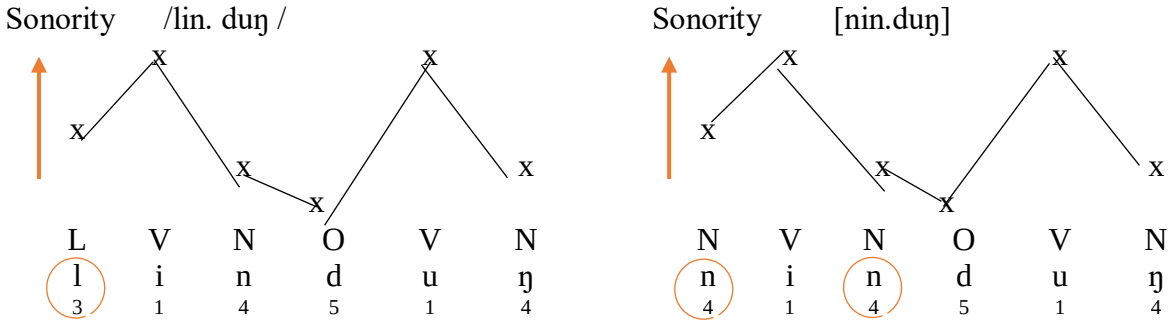

Figure 7. Reverse ordering sonority

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Phonological Errors on Impaired Language ModalityProduced by Individuals with Broca's Aphasia

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Abstract

Nearly all of Broca's aphasic patients have the tendency to produce phonological errors in their non-fluent speech output. The grade of errors may vary depending on the severity of brain pathology, affected language area, and the scope of impaired sounds. Any types of the phonological process might be found in their weakening language modalities. So, the present study investigates the severity of the aphasics' language modality, phonemic and phonetic errors of the impaired speech. This descriptive study analyzes Balinese speech produced by three individuals who suffer from Broca's aphasia. To find out, they were requested to repeat words, name pictures, answer questions and read short text orally. As the result, their language modalities were categorized severe. The listeners required some hard efforts to conclude, question and predict what the informants said and further communication was impossible on more complex words. They produce not only distortions as phonetic errors but also substitutions, deletions, insertions, and metatheses as phonemic errors. Sound

substitutions mostly appeared in a greater percentage for every phonological task given. By analyzing the errors with generative phonology, the findings suggest that the PND can lead a better phonetic realization, one of which is by substituting the target sounds in terms of their phonological features similarity. Though phonemic processing is more common in fluent aphasia, non-fluent aphasics also produced sonority substitutions. Furthermore, there was not synchronous coordination between the underlying form in the posterior region and phonetic representation in the anterior region due to the loss of the linguistic message.

Keywords: Non-fluent aphasia, Phonological errors, Sonority, Neurolinguistics

1. Introduction

Language function is one of the most prominent components in behavioral neurology becausethe most specific feature of human beings is their ability to express notion, information, and emotion through speech and language. A language disorder can happen to anybody especiallyadults if there is a lesion in the left hemisphere of the brain caused by traumatic brain injury (TBI) or any kinds of a cerebral vascular accident (CVA). Stroke can cause so many changes in human behavior components, one of which is considered as language disorder or aphasia. Den Ouden (2011.p.321) states that aphasia is an acquired impairment of language in adult, resulting from focal brain damage. Lesion in the posterior area can trigger impairment in phonemic level and the lesion in the anterior area can contribute the phonetic disorder(Gandour, 1998). However, both can cause individuals to suffer from a non-fluent aphasia with the diagnostic syndrome of slight mutism, phonological anomia, repetition, reading, and writing (Benson, 1979). Previous research findings have contributed empirical pieces of evidence about additional types of phonemic or phonetic disorder produced by Broca'saphasic patients. However, the notion of disorder either at the phonetic level, which may influence phonological processing or at the phonemic level, which may influence phonetic processing, remains to be explored.

Therefore, this study tries to find out the shreds of evidence of phonemic and phonetic disorders in Balinese speech output spoken by three individuals with Broca's aphasia. Phonological investigation on the aphasics' speech output has been very few in Bali, however,the number of stroke patients are increasing gradually. After the stroke, they used body language to communicate due to the difficulties of expressing ideas or responding simple orders. They can say two or three words bit clearly but other words seem to be very hard to express. An example of this phenomenon is when one of them wants to ask 'do you have any money?' and the target sounds are: //*sube ngelah pipis*// but it is realized as [bə…lah pieh]. This phonological phenomenon is very challenging to be further investigated by applying the theory of generative phonology and the description of a neurolinguistic side of view. By identifying the phonological errors either at the phonemic level or at the phonetic level, the evidence of aphasics' decreasing language modality can be used as feedback not only for scientific purposes but also for further rehabilitation treatments. In fact, this study might find a description of the impaired sound that differs from any other findings.

In spite of the fact that those three informants are able to pronounce vowel sounds of /a/, /i/,

/u/, /e/ and /o/ and other consonant sounds of /p/. /t/, /k/, /b, /d/, /g/ etc. independently, they can not sequence the sounds functionally into correct syllable structures. When the segment is combined together to form morphemes and from the morphemes into syllables, the segments influence one another by assimilating, substituting, deleting or adding other segments. Based on initial observation of their speech output a couple of weeks after stroke, each individual had different speech output for the same words or for the same pictures. One could say a written word but could not name a picture of the word he mentioned and the other one could not mention both of them correctly. The target sound of /kipas/ 'a fan' was realized by threeof them as [ipas], [apah], and [ipat]. One thing can be observed here is they had difficulties instarting words that are commonly known as phonological anomia; one syndrome of Broca's

aphasia. They had a strong spirit to say things to keep up the conversation but they oftenmade phonological errors of each word given.

In the line of the example given above, the speech of Broca's patients is mainly composed of one and two-word utterances, mostly content words known as telegraphic speech (Cera & Ortiz, 2010). Many of Broca's aphasics produce phonemic errors in speech production but comprehension is relatively intact (Bastiaanse, Gilbers & Linde, 1994). The phonemics errorsoccur due to disorders in phonetic processing that involves planning and executing articulatory programs. Phonological errors across diagnostic categories of Broca's aphasia refer to inaccurate phonetic articulation and inappropriate concepts of phonemes. Empirical studies claim that the impaired sounds are dominated by substitution of a target sound withthe sound that has neighboring features. In this case, a Balinese Broca's aphasic, KW has phonological errors in saying /juju/ 'a crab' and it is realized as [juluh]. He can not say /j/ in the second syllable and tend to substitute the phoneme with /l/ because it belongs to the same group of similar features called *Phonological neighborhood density* (PND). Munson & Solomon (2004) define PND as the number of words that differ from a target word by a singlephoneme. This is well known as sonority substitutions, the errors in which one segment is replaced by another that differs only one step on the sonority scale (Bastiaanse, Gilbers & Linde, 1994).

The scientific investigation of phonological errors on speech output produced by Brocas's aphasics may not be partially approached by only linguistics side of view but it must be also slightly viewed from neurolinguistics points of description (Bambini, 2012, Kemmerer, 2014).Neurolinguistics covers three interrelated domains namely thought, brain and language (Fromkin dan Rodman, 1989). According to Bambini, (2012), the theory of neurology explores parts and brain structure and mechanism of the brain functions, meanwhile linguistic theory explores how structure and language system functions. The goal is to comprehend how the cognitive capacity for language is controlled by biological tissues of the brain (Kemmerer, 2014, Bambini, 2012). So this study describes the relationship between phonological errors of non-fluent speech output produced by Broca's aphasics and the underlying lesion in phonological aspects of the brain.

To lead the phenomenon to the analysis, this present study investigates the forms and sound structures of speech produced by Balinese Broca's aphasics and categorizes the severity of their language modality. All the phonemic and phonetic processing can show how the phenomenon of phonological error can appear. Thus the study is conducted to investigate the forms and structures of the phonological errors and types of phonological processing of speech output of Broca's aphasics. All the error cases will be classified and categorized into types of errors. To analyze the phenomenon, the theories applied are generative phonology and neurolinguistics.

Concerning literature cited in this paper, it has been proposed that the phonetic errors are tightly related to non-fluent aphasia. Phonetic disintegration, an articulatory failure to realize sounds with the correct precision, would be characteristic for the speech of non-fluent aphasia(e.g., Lesser, 1995). There is a great dichotomy between phonemic disintegration for fluent

aphasia and phonetic disintegration for non-fluent aphasia, however, there is some degree from both disintegrations. Blumstein (1973) has investigated aphasic speech and has found evidence of many phonological patterns of that. Blumstein reports in the three other studies, the number of substitutions lays a lot higher than the amount of substitution in fluent aphasia. Related to phonetic disintegration, the studies of phonological errors have been ever conducted by using software speech analyzer or PRAAT (Adam, 2014, Marotta, Barbera, & Bongioanni, 2008). This property can explain sound system phenomenon, especially phonation, frequency duration, and intonation produced by aphasics. Studies in phonetics andphonology on aphasia have been exposed by Buckingham & Chrisman (2008), Gordon & Ledoux (2008), and Gandour (1998).

In line with substitution sonority, the notion of sonority provides a definition of the syllable. According to the Sonority Sequencing Principle (SSP) (Romani & Calabrese, 1998), a syllable is a string of sounds organized in such a way that sonority rises from the beginning toa peak and then falls (vowels always correspond to syllabic peaks since they have the highest sonority value) (Coda, & Ball, 1994). For example, in Balinese the word ‘pripit’ meaning ‘stingy’ is sequenced by /p/ to /r/ and from /r/ to /i/ and drops. It is not legal syllable if the sequence of sounds is constructed /r p i pit/, because there is a drop in sonority between the beginning of the syllable and the peak. The substitution sonority can happen to the word ‘pripit’ which is realized as [pli..pit].

Therefore, the theory of generative phonology is considered appropriate to analyze the phenomenon of substitution, omission, distortion, reduplications, and metatheses. Schane (1992) elaborates that generative phonology is a mechanism of any mental sounds processthat occurs in every language. A phonological process is the alteration or changes of segments in sequences of morphemes that are neighboring and combined to form words. Sound changes can also occur outside of its clustering environment, i.e. in initial, middle and final distribution, or between vowels in which the second one is stressed. Sounds change into four phonological processes, including assimilation, syllable structure, weakening and strengthening, and neutralization. Phonological disorder in Broca's aphasia may becommonly related to the semantic disorder, especially the difficulty of naming and repeating words or sentences. In the line with phonological processing, Gandour, (1998.p.209) states that generative phonology organizes features in a hierarchical tree structure. The majority of phoneme substitution errors manifest feature changes within a single tier rather than across tiers (Blumstein, 1990).

The theory claims that the smallest sound units are not known as phonemes but their distinctive features. The phonological process, according to Schane, (1992) consists of three stages, lexical representation, phonological representation, and phonetical representation.There are three components which are used as fundamental analysis in generative phonology;

(1) underlying representation (UR) is known as mental or basic representation using the notation of / /, (2) phonological rules /and (3) phonetic representation (PR) using the notation of [ ]. It is al structured in the brain. In general, neurolinguistics is concerned withthe relationship between language and the brain (Bambini, 2012). Its final goal is the comprehension and explanation of the neural bases for language knowledge and use

(Gandour, 1998). Neurolinguistics is by its nature an interdisciplinary enterprise and straddlesthe borders between linguistics and other disciplines that are connected to the study of the mind/brain (Bambini, 2012). From the perspective of the neurosciences, neurolinguistics focuses on how the brain behaves in language processes, both in healthy and pathological conditions; conversely, from a linguistics standpoint, neurolinguistics aims at clarifying how language structures can be instantiated in the brain

Based on the description of the phenomenon, related reviews, and theory above, we hypothesized that 1) the phonemic representation may be obscured by phonetic processing of speech output produced by patients with Broca's aphasia and 2) PND may lead the selection of target sound, one of which by substituting the closest level of the features group.

2. Method

Badung Regional Hospital in Bali had 36 patients with stroke and after the language disorder test, this study involved 3 patients, KW, NS and MD who were positively suffering from Broca's aphasia and the rest of the patients were diagnosed dysarthria. From each patient, oneor more audio tapes were available containing spontaneous speech. The tests were in the formof four phonological tasks, namely words naming, pictures naming, answering questions and oral reading. Each task had 65 words or pictures that mainly represented consonants and vowels in different distributions. The recorded data were then phonetically and phonemically described and classified into phonological errors. The number of errors is then calculated to determine the sound severity on four different language modality. To ensure the errors of consonant and vowels sound, the doubtful interpretations were double checked by using a software program, that is speech analyzer. All alterations were analyzed by using generative phonology to know the phonological process of speech output, such as substitutions, omissions, insertions, reduplications, and metatheses. Aphasia Severity Rating Scale of Boston test is used to measure the language modality of the informant that ranges from ascale of 1 to 5 with specific criteria. All total correct and incorrect sounds were calculated to find out the percentage of the deficit. After severity level was found, the numbers of types of errors were definitely measured to know what errors were more and less dominant. All quantitative data are presented in tables and figures.

3.Results

Benson (1979) lists the syndrome of ***Broca's aphasia as that of impairment of spontaneous speech, repetition, naming, and writing. Thus, to measure the language modality, all participants were given phonological tasks that is an act of asking them to name listed words, naming pictures, answering some short questions and reading a short reading passage. Each constructed task consisted of words which may enable the researcher to obtain knowledge of phonological errors.***

3.1 Severity of Language Modality

KW, NS, and MD were shown 65 words, 65 pictures, 65 words in spontaneous speech and 65words in the reading text. The speech was then recorded and tabulated. Each word was then phonetically and phonemically transcribed and then classified into 4 different phonological errors, namely phonemes distortion, substitution, addition, and omission. All data were then observed comprehensively both to find linguistic phenomenon and underlying pathology in his language area. The data were counted to determine the percentage of correct, incorrect sound and sound severity. To know each participant's ability in performing the task, only one data out of 65 words are listed for each task presented here.

Table 1. Representation of speech output of Broca's aphasics

KW	*Target*			*realization*	*errors*
Word naming	*roko*	'cigarette'	/roko/ →	[lokoh]	substitution
Picture Naming		'fan'	/kipas/ →	[ipas]	omission
Spontaneous answer 'Where does your wife work?'	*petani*	'a farmer'	/pətani/	[penadi]	metatheses
Oral reading	*Ada katuturan satua I Siap Selem*	Once upon a time, lived a black hen	/adə → katuturan satuə i siap → sələm	[Sade..adə katuturan.cu pulia..pula.. eyap ketem]	Addition, distortion, omission, substitution
NS					
Word repetition	*pianak*	'children'	/pianak/	[pilanak]	insertion
Picture naming		'a hen'	/siap/ →	[ipas]	metatheses
Spontaneous answer 'Have you got any rice?'	*Tyang suba ngelah bas*	'I have you got some rice/	→ /Suba ŋelah bas/ →	[..be….lah bans]	omission insertion
Oral reading	*Ada katuturan satua I Siap Selem ngelah*	Once upon a time, lived a black hen	/adə katuturan satuə i siap → sələm	[...adə ka..tut..turan sa..sahua..i seyap elem,.	Submission omission
MD					
Word repetition	*Emas*	'gold'	/ əmas/	[əmah]	substitution
Picture Naming		'a comb'	/suwah/ →	[hu..iah]	substitution
Spontaneous answer 'Would you like coffee or tea?'	*'Tyang minum kopi'*	'I drink coffe	→ /tiakopi/ →	[ko..pik]	addition

Oral reading	*Ada katuturan satua I Siap Selem ngelah*	Once upon a time, lived a black hen	/adə→ katuturan satuə i siap sələm/	[...ahdə..tura n sa..cahua… se……yap elem,..	omission substitution distortion addition

Based on the data above, phonological errors in every speech output of KW, NS, and MD indicated their decreasing language modality. It can be seen from the errors they made in words naming, pictures naming, answering short question and reading. It was clear that they tended to prolong the stress in the first vowel of the first syllable, in contrary Balinese words, are usually stressed in final syllable. There were a lot of silence and murmuring sound. Every participant had different speech output even though they had the same task to do and thesame syndrome of aphasia they suffer from. It can be observed here that different stimulation triggered different speech output even though the target is the same. The informants' language modality is summarized as follows.

Table 2. Distribution of Broca's aphasics on phonological task

Informants	Phonological Task	Total Correct (n=65)	% correct	Phonemic errors/ Total errors	% errors = phonology	Level of severity
KW	Word naming	21	0.32	35/44	0.80	severe
	Picture Naming	25	0.40	37/40	0.92	severe
	Question	19	0.29	40/46	0.87	severe
	Oral reading	22	0.34	38/43	0.89	mild
	Total	87	1.35	150/173	3.48	severe
NS	Word naming	19	0.29	80/46	1.74	severe
	Picture Naming	27	0.41	30/38	0.78	mild
	Question	15	0.23	26/50	0.52	mild
	Oral reading	13	0.20	42/52	0.83	severe
	Total	45	1.13	178/186	3.87	severe
MD	Word naming	10	0.15	90/55	1.64	severe
	Picture Naming	15	0.23	60/50	1.20	severe
	Answering	12	0.18	30/53	0.57	mild
	Oral reading	8	0.12	52/57	0.91	severe
	Total	45	0.68	232/215	4.32	severe

Referring to the criteria of 5 of Aphasia Severity Rating Scale of Boston test, KW had 1.35% correct sound and 3.48% incorrect sound in which the errors are mainly dominated byphoneme substitution. NS had 1.13% correct sound and 3.87% incorrect sound that consisted of errors of substitution. MD was considered weak in expressing verbal language. He achieved 0.68% correct sound and 4.32% incorrect sound due to the number of substitution was quite high that is 4.32%. Based on Aphasia Severity Rating Scale of Boston test, KW's, NS's and MD's speech performances were categorized severe. They could not perform fluentverbal expression, i.e. double repetition of the first syllable. It was required some hard effort for the listener to conclude, question and predict what he was trying to be said. They showed

limited information range and communication burden was on the listener's side. They had difficulties in repeating words and articulating sounds. Rating showing decreasing language modality is presented below.

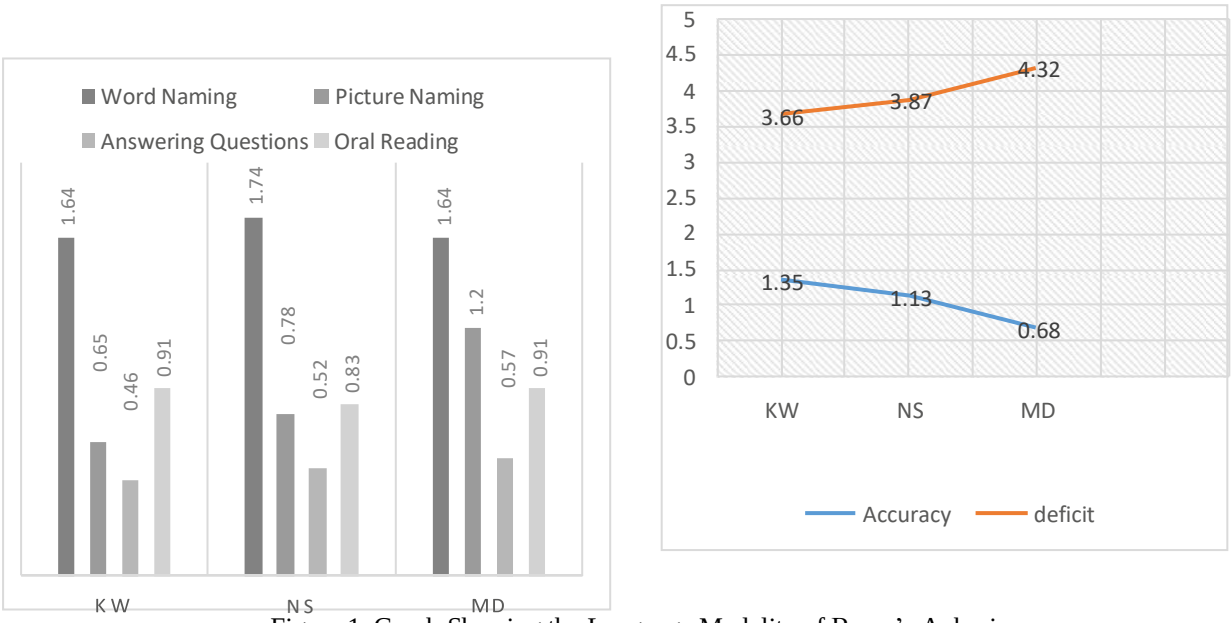

Figure 1. Graph Showing the Language Modality of Broca's Aphasic

From the graphic above, it can be kept in mind that the language modality of the informants was gradually decreasing after the stroke. KW had problems in pronouncing vowel and consonants sound at the beginning of words and so did NS and MD. One of the aphasics' syndrome is called anomia which means the difficulty of starting words. All informants tended to substitute the phonemes with the closest features with the target. To know the real phenomenon of phonological errors of the words mentioned by the informants, here is the list of distribution of Broca's aphasic errors.

Table 3. Distribution of Broca's aphasic errors

Broca's	KW	NS	MD
Phoneme substitution	65%	68%	71%
Distortion	20%	20%	18%
Omission	5%	11%	10%
addition	10%	1%	1%

Compared to the previous findings, Blumstein (1973) reports in the three other studies the amount of substitutions lays a lot higher with 61.5% being the lowest percentage. In this study, there was a different amount of phoneme substitution which was the dominant error type. KW made 65% substitution in his words, NS produced 68% substitution in his words and MD had the highest substitution error type. This type was then followed by other rank order of the error types: distortion, omission, and addition. Ferreres (1990) showed a somewhat similar distribution of error types for Spanish speaking people with Broca"s aphasia. Substitutions were the error type most often made (59%), followed by omissions (29%), then insertions (10%) and at last metathesis (2%). So these findings show that the

amount of phoneme substitution which was the dominant error type compared to the previousstudy. Rating showing phonological error produced by KW, NS and MD and acoustic features of vowels can be seen in the following figure

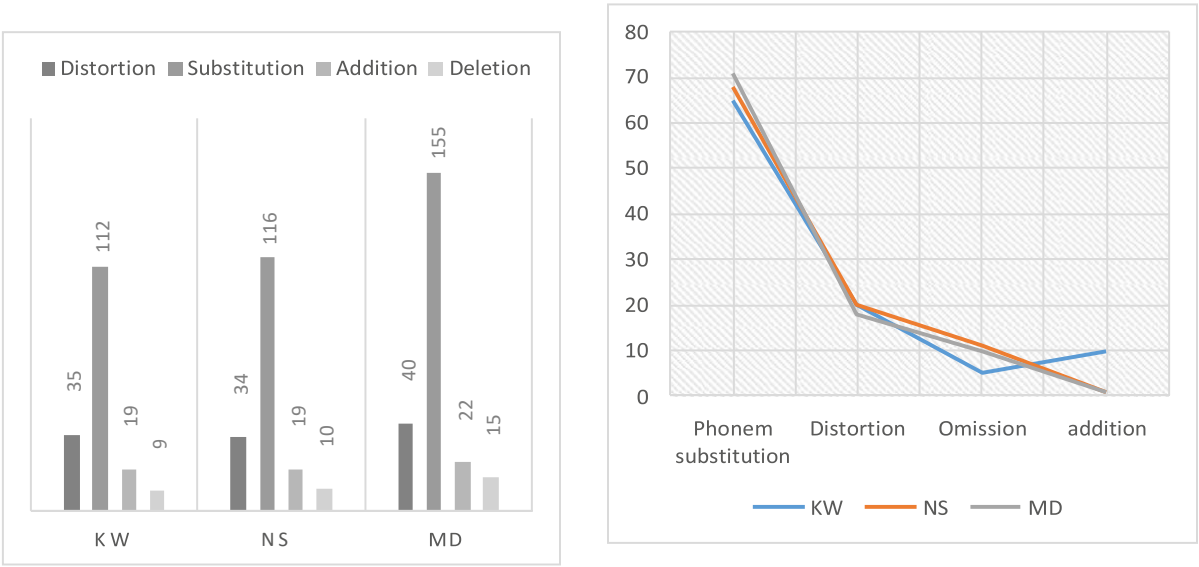

Figure 2. Rating Showing Phonological Error Produced by KW, NS, and MD

Phonological errors produced by KW, NS and MD covered two domains; phonetics errors, and phonemic errors. Phonetic errors are related to an inaccuracy of individual sound articulation, either place of articulation or manner of articulation. The phonetic errors can be recognized from formant value and physiology of speech sounds. Meanwhile, the later ones were related to neighboring sounds rules, in which a sound segment in a word can undergo a phonological process due to the characteristic or distinctive features and position in identical or contrast environment (Schane, 1992).

3.2 Phonological Errors

Phonological errors that were produced by informants listed above are mainly attributed to a breakdown in phonological processing, that is, in transforming the underspecified lexical phonological form into a phonemic representation. Gandour, (1998) states that the deficit at the phonological level due to posterior lesions are discussed in relation to phonological features, markedness, syllable structure, and sonority. Meanwhile, the segmental deficits atthe phonetic level due to anterior lesions are discussed in terms of parameters of vowel and consonants, segmental coarticulation and speaking rate effects. A phonological process canbe explained as an articulatory phenomenon or conceptual (Schane, 1992). In this study, the phonological errors produced by Broca's aphasics are discussed in two levels; phonetic level and phonemic level.

3.2.1 Phonetic Errors

There are two types of phonetic variation in this study: 1) almost accurate and 2) least accurate. The sounds simplification in this study belongs to almost accurate, meanwhile, the phoneme substitution and distortion belong to the variation of the least accurate.

Simplification in this study includes vowel assimilation, devoicing and sonority substitution. For example, /titi/ ‘bridge' was realized as [tIdI]. This phenomenon is shown in acoustic features by analyzing the target sound on the left and the realization sound on the right spectrogram of speech analyzer below.

almost accurate /titi/ least accurate [tidɪ]

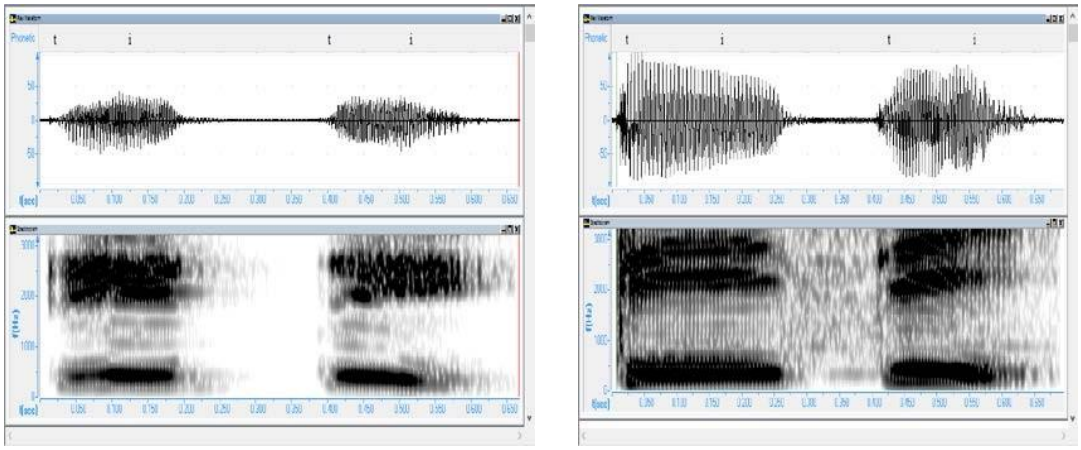

Figure 4. Graph Showing the Articulation of /i/ and /t/

The graph shows a significant difference between sound wave on the left and other one on theright. The formant value tells the condition of a specific place and manner of articulation. Briefly, the formant value for the shape of the lips (F3) on the left graph in articulating /i/ waslower than the value of F3 in the right graph. It means that the lips were not widely spread aside as normally. The right graph is much darker than the left, meaning that the informants had more stress, intensity, and prolongation on the first syllable. Silent wave for stop sound

/t/ in ‘titi' in left graph and the right was slightly different. The right was bright and there was not any dark band below (F0). It means that this sound was /t/. However, the right graph hada darker silent wave which means that the larynx vibrated and the sound produced was /d/. The final /i/ for the word ‘titi', the formant value of F2 in the right graph was slightly raising and on the other hand, there was the decreasing formant value of F1 as an indicator of lack vowel /ɪ/. This can be seen from the formant value of F1 and F2 ranges between 300 Hz and 2500 Hz. It means the pharynx was narrow due to the lowering tongue. In Balinese, the lack vowel of /i/ is usually in the closed position in final. To know the difference between the acoustic variations in the study, the graph showing the formant values of three informants in articulating vowels in sequences of word sounds is presented below.

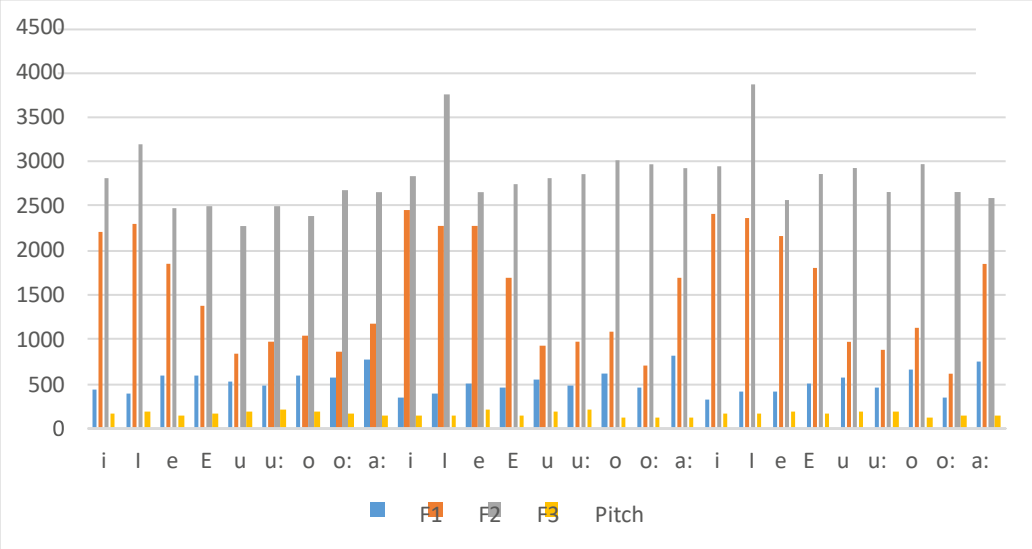

Figure 5. Formant values of Broca's aphasic in articulating vowels

3.2.2 Phonemic Errors

In the present study, some evidence were found that the Broca's aphasics also produced phonemic errors resulting from the lesion in the posterior. This may occur due to a disorder inphonetic processing, namely, planning and executing the articulatory programmes. The type of phonemic errors included substitution, assimilation and syllable structure. To know the phonological process of the speech error produced by Broca's aphasics, all contributions are presented below.

(1) Phoneme forwarding

There were pieces of evidence showing phoneme substitution by forwarding thefeatures from + coronal into + anterior (from velar sound to alveolar sound or from alveolar sound to bilabial sound). A substitution based on phonological neighborhood density may also occur. Referring to sonority scale, phoneme forwarding may occur from trill sound to lateral sound. This finding is in the line with an investigation conducted by Bastiaanse, Gilbers & Linde (1994). Here is some evidence of one type of substitution.

Target	meaning	underlying form	realization	Notation
kasur	'mattress'	/kasur/	[satul]	/r/ [l]
ngangah	'hurt'	/ŋaŋah/	[naŋah]	/ŋ/→ [n]
cicing	'dog'	/ciciŋ /	[seice]	/c/→ [s]

(2) Stop actualization

The term of stop actualization is a term of the phonological process in which fricative sounds are substituted by stop consonants. This process happened to any sounds that were produced by Broca's aphasia patients, such as /c/-[p], /s/-[b] dan /c/-[k]. Here is some evidence of substitution with stop actualization.

Target	meaning	underlying form	realization	Notation

cedok	'bucket'	/cedok/	[peye]	/c/⟶ [p]
selem	'black	/sələm/	[pənləm]	/s/⟶ [p]
cerike	'little'	/cərike/	[kəlike]	/c/⟶ [k]

(3) Nasal actualization

The term of nasal actualization refers to the substitution of a segment with nasal sounds. Different to nasalization, nasal actualization is a phonological process of substituting all segments into nasal. In this study, there was some evidence of this typeof substitution as follows.

Target	meaning	underlying form	realization	Notation
entip	'rice'	/əntip/	[nitip]	/e/ [n]
sumping	'cake'	/sumpiŋ/	[numpiŋ]	/s/⟶ [n]
lindung	'eel	/linduŋ/	[ninduŋ]	/l/⟶ [n]

(4) Trill substitution

The phonological process of substituting the trill sound into lateral is known aslateralization. This process refers to the substitution /r/ by [l]. Most of the informantof this study could not produce /r/ in the correct manner, therefore, based on the evidence, all /r/ were substituted by [l] in any position. Here is some evidence of trill substitution.

Target	meaning	underlying form	realization	Notation
rerama	'parent'	/rəramə/	[ləlamə]	/r/ [l]
guru	'teacher'	/guru/	[kulu]	/r/⟶ [l]
murid	'student'	/murid/	[muhlib]	/r/⟶ [l]

(5) Assimilation

Assimilation is one type of phonological process in which a segment changes other segments by adapting the features of that segments. Assimilation occurs when one segment modifies the proceeding. For example, the target sound of /entip/ was pronounced by the informants as [empit]. The sound /t/ was substituted by [p] and modified /n/ into [m] because they have identic feature [+nasal, +anterior]. This canbe stated that [+coronal] is substituted by [+anterior].

(6) Harmonization

Consonant harmonization occurs when a consonant assimilates another neighboring consonant, either by place of articulation or manner of articulation. Phoneme substitution by assimilation is associated with the strong influence of PND. Forexample, the voiceless velar at final changed the voiced velar in initial by taking the voicing feature. Here is some evidence of consonant harmonization.

Target	meaning	underlying form	realization	Notation
guak	'crow'	/guak/	[kuak]	/ g/ ↔ [k]
beteg	'swollen'	/bətəg/	[botek]	/t/↔ [k]
rebab	'violin'	/rəbab/	[papa]	/p/↔ [p]

(7) Syllable structure

Syllable structure is a term that refers to the omission of a segment in all distribution. This type of reduction can occur in initial, in the middle or at the end of a syllable.

Broca aphasics tended to delete the initial phoneme because they suffer from anomia; difficulties of starting words. Here is some evidence of initial omission.

Target	meaning	underlying form	realization	Notation
bulu	'crow'	/bulu/	[uluh]	/b/ → Ø
tomat	'swollen'	/tomat/	[opat]	/t/ → Ø
kipas	'violin'	/kipas/	[ipas]	/k/ → Ø

(8) Consonant cluster reduction

Reducing one segment of a cluster is omitting one segment either the first or the second. The reduction can be related to the ability to blend one of the segment due to the impairment in phonetic level or phonemic level. Here are some evidence of a consonant cluster reduction

Target	meaning	underlying form	realization	Notation
sambel	'sauce'	/sambəl/	[saməl]	/b/ → Ø

(9) Haplology

Haplology is a term of a phonological process that changes the sound target byomitting the consonant in middle position. In this study, it only omits the semivowel

/w/ and /y/. Here are some evidence of haplology

Target	meaning	underlying form	realization	Notation
suwah	'comb'	/suwah/	[suoh]	/w/ → Ø/ V-V
sayah	'starving'	/sayah/	[saah]	/y/ → Ø /V-V

4. Discussion

Of the other three types of phonological errors, sound substitutions mostly appeared in all position. Based on generative phonology, sound segments may alter other segments, either with homorganic features or distinctive ones (Schane, 1992). The mental process of sound judgment occurs from underlying representation into a phonetic representation. We argue thatdifferent speech stimulation could trigger sound inconsistency for the same word. The sound

[k] that starts the word 'kapak' in repetition task was substituted by lateral sound [l] resultedin a non-word [lapak]. However, the sound [k] both in initial and final was substituted by glottal fricative [h] as [hapah] in pictures naming task. Sound distortion in aphasia refers to errors caused by prolongation and devoicing. Distortion which is related to phonetic errors due to the lesion in anterior also indicated to occur when the second syllable was put forward before the target sounds were completed. The evidence of error pattern is listed below.

1) /V1-C1-V2-C2/ → /V2-C1-V2-C2

[i]- [p]-[a]-[h] → [a]-[l]-[e]-[h]

2) V1-C1- V2 -C2 → C1-V2- C 1 → V1 -C1-C1-V2-C2

[a] - [l] - [u] -[h] → [l] -[u] [l] → [a] -[l] -[l]- [u]- [h]

3) C1-V1-C2-V2 → C3-V2–V3 → C1-V2 – C2-V –C3

[b]- [a]- [t]- [ə] → [d]- [ə]- [e] → [b]- [a] –[t]- [o]-[h]

4) C1-V1-C2-V2 → C2-V2-C3 → C1 -V1-C2-V2-C3

	[b] -[a]-[t]-[u] ⟶	[t]-[u]-[h]	[b] - [a]-[t]-[u]-[h]
5)	C1-V1-C2-V2 ⟶	C1-V1-C2-V2	C2-V2
	[k]-[a]-[s]-[a] ⟶	[s]-[a]-[s]-[ə]	[s]-[ə]

A high front vowel /i/ was altered into a low middle vowel [a] and in the second syllable, the vowel /a/ was substituted by [e]. These errors commonly occurred in aphasia speech production when semantic layer moved to lemma selection and finally to phonological encoding did not work properly due to a breakdown in phonetic implementation (Dell, et, al 1997). Alteration of syllable structures from a standard system was caused by a failure of the phonological processing to phonetic implementation. Lexical knowledge of KW, NS, andMD was packed in three layers of networks known as the semantic layer, word layer and phonological layer each of which is connected bidirectionally from semantic feature tophonological features. (Dell, 1997. Schwartz, et. al, 2006). Word naming was begun from encoding the orthography, to word concept, and to phonetic representation.

The phonological errors were related to a breakdown of phonetic processing (Bastiaanse, Gilbers & Linde, 1994). Based on the pieces of evidence, it can be stated that PND leads the selection of target sound, one of which by substituting the closest level of the group features. Another finding related to PND is sonority. The pieces of evidence in substitution sonority occurred when one segment [+sonorant] was substituted by one level of another segment [+sonorant] in sonority scale. The word /linduŋ/ was realized as [ninduŋ], so /l/ was substituted by /n/. This evidence is considered as exception of sonority hierarchy that operates the segments from the least sonorant to the most sonorant. Thus, sonority is a structural, rather than an articulatory pattern in phonology. The implementation of segmentsin aphasia may change either into identical features or distinctive ones. Voiceless sound /k/ was altered by voiced sound /g/ or voiced sound /g/ was altered by voiceless [k] before high back vowel /u/. The word ‘guru’ was realized as [kulu] or ‘guak’ was pronounced [kuak]. Instead of voicing, segment alteration may be determined by place of articulation distinctive features; trill sound /r/in the word ‘murid' was realized as [muhlid]. These errors were produced by informants because there was not any appropriate coordination between underlying form and phonetic representation due to the lesion in the anterior zone.

As hypothesized, the conclusion from this study is that that the **phonemic representationwas obscured by phonetic processing of speech output produced by patients with Broca’s aphasia** under investigation. This study relays some evidence that patients with Broca's aphasia tend to substitute, omit, insert and mutate the phonemes as part of phonemic errors. In other hand, distortion which refers to prolongations and devoicing belongs to phonetic errors. However, previous studies claim that these two terms do not belong to distortion types of errors. In fact, all substitution occur due to the complexity of articulation. The more complex the sound is, the more possibility the sound is substituted, especially by a more sonorant segment. Based on the fact that the substitution of one segment is influenced byneighboring segment in the features groups of sonority scale. Those phonological error types are not only based on the features of sonority hierarchy but also partial role of PND. PND

leads the substitution of the target sound by using the closest level of the features group and features environment.

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Notes

1. Mostly, the patients with Broca's aphasia produced non-fluent speech output by repeating initial or final syllables, forwarding the second syllable or substituting the target sounds based on hierarchy sonority scale.
2. The sounds with marked features are mostly substituted by the markedness features and this leads to the fact that there are more phonemic errors than the phonetic ones in speech production without comprehension problems.
3. Bastiaanse, Gilbers & Linde, (1994) propose the rank of sonority from the least sonorant [obstruent] to the most sonorant [vowel] but in this study, the substitution was constructed by the patients in reverse ordering or within the group's features rank.

Appendix A

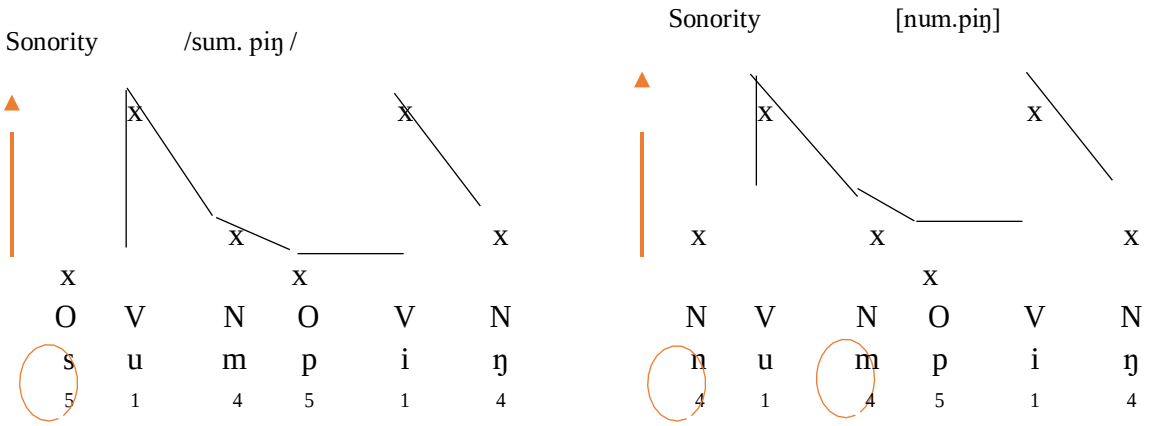
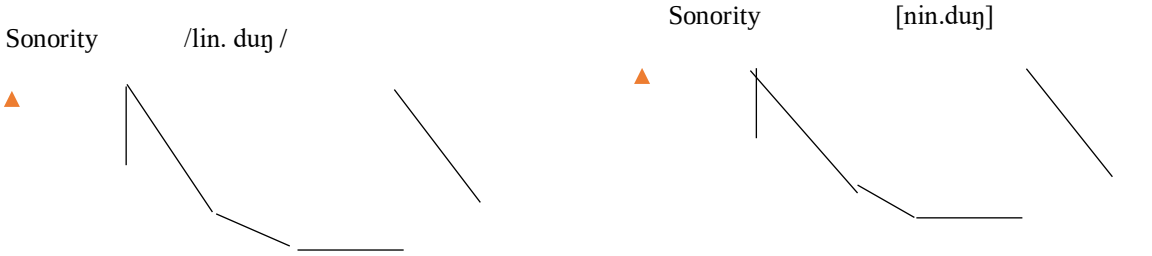


Figure 6. Substitution sonority

Appendix B



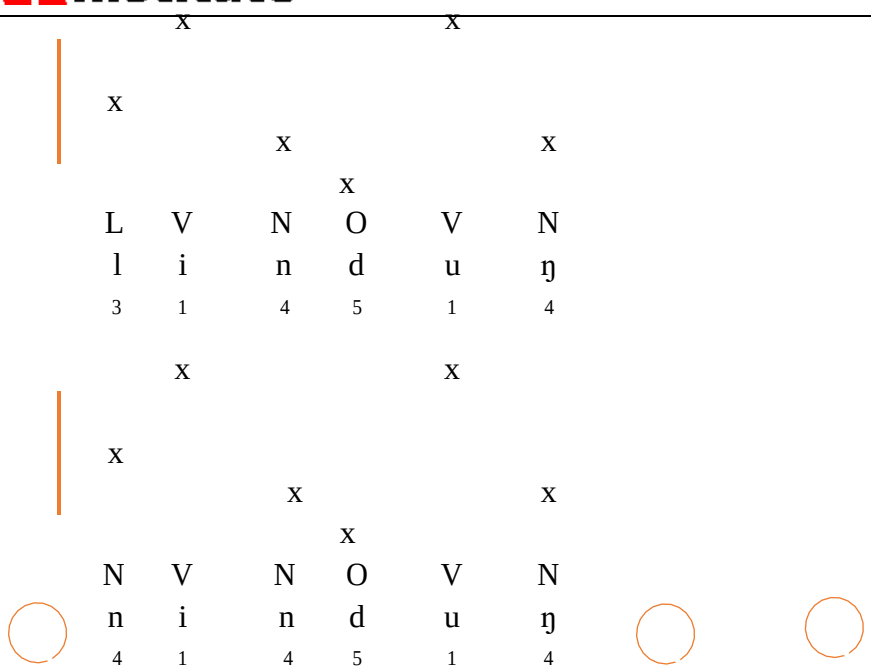


Figure 7. Reverse ordering sonority

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