Original Article

Effect of Distance between Marker Agreement Dependencies on Sentence Comprehension in Persons with Aphasia

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Abstract

Background: Rules and regularities are embedded in all the language structures. Extracting these helps in speech-language acquisition and processing. Sentence processing relies on transitional probability of the dependencies and its distance which are present within the sentence. **Aim:** To investigate the effect of distance between marker agreement dependencies on sentence comprehension in Persons with Aphasia (PWA) and Neuro- Typical Individuals (NTI). **Methods:** Ten PWA and Ten NTI were recruited for the study. Participants whose native language was Kannada (a South Indian Language) and received formal education of minimum 10th grade were selected. **Materials:** A total of 60 Kannada sentences were used and grouped into three categories i.e., short sentence (had short distance between dependencies) (SSD); Longer sentences (had long distance between dependencies) (LLD) and longer sentences (had short distance between dependencies) (LSD). The agreement markers in the sentence were manipulated w.r.t distance among them and grouped it as adjacent (short distance) and non-adjacent (long distance) type of sentences. **Procedure:** The participants were instructed to read the sentence and judge whether it is grammatically correct or not by pressing the key corresponding to 'yes' or 'no' on the keyboard. In addition, modified N-back task was administered. **Results and Discussion:** Accuracy and reaction time measures were derived for each sentence types. NTI showed better performance than PWA in sentence judgment task. Both the groups, performed poorly on LSD type of sentence when compared to other sentence types. LSD type was more complex due to the syntactic demands placed by the antecedent preposition, pronoun and adverb placed nearer to the verb and also longer distance between subject agreement to the verb.

Keywords: Aphasia, sentence processing, subject-verb agreement, working memory

Guest editor's notes: This paper will give general neurologists some ideas as to what type of narrowly focussed neuro-linguistic research questions agitate the minds of scholars in aphasiology. It makes an intuitive sense that auditory and reading comprehension of long and complex sentences will tax the short term and working memories. The same has been documented here with fine variations in the theme.

Introduction

Humans uncover the structure of the language by extracting the statistical rules and regularities present within the language. This extraction process helps in speech–language acquisition[1] and processing.[2,3] Wide range of information like phonetic, lexical-semantic, morpho-syntactic, and contextual cues plays a crucial role in processing language in real life situations. Sound and word segmentation, syntax, and other non-linguistic aspects are processed based on the sequential or transitional probabilistic information of the dependencies which are present in the input.[4-6]

Recently the topic of debate is how individuals utilize these covert structures present in a sentence while processing it. Sentence processing relies on transitional probability of the dependencies which are present within the sentence.[7] Predictive dependencies present in the sentence acts as helpful information in processing the complete sentence in a stream of speech. For example, the presence of a word like "*the*" or "*a*" in the sentence predicts a noun somewhere in proximity; the existence of a preposition in the sentence predicts a noun phrase present subsequently. The relationship or the dependency present in the sentence between words can be in short distance or long distance. Simple relationships can be between auxiliaries and inflectional morphemes (ee.g., short distance/adjacent dependency "he is driving," long distance/non-adjacent dependency "the flowers in the garden are blossoming"). Word class and agreement markers are dependent in the sentence. The relationship can be adjacent and non-adjacent type. More complex relationships can be observed in anaphoric references (e.g., "Mary went to hospital where she consulted

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Submitted: 24-May-2020 **Revised:** 18-Jun-2020 **Accepted:** 03-Jul-2020
Published: 25-Sep-2020

DOI: 10.4103/aian.AIAN_510_20

the doctor") and cataphoric references (e.g., "I called him every day still my father complains that I don't call often"). A listener or reader makes use of one dependency cue in predicting the upcoming dependent information present in the sentence to process it efficiently and quickly.

Throughout the literature, researchers have attempted to study how an individual makes use of this complex and varied dependency information while processing and during acquisition process at infancy stage. Studies conducted have utilized sentences containing relative clauses that alter the head noun phrases. Processing of subject and object relative clauses have been studied extensively. Both types of relative clause sentences involve a non-adjacent dependency between the head-noun and the main verb, across the embedded clause. Warren and Gibson[8] stressed on the importance of the position of the thematic role assignments and the involvement of working memory in maintaining the noun phrases in memory before thematic roles are assigned to integrate into the sentence. In addition to that, object relative clause particularly involves back-tracking of non-local dependency (between embedded verb and its antecedent object). The word order of object relatives requires longer maintenance of unanalyzed noun phrases than in subject relatives. This unintegrated noun phrase within the sentence puts more burden on working memory.[9-11] Because of this kind of structure, object relative clauses are complex in nature. It has been concluded that object relative sentences are complex, and it is difficult to process when compared to subject relative sentences.[9] These well-established results are put forth using tasks like reading aloud task, response accuracy to probe questions and online lexical decision. Discussing about the sentence processing in Kannada (a South Indian language), which is used in the present in the study. Sentences in Kannada follow subject–object–verb (SOV) order. The word order in Kannada is flexible and any violations present, it does not affect the understanding of the grammatical relations present in the sentence. The written form in Kannada remains uniform even though there are many spoken dialects.

A study by Zurif *et al*.[12] explored the effect of linear distance in processing the sentences in younger adults. Linear distance is the intervening words in a linear order between the two dependencies in a sentence. Structural distance is the intervening nodes in the syntactic tree. When the linear distancing in the sentence increased, poorer performance was observed. It is assumed that linear distance is related to working memory ability and structural distance is directly related to syntactic ability.[13,14] The hypothesis of linear distance and structural distance states the difficulties in processing of relative clause sentences. It is hard to delineate the effect of structural and linear distance in object relative clauses or object-cleft or passive voice forms, as it in involves longer structural and linear distance. There is no study which specifically explains the processing of relative clauses in Kannada language. Active sentences are syntactically simpler compared to other forms in all languages. It can be assumed that subject relative clause and object relative clause in Kannada may not have greater difference in processing, considering the word order in Kannada, that is, the distance between the two dependencies in a sentence is lesser or not straightforward when compared to English.

A study by Liu and Wang[15] explored the comprehension of Mandarin relative clauses by manipulating long-distance dependencies, that is, between linear distance and structural distance. A total of 33 younger adults and 30 older adults participated in the study. It was found that slower processing was observed for structural distancing clauses for both groups. But older adults performed less accurately for linear distancing clauses. This could be attributed to age-related working memory decline. To see the effect of distance in sentences which were manipulated in terms of short and long distance, Newman *et al*.[16] studied processing of sentences by manipulating the distance (short vs. long) between subject and verb in conjoined-active and object relative clauses. A total of 18 neuro-typical individuals with the average of 22 years were included in the study. Participants read the sentences and responded to the probes asked by the researcher. Probes were about the noun performing the act and which is denoted by verb. It was found that poorer response accuracy was observed for object relative clauses when compared to conjoined active clauses. Short distance dependency sentences had higher demands in processing because the sentence structure was in non-canonical order.

Research on clinical population like Specific language Impairment, Learning Disability, Dementia, and Aphasia have been carried out and most are from western context. The effect of distance on number agreement markers has been studied by Almor *et al*.[17] in persons with Alzheimer's disease (AD). The aim of the study was to find the correlation of sentence processing and working memory. Experiment included 10 persons with AD and 10 neuro-typical individuals. English sentences were manipulated for subject–verb number agreement and pronoun number agreement in short and long distances. It was found that no differences in length condition in both agreement types. With respect to subject–verb agreement, working memory performance is independent of sentence processing suggesting that both are two different processes. Pronoun number agreement correlated with working memory performances. This result suggests that there is no interference of working memory deficits in online sentence processing but not for discourse processing in persons with AD. Another study which considered the dependency length and agreement markers as variables in investigating its role in sentence comprehension and correlation with working memory. Friedman and Gvion[18] conducted the study in the aphasia population. A total of six participants in the clinical group, three persons with agrammatic aphasia, and three persons with conduction aphasia were recruited. Six neuro-typical individuals were included in the study and their native language was Hebrew. The commonly used word order in Hebrew sentences is similar to English but in some cases verb–subject–object order also used.[19] The experiment of the study was two-fold. In the first experiment, subjective and objective relative clauses were used by manipulating its number agreement. In addition to this, digit

span, word and non-word span and listening span working memory tasks were used. It was noted that persons with agrammatic aphasia had better performance on subject relative clauses irrespective of their length between dependencies and person with conduction aphasia showed no differences in performances on both relative clauses and length, even though they displayed poor working memory scores. In the second experiment, disambiguation distance effect in sentence was studied. Persons with agrammatic aphasia showed no difference in performance on short and long-distance disambiguation. But persons with conduction aphasia exhibited difficulty in comprehension of sentences which had long distance disambiguation as it demanded phonological reactivation. The results highlight the importance of determining the working memory effect on sentence processing in persons with aphasia.

Need for the study

For successful sentence processing, available information about the dependencies present within the sentence must be used. This transitional probabilistic information about the dependencies helps in sentence comprehension. In the literature, many studies have been carried out on different relative clause sentences in natural language, learning in artificial language, adjacency effect of dependencies in normal and clinical population. It is important to study in persons with aphasia, as comprehension deficits is one important characteristic in this clinical population. There is a greater need to investigate sentence comprehension process in persons with aphasia. From earlier studies on persons with aphasia, it was observed that the data sample size was small and this research has been focused more in the Western context. There is a dearth of research literature on this topic in the Indian context and in one of the South Indian languages, that is, Kannada, which is highly rich in morphology and called as agglutinative language. It will be important to study adjacency effect between agreement markers on sentence comprehension in this language, which can throw light on selection of sentences based on its dependency's adjacency nature during assessment and intervention procedure. Dependency distance can be considered as a variable to study the role of transitional probabilistic information in sentence comprehension process using sentence judgment task in aphasia.

Aim

The present study aimed at investigating the effect of distance between marker agreement dependencies on sentence comprehension in Persons with Aphasia (PWA) and Neuro-typical Individuals (NTI).

Objectives

1. To compare the accuracy scores and reaction time across three types of sentences in PWA.
2. To compare the accuracy scores and reaction time across three types of sentences in NTI.
3. To compare the sentence judgment task performance between PWA and NTI.
4. Correlation between performance of sentence judgment task and modified n-back task in PWA and NTI.

Method

Participants: 10 PWA following stroke were recruited to the study. PWA with scores more than or equal to 100 in Auditory comprehension section of Western Aphasia Battery-Kannada[20] and scores more than or equal to score 24 in Mini-Mental State Examination (MMSE)[21] were selected. Additionally, those who had enough motor ability to give their responses on the computer keyboard and with normal or corrected to normal vision and hearing were included. Further none of the participants showed any form of perseveratory errors (See Table 1 for demographic details).

Ten NTI who were caretakers or family members of the PWA to match both the groups with respect to their communicating background and socioeconomic status were included. For the inclusion to NTI group, individuals with no sensory, developmental, learning, or neurological deficits were considered.

Participants from both the groups whose native language was Kannada (a Dravidian, South Indian Language) and received formal education of minimum 10th grade (This is to ensure that they possess sentence level reading skills in the Kannada language) were selected. Informed written consent was taken before them participating in the study. Present study followed AIISH ethical guidelines before recruitment of subjects.

Materials: Sentence judgment task- The sentences used in this task was manipulated based on the distance between the dependencies of the marker agreement. The examples in English (1 & 2) and Kannada (3 & 4) are as given below.

Example 1: The boy is sleeping; Example 2: The boys are sleeping

In the above example 1 and 2, an auxiliary verb (is/are) is dependent on the plural marker or inflectional morphemes of the word "boy/boys."

Example 3: Non-anomalous sentence -/ava**nu** malagi**danu/(**he slept**):** short distance gender agreement. Anomalous sentence –/ava**nu** malagida**lu/(**he slept (sleep + gender (female)+past tense)) **:** short distance gender disagreement

Example 4: Non-anomalous sentence:/Ava**nu** manchchada mele malagida**nu/**(he- cot-on- slept/he slept on the cot): long distance subject-verb agreement long distance gender agreement. Anomalous sentence:/Ava**nu** manchchada mele malagida**lu/**(he-cot-on-slept (sleep + gender (female)).

Example 5: Non-anomalous sentence:/Avanu bengalurige **naale** hogutt**aane**/(he-Bangalore-tomorrow-go/He will go to Bangalore tomorrow): Short distance long sentence. Anomalous sentence -/avanu bengalurige **naale** hod**anu**/(he went to Bangalore tomorrow).

The developed sentences were validated by three speech–language pathologists for appropriateness of meeting the grammaticality, ungrammaticality, and adjacency rule in the sentence before selecting as the final stimuli (see appendix).

Table 1: Demographic details of participants (clinical group) who participated in the study

SI NO	Age/G	Education	Occupation	Post-onset	AQ	Aphasia type
PWA1	26/M	Diploma	Factory worker	5months	46	Broca's aphasia
PWA2	26/M	Diploma	Hotel Captain	8 months	84.7	Anomic aphasia
PWA3	35/M	Post-graduation	Private employee	4 months	62.8	Broca's aphasia
PWA4	40/M	Higher Secondary Education	Farmer	1 year	56	Brocas's aphasia
PWA5	36/M	Post-Graduation	Private employee	1 year	89	Anomic aphasia
PWA6	62/M	Graduation	Panchayat secretary	5 year	52.9	Broca's aphasia
PWA7	68/F	Higher Secondary Education	Anganawadi Teacher	3 months	73	Anomic aphasia
PWA8	39/M	Diploma	Private Employee	3 months	89.4	Anomic aphasia
PWA9	34/F	Higher Secondary Education	Housewife	1 year	65	Broca's aphasia
PWA10	36/M	Graduation	Business	3 months	85	Anomic aphasia

PWA=Persons with Aphasia

The written stimuli were given to speech–language pathologists whose first language was Kannada were selected and asked to rate the sentences as "appropriate" or "inappropriate." A total of 60 Kannada sentences were finalized and grouped into three categories, that is, short sentence (had short distance between dependencies) (SSD); Longer sentences (had long distance between dependencies) (LLD), and longer sentences (had short distance between dependencies) (LSD). The agreement markers in the sentence were manipulated w.r.t distance among them and grouped as adjacent (short distance) and non-adjacent (long distance) type of sentences. These sentences were included to study the distance effect between the dependencies.

In addition to sentence judgment task, a modified n-back task was used to assess the working memory capacity of the participants. Modified n-back task paradigm was developed and fed into Psychopy. In the Modified n-back task, pictures of lexical items which are most familiar like car, bus, scooter, apple, cow, etc., were used as stimuli.

Procedure

Participants were seated in front of the laptop screen in a room free from noise and visual distractors. The participants were instructed to listen to the sentences which were presented through headphone (also it was presented visually on the laptop-screen) and judge whether it is grammatically correct or incorrect by pressing the key corresponding to "yes" or "no" on the keyboard. A set of stimuli was presented using a laptop (Lenovo, Z570, 14.5-inch display screen) through Psychopy software (version 2.3).[22] Presentation of sentences was counterbalanced across participants with respect to sentences types.

Modified N-back task- The participants were given instructions "You will see a sequence of pictures (lexical items) on the computer screen, you need to judge whether the current picture matches with previous stimulus which is at n^{th} place ($n = 1$, $n = 2$ etc)". The complexity of the task increased from $n = 1$ to $n = 7$. In each level, five times the stimuli were presented. When a participant gives the correct response greater than or equal to three out of five times, the next level was initiated.

Scoring: Sentence judgment task (SJT)- Correct judgment of sentence was scored as 1 and incorrect as 0. Total score of 20 in each sentence type which consists of 20 sentences.

Modified N-back task- The level at which the participants fail to consistently give a minimum of three correct responses out of five sets of trials in n^{th} level, the previous level score will be considered as working memory span. For example, if the participants fail to match the picture at $n = 4$ level correctly, then working memory span will be three.

Results and Discussion

Statistical analysis was done using Statistical Package for Social Science (SPSS) version 17 software. The results of the present study were discussed under the following subheadings: (a) comparison of reaction time and accuracy scores across three types of sentences in PWA; (b) comparison of reaction time and accuracy scores across three types of sentences in NTI; (c) To compare the SJT performance across PWA and NTI; (d) correlation between performance of sentence judgment task and n-back task.

(a) To compare the reaction time and accuracy scores across three types of sentences in PWA

Accuracy and reaction time measures were derived for each sentence type. Data was subjected to a normality test and found that it was not normally distributed. Hence, non-parametric tests were applied. To verify the difference between accuracy scores of all three sentence types, the Friedman test was applied. It was found that there was a statistically significant difference ($P < 0.05$). Further, the Wilcoxon signed rank test was used to see difference across all possible pairs and found a statistically significant difference for SSD vs LLD ($|Z| = 2.38$, $P < 0.05$, $r = 0.53$), SSD vs LSD ($|Z| = 2.68$, $P < 0.05$, $r = 0.59$) and no statistically significant at ($|Z| = 1.80$, $P > 0.05$, $r = 0.39$) for the pair LLD vs LSD.

To verify the difference between reaction time for all three sentence types, the Friedman test was applied and found a statistically significant difference ($P < 0.05$). To see the difference between the possible pairs of the sentence types on the reaction time measure, Wilcoxon signed rank test was

applied and observed a significant difference for SSD vs LLD and SSD vs LSD ($|Z| = 2.80$, $P < 0.05$, r = 0.62). For the pair LSD vs LLD, there was no significant difference ($|Z| = 1.68$ $P > 0.05$, r = 0.37). Additionally, within the aphasia group, there were five Broca's type of aphasia and five Anomic type of aphasia. In Broca's type of aphasia, mean accuracy scores of SSD type was 16.20 (SD = 2.77), LLD type was 15.01 (SD = 3.53), and LSD type was 13.20 (SD = 3.63). Reaction time scores of SSD type was 3397 ms (SD = 789.01), LLD type was 4305.2 ms (SD = 880.7), and LSD type was 5067 ms (SD = 915.2). In Anomic type of aphasia, mean accuracy scores of SSD type was 17.40 (SD = 1.51), LLD type was 15.60 (SD = 2.70), and LSD type was 14.40 (SD = 2.07). Reaction time scores of SSD type was 3887.8 ms (SD = 1511.6), LLD type was 5804.2 ms (SD = 2615.7), and LSD type was 6295.6 ms (SD = 2111.9). Their performance was compared using the Kruskal–Wallis test and found no significant difference between Broca's aphasia and Anomic aphasia [Table 2].

Among three types of sentences, performance on SSD type was better when compared to the other two types. This can be attributed to the shorter length of the sentence leading to better accuracy and faster reaction time in judgment. Shorter the sentence, load on working memory will be lesser, time taken to read, and processing will be faster, even though LLD and LSD type of sentences were maintained with the same sentence length. It was noted that better accuracy scores were seen for LLD type and reaction time was faster than LSD type. It was hypothesized that reaction time will be more to judge LLD type when compared to LSD type, assuming that greater time will be required to process the LLD type of sentence when the distance between the dependencies is more. As there will be more demand on working memory in order to hold the information to process because of the intervening words present between the two dependencies in the sentence. But this hypothesis was discarded. Relatively slower reaction time on LSD type of sentence can be attributed to its sentence structure, that is, the subject, object, preposition placed nearer to the verbs (which are inflected with the morphemes (PNG and tense markers) leading to syntactic load along with the working memory demands. This result is supported by findings of Newman *et al*.[16] study. Another reason would be that in day-to-day life, listeners and speakers use the LLD type of sentence structure in conversation and other speech acts. The LSD type structure, which is not generally used, this might have led to the slower reaction time and poor accuracy scores. A study by Friedman and Gvion,[18] where persons with agrammatic aphasia performed equally irrespective of distance between variables in subjective relative clause and persons with conduction aphasia exhibited difficulty only when comprehension of sentences involved complex phonological reactivation, a similar result was observed in the present study. Findings of the present study provide inflected language like Kannada to have such effects. Further, the findings of the study add to the existing research that such trend can be even be generalized for the inflected languages. During the assessment and treatment of sentence comprehension, the selection and use of sentences with respect to its distance between agreement markers should be carefully considered. However, this needs to be further explored in detail to make the findings of the study more robust. Hence it is suggested generalisation of the findings of the study is warranted.

Table 2: Accuracy scores and reaction time of Sentence judgment task in PWA

	SSD		LLD		LSD	
	Mean	SD	Mean	SD	Mean	SD
Accuracy scores	16.80	2.20	15.30	2.98	13.80	2.85
Reaction time (in ms)	3642	1165.7	5055	2002.6	5681.1	1665.5

PWA=Persons with Aphasia, SSD=short sentence with short distance, LLD=Longer sentences with long distance, LSD=longer sentences with short distance

(b) To compare the reaction time and accuracy scores across three types of sentences in NTI.

Accuracy and reaction time measures were derived for each sentence type for NTI group. To verify the difference between accuracy scores of all three sentence types, the Friedman test was applied. It was found that there was no statistically significant difference ($P > 0.05$) [Table 3].

To verify the difference between reaction time for all three sentence types, the Friedman test was applied and found a statistically significant difference ($P < 0.05$). Further, to see the difference between the possible pairs of the sentence types on the reaction time measure, Wilcoxon signed rank test was applied and noted a significant difference for SSD vs LLD, SSD vs LSD, and LSD vs LLD ($|Z| = 2.80$, $P < 0.05$, r = 0.62). The results of NTI are complemented by Newman *et al*.[16] study findings. Difference in performance was observed for short and long distances in both conjoined-active sentences and object relative clauses. Due to the non-canonical structure in the short distance of object relative clause, it was more difficult than the short distance condition of conjoined-active sentences. Similarly, in the present study LSD type had more demands due to the syntactic demands placed by the antecedent preposition, pronoun and adverb placed nearer to the verb and also longer distance between subject agreement to the verb.

c) To compare the SJT performance across PWA and NTI.

Performance of PWA and NTI on accuracy scores of SJT were analyzed using descriptive statistics. To find the statistical difference across two groups, Kruskal–Wallis test was used. Results revealed a statistically significant difference across two groups for SSD ($|Z| = 10.36$, $P < 0.05$), LLD ($|Z| = 13.91$, $P < 0.05$), and LSD ($|Z| = 8.01$, $P < 0.05$).

Similarly, PWA and NTI on the reaction time of SJT were analyzed using Kruskal–Wallis test. It was observed that there is a statistically significant difference for SSD ($|Z| = 12.62$, $P < 0.05$), LLD ($|Z| = 9.14$, $P < 0.05$), and LSD ($|Z| = 12.09$, $P < 0.05$). The performance from NTI was better and

Table 3: Accuracy scores and reaction time of Sentence judgment task in NTI

	SSD		LLD		LSD	
	Mean	SD	Mean	SD	Mean	SD
Accuracy scores	19.10	0.87	18.90	0.99	18.80	1.22
Reaction time (in ms)	2247.7	359.1	3145.6	382.6	3679.2	731.9

NTI=Neuro-Typical Individuals, SSD=short sentence with short distance, LLD=Longer sentences with long distance, LSD=longer sentences with short distance

it was statistically significant compared to PWA. This result is supported by studies by Friedman and Gvion[18] and Almor *et al*.[17] study. Both the clinical and normal group performed better in SSD, which is due to lesser demands in processing which is attributed to its sentence length. Poorer performance in LSD type comparing to the LLD type was observed in both groups, suggesting both the groups had difficulty in processing the extra demands placed by word class antecedents which was nearer to one of the dependencies in the sentence even the distance was lesser.

(d) Correlation between performance of sentence judgment task and n-back task.

Working memory capacity scores were derived for modified n-back task based on participant's performance. Mean values of working memory capacity score for NTI was M = 6.2 (SD = 0.63). The performance was nearly to ceiling level. Mean value of working memory capacity score for PWA was M = 3.9 (SD = 0.73).

Correlation between performance of sentence judgment task and n-back task was analyzed using Spearman Correlation and found no significant correlation between the accuracy scores and reaction time of sentence judgment task and working memory capacity in PWA and NTI. Regarding the correlation between the two tasks, our results contradicted the earlier results of McDonald (2008) and supported one of the objectives of Almor *et al*.[17] study.

From the sentence types, when the intervening words are in a linear order, it is considered as a linear distance between the two dependencies. LLD type sentence has linear distance between dependencies. In LSD type, the sentence had relative structural distance in it. According to the researcher's hypothesis, LLD type processing will lead to higher reaction times than LSD type, due to higher working memory load as the distance between the two dependencies was more. But the results showed performance on LLD type was better compared to LSD type. As LSD type of sentence involved higher syntactic demands placed by antecedent word class which present nearer and between the two dependencies. From this, it can be concluded that working memory and processing of sentences which have linear distancing rules are independent processes. Another reason for no correlation between sentence processing and working memory could be due that individuals are able to process or interpret the sentence when they read or hear it but might perform poorly on sentence judgment or comprehension task because of the task demands like read and process the sentence and give response to it by pressing the key button or in any other response mode. This effect is called "post- interpretive deficit."[23]

The interaction between working memory and sentence comprehension is extremely complicated. In the present study, use of n-back task may not be a better measure for the correlation with linguistic task , that is, sentence judgment task in the present study. Rather, a linguistic working memory based task, or designing a task which externally imposes working memory load on the main linguistic (sentence judgment) task might give clear evidence.

Conclusion

The present study aimed at understanding the effect of distance between the subject–verb agreement dependencies on sentence comprehension in PWA and NTI. It was found that there was a significant difference across the types of sentence for both accuracy and reaction time measure between the two groups. Better performance was seen for SSD compared to LLD and LSD. LSD type of sentence yielded lesser scores when compared to other two types. Accuracy and reaction time measures can yield more information on online-sentence comprehension with variables as sentence type, dependencies present within the sentence and its distance. The present study highlights the impact of working memory and syntactic demands caused due to the distance between the dependencies on sentence comprehension.

The first limitation of the study was the small number of participants included in the experiment. In the present study, the clinical group did not involve other types of aphasia like Wernicke and Conduction aphasia. Another limitation of the study was, there is no exclusive evidence from the present study regarding reading time of the sentence. Even though past studies have shown that there will be a difference in reading time among sentence types like subject and object clause which involves inanimate sentential subjects. Discussing the effect of individual agreement markers like PNG and tense markers on comprehension might lead to better knowledge on sentence comprehension in aphasia. Use of other sentence types like conjoined sentences, relative clauses and reversible sentences might provide more information regarding the same in Kannada language. It will be interesting to study these aspects using ERPs and eye-tracking based methods. The study can be extended to other language disordered population.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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Appendix

Practice

1. avaLu barejuttida:Le
2. akka tinnuttiddaane
3. avanu pratinitja vyayaama maaḍuttaane
4. sebu maradinda keLage biddanu

Shorter sentences (SSD)

1. avanu malagidanu
2. kudure oḍuttide
3. huḍuga oduttidaane
4. hakkigaLu haaruttive
5. huḍuga biddanu
6. avaLu naguttidaaLe
7. pakshi haaruttide
8. avaLu aLuttiddaaLe
9. naaji bogaLuttide
10. avanu bandanu
11. huḍugi haaḍuttiddaale
12. magu tevaLuttide
13. avalu kuḍidanu
14. naaLe hodenu
15. hasu oḍidaLu
16. avanu oḍidaLu
17. appa hodaLu

18. avanu nintiddaaLe
19. avaru naguttide
20. avanu hoguttaare

Longer sentences (LLD)

1. avanu manʧada mele malagidanu
2. amma mattu appa maarukattege hOdaru
3. avaLu pustakadalli ʧitra bareyutiddaaLe
4. huɖuga maradinda kelage biddanu
5. avaLu haŋŋannu kattarisi tindaLu
6. huɖuga gaaLipaTavannu maaɖi haarisidanu
7. aŋŋa tangige jaɖe haakuttiddaane
8. huɖuga naajige kallu hoɖedanu
9. bekku naajijannu noɖi oɖuttide
10. avanu ooTa maaɖi kai toLedanu
11. avanu devastaanakke hoovannu tegedukonɖu hodanu
12. avara manejalli naaji saakiddaare
13. avanu manejinda ʃaalige hodaLu
14. amma makkalige haalu koTTanu
15. koti marada mele iddaaLe
16. avanu naaLe bengalUrige hodanu
17. aʤʤi makkalige kathe helidanu
18. magu hoTTe hasivininda aLuttidaare
19. aŋŋa poodʒege hoovu tandaLu

20. avalu saikalninda biddanu

Longer sentence (LSD)

1. avanu oorinda naaLe baruttane
2. avanu sinemaage nenne hogiddanu
3. skuTarninda kelage avanu biddanu
4. avaLu hoovannu naaLe taruttaaLe
5. makkalu ʃaaLege naaLe hoguttaare.
6. naavu kaaDige naaLe hogutteve
7. akka manege naaLe baruttaaLe
8. aŋŋa baLehannanu nenne tandanu
9. maisUrige avaLu naaLe baruttaale
10. naanu mangalurrige naale hoguttini
11. appa manege naaLe baruttaare
12. avalu ʃaaLege nenne hogiddaLu
13. appa haŋŋannu naaLe tandaru.
14. ʃaaLege karinalli avanu hodalu.
15. manejalli naalku kiTakigalu ide
16. horagaḍe tumbaa bisilu ive
17. kaaḍinalli simhavannu makkaLu noḍidalu
18. namma manejalli mUru najigalu iddaare
19. maLe baruvaaga avanu hodaLu
20. hasuvige hullannu avanu haakidalu