

## **Comprehending Word Order: The Language of Bangla speaking Broca's Aphasics**

**Sadika Parvin Tamanna**\*

**Abstract:** This research has revealed the language comprehension limitations of the Bangla speaking Broca's aphasics. This research examined the sentences in three different word orders of Bangla with a picture-matching task. Two groups, including Broca's aphasics and a control group, participated in this experiment. This experiment has shown that the people with Broca's aphasia have more impairment in the comprehension task than the control group. The significant outcome of this research is that they have shown difficulty in the 'OVS' construction with the 'opposite' and 'distractor' picture orders with intact comprehension in 'SOV' and 'VOS' construction.

**Keywords:** Broca's Aphasia, Bangla word order, Comprehension difficulty, 'OVS' construction

### **Introduction**

This study explores the comprehension deficit of the Bangla speaking Broca's Aphasics and neurologically intact individuals. Broca's aphasia is mainly known to imply problems in language production. The brain's language area, known as Broca's area, is the seat of language production. Therefore, any damage occurs in Broca's area, creating a barrier to producing different grammatical components of a language. The reduced ability to use grammatical components is called Agrammatism, a common problem for people with Broca's aphasia. The sign of Agrammatism differs from language to language. A particular grammatical element might be impaired in one language but not necessarily in other languages.

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## **Research Purpose**

This research aims to discover the limitations of Broca's aphasics in comprehending the word order of the Bangla language. The standard word order in Bangla is SOV (subject-object-verb). The alternations in this word order only shift the sentence's focus without changing the meaning, which is a unique grammatical feature of the Bangla language.

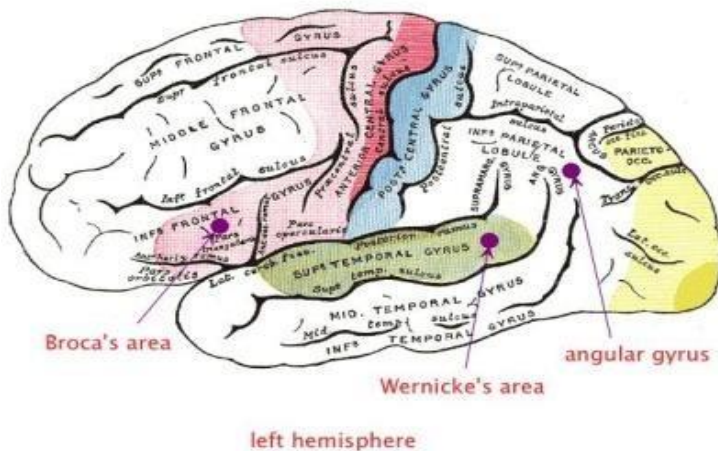
This research is designed and carried out with a test in which three different word orders have been associated with three different pictures. The word order task is focused on the understanding of relating the sentences with the action of the pictures. This task aims to identify impairments related to the processing of the sentences with different word orders in Bangla speaking Broca's aphasics. The dissociation between the word order and picture order might indicate that Bangla speaking Broca's aphasics have difficulty in processing sentences with different word orders.

The usual notion about Broca's aphasia implies an impaired production with an intact comprehension capacity. However, recent research has shown that these aphasics have comprehension problems, especially in dealing with complex syntactic structures. The word order task is set to test Bangla speaking Broca's aphasics comprehension ability. It could be partial or complete comprehension disassociation. A possible outcome of the word order task is that the comprehension ability might be intact or impaired for all word orders. It is also possible that one specific word order could be intact or impaired. Therefore, the outcomes of this research will identify the nature of the comprehension inability of the Bangla speaking Broca's aphasics. The findings will help develop therapies to improve the language ability of Broca's aphasics.

## **Aphasia and Brain**

The brain's language area is responsible for all the speech production and comprehension functions. The left hemisphere of the brain is called the language area. If any damage happens in the

left hemisphere, it may cause language impairment. The posterior inferior frontal lobe in the anterior area is called Broca's area. Broca's area is the closest area of the primary motor cortex for the speech muscles, which is essential for planning speech movements (Brookshire, 2003). The posterior superior left temporal lobe of the brain sustains the whole process of lexical selection. Wernicke's area communicates with Broca's area and other brain's frontal regions with the help of banded nerve fibres called the arcuate fasciculus. The arcuate fasciculus goes through the mid temporal lobe and the lower regions of the frontal lobe in connection with the parietal lobe, which is considered a primary route to transfer linguistic messages from Wernicke's area to Broca's area. The reading and writing process is executed in and around the angular gyrus area at a junction of the temporal, parietal and occipital lobes (Brookshire, 2003).



**Figure 1.1:** Language areas of brain (Source: <http://webspaceship.edu/cgboer/speechbrain.html>)

Aphasia is an acquired disorder that can hamper an individual's language abilities (Nikolova, Boyd-Graber & Fellbaum, 2011). Aphasia is an impairment of producing, comprehending, or repeating language due to brain injury. Aphasic patients have difficulty retrieving words for objects and actions during language

production. Aphasic patients also have impairments in phoneme perception, word recognition, and syntactic parsing during language comprehension (Kemmerer, 2015). Broca's area lies in the third frontal gyrus of the cerebral cortex (Geschwind, 1972). Broca's aphasia is also called agrammatic aphasia or non-fluent aphasia. Hillis (2007) states that nonfluency includes reduced phrase length, impaired melody and articulatory agility and reduced speed (words per minute). Agrammatism is a distinctive characteristic of Broca's aphasia. The speech of agrammatic patients clearly indicates the lack of markers in the organization of sentences and relatively small use of closed-class items (Szczegiłniak, 2007).

The general view on the neurological basis of language is that Broca's area and Wernicke's area in the left hemisphere have crucial functions in processing language. The neurological aspect of language has changed in recent years, and new ideas have come up regarding language functions. Stowe, Haverkort, & Zwarts (2005) discussed that the function of production and comprehension could not be split up in a way that Broca's area is only handling production, and Wernicke's area is handling comprehension. There is a connection between these two areas. The activation of language processes in one area leads to the activation of other areas. However, several studies showed that Broca's aphasics with severe impairment in language production also suffered in understanding complex syntactic structures. Therefore, the functional language areas of the brain cannot be labeled with specific tasks. Several different studies have been done, and theories have been developed about the functional role of language according to the neurological basis of language. Thus, it is still a matter of argument to which extent the brain's language areas are interconnected or separate from each other based on their functions in language processing.

### **Bangla Word Order**

Comprehension difficulty in noncanonical sentences in different languages is widely observed in Broca's aphasia. Noncanonical sentences are derived from the movement of certain sentence

constituents in the syntactic tree. The alternation of word order depends on emphasizing a specific action and situation. Some examples of Bangla sentence constructions are discussed below to illustrate this.

Simple sentences in Bangla are formed with one or two nouns and a verb, as in (1). The first noun is usually the subject; a second noun is then an object of the verb, and the verb is placed at the final position of the sentence. If the sentence has only one noun, it is considered the subject. Adjuncts can be added to subjects; adjuncts and complement can be added for the predicates. An adjunct is an optional element and can be deleted without affecting the sentence construction (Morshed, 1982).

(1) a.

paul k<sup>h</sup>acc<sup>h</sup>e.

Paul eat.PRS.PROG

‘Paul is eating’

b.

paul b<sup>h</sup>aṭ k<sup>h</sup>acc<sup>h</sup>e.

Paul rice eat.PRS.PROG

‘Paul is eating rice’

Example (1a) shows a sentence with a noun and a finite verb. Sentences without subject can only be constructed in certain discourse contexts. Example (1b) shows the basic SOV sentence structure of Bangla where the first noun ‘Paul’ is the subject, the second noun /b<sup>h</sup>aṭ/ ‘rice’ is the object, and /k<sup>h</sup>acc<sup>h</sup>e/ ‘is eating’ is the verb.

(2) a.

paul raṭ̣-e dud<sup>h</sup> k<sup>h</sup>ay.

Paul night.LOC milk drink.PRS

‘Paul drinks milk at night’

b.

raṭ-e        dud<sup>h</sup>    k<sup>h</sup>ay        paul.  
 night.LOC   milk    drink.PRS   Paul  
 'Paul drinks milk at night'

c

raṭ-e        paul    dud<sup>h</sup>    k<sup>h</sup>ay.  
 night.LOC   Paul    milk    drink.PRS  
 'Paul drinks milk at night'

Examples (2) show alternative positions of the subject in Bangla sentences. Example (2a) shows the default construction where the subject, 'Paul', occurs at the beginning of the sentence. However, the subject can also be placed in the other parts of the sentence that do not affect the meaning. Examples (2b) and (2c) show the subject's movement to the end and middle of the sentence, respectively.

Usually, in a Bangla sentence, the indirect object comes before the direct object. However, this order also can be altered due to focusing on the argument without changing the meaning of the sentence.

(3) a.

paul    mary-ke    upohar    dicc<sup>h</sup>e.  
 Paul    Mary.DAT    gift        give.PRS.PROG  
 'Paul is giving a gift to Mary'

b.

mary-ke    paul    upohar    dicc<sup>h</sup>e.  
 Mary.DAT   Paul    gift        give.PRS.PROG  
 'Paul is giving a gift to Mary'

c.

paul upohar dicc<sup>h</sup>e mary-ke.  
 Paul gift give.PRS.PROG Mary.DAT  
 'Paul is giving a gift to Mary'

\* d.

paul upohar mary-ke dicc<sup>h</sup>e.  
 Paul gift Mary.DAT give.PRS.PROG  
 'Paul is giving a gift to Mary'

e.

mary-ke upohar dicc<sup>h</sup>e paul.  
 Mary.DAT gift give.PRS.PROG Paul  
 'Paul is giving a gift to Mary'

f.

upohar paul mary-ke dicc<sup>h</sup>e.  
 gift Paul Mary.DAT give.PRS.PROG  
 'Paul is giving a gift to Mary'

The examples in (3) show the direct and indirect object situation of Bangla. In (3a), 'Paul' is the subject, /dicc<sup>h</sup>e/ 'is giving' is the verb, /upohar/ 'gift' is the direct object and 'Mary' is the indirect object. The examples in (3b–f) are the possible alternations of Bangla sentences. The changing pattern of word order in these examples does not affect the meaning of the sentences. In (3b), the indirect object starts the sentence, and in (3c), the sentence ends with the indirect object. In (3e), the direct object is placed before the verb; in (3f), it is in an initial position. If the direct object were placed before the indirect object without any particle or determiner, the sentence would be ungrammatical. In example (3d), the direct object

/upohar/ occurs before the indirect object Mary without any particle or determiner, and the verb is in the final position, making the sentence ungrammatical. Placement of the verb between the direct and indirect object, as in (3c), is grammatical in Bangla.

Determiners, adjectives, and adverbs can be included in simple sentences to extend the meaning in different situations. The determiner always comes before the noun in a noun phrase. However, Adverbs are placed before the verb and after the nominal subject. Adjectives are placed before the head noun in a noun phrase. Examples including determiner, adjective and adverb are presented in (4).

(4) a.

mary d̥ruʒo hatʰe.

Mary fast.ADV walk.PRS.PROG

‘Mary is walking fast’

b.

meye-ti juᅇdor juᅇa poreʰe.

Girl.DET beautifull.ADJ shoe wear.PRS.PROG

‘The girl is wearing a beautiful shoe’

Another important aspect of sentence construction is relative clauses. A relative clause can be constructed with a relative pronoun, antecedent, and postcedent along with other elements like determiner and so on. In Bangla, relative pronouns are added in the relative clauses in terms of honor, number, and animacy. Relative pronouns have correlatives to make relative clauses in Bangla such as /je/ ‘who’ and /je/ ‘he or she’; /jini/ ‘who’ and /ᅇini/ ‘he or she’; /ja/ ‘what’ and /ᅇa/ ‘that’ and /jara/ ‘who’ and /ᅇara/ ‘they’. Correlative items are a common phenomenon in constructing complex sentences in Bangla. Examples of relative clauses are given in (5) and discussed below.



(5) a.

paul mary-ke upohar dicc<sup>h</sup>e.  
 Paul Mary.DAT gift give.PRS.PROG  
 'Paul is giving a gift to Mary.'

b.

paul je je mary-ke upohar dicc<sup>h</sup>e.  
 Paul he who Mary.DAT gift give.PRS.PROG  
 'Paul is the one who is giving a gift to Mary.'

c.

mary-ke upohar dicc<sup>h</sup>e je je paul  
 Mary.DAT gift give.PRS.PROG who he Paul.  
 'Paul is the one who is giving a gift to Mary.'

The examples in (5) show the pattern of relative clauses. (5a) shows the basic SOV word order of Bangla. The examples in (5b) and (5c) are expanded with relative markers to make it a relative clause. In (5b), there is a relative object clause, and in (5c), there is a subject relative clause.

Bangla has two patterns of making question sentences, with a Wh-marker and without a Wh- marker. First, yes-no questions can be formed without using any Wh-marker. In that case, an additional particle will be added, which is /ki/ 'it' or 'this' for the yes/no questions. Wh- questions are typically formed with the Wh-marker at the focus position of the sentence. Some examples in (6) are discussed about the formation of the Wh-question in Bangla.

(6) a.

koṭ<sup>h</sup>ay ṭomar baṛi ?  
 where.Q your home  
 Where is your home?

b.

koṭ<sup>h</sup>ay [hoy] ṭomar baṛi ?  
 is your home  
 where.Q  
 Where is your home?

c.

ṭomar baṛi koṭʰay ?  
 Your home where.Q  
 Where is your home?

d.

baṛi koṭʰay ṭomar ?  
 Home where.Q your  
 Where is your home?

The examples in (6) show Wh-questions. A notable feature in the case of both declarative and interrogative sentences is that the verb could be omitted, which does not affect the meaning. Example (6a) presents a question using a Wh-marker that does not contain any verb. Example (6b) shows the sentence with the verb /hoy/ 'is', which is also grammatical but is not usual in Bangla. This kind of construction is only produced for stylistic and discourse demands. The examples in (6c) and (6d) show the free word order of Bangla that is also appropriate for the Wh-question.

As mentioned before, the yes/no question formation requires an extra particle /ki/. Some examples of this phenomenon are discussed in (7).

(7) a.

paul ki mary-ke upohar diccʰe ?  
 Paul this.Q Mary.DAT gift give.PRS.PROG  
 'Is this Paul who is giving a gift to Mary?'

b.

mary-ke upohar diccʰe ki paul?  
 Mary.DAT Gift give.PRS.PROG this.Q Paul  
 'Is this Paul who is giving a gift to Mary?'

c.

upohar diccʰe ki paul mary-ke ?  
 Gift give.PRS.PROG this.Q Paul Mary.DAT  
 'Is this Paul who is giving a gift to Mary?'

d.

paul ki je je mary-ke upohar dic<sup>h</sup>e ?  
 Paul this.Q He who Mary.DAT Gift give.PRS.PROG  
 'Is this Paul who is giving a gift to Mary?'

e.

mary-ke dic<sup>h</sup>e upohar je paul Ki je ?  
 Mary.DAT give.PRS.PROG gift who Paul this.Q he  
 'Is this Paul who is giving a gift to Mary?'

f.

dic<sup>h</sup>e upohar je mary-ke je Ki paul ?  
 give.PRS.PROG gift who Mary.DAT he this.Q Paul  
 'Is this Paul who is giving a gift to Mary?'

The examples in (7) show the patterns of yes/no questions in three different word orders. Examples from (7b-c) are declaring a definite question about the statement (7a). On the other hand, examples (7d-f) show questions about the relative statement. The use of the relative pronoun in the questions creates doubt about the subject's action. For example, sentence (7d) requires a clarification between the pronoun /je/ and 'Paul' because the relation between the pronoun /je/ 'he/she' and 'Paul' may be unclear. This task might be more difficult with reversed word order for language-impaired individuals. In (7e), the indirect object 'Mary' comes in a sentence-initial position, and the pronoun /je/ has taken the final position in the sentence. Also, here, the relation is unclear since /je/ 'he/she' may refer to the indirect object 'Mary' instead of 'Paul'. In (7f), the verb has taken the first position in the sentence, and the subject is shifted to the final position of the sentence. The indirect object 'Mary' is closer to the pronoun /je/, which could also prevent the correct response from the speakers.

The above discussion has given a concise overview of Bangla sentence construction and alternative word orders. Yes/no questions with reversible orders are essential in the present research paper. Declarative sentences, relative clauses, and Wh-questions have been discussed to make the basics of Bangla sentence structures more understandable.

### **On the word order in aphasia: cross-linguistic evidence**

In this segment, we will be looking into different linguistic entities concerned with the word and other syntactic deviations found in aphasia. As there is not much work on Bangla word order and aphasia, we will be illustrating the word order deviations and variations among aphasics in different languages that would provide some cross-linguistic data. Recent research in psycholinguistics has shown that using heuristic methods can make normal sentence comprehension easier in the English language (Clark, 2011; Ferreira & Patson, 2007; Townsend & Bever, 2001). These studies also assert that heuristics play a part in forming the aphasic comprehension paradigm. The evidence accumulated over the past two decades reveals that heuristic processes play a role in common sentence understanding. The findings of the study conducted by Gahl (2002) in the English language suggest that lexical issues may be one of the sources of variability shown in results obtained from other investigations. The degree to which lexical bias and syntactic structure are a good fit and influenced by the verbs employed in sentences intended to depict particular syntactic patterns. Apart from English, studies represent how this dispersion in word order occurs in other European languages. Bates et al. (1988) argue that patients also keep their ability to sequence nouns around a preposition. This ability also includes access to a high-frequency variant of pragmatic word-order variation among Italian patients. The reduction in syntactic complexity appears to be the source of syntactic issues rather than the loss of ordering rules. The findings from the study of Ostrosky-Solis et al. (1999) revealed substantive distinctions between syntactic and non-syntactic approaches to problem-solving in the Spanish language. Patients with Broca's aphasia relied solely on morpho-syntactic markings with a high cue validity level. There were no discernible impacts discovered to be caused by the word order. These findings suggest that particular offline language processes influence the understanding of non-fluent aphasic individuals. These mechanisms affect the patients' ability to communicate.

Duman (2011) demonstrated that the arrangement of words in a phrase and their case affected how well it was understood in the

Turkish language. When information concerning the base case and the base word order were available, clauses were understood most effectively. If there was information in the base case, but it was derived in a different order, performance impact. When neither the base case information nor the base word order was available, sentences were comprehended the least effectively. Bangla is another Subject-Object-Verb (SOV) language like the Turkish; therefore, we would get the idea of how the base case and base word order would be applicable. It was noted in the research carried out by Jap et al. (2016) as they were attempting to evaluate the comprehension of the passive as a derived formation in the Standard Indonesian language and the influence of frequency. Comprehension of reversible sentences derived from word order has frequently been reported as impaired in agrammatic aphasia. This was remarked upon as the researchers were attempting to explore the ability to comprehend the passive as a derived structure in the Standard Indonesian language. There was no discernible difference in the level of comprehension between the active and passive sentences. The embedding had little impact because the topic clefts, and the actives and passives were comprehended. On the other hand, object clefts were grasped inadequately and much less effective than the other three forms of sentences.

### **Hypothesis and Research Question**

The main hypothesis of this research is that Bangla speaking Broca's aphasics show a comprehension deficit in understanding the word orders compared to neurologically intact individuals. The primary expected outcome is that neurologically intact individuals of the Bangla language would not show any difficulties in understanding the word order task. On the other hand, Broca's aphasics are expected to make mistakes due to damage in the brain's language area. The following two specific research questions are guiding the present research:

1. What is the pattern of difficulties in comprehension tasks for the Bangla speaking Broca's aphasics?
2. What are the significant features of the comprehension impairment in the task?

## Methodology

This experiment tested canonical and alternative word orders. The materials were pictures and yes/no questions. The word order of these yes/no questions was changed in different ways to test the comprehension ability of Agrammatic aphasics. Two variables are of interest that is canonical and non-canonical word order, and relative frequency of structures.

## Participants

Two groups 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 standard speakers of the Bangla language. Broca's aphasics were from three hospitals: the National Institute of Neurosciences Hospital (NINS), Bangabandhu Sheikh Mujib Medical University (BSMMU) Hospital, and Uttara Adhunik Medical College, Dhaka. The age ranges of the participants were 40-70 for both Broca's aphasics and normal speakers. In addition, there were 26 male and 4 female participants. Broca's aphasics took approximately 20-30 minutes, and normal speakers took approximately 15-20 minutes for this experiment.

## Materials

A sentence-picture matching task has been set for this experiment. Five yes/no questions from the Bangla language have been constructed for this experiment. Three pictures were included with each question, one of which was to be selected by the subjects. This test was designed to observe the comprehension ability of the participants. Practice sessions were also part of this experiment, formed with two yes/no questions and three pictures regarding these questions. As stated before, the basic sentence construction of Bangla is SOV. Due to the relatively free word order, this construction could be shuffled in many ways. Each sentence was altered into three different word orders, as presented in (8a-c).

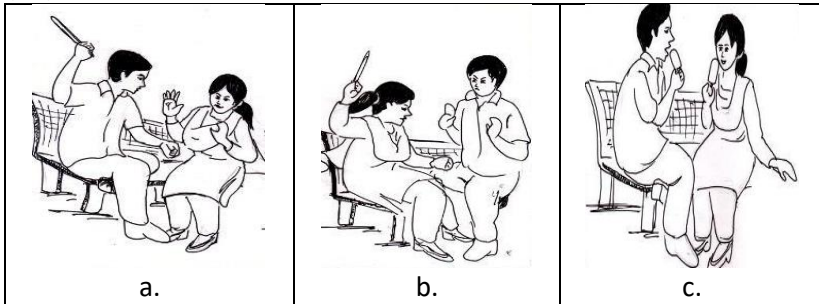
- (8) a. SOV – Subject+Object+Verb
- b. OVS – Object+Verb+Subject
- c. VOS – Verb+Object+Subject

Pictures were tagged as R means 'Related', O means 'Opposite', and UR means 'Unrelated'. Three picture orders were made for this experiment. Picture orders are presented in (9a-c).

- (9) a. UR+O+R – unrelated+opposite+related  
 b. O+R+UR – opposite+related+unrelated  
 c. R+UR+O – related+unrelated+opposite

The picture materials have been developed for this experiment to give a proper stimulus leading to the right responses. Each picture contains animate and inanimate elements.

(10)



Example (10) shows three different pictures containing an agent, a patient, and an instrument. Example (10a) shows a boy hitting a girl with a stick, and both are sitting on a bench. Example (10b) shows the inverse: a girl is hitting a boy with a stick. Finally, example (10c) shows a boy and a girl sitting together on a bench and eating ice cream. The 'boy' and the 'girl' act as an agent and patient in alternate pictures, and a 'stick' or 'ice cream' act as an instrument in the pictures. A common ground 'bench' was put in all the pictures. There are many similarities between the pictures to keep conditions constant. Other pictures included in this experiment had animate items such as 'boy', 'girl', 'child', 'dog' and inanimate items such as 'stick', 'ice-cream', 'chocolate', 'biscuit', 'flower', 'book', 'gift', 'bench' etc.

Each sentence was randomized with different word orders and picture orders. Then, all the randomized sentences were equally distributed among the participants to check if different orders of pictures with each sentence had any effect on the results. Three

different sets of trials were made for this experiment. Each trial contained 15 randomized sentences. The distribution of Randomized sentences with pictures is in Table 1.1.

Number of participants	Word order	Picture order
4	SOV	UR+O+R
3	SOV	O+R+UR
3	SOV	R+UR+O
4	OVS	UR+O+R
3	OVS	O+R+UR
3	OVS	R+UR+O
4	VOS	UR+O+R
3	VOS	O+R+UR
3	VOS	R+UR+O
Total = 30		

**Table 1.1: Randomization of sentences and pictures.**

The overall situation is that each sentence order is randomized with every picture order. Then, all the picture orders are mixed with all the sentence orders to see whether the response is affected by the picture order and sentence order distribution.

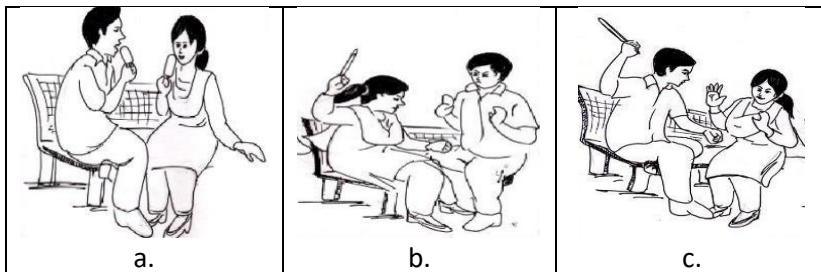
### **Procedure**

This experiment was conducted in the same way for both groups of participants. This experiment started with the basic instructions. Participants were instructed to first participate in the practice sessions and begin the main experiment. Each trial of 15 sentences was presented to them. They were asked to listen to each sentence first and then point out the picture which they thought was related to that sentence. This experiment was a test for the comprehension ability of Broca's aphasics. Listening to the sentences and pointing them out in the picture was sufficient for this task. Pictures were sequenced as 1, 2, and 3. This sequence helped to make the response faster.



(11) john ki je je mary-ke marc<sup>h</sup>e ? UR+O+R SOV  
 John this.Q he who Mary.DAT hit.PRS.PROG

'Is this John who is hitting Mary?'



Example (11) shows the sentence 'Is this John who is hitting Mary?' Three pictures were put in sequence: one with unrelated meaning, one with the opposite meaning, and one that corresponds to the sentence. The correct response for this sentence is picture number (11c) which represents a situation that would give an affirmative answer to the question 'Is this John who is hitting Mary?' This picture shows the action of 'hitting' done by the agent John. On the other hand, picture (11b) shows the opposite action, i.e., the actor and patient have switched roles: the action of 'hitting' is done by Mary. Picture number (11a) is unrelated to the sentence and is therefore considered as the distractor for the participant.

### Data Analysis and Findings

This experiment investigated the effect of alternative word orders in Bangla on the comprehension capability of Bangla speaking Broca's aphasics. The null and alternative hypotheses of this test are the following.

H0: Aphasic and normal participants do not differ according to the different word orders.

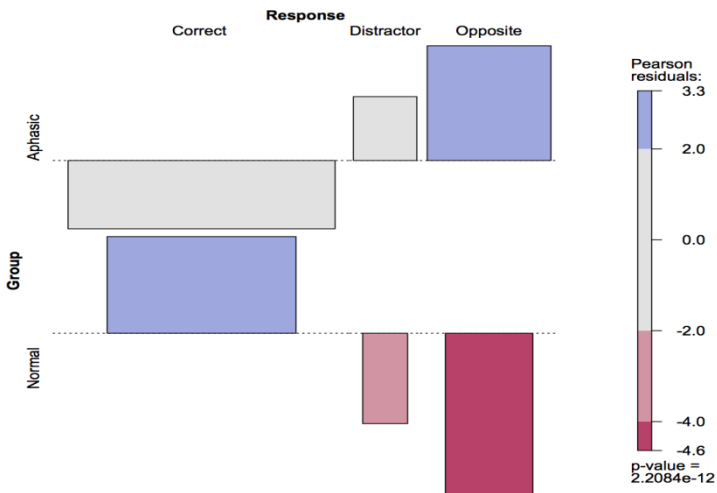
H1: Aphasic and normal participants respond differently to the different word orders.

### Question 1: Are response categories different according to the participant groups?

Group	Response		
	Correct	Distractor	Opposite
Aphasic	206	20	74
Normal	148	0	2

**Table 1.2: Analysis of all responses by groups (normal vs. aphasic)**

Table 1.2 shows the responses according to the groups of participants, i.e., Broca's aphasics and normal speakers of Bangla. The tag 'Response' has three categories, 'Correct', 'Distractor', and 'Opposite' refer to the choice of pictures used as stimuli for this experiment. A Chi-squared test showed that the 'Opposite' category suggests a significant difference between the participants. Aphasic patients significantly more often chose the opposite picture. Another notable output is that the normal speakers never chose the 'Distractor' category. The Pearson's Chi-squared test shows significance at the level of  $p < 0.001$ , which is  $\chi^2(df=2)=53.6$ ,  $p=2.2084e-12$ . Figure 1.2 is a graphical representation of the data in Table 1.2.



**Figure 1.2: Analysis of responses by group for (normal vs. aphasic).**

Figure 1.2 shows that the aphasic group has a significantly higher frequency of opposite responses. It also shows that the normal group hardly ever chose the distractor. The bar length of the graph represents the number of observations, and the bars' height represents the participants' responses. The colors show the p-values. The aphasics have not shown a good response compared to the normal speakers of the Bangla language in any response categories.

### Question 2: Are response categories different according to the word orders?

Condition	Response		
	Correct	Distractor	Opposite
OVS	111	10	29
SOV	121	5	24
VOS	122	5	23

**Table 1.3: Analysis of responses by word orders**

Table 1.3 shows the responses according to the different word orders. Again, there are no significant differences, but the OVS construction of the sentence seems to be marginally more difficult with Distractor and opposite pictures.

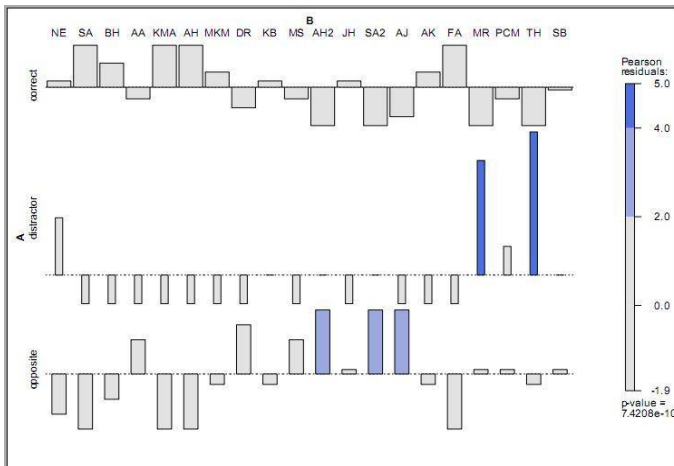
### Question 3: Are response categories different according to the individual subjects?

Response	Subjects									
	NE	SA	BH	AA	KMA	AH	MKM	DR	KB	MS
Correct	11	15	13	9	15	15	12	8	11	9
Distractor	3	0	0	0	0	0	0	0	1	0
Opposite	1	0	2	6	0	0	3	7	3	6

Response	Subjects									
	AH2	JH	SA2	AJ	AK	FA	MR	PCM	TH	SB
Correct	6	11	6	7	12	15	6	9	6	10
Distractor	1	0	1	0	0	0	5	2	6	1
Opposite	8	4	8	8	3	0	4	4	3	4

**Table 1.4: Analysis of responses for the aphasic subjects**

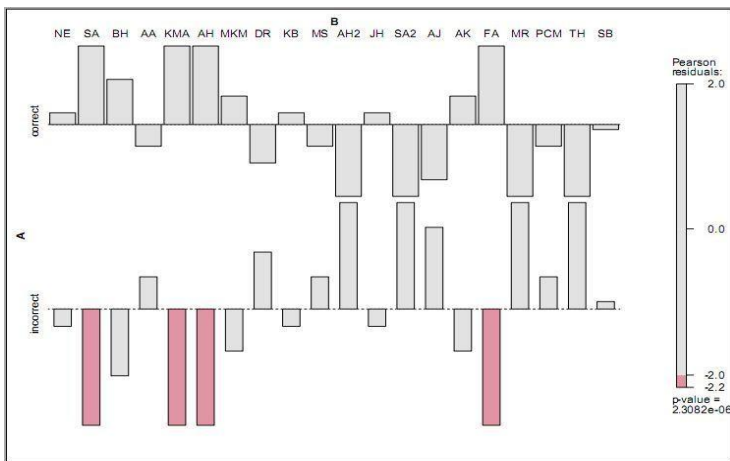
Table 1.4 shows the responses by subject in three categories: ‘Correct’, ‘Distractor’, and ‘Opposite’. The ‘Distractor’ and ‘Opposite’ responses are incorrect answers, and only two or three aphasic subjects chose mainly ‘distractor’ images. More reliable statistics might be obtained by conflating distractor and opposite responses to “incorrect” choices. In Table 1.4, SA, AH, and FA show perfect scores for this test, which is somewhat unexpected. There are two subjects, MR and TH, which stand out as choosing more distractors, which is different from the profile of the others. Participants AH2, SA2, and AJ stand out with more errors toward the ‘opposite’ response. Figure 1.3 shows the graphical representation of Table 1.4. Significance is color-coded.



**Figure 1.3: Analysis of responses by aphasic subjects**

In Figure 1.3, five subjects seem to be more severely affected than the others; these are AH2, SA2, AJ, MR, and TH. The significant part of this graph is the choice of 'Distractor'. The participants' MR' and 'TH' took the response 'Distractor' significantly more often than other participants. The participants' AH2', 'SA2' and 'AJ' took the response 'Opposite' significantly more often than the other participants.

An analysis was also performed with only two categories by conflating 'Distractor' and 'Opposite' into the 'Incorrect' category. The correct and incorrect responses from individual aphasic patients are shown in Figure 1.4. From this analysis, it can be seen that there are four subjects, SA, KMA, AH and FA, who stand out with a perfect score. They have performed just like the normal participants, which is different from the expected. The Pearson's Chi-squared is highly significant:  $p < 0.001$ ,  $\chi^2_{(df=19)} = 61.4$ ,  $p < < 0.001$ , which means that some subjects are significantly different in their responses. From the previous tests, MR and TH, and to some extent NE, have been pointed out as choosing the distractor more often, while SA, KMA, AH, and FA have scores that would place them in the normal group.



**Figure 1.4:** Analysis of responses for the aphasic subjects (Correct vs. incorrect)

## Discussion

The results show that the null hypothesis has been rejected. Four participants, SA, KMA, AH, and FA, have shown perfect scores in this experiment. These participants were tested with different trials. The reason behind the perfect score might be the difference between the trials. Trial set 1 was given to the participants' KMA', 'AH', and 'SA', while trial set 3 was given to participant 'FA'. The noteworthy part is that there is no perfect score for trial set 2. The design with different trial sets, which was intended to check whether the difference in the randomization of pictures and sentences has any effect on the responses, has resulted in different sets which may have different levels of difficulty so that trials 1 and 3 were more comprehensible for aphasics than the trial 2.

The two participants, 'MR' and 'TH', who frequently chose the 'Distractor' might be confused by the verb, which is perhaps why they do not choose the 'Opposite' one. Another possibility is that participants with perfect scores or choosing the 'Distractor' might have improved their language capability. The participants' AH2', 'SA2' and 'AJ' who responded 'Opposite' might have difficulty understanding the role of agent and patient and the verb. In the opposite pictures, the role of the agent and patient has shown in a reversed way. The reversed action in the opposite pictures was more difficult for the participants' AH2', 'SA2', and 'AJ'.

In this experiment, the subject 'KMA' showed a perfect score and perhaps belonged in the 'normal' group. In contrast, the subject 'AH2' showed severe impairment in the task. The other subjects showed more or less impairment in the task. It, therefore, seems that the experiment could lay the grounds for developing tests that assess the level of severity of the impairment.

The above discussion on the result of the experiment, which has been done for this research, shows that Broca's aphasics showed a comprehension deficit. Another idea is here that those who have a problem with production must have comprehension problems and vice versa. There is a possibility that some participants can have problems with production with intact comprehension ability, and

some other participants have problems with comprehension with intact production ability. Patients with agrammatic aphasia have problems producing and comprehending grammatical categories that may be language-dependent. The comprehension deficit with the alternative orders of the sentences seems to indicate that the Bangla speaking Broca's aphasics have difficulty in this area.

## Conclusion

This work has resulted in new knowledge about the Bangla speaking Broca's aphasics. In summary, this work has shown more errors for Broca's aphasics than the normal speakers in specific categories of the Bangla language. This experiment has demonstrated that the aphasics make more mistakes in the 'OVS' construction of the sentences with 'distractor' and 'opposite' pictures. Furthermore, the test on the comprehension capacity of Broca's aphasics with the reversible word orders of Bangla has clearly portrayed that Broca's aphasics not only suffered from language production but could also suffer from comprehension and the link between syntactic and semantic processing.

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