Difficulties of Producing Postposition in Broca's Aphasia: A Test in Bangla Language

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Abstract : This research aims to examine the nature of language production deficits of Bangla speaking Broca's aphasics. The grammatical category postposition has been taken for this research. The tests were designed and performed on Bangla language speaking aphasics. The task related to postposition was aimed at production deficits. The research has done between two groups of people. One group was Broca's aphasics and the other group was the normal speakers of Bangla language. The results showed that the Broca's aphasics face more difficulties in this task than the normal speakers of Bangla. The result of this task showed a notion of impairment. Future studies could show more detailed evidence on the basis of repetitive tasks related to the postpositions.

Introduction

Broca's aphasia refers to the problems in the production of language. The language area of the brain, which is related to the production capability, is called Broca's area. Any kind of damage in this area can cause Broca's aphasia. Damage in Broca's area not only hampers the production of the language but also creates a barrier for the grammatical components of a language. This means that the ability of using grammatical categories of a language can be interrupted due to an injury in Broca's area. The reduced ability to use grammatical components is called agrammatism. It is one of the most salient features of Broca's aphasia. The manifestation of agrammatism is not same for all languages. A particular grammatical component might be impaired in one language but not necessarily in other languages. A comparative study of two groups of Bangla language speakers:

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neurologically intact individuals and individuals with Broca's aphasia will be discussed in this research. Many previous studies have been conducted on Broca's aphasia in different languages. Bangla language has received very little attention in this area. Therefore, the grammatical and functional categories of Bangla language are taken into account to study the nature of agrammatism for Bangla-speaking Broca's aphasics as compared to neurologically intact individuals. From the perspective of Bangla language, this research will be able to add a new dimension to understanding the production deficits of Bangla speaking Broca's aphasics. If there is no difference between the Broca's aphasics and the control group, then it might indicate that the damage in the Broca's area does not have any impact on the production of postpositions in Bangla.

Research Purpose

The main focus of this research is to classify the pattern of impairment of Bangla speaking Broca's aphasics, specifically in the production of postposition. In Bangla grammar, postposition is considered interesting due to the finding that Broca's aphasics have met difficulty with prepositions in other languages. There is a possibility that Bangla speaking Broca's aphasics also exhibit difficulty in this category. As Bangla language has postpositions instead of prepositions which are similar in function. Both are closed class grammatical items with comparable functions. Postpositions typically occur after the object in Bangla and link nominal objects to other parts of sentences. Most postpositions require a case marker on the object nouns. Bangla sentences which are expected to come out with a postposition can be replaced with a locative marker. In fact, three possible outcomes are possible in comparable situations. One possibility is to produce the sentence with a postposition only. Second possibility is to mark the object with the locative case in the sentence. Third possibility is to produce the sentence with both postposition and locative marker. All these possibilities in Bangla are needed to be considered so that the experiment results can show the correct responses. The materials and method for this experiment were designed in a way so that it will only trigger the production of a postposition and avoid the production of a locative marker. The primary assumption is that the use of postposition might be difficult for the Bangla speaking Broca's aphasics. There is a

possibility that they might omit the postposition or exchange it with other functional words.

Research Question and Hypothesis

The main hypothesis underlying this research is that Bangla speaking Broca's aphasics show impairment in the production of postpositions in comparison to neurologically intact individuals of Bangla language. Our primary idea was that normal speakers of Bangla language would not make any mistake in producing postpositions and give correct responses in this task. On the other hand, the Broca's aphasics are expected to mistakes in this task as their language production capacity is damaged due to injury in the language area of the brain.

The following two specific research questions are guiding the present research:

1. What is the pattern of difficulties in the production of postpositions?
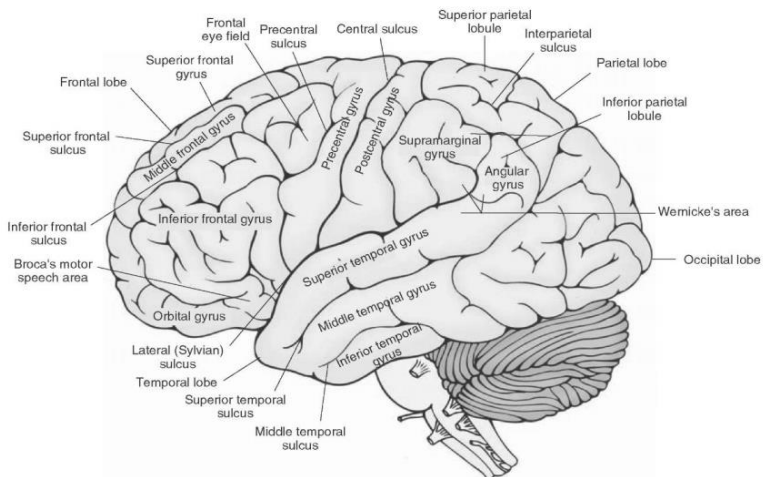2. What are the specific characteristics of the impairment exhibited in this task?

The null and alternative hypotheses for this analysis is the following:

H0: Aphasic and normal participants do not show any difference in their responses.
H1: Aphasic and normal participants show differences in their responses.

Language and human brain

The functioning and processing of language is performed by the human brain. The central nervous system provides a context to understand the brain functions for language. In this section, the parts and functions of the central nervous system will be discussed briefly, mostly focusing on the language function. The cerebrum is the part of central nervous system that is most important for speech and language. The cerebrum is divided into two hemispheres, which are called right and left hemisphere. Obler of Gjerlow remarked about two types of fissures, which are called the Rolandic fissure that divides the frontal and parietal lobe and Sylvian fissure that cuts through the language area that parts the temporal lobe below and the parietal and frontal lobes above. They also noted that the frontal lobe is referred to as the anterior region of the brain. While the parietal and occipital lobe are in

posterior region and the temporal lobe runs in both anterior and posterior sections (Obler & Gjerlow, 1999). Damage in the anterior language zone in the left hemisphere may cause language impairment. The left hemisphere is important for speech and language. Any kind of damage in this area can cause different types of language impairment. As per Brookshire (2003), the anterior language zone in the frontal lobe takes part in expressive language action such as speech and writing. It helps to plan and process language utterances. He also mentioned that the posterior language zone in the left temporal and parietal lobes are important for comprehending, recalling and formulating linguistic messages by using appropriate syntactic and semantic content. The posterior inferior frontal lobe in the anterior area is called Broca's area. Broca's area is a closest area of primary motor cortex for the speech muscles, which is important for the planning of speech movements (Brookshire, 2003).

Figure 1.1: A view of lobes, fissures, gyrus and sulcus. (source:https://s-media-cacheak0.pinimg.com/originals/67/d8/ed/67d8ed4f405baa443492507f63382e5f.jpg)

Aphasia

The production and comprehension of language are controlled by two specific areas of human brain. These two language areas can be damaged by many factors such as stroke, tumor, head injury or progressive degenerative disease that can interrupt the total processing system of language. There are different types of language

disorders that can be caused by a disruption in the language areas. Aphasia is an acquired language disorder that results from damage to the brain and could hamper an individual's language abilities (Nikolova, Boyd-Graber & Fellbaum, 2011). The scientific investigation of aphasia began in the middle of the 19th century. In 1861, Paul Broca first pointed out that a portion of the brain, more specifically the left hemisphere, is related to the output of language. He mentioned a particular type of aphasia that is called by his name as Broca's aphasia.

Broca's Aphasia

Damage in Broca's area can cause Broca's aphasia which disrupts the speech and limits the speech into broken words. Paul Broca examined two patients named 'Leoborgne' and 'Lelong'. Both of them were incapable of speech for many years. 'Leoborgne' was able to produce a single word 'tan' and 'Lelong' was able to produce only five words. An autopsy of both patients showed damage area in the left hemisphere (Kemmerer, 2015). People who suffer from Broca's aphasia are called Broca's aphasics. Agrammatism denotes the impaired production of closed-class elements and ungrammatical utterances as well as the lack of comprehension of certain grammatical constructions in Broca's aphasia (Avrutin, 2001).

Postposition

Grodzinsky (1988) discussed the syntactic deficits of using prepositions in Broca's aphasia. His idea was linked to the notion of Government (Chomsky 1981): when a preposition is governed, the agrammatic speakers will tend to omit it, while an ungoverned preposition will be intact in the production of the agrammatic speakers. In English a preposition is ungoverned when it is a sentential adjunct, as illustrated in example (1a); elsewhere prepositions are governed, as illustrated in example (1b).

(1)   a. John plays tennis *after* work.
      b. John always counted *on* Mary.

Friederici et al. (1982), referred to by Grodzinsky (1988) showed that agrammatic aphasics performed almost normally in picking a correct preposition in a sentence completion task where the preposition carried semantic content, as in (2).

(2) The cat is lying under the table.

The discussion by Grodzinsky and others stimulated the investigation of the use of postpositions by Broca's aphasics in Bangla Language. Either the Broca's aphasics of Bangla have difficulty to produce all types of postpositions or they might show difficulty in certain types of postpositions. There is also the possibility that Broca's aphasics perform well in all postposition tasks, which would imply no impairment of this functional category of Bangla.

In Bangla, Postpositions are often placed after nouns and pronouns; sometimes they are also found after verb as well. Postpositions need case markers in Bangla to relate with a noun phrase. A very common pattern of Bangla postpositions is that they can act as functional adverbs in postpositional or adverbial phrases. Postpositions are functionally capable of expressing spatial, temporal, situational, locational, directional and conditional information. The materials that have been used in this experiment, which is a sentence production task, where the semantic interaction between postposition and noun phrase has been observed.

In Bangla, postpositions can be divided into two categories based on their linguistic roles and functions. The first category consists of postpositions acting as an adverb. In this category, the postpositions tend to express information such as time, place and manner of an action expressed by the noun or verb. This is exemplified by the postposition *paʃe* 'beside' in (3).

(3) karim   rahim-er   paʃe   boʃe acʰe
     Karim   Rahim.ABL   beside.POST   sit   be
     'Karim is sitting beside Rahim'

Postpositions of the second category are in phrases which express some other aspects of nouns and verbs such as causation, content, direction, comparison, status etc. (Dash, 2015). An example is the postposition /diye/ 'by' in (4).

(4) take   diye   e   kaɟ   hɔbe-na
     He   by.POST   the.DET   work   do.NEG
     'This task cannot be done by him'

In Bangla, postpositions can take the locative or ablative case. The direct use of a locative marker on the noun does not require the use of a postposition. It is possible to produce a sentence without a postposition if the situation indicates a locative aspect on the noun. This does not mean that locative case and postposition cannot apply in the same sentence. It is still possible that both can be in the same sentence. However, the appropriateness of each construction may depend on the context. These possibilities of context are exploited in the design of an experimental task in which the speaker's production of postpositions can be examined. Some examples are discussed below that can give a clear view about the use of postpositions and locative case.
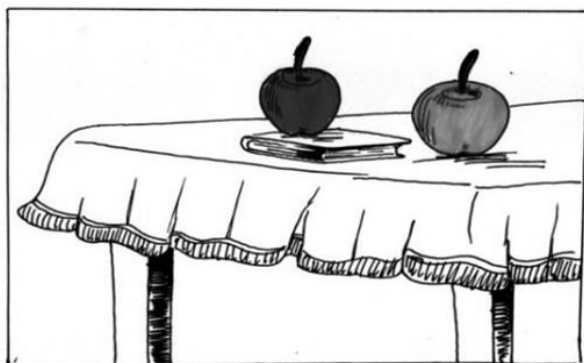
Figure 1.2: Picture regarding postposition and locative case

(5) a. ʃabuɟ   apel-ti   tebil-e   raᵏa   acʰe.
      Green apple.DET table.LOC   keep   be
      'The green apple is on the table.'

   b. ʃabuɟ   apel-ti   tebil-er   upore   rakʰa   acʰe.
      Green apple.DET table.ABL   on.POST   keep   be
      'The green apple is on the table.'

The example (5a) shows a locative case while (5b) shows a postposition combined with an ablative marker on the noun. Figure 1.2 shows a picture where locative and postposition are both applicable, as expressed in (5b). However, two different situations have been put in this picture. The first situation is that a green apple is on the table and

the second situation is the red apple is on the book. Examples (6) which are two possible questions could be formed with this picture.

(6) a. apel-ti   koṭʰay   rakʰa   acʰe?
        Apple.DET   where   keep   be?
     'Where is the apple?'

(6) b. Sabuz apel-ti   Kotʰay   rakʰa   acʰe?
       Green apple.DET where   keep   be?
       'I where is the green apple?'

Question (6a) does not require the answer to have a postposition. The answer can be given with locative case, which will be correct in Bangla. Question (6b) does not indicate any locative part of the sentence so that the answer requires the use of a postposition. To make the statement more unambiguous, more sample sentences (7a and 7b) are discussed.

(7)   a. lal   apel-ti   boiy-e   rakʰa   acʰe.
         Red   apple.DET   book.LOC   keep   be
         'A red apple is on the book.'

      b. lal   apel-ti   boi-er   upore   rakʰa   acʰe.
         Red   apple.DET   book.ABL on.POST keep   be
         'A red apple is on the book.'

Figure 1.2 is also applicable to these examples. Example (7a) is showing a locative trace in the sentence and (7b) is showing a postposition with an ablative marker in the sentence. Now the view will be more structured. The question can be formed as (8).

(8) lal   apel-t   koṭʰay   rakʰa   acʰe ?
    Red apple.DET   where   keep   be ?
    'Where is the red apple?'

The answer to the question (8) can come out only with a postposition. Example (7b) is the right answer to this question, which shows the postposition. Sentence (7a) is not an appropriate answer to this question; it is unable to convey the idea clearly and the meaning of the sentence would also be ambiguous.

The above discussion has explained some relevant aspects of the use of postpositions in Bangla. Postpositions in Bangla are considered as a complex functional category like prepositions in English. Therefore, the Broca's aphasics of Bangla language could face problems in using and producing the postposition. They might omit the postposition in the

sentences and use the locative case or another grammatical category in the position of the postposition. This research will focus on the production of the postpositions along with the omission or replacement of the target item; these phenomena could reveal deficits of agrammatic aphasics.

Methodology

This experiment has been performed to test the impairment of Broca's aphasics in comparison with normal speakers of the Bangla language focused on postposition. The main concern of this task is to investigate the production capacity of agrammatic aphasics.

Participants

Two groups have participated in this experiment in total with 30 participants. The first group consisted of 20 Bangla-speaking individuals with Broca's aphasia and the second group had 10 normal speakers of Bangla language. Broca's aphasics were from three different hospitals: the National institute of neurosciences hospital, Bangabandhu sheikh mujib medical university and Uttara adhunik medical college, Dhaka. The age range of the participants were 40-70 for both Broca's aphasics and normal speakers. There were 26 male and 4 female participants. Broca's aphasics took approximately 10-15 minutes and normal speakers took approximately 5-7 minutes for this experiment.

Materials

This experiment was done with five sentences which are basically questions and five picture stimuli that are related to questions. The pictures that were taken in this experiment expressed the spatial and temporal situations. A practice session has conducted to introduce the experiment to the participants. There were two separate questions and pictures for the practice session for the participants. The first practice question and picture expressed the spatial or temporal situation and the second one expressed a causal situation. There was a set of expected answers for all the sentences. The pictures were made in way that the participants could differentiate all the elements and could give

the right response. The pictures included animate and inanimate elements. Animate elements were 'cat', 'boy', 'girl', 'man' and inanimate elements were 'table', 'chair', 'almirah', 'bed', 'hammer', 'sofa' etc. The animate and inanimate elements in all the stimuli were distributed in same way to make the task more comprehensible for the participants.

Procedure

This experiment was presented to both groups of participants. Participants were instructed to participate firstly in the practice sessions and then they begin the main experiment. Every session started with the presentation of a picture and a question regarding that picture was presented in front of them to reach the target answer.

Figure 1.3: A Picture stimulus regarding Postposition.

Figure 1.3 is showing a chair, two books and one football. The question for this picture is 'Where is the football?' and the expected answer is 'The football is on the book.' If the participants are able to produce the target sentence with the correct postposition then it could considered as a correct response. This picture will only activate the production of a postposition, as in (9a).

(9) a. Football-ti   boi-er   upore   rak^{h}a   ac^{h}e.
        Football.DET   book.GEN   on.POST   keep   be
        'The football is on the book.'

    * b. Football-ti   boi-e   rak^{h}a   ac^{h}e.
        Football.DET   book.LOC   keep   be
        'The football is on the book.'

The example (9a) is the expected and correct response for this task. On the other hand, if we look at the figure 1.3 and the outcome of the task came out as an example (9b) then it is an incorrect answer because it makes the meaning ambiguous. It can be expressed that the football in on the top of the book and at the same time it could make sense as the football is in the book. It might be difficult for the aphasic patients to figure out and it will distract them to the main concentration of the task.

Figure 1.4: Picture stimulus regarding locative marker.

In Figure 1.4, the picture shows two elements which are 'chair' and 'football'. In this case, the question 'Where is the football?' may lead to two different correct answers, one with a postposition and the other one with a locative marker, as shown in (10).

(10) a. Fʰutbɔll-ti   ceyar-e   rakʰa   acʰe.
         Football.DET   chair.LOC   keep   be
         'The football is on the chair.'

     b. Fʰutbɔll-ti   ceyare-er   upore   rakʰa   acʰe.
         Football.DET   chair.ABL   on.POST   keep   be
         'The football is on the chair.'

The above construction of the sentences matches to the figure 1.4 though it leads to two correct answers. The figure 1.4 avoided in this experiment to remove the ambiguous situation for the participants with Broca's aphasia. The main focus was to test the production of postpositions. Therefore, all the pictures were prepared with three elements to make sure the production of postpositions was intended.

Data Analysis and Findings

The primary assumption of this experiment was that the aphasic patients make more mistakes than the normal speakers of Bangla in producing the postpositions. The collected data of this experiment has been analyzed and interpreted in the light of different research questions. The outcomes will be presented one by one.

The target postpositions set for this task are listed in (11)

(11) a. /upore/ 'on'
   b. /nice/ 'under'
   c. /pecʰone/ 'behind'
   d. /ʃamne/ 'front'
   e. /maɟʰkʰane/ 'middle'

Based on the target responses as in (11a–e), the task has been designed and executed. A noteworthy part of these responses is item number five, which comes with three different types of responses that represent the same meaning in Bangla.

(12) a. kalo   cek-er   baliʃ-ti   kot̪ʰay   rakʰa   acʰe?
    Black   striped.ABL   pillow.DET   where   keep   be
    'Where is the black striped pillow?'

  b. kalo   cek-er   baliʃ-ti   sofa-r   maɟʰkʰane   rakʰa acʰe.
    Black   striped.ABL   pillow.DET   sofa.ABL   middle.POST   keep   be
    'The black striped pillow is in the middle of sofa.'
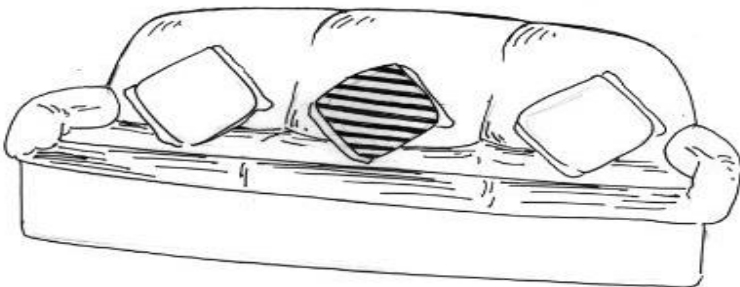
Example (12a) shows the question, (12b) shows the expected answer and (12c) shows the picture for item number 5. The target postposition for this sentence is /maɟʰkʰane/ 'in the middle'. The collected responses contain three different postpositional words, which are /maɟʰkʰane/ 'in the middle', /maɟʰe/ 'middle' and /mod̪d̪ʰe/ 'between'

that carry similar meanings in Bangla. Therefore, these three responses have been taken as equivalent and are considered correct responses for the two groups of participants.

The analysis of this experiment has been done with different assumptions. The outcomes of these assumptions is discussed below-

Question 1: Are response categories different according to the types of responses?

**Table 1.1:** Analysis of responses by participant type (normal vs. aphasic)

Type	Correct	
	Yes	No
Aphasic	73	27
Normal	45	5

Table 1.1 shows the response data in terms of correctness according to the type of participants. These are also graphically presented in Figure 1.5, in which the dotted lines represent the average for both groups. Figure 1.5 shows that there is an association between the responses 'No', which is the incorrect answers and the participant group 'Aphasic'. The number of observations is higher in the category 'No' for the aphasics, which means that they have faced difficulty to produce postpositions. On the other hand, the number of observations in the category 'Yes', which is the correct responses for the normal speakers means that they did not show difficulty in the production of postpositions.
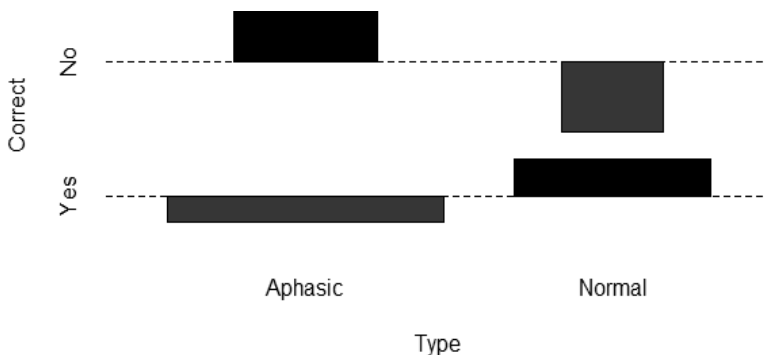
Figure 1.5: Analysis of responses by participant type

A Pearson's Chi-squared test was performed and its results are shown in Figure 1.6. The significance level was $p < 0.05$, which is-χ^2 (df = 1) = 4.8, $p = 0.03$. This suggests that there is a significant difference between aphasics and normal speakers with respect to mistakes in producing postpositions. Aphasia patients and normal participants react to the test in significantly different ways. The analysis of this experiment suggests that we reject the null hypothesis and accept the alternative hypothesis that the Broca's aphasics show a difference in the response categories of correct and incorrect answers.
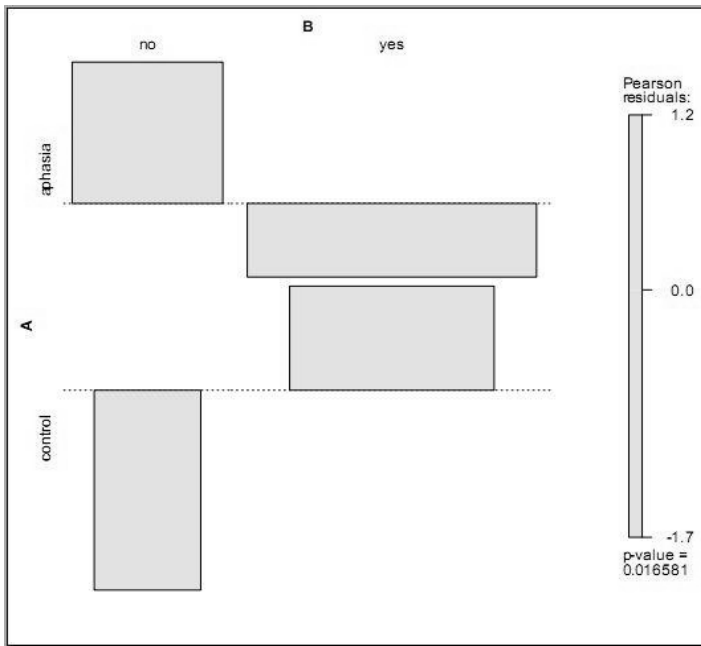
Figure 1.6: Analysis of responses by correctness of answer (yes = correct, no = incorrect)

The Phi test, which is a measure of effect size shows a small to medium effect of $\phi = 0.18$. A value of 0.1 is considered a small effect in Phi. The effect size, which is between small and medium, suggests that the questions need to be repeated many times for reliable answers. Here, the significance of the experiment has detected with only five items due to the impossibility to do a repetition task although it shows a representative output for this study.

Figure 1.6 shows that the significance is not from any specific cell, but it has an overall crossover effect. Aphasics show relatively more errors and less correct responses than average and the reverse for the normal group, which show less errors and more correct responses than average.

Question 2: Are response categories different according to the items of responses?

Table 1.2: Analysis of responses by items

Type	Item					Correct	Type	Item					Correct
	1	2	3	4	5			1	2	3	4	5	
Aphasic	14	17	9	14	19	Yes	**Aphasic**	6	3	11	6	1	No
Normal	8	10	9	9	9	Yes	**Normal**	2	0	1	1	1	No

Table 1.2 shows the data per item with 'Correct' and 'Incorrect' answers for both participant groups. The number of correct answers of normal participants is higher than the answers of the aphasic group of participants. The correctness of answers per group does not show any significant difference between items. The correct answers are independent of the items. The aphasic patients also give correct answers. In some cases, aphasics performed as the normal participants. The item number 3 and 5 looks stand out in the incorrect responses. The item number 3 where the aphasics gave most incorrect answers. On the other hand, the item number 5 does not have much distinguishing value because participants from both groups have given different types of answer which are also taken as a correct response. They have used different postpositional words which have same in the meaning. Therefore, all these postpositional words have taken as correct responses.

In Figure 1.7, the Pearson's Chi-squared test shows $\chi^2(df=4) = 1.55$, p = 0.8, so the effect for items are not significant. The notable part of this test is that item 3 has *less* correct answers and item 5 has *more* correct answers than expected from the aphasics.
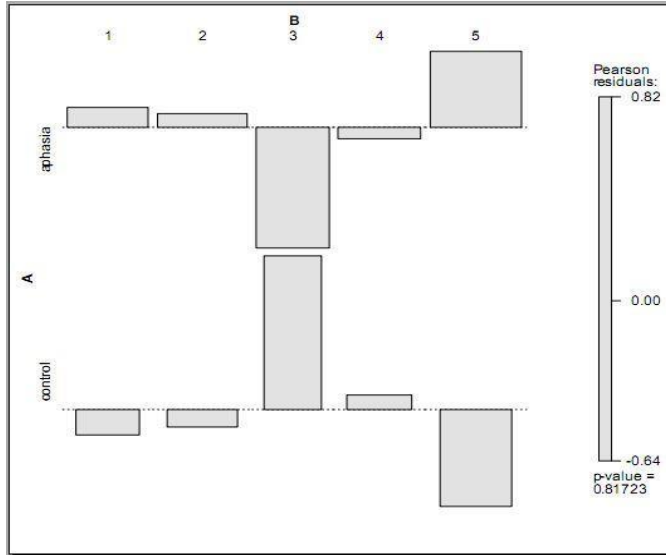
Figure 1.7: Analysis of correct responses by the items (normal vs. aphasic)

The Phi test of effect size is shown below-

Table 1.3: Phi test of the Effect size

Participant groups	Items				
	1	**2**	**3**	**4**	**5**
Aphasic	0.50	0.47	-2.29	-0.47	1.18
Normal	-0.53	-0.49	3.43	0.48	-1.63

Table 1.3 shows the effect size per cell or serendipity (Johansson, 2017). Each number of the above table shows the signed effect size *multiplied* by 100, if distributed by each cells contribution to χ^2 (significance), to test the effect of each item. For example, in item 1, the number for the aphasic group is 0.50/100 = 0.005, which is close to no effect for this item. The other numbers also can be divided like this to testify the significance of each item in this study. Item 3 has an effect size of at most 0.03, which is negligible.

Question 3: Are response categories different according to the subjects?

Table 1.4: Analysis of the responses by the aphasic subjects

Response	Subjects									
	NE	SA	BH	AA	KMA	AH	MKM	DR	KB	MS
Yes	4	4	3	3	5	4	3	3	2	5
No	1	1	2	2	0	1	2	2	3	0

Response	Subjects									
	AH2	JH	SA2	AJ	AK	FA	MR	PCM	TH	SB
Yes	1	4	3	4	5	4	3	5	5	3
No	4	1	2	1	0	1	2	0	0	2

In Table 1.4, the response of the aphasic subjects is presented. The participants 'KMA', 'MS', 'AK', 'PCM' and 'TH' show the perfect score. The participant 'AH2' is showing less number of correct answers.

Discussion

The results show that in this experiment the null hypothesis has been rejected. This Experiment has limited effect size for the aphasics but the outcome has given a platform to do further research, especially a repetition of the tasks. Of particular interest are the participants who showed correct responses, which would place them in the normal group.

The participants 'KMA', 'MS', 'AK', 'PCM' and 'TH' had perfect scores. The reason behind these perfect scores may be that for the item number 5 three different answers were accepted as correct responses. If the answers of these five participants were not the same as the originally expected answer then there had been no chance to get a perfect score in this task. The participant 'AH2' is showing less correct answers. 'AH2' showed the highest number of errors among all the aphasic patients.

The subject 'KMA' showed a perfect score and should therefore perhaps be considered to belong in the 'normal' group. In contrast, the subject 'AH2' showed severe impairment in this task. The other subjects showed more or less impairment in the both tasks. It therefore seems that the experiment could lay the grounds for

developing tests that assess the level of severity of the impairment.

The Broca's aphasics have shown production deficit to some extent but it does not enough to conclude and establish that the Bangla speaking Broca's aphasics have difficulty in this category. It only shows a tendency of deficit that needs to be in further examination.

Conclusion

The deficit and inability of using grammatical components in aphasia is a situation that affects the whole language system of a person. The specific pattern of the deficit differs from language to language. The outcome of this research has found evidence to production deficits in Bangla speaking Broca's aphasics. Broca's aphasia focuses on the production deficit due to the damage of language area in the brain.

This experiment has dealt with the production deficit of postpositions. The result of this experiment has drawn attention to the trend but does not give definitive evidence about the production deficit regarding postpositions. There is a chance that errors of items are correlated, but the amount of the data of this experiment was not sufficient to establish the correlations. Repetition of the same task would be a way of strengthening the evidence.

This research has great opportunities to do further investigations on the production complexity of Bangla speaking Broca's aphasics. This experiment only focuses the production task of postpositions. There is a larger scope of function words that we can examine in addition to postpositions, and we can also design a comprehension task for them.

References

Avrutin, S. (2001). Linguistics and agrammatism in *Glot International*, *5*(3), 1-11.

Brookshire, R. H. (2003). *Introduction to Neurogenic Communication Disorders* (6th ed.). Missouri: Mosby.

Drokers, N.F., Plaisant, o., Iba-Zizen, M.T. & Cabanis, E.A. (2007). Paul Broca's historical cases : high resolution MR Imaging of the brains of Laborgue and belong. *Brain*, 130(5), 1432-1441. doi:10.1093/brain/awao42

Grodzinsky, Y. (1988). Syntactic representations in agrammatic aphasia: The case of prepositions in *Language and speech*, *31*(2), 115-134.

Johansson, C. (2017). One word or two? Manuscript. University of Bergen, Norway: UiB Archive.

Kemmerer, D. (2015). *Cognitive Neuroscience of Language*. New York, NY: Psychology Press.

Nikolova, S., Boyd-Graber, J., & Fellbaum, C. (2011). Collecting semantic similarity ratings to connect concepts in assistive communication tools. In *Modeling, Learning, and Processing of Text Technological Data Structures* (pp. 81-93). Berlin Heidelberg: Springer

Obler, L. K., & Gjerlow, K. (1999). *Language and the Brain*. Cambridge: Cambridge University Press.